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Indonesia Climate Change Sectoral Roadmap
ICCSR

Water Resource Sector

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The Indonesia Climate Change Sectoral Roadmap (ICCSR) is meant to provide inputs for the next five year Medium-term Development Plan (RPJM) 2010-2014, and also for the subsequent RPJMN until 2030, laying particular emphasis on the challenges emerging in the forestry, energy, industry, agriculture, transportation, coastal area, water, waste and health sectors. It is Bappenas' policy to address these challenges and opportunities through effective development planning and coordination of the work of all line ministries, departments and agencies of the Government of Indonesia (GoI). It is a dynamic document and it will be improved based on the needs and challenges to cope with climate change in the future. Changes and adjustments to this document would be carried out through participative consultation among stakeholders.

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Remarks from Minister of National Development Planning/ Head of Bappenas

We have seen that with its far reaching impact on the world's ecosystems as well as human security and development, climate change has emerged as one of the most intensely critical issues that deserve the attention of the world's policy makers. The main theme is to avoid an increase in global average temperature that exceeds 2°C, i.e. to reduce annual worldwide emissions more than half from the present level in 2050. We believe that this effort of course requires concerted international response – collective actions to address potential conflicting national and international policy initiatives. As the world economy is now facing a recovery and developing countries are struggling to fulfill basic needs for their population, climate change exposes the world population to exacerbated life. It is necessary, therefore, to incorporate measures to address climate change as a core concern and mainstream in sustainable development policy agenda.

We are aware that climate change has been researched and discussed the world over. Solutions have been proffered, programs funded and partnerships embraced. Despite this, carbon emissions continue to increase in both developed and developing countries. Due to its geographical location, Indonesia's vulnerability to climate change cannot be underplayed. We stand to experience significant losses. We will face – indeed we are seeing the impact of some these issues right now- prolonged droughts, flooding and increased frequency of extreme weather events. Our rich biodiversity is at risk as well.

Those who would seek to silence debate on this issue or delay in engagement to solve it are now marginalized to the edges of what science would tell us. Decades of research, analysis and emerging environmental evidence tell us that far from being merely just an environmental issue, climate change will touch every aspect of our life as a nation and as individuals.

Regrettably, we cannot prevent or escape some negative impacts of climate change. We and in particular the developed world, have been warming the world for too long. We have to prepare therefore to adapt to the changes we will face and also ready, with our full energy, to mitigate against further change. We have ratified the Kyoto Protocol early and guided and contributed to world debate, through hosting the 13th Convention of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), which generated the Bali Action Plan in 2007. Most recently, we have turned our attention to our biggest challenge yet, that of delivering on our President's promise to reduce carbon emissions by

26% by 2020. Real action is urgent. But before action, we need to come up with careful analysis, strategic planning and priority setting.

I am delighted therefore to deliver *Indonesia Climate Change Sectoral Roadmap,* or I call it ICCSR, with the aim at mainstreaming climate change into our national medium-term development plan.

The ICCSR outlines our strategic vision that places particular emphasis on the challenges emerging in the forestry, energy, industry, transport, agriculture, coastal areas, water, waste and health sectors. The content of the roadmap has been formulated through a rigorius analysis. We have undertaken vulnerability assessments, prioritized actions including capacity-building and response strategies, completed by associated financial assessments and sought to develop a coherent plan that could be supported by line Ministries and relevant strategic partners and donors.

I launched ICCSR to you and I invite for your commitment support and partnership in joining us in realising priorities for climate-resilient sustainable development while protecting our population from further vulnerability.

Minister for National Development Planning/

Head of National Development Planning Agency

Prof. Armida S. Alisjahbana

Remarks from Deputy Minister for Natural Resources and Environment, Bappenas

To be a part of the solution to global climate change, the government of Indonesia has endorsed a commitment to reduce the country's GHG emission by 26%, within ten years and with national resources, benchmarked to the emission level from a business as usual and, up to 41% emission reductions can be achieved with international support to our mitigation efforts. The top two sectors that contribute to the country's emissions are forestry and energy sector, mainly emissions from deforestation and by power plants, which is in part due to the fuel used, i.e., oil and coal, and part of our high energy intensity.

With a unique set of geographical location, among countries on the Earth we are at most vulnerable to the negative impacts of climate change. Measures are needed to protect our people from the adverse effect of sea level rise, flood, greater variability of rainfall, and other predicted impacts. Unless adaptive measures are taken, prediction tells us that a large fraction of Indonesia could experience freshwater scarcity, declining crop yields, and vanishing habitats for coastal communities and ecosystem.

National actions are needed both to mitigate the global climate change and to identify climate change adaptation measures. This is the ultimate objective of the *Indonesia Climate Change Sectoral Roadmap*, ICCSR. A set of highest priorities of the actions are to be integrated into our system of national development planning. We have therefore been working to build national concensus and understanding of climate change response options. The *Indonesia Climate Change Sectoral Roadmap* (ICCSR) represents our long-term commitment to emission reduction and adaptation measures and it shows our ongoing, inovative climate mitigation and adaptation programs for the decades to come.

Deputy Minister for Natural Resources and Environment

National Development Planning Agency

U. Hayati Triastuti

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List of Abbreviations

AC	:	Adaptive Capacity
ANI	:	Indonesian National Atlas
Bappenas	:	National Development Planning Agency
Bakosurtanal	:	National Coordinating Agency for Surveys and Mapping
BMKG	:	Meteorology, Climatology, and Geophysics Agency
BWS	:	River Basin Agency
CAT	:	Confined Aquifer
CH		Rainfall Pattern
CDF	:	Commulative Frequency Distribution
DAS	:	Water Source Area
Depkes	:	Ministry of Health
DESDM	:	Ministry of Enegy and Mineral Resources
DRO	:	Direct Run Off
EE	:	Extreme Event
DPU	:	Ministry of Public Work
FGD	:	Forum Group Discussion
GIS	:	Geography Information System
GHG	:	Grenhouse Gasses
GNRHL	:	National Action on Forest and Land Rehabilitation
GTZ Germany	:	Deutsche Gesellschaft für Technische Zusammenarbeit
IPCC	:	Intergovernmental Panel on Climate Change
IPCC AR4	:	Intergovernmental Panel on Climate Change The Fourth Assessment Report
KLH	:	Ministry of Environment
MPW	:	Ministry of Public Work

NOAA	:	National Oceanic and Atmospheric Administration
PD	:	Population Density
PKA		Water Supply Shortage
PLG	:	Centre for Geological Environment
Prokasih	:	Clean River Program
RPI	:	Roadmap for Climate Change
RPJP	:	Long-Term Development Plan
RPJPN	:	National Long-Term Development Plan
RPJPD	:	Local Long-Term Development Plan
RPJMN	:	National Medium-Term Development Plan
RPJMD	:	Local Medium-Term Development Plan
RTRN	:	National Spatial Planning
RTRD	:	Local Spatial Planning
SDA	:	Water Resources
SLR	:	Sea Level Rise
SRES	:	Special Report on Emissions Scenarios
SST		Sea Surface Temperature
SWS	:	Water Capture Area
TRO	:	Total Run-off
UNFCCC	:	United Nation Framework Convention on Climate Change
WB	:	Water Balance

Chapter 1. Introduction

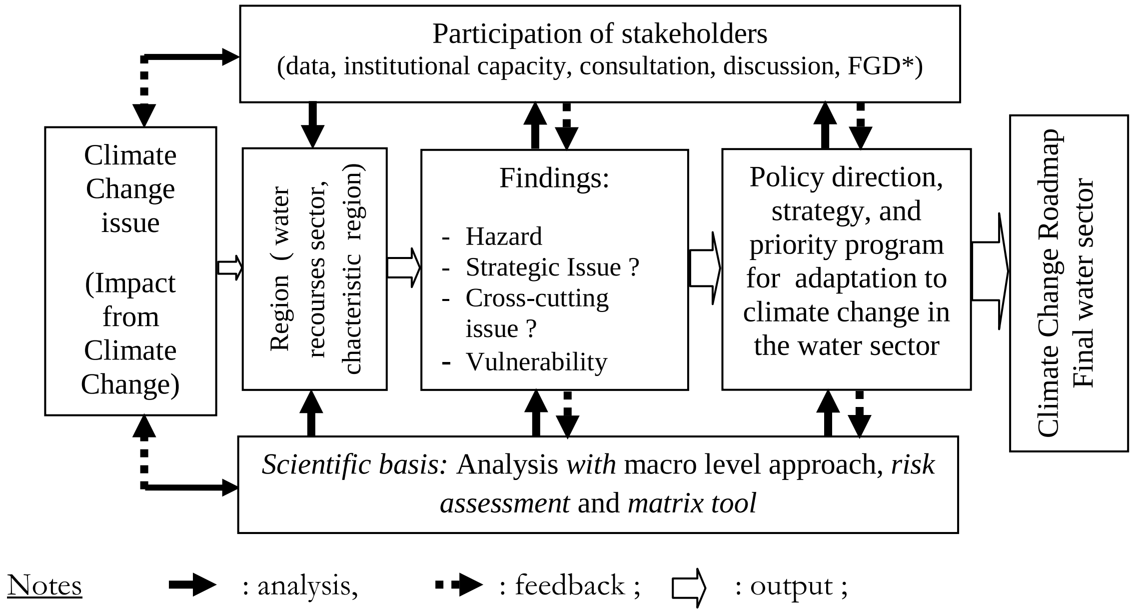
1.1 Background

As stated in the Long-Term Development Plan (RPJP) 2005-2025, sustainability of development will face challenges of climate change. To elaborate this vision, there is an urgent need to develop a roadmap for mainstreaming climate change into Indonesia's national development plan (hereinafter referred to as "Roadmap on Climate Change" or simply "the Roadmap"). The Roadmap looks out over a time frame of 20 years (2010-2029). Priority activities proposed in the Roadmap are outlined in four phases of RPJMN. Hence, it is timely well suited to integrate activities of the Roadmap into the RPJMN 2010-2014. Subsequently, the Roadmap will be considered in formulating the strategic plans of each ministry and agency.

The Roadmap recognizes that, because of its diversity along physical, economic, political, and cultural dimensions, regional approaches are essential for development planning in Indonesia. The proposed policy response to climate change has been tailored to the specific characteristics of the main regions: Sumatra, Jamali (Jawa, Madura, Bali), Kalimantan, Sulawesi, Nusa Tenggara, Maluku, and Papua.

Following the international convention, responses to climate change in the Roadmap consist of two groups of measures (i.e. mitigation and adaption) that can be implemented in Indonesia. Mitigation involves taking action to reduce greenhouse gas emissions and to enhance carbon sinks so as to reduce the risks of future global warming. Adaptation refers to the deployment of technology and institutional responses in Indonesia that can reduce the damages due to impacts of climate change by raising awareness and increasing the resilience of Indonesian society at both the national and local level .

The water sector is one of the most important sectors of Indonesian society and needs to be taken into account in creating the Roadmap on Climate Change. Most responses to climate change in the water sector are considered as part of the portfolio of adaptive responses. However, some activities and programs in the water sector could also contribute to mitigation; other activities and programs are recommended as cross-cutting initiatives. This Roadmap is built on the foundation of scientific analysis using macro study approach to simplify the study analysis, risk assessment and a matrix tool, that focuses on the diversity of regional impacts as well as cross-cutting issues. (See Figure 1.1 below)



*FGD : *focus group discussion*

Figure 1.1 Framework on building a Roadmap on Climate Change, involving scientific basis analysis, regional diversity and cross-cutting issues.

1.2 Objectives

The objectives of formulating a Roadmap on Climate Change for the water sector are as follows:

1. To identify current condition and problems as well as future challenge in the water sector in connection with climate change;
2. To identify the vulnerabilities in the water sector against climate change based on the identified threats.
3. To identify impacts or risks on water resource after its vulnerability has been identified and develop strategic issues, including cross-sectoral issues such as water and health, water and foresty, etc.
4. To identify and formulate policies and measures to integrate the adaptation in water resource sector foward climate change. The purpose consists of: a) a 20 years of long-term policy (2010-2030), b) to integrate the policy and programs into the National Medium Term Development Planning, c) Cross-cutting issues; and
5. To identify other necessary and significant aspects such as uncertainty factors, information validity level, and need for further research.

1.3 Approach

1.3.1 The Scientific Basis of the Roadmap

The steps used in building the roadmap are as follows:

1. Identification of the problem, existing capacities and future challenges, including what kind of analytic approach to be used, the exploration of specific conditions and problems, authorities' and current institutional capacities for adaptive responses in the water sector, as well as future challenges;
2. Identification of relevant climate impacts, including direct threats such as increase of temperature, change of rainfall patterns, increasing frequency and intensity of extreme weather events and sea level rise. Focus on additional threats and impacts to the water sector such as: water supply shortage, floods, droughts, landslides, and seawater intrusion;
3. Identification of key vulnerabilites in the water sector. Vulnerability is defined as a function of the character, magnitude, and rate of climate change as well as the degree of variation to which a system is exposed, its sensitivity, and its adaptive capacity (*Affeltranger, et al, 2006 as quoted in Suroso, D.S, 2008*);
4. Analysis and evaluation of risks and impacts. Risk is determined by analyzing threats and vulnerability quantitatively as well as qualitatively. Strategic issues are important to findings of the study as the primary basis of political decision making .
5. Finding a sound adaptation strategy and mainstreaming of such strategy into the national development plan through the implementation of priority policies and programs.

An ideal scientific study should be based on the risk assessment framework, which can be described in the following notation: $R = H \times V$; and $V = (E \times S)/AC$ (*Affeltranger, et al, 2006 as quoted in Suroso, D.S., 2008*).

In this notation, R represents risks, H represents hazards V represents vulnerability. E represents exposure, S represents sensitivity, and AC is adaptive capacity for coping with the hazard or risks. But as this study has been conducted at the macro level with significant time and data constraints, the risk assessment framework is applied only in principle. For the next analysis, a matrix with detailed regional mapping of threats, vulnerabilities, risks or impacts, and detailed recommendations for adaptation strategy and program recommendation (Attachment 1-2) will be used.

Risk is assessed based on the direct hazards due to impacts of climate change. Impact is a risk strengthened or weakened by vulnerability level. Table 1.1 shows the matrix which is used to identify the risks and impacts of climate change on the water sector.

Table 1.1 Matrix containing risks and impacts of climate change on the water sector

Direct Hazard	Further hazard to Water Sector	Impact on Water Sector	Data	Analysis
Temperature (T) Rise	- Increasing evapotranspiration - Change of rainfall pattern: *surface water flow decline*	- Water supply shortage - Drought - Water imbalance disorder	- potential physical hazard [1] - Vulnerability related to: population density, land use planning, etc.[3]	- water balance (WB) Analysis - Statistic Analysis CDF[2] - Qualitative Analysis
Change of Rainfall Patterns	- Rise of surface water - Rise of temperature: *surface water flow decline* - Rise of soil humidity	- Flood - Water supply shortage - Drought - Water imbalance disorder - Landslide	- potential physical hazard[1] - Vulnerability related to: population density, land use planning, etc.[3]	- water balance (WB) Analysis - Statistic Analysis CDF[2] - Qualitative Analysis
Sea level Rise (SLR)	- Groundwater withdrawal, freshwater – seawater *interface*– groundwater pressured up	- Seawater intrusion	- Climate (SLR) - Vulnerability: groundwater withdrawal, etc.[3]	- water balance (WB) Analysis - Statistic Analysis CDF[2] - Qualitative Analysis
Increasing of frequency and intensity of extreme weather	- Rainfall above normal: rise of surface water flow and soil humidity - Rainfall below normal and rise of T: *decline of surface water flow*	- Flood - Water supply shortage - Drought - Water imbalance disorder - Landslide	- potential physical hazard [1] - Vulnerability related to: population density, land use planning, etc.[3]	- water balance (WB) Analysis - Statistic Analysis CDF[2] - Qualitative Analysis

Notes:[1]potential physical hazard, among others: temperature and rainfall; land-use planning data related to hazard; [2]*CFD* : *cumulative frequency distribution*; 3) see Attachment 1-2.

Furthermore, for each hazard vulnerability assessment is undertaken prior to the impact identification (Chapter 3 and Attachment 1-2).

1.3.2 Stakeholder consultation process

Stakeholders are key actors dealing with water resources such as the Ministry of Public Works (Departemen Pekerjaan Umum/DPU); Ministry of Agriculture (Departemen Pertanian/Deptan); Ministry of Forestry (Departemen Kehutanan/Dephut); Agency of Climatology, Meteorology and Geophysics (Badan Klimatologi, Meteorologi dan Geofisika/ (BKMG);and others. The participatory process of stakeholder engagement in building the roadmap involved various activities and programs, including among others:

1. Early Consultation and introduction session for all Adaptation programs, with task-force led by Bappenas (Bappenas, Jakarta, 11 January 2009);
2. Kick-off meeting, attended by all representatives of National Council for Climate Change (Hotel Borobudur, Jakarta, 27 January 2009);
3. FGD for climate sector (Hotel Parklane, Jakarta; 4 February 2009);,
4. Consultation Pre-FGD I (Water Sector and Waste Management); preparatory for FGD's material and technical implementation in collaboration with discussant, Mr. Mochammad Amron, from Ministry of Public Works (DPU (Ministry of Public Works), Jakarta, 7-8 February 2009);
5. FGD I on Water and Waste Management sector, with discussants from Ministry of Public Works, Climatology, Meteorology and Geophysics Body, Ministry of Forestry, and other participants from related sectors (Bappenas, Jakarta, 24 February 2009);
6. Participation in FGD I on Agriculture sector (Ministry of Agriculture, Jakarta);
7. Participation in FGD I on Health sector (Bappenas, Jakarta);
8. Participation in FGD I on Industrial sector (Hotel Borobudur Jakarta);
9. In collaboration with Dr. Irving Mintzer, an unstructured in-depth interview with DPU (Ministry of Public Works) was conducted in Jakarta, 20 March 2009).
10. Pre-FGD II on Water and Waste Management sector; discussion and consultation for FGD II (Ministry of Public Works), Jakarta, 6 April 2009);
11. Discussion with Directorate General of River Basin, Ministry of Forestry (Ministry of Forestry, Jakarta, 16 April 2009);
12. Preparatory conference for FGD III on Health sector (Ministry of Public Works), Jakarta, 29 April – 1 May 2009;
13. Participation in FGD III on Health sector (Ministry of Health, Jakarta, 1 May 2009):

14. FGD II on Water and Waste Management sector, clarification on roadmap of climate change in water and waste management sector matrix (Ministry of Public Works; Jakarta, 6 May 2009);
15. Personal communication with experts on ground water from PLG and landslide, Geological Body (Geological Body, Bandung, April 2009).:
16. Internal evaluation by Bappenas-GTZ (Wisma Bakrie, Jakarta ,15 May 2009);
17. FGD evaluation by Bappenas and sector (Bappenas, Jakarta, 25 May 2009);
18. Inter-sectoral FGD, (Hotel Niko, Jakarta, 17 June 2009);
19. Water resources meeting with Planning Bureau of DPU (Ministry of Public Works, Jakarta 14 September 2009):
20. Review roadmap water sector and waste (Hotel Borobudur, Jakarta, 20 October 2009).

1.4 Summary

The Roadmap on Mainstreaming Climate Change into National Development Planning (also referred to as: "Climate Change Roadmap") for the water sector a follow-up of the RPJPN 2004-2025 that is related to climate change and the water sector. The contents of the climate change roadmap generally are adaptation strategies. However, several of them evolved into a combination of adaption strategies and mitigation strategies and can be a solution for issues of the cross-cutting issues. The objectives of building a Roadmap on climate change for the water sector are as : 1) To identify current condition and problems as well as the future challenge in water sector in connection with climate change; 2) To find the vulnerabilities in the water sector against climate change based on the identified threats. 3) To identify impacts or risks on water resources after their vulnerability has been identified and developed strategic issues, including cross-sectoral issues. 4) To identify and build sector policies and measures to integrate adaptation in the water resource sector against climate change; and 5) Others necessary and significant aspects such as uncertainty factors, information validity level, and need of further research or lack of research.

The Roadmap is based on a scientific basis (i.e. climate projection and sea level rise modeling) using vulnerability assessment at a macro level. This means a simplification of the risk assessment approach due to availability of data, time, and depth or scope of study. The further analysis is carried out to identify policies, strategies, and programs. This analysis uses the matrix tool to map hazards, vulnerability, the potential of impact or risk, recommendations on an adaptation strategy and a priority adaptation program of climate change in the water sector.

The risk assessment of climate change include the identification of hazards, vulnerability of the sector based on the direct results of climate change, (such as) rise in temperature and changes intensity of rainfall and rainfall patterns. Immediate hazard of climate change are the increase of frequency and the intensity of extreme climate events (la Nina and El Nina), this has been included in the temperature variation. As a direct result of climate change sea level rise and the subsequent effect of seawater immersion studies have been reviewed in the coastal and marine sectors. Further analysis of the rise in temperature (T) and changes in intensity and rainfall patterns (CH) using the analysis of water balance (WB) and the statistical analysis of cumulative frequency distribution (CDF) can be formulated as hazard (H) of the water sector to climate change and includes: reduction in water availability, floods, droughts, and landslides. Vulnerability (V) and risk (R) climate change obtained by reference to the formula V = (E x S) / AC and R = H x V, where E is exposure, S is sensitivity, AC is a adaptive capacity.

Chapter 2. Conditions, Problems, and Challenges in the Water Resource Sector

Conditions and problems in the water resource sector include aspects of water use and its destructive force. Water use includes water supply, water distribution and water quality. Destructive force of water includes floods, droughts, landslide, and seawater intrusion. The current capacity building challenge to be addressed is how to improve the responses and policies in relation to risks and hazards directly caused by climate change in the water sector and other related important implications for the water sector resulting from climate-related risks and hazards.

2.1 Current Conditions and Challenges in Water Resource Sector

2.1.1 Supply, Demand Distribution and Time of Water Resource

The condition of water resources in Indonesia generally depends on rainfall and on external surface conditions including aspects of the local geology, prevailing humidity, evapotranspiration, and evaporation rates. Besides rainfall, water resources in Indonesia include surface waters such as rivers, lakes, swamps; and ground water. Fluctuations in water quality are mostly affected by surrounding vegetation and pollution. Rivers that have vegetation in better condition also tend to have a low river flow fluctuation between dry season and wet season, thus minimizing flood threat during both dry season and wet season in the surrounding area.

The supply of surface water and ground water across Indonesia varies widely across islands in both quantity and quality. Water use depends also on the local communities' demand and the characteristics of local economic activity, such as agriculture or industry. The results of water availability calculation are as follows: total surface water of 2,746,564 x106 m^3/year and groundwater of 4,700 x 10^6 m^3/years, total water supply is 2,751.264 x 10^6 m^3/years or total water measured is 691,341 x 10^6 m^3/year and average water supply per capita is 3,138.6. Details and criteria of water supply are provided in Appendix 2.1.1.

The demand for freshwater in Indonesia is constantly increasing due to the growth of population and the increased economic activity in urban and rural areas. In this study, the total water needs are calculated to include household use, agricultural demands, and industrial use, applying the criteria and analysis referred to in Appendix 2.1.1. The total amount of water demand in Indonesia is 175,179.29 x10^6 m^3/year which consists of **household use** of 6,431 x10^6 m^3/year,

agricultural use of .141, 005 x10^6 m^3/year, and **industrial use** of 27,741 x10^6 m^3/year. More than 50% of water demand is supplied from ground water. Water resources in urban areas are in general groundwater, processed surface water and spring water, whereas in rural areas usually springs, groundwater and surface water are used.

Based on water supply, water demand and current conditions, we can create a Water Balance in Indonesia (at present 2009, as referred to Table 2.1. and detailed one in Appendix 2.1.2. From Table 2.1). The water balance in Java-Bali region shows deficits; in Nusa Tenggara, Sulawesi, Maluku and Sumatra it is critical or nearly critical. For the areas of Kalimantan and Papua, the water balance is still relatively safe.

Table 2.1 Indonesia's current Water Balance (2009)

No	Area	Supply *(S)*	Demand *(B)*	Balance *(S – B)*	Note
1.	*Sumatera*	111,077.65	37,805.55	73,272.10	near critical
2.	*Java-Bali*	31,636.50	100,917.77	-69,281.27	deficit
3.	*Kalimantan*	140,005.55	11,982.78	128,022.77	surplus
4.	*Sulawesi*	34,787.55	21,493.34	13,294.21	near critical
5.	*Nusa Tenggara*	7,759.70	2,054.04	5,705.66	critical
6.	*Mollucas*	15,457.10	540.23	14,916.87	near critical
7.	*Papua*	350,589.65	385.58	350,204.07	surplus
Indonesia		691,313.70	175,179.29	516,134.41	

As illustrated in Table 2.1, the water balance in Java-Bali and Sumatera is in critical condition, and current water supply is almost equal to current water demand.

Besides water supply and demand problem, another issue with which Indonesia has to deal now is water distribution. Water distribution includes distribution of water quantity, quality and demand. Table 2.1 and Appendix 2.1.2 show that water supply and demand is not evenly distributed across Indonesia. Papua and Kalimantan show the highest water availability and water needs with the lowest population growth; agriculture and industry levels are also low. Meanwhile, Java-Bali shows the availability of natural resources, but also very high levels of demand and population and industrial growth is also high. Distribution of resources in Indonesia should be considered in development policy. This data shows that there is an imbalance between water supply and demand as well as an uneven distribution of water across regions and islands in Indonesia.

Another important factor to consider in assessing the availability of water is time or season. Supply and demand are really influenced by time, which is closely related to climate. The impact of climate change has occurred among others in the form of crop failure due to drought or flood, or a shift in the maximum rainfall intensity. This situation must be taken into consideration in the government's future development policies and programs.

2.1.2 Water Quality

The use of water depends not only on quantity but also on water quality. That is why in the assessment of water resources, water quality needs to be taken into account. Generally speaking, the topic of water quality has not been given enough attention and comprehensive study. In particular, the problem of water quality is related to significant losses in public health, in particular in urban areas with large populations, like cities in Java.

Information on water quality in Indonesia is hard to come by and usually only available in cities and towns in the western part of Indonesia, particularly in Java. The following institutions provide information on water quality across Indonesia: DPU, DESDM, Depkes, and KLH (Appendix 2.1.3 for details). The general conditions and problems of water quality in Indonesia are as follows: 1) Java-Bali areas are highly polluted, in particular in cities, town and their surrounding in Java; 2) non Java-Bali areas still have relatively good water quality. Appendix 2.1.4 below includes some case study information on water quality.

2.1.3 Flood

Almost all parts of Indonesia are vulnerable to flood hazard. According to the Indonesian National Atlas (ANI, Bakosurtanal), Sumatera and Java-Bali region have the largest vulnerable areas. Situ Gintung flood, Banten, in March 2009 and the Samarinda flood, in November 2008 were the most recent cases of flood, with different causes. Sometimes floods are triggered by landslides or occur together with landslides, which is known as flash flood, as occurred in Sinjai, South Sulawesi in July 2006,which caused many casualties.

Major factors contributing to floods are the extreme rainfall of up to 400/mm/month (as per BMKG); overloaded surface waters or water reservoirs, such as rivers, ponds, dams, etc; and land characteristics and conditions in upper reaches of the catchment area. Analyses of historical causes of floods in Indonesia are provided in Appendix 2.1.5.

2.1.4 Drought

Drought has recently hit Indonesia and became a usual phenomenon in the dry season. Drought makes it difficult for people to find freshwater, reduces surface water in reservoirs; and limits the yield of crops, particularly rice or *puso*. Cases of drought in Indonesia are provided in Appendix 2.1.6.

Drought can be defined in many ways such as meteorologically, hydrologically, agriculturally, and otherwise (Appendix 2.1.6). The eastern part of Indonesia is vulnerable to meteorological drought. Drought risk is particularly high in areas with high population like Java-Bali. Although drought can cause a disaster, it can also create economic opportunity in sea-fishery sector.

Climate Change will further stress water resources, again, this is going to be elaborated in the following chapters

2.1.5 Other conditions and problems related to water resources

Landslides, land subsidence, and seawater intrusion are some of the water resource problems that need to be taken into consideration by the Government in terms of planning for measures against the impacts of climate change. The following is a brief description of related problems in the water resource sector (Appendix 2.1.7):

1) Landslides frequently hit Indonesia causing loss of life and property. For example, in the period of 2003-2005 Indonesia suffered from 103 landslides across seven provinces with a huge amount of loss. **Landslides** must be taken into account in any comprehensive water-related study, considering that water is often a trigger in landslide occurrences. There are at least 918 landslide zone, with Central Java having the most landslide zone (327 location), West Java (276 locations), West Sumatera (100 locations).
2) **The decline in groundwater** occurs in many large cities such as Jakarta, Semarang, Surabaya and Bandung from excessive groundwater pumping for both domestic and industrial uses. This decrease is due to pumping that exceeds the capacity of natural recharge. For the case of Jakarta, for example, in the 10-year period since 1975-1985 a decline in groundwater level reached 15 meters (Sumawijaya, 1994).
3) **Land subsidence** is caused by over-pumping or withdrawal of groundwater in excess of natural recharge rates. Land subsidence occurs in big cities such as Jakarta, Semarang, and Bandung.

4) **Seawater intrusion.** Seawater intrusion is related to groundwater withdrawal in coastal areas. Seawater intrusion can contaminate groundwater and make it unsuitable for drinking water. Areas like Jakarta and Semarang, in Central Java continue to be affected by seawater intrusion (See Appendix 2.10);
5) **Changes to layout and land cover** can affect water availability in quality and quantity
6) **Local initiatives** based on socio-cultural initiatives can be found in many areas of Indonesia. Such initiatives are essential tools for implementing sustainable water resource management
7) Climate change raises new challenges for water resource management. Water resource management, is critical to sustainable water supply, water demand, water distribution and water quality. Based on Law Number 7 of Year 2007 on Water Resources, the main governmental institution having authority for water resource management at national level are the Ministry of Public Works (for surface water management), and the Ministry of Energy and Mineral Resources (for management of groundwater resources). Some authorities have been delegated to the regional level.
8) Lay out of water resources include storage area of water catchment, watershed conditions, forest land cover; vulnerabilities include environmental conditions of irrigation networks, and reservoir conditions, condition of lakes and rivers, springs; and economic vulnerability include transportation river, hydroelectric power, the percentage of industrial growth.

2.2 Current Capacities

2.2.1 Response to Climate Change

Indonesia signed the UN Framework Convention on Climate Change (UNFCCC) in 1994. This Convention mandates three main things: 1) stabilizing greenhouse gas concentrations in the atmosphere at a safe level; 2) promoting common but differentiated responsibilities in protecting the atmosphere; and 3) establishing vehicles for multilateral cooperation with other countries to finance adaptation, insurance, and technology transfer. The first element provides a solid base for mitigation measures. The second element encourages adaptation measures. The third element facilitates achieving both mitigation and adaptation.

Adaptation is defined as technological and social measures to reduce the damages due to impacts of climate change. Adaptive measures may include: a) direct measures to reduce social and economical impact of climate change, b) capacity building in community and ecosystem, and c) measures to enhance resilience and to increase local community welfare.

2.2.2 Policies in connection with climate change

The Ministry of Public Works has developed a policy on adaptation and mitigation to climate change in order to achieve the following goals:

(1) To enhance security (against hazard potentials), convenience (good environmental conditions), productivity (the dynamic relationships of social and economical livelihood), and sustainability (to meet both current and future demand);
(2) To improve the water infrastructure and service quality in the framework of strengthening national food security and minimizing the risks of floods, landslides and droughts;
(3) To improve the quality of service provided by water infrastructure in urban and rural areas so as to minimize risks from flood, water shortage, and sanitation crisis; and
(4) To improve the quality of service provided by land infrastructure in order to facilitate mobility and access by citizens to Indonesia's social and economic facilities.

The above goals drive MPW's strategy and development program plan in relation to mitigation of GHGs and adaptation to climate change (details provided in Appendix 2.2). Specific policy objectives include: 1) Creating sustainable water resource management and capacity building for each river basin; 2) Constructing, managing, and rehabilitating water infrastructure in each river basin as well as in coastal areas; and 3) Improving disaster risk management.

2.3 Specific Challenges to the Water Resource Sector in relation to Climate Change

Challenges for the water resource sector are mainly due to hazards or risks particular for the water sector which may potentially be caused by climate change. Those hazards are the secondary impacts of climate change that devolve from direct impacts such as temperature rise, change in rainfall patterns, increase of frequency and intensity of extreme weather, and sea level rise. Direct effects of climate change are derived from studies of climate science (scientific basis).

2.3.1 Direct Impacts of Climate Change

The monthly temperature is increasing only around $0,5^0$ C in wet season but it could be reach 1.5^0 C in dry season compared to the condition baseline in period 2010-2030s. The results of the sensitivity analysis on Lombok island show prove in the results of the sensitivity analysis in the Lombok Island, that temperature in general is increasing 1^0 C within the next 50 years and until 3^0 C within 100 years time. It is also proven from the result of analysis of temperature data in Jakarta station which is shown significant temperature increase between years in 1870s and

1980s. Temperature increase during dry the season month in Jakarta is most likely influenced by local condition in the form of urban heat island (Tri Wahyu Hadi, 2009).

The rainfall in projection period is shown the increasing of standard deviation that can be interpreted as an increase in climate uncertainties as a result of the strength of climate variability in a particular area. For example, Sumatera still has the potential to undergo rainfall increase until 2020 and the potential threat of change in mean value and its variability are projected to happen in 2015-2020. In some area like as Nusa Tenggara and in Java Island, rainfall is tend to decrease in January, with increasing of variability although not a great extent (Tri Wahyu Hadi, 2009).

The Extreme Event (EE) aspect and Sea Level Rise (SLR) are based on results of the same study also increasing in the future. In this study, the EE effect was included in results of the projection of the temperature and rainfall. As for the SLR effect, it was studied further by the coastal sector, except the aspect of the intrusion of sea water. Further information about the direct effect of climate change are shown in Appendix 2.3.1.

2.3.2 Water Sector Hazards Due to Climate Change

The analysis on hazards in the water sector is based on the potential for the climate hazard and physical potential hazard using the method of water balance analysis. The simulation is using polynomial trend analysis follow climate projection and used the same baseline as result in climate projection. Cumulative Frequency Distribution (CFD) analysis as the results of the water balance analysis that is the total runoff (TRO) and direct runoff (DRO). Another analysis for the physical potential of climate change hazard is the projection of the climate or the direct effect of the hazard, such as projection of the temperature and rainfall. Physical potential hazards are land use, slope of the land, porosity of soil or rock that is matched with another hazard had been analyzed. Based on period that involved in analysis, it is done on two time periods that is 30 (2000-2030) and 5 yearly periods. First, 30 year periods, the results have a higher level of confidence due to the periods that same which use in scientific basis (rainfall and temperature analysis). Second, 5 year periods, the results have low level of confidence due to simplify assumption from the scientific basis.

Based on our analysis, the climate change hazards for the water sector in Indonesia include:

1) **Water Supply Shortage (PKA).** The calculation of PKA is based on two indicators that are physic potential (land use and geology) and climate condition. The Total Runoff (TRO) is calculated from water balance analysis, that is rainfall (CH) and temperature (T). PKA is total

decreasing of total runoff at projection time to total run off at baseline time. Based on the analysis of TRO and annual CH during normal condition (TRON), PKA hazard is likely to occur when the TRON value during the future projection period (TRON,P), is smaller than baseline TRON (TRON,B), or TRON,P - TRON,B < 0, is 169 to 0 mm/year.

Based on PKA calculation in 30 yearly analysis (period of 2000-2030), it shown the area with high risk is Java, Province Bengkulu and Bangka-Belitung. Whereas the whole of Sumatera Island, Western Kalimantan, Nusa Tenggara and South Sulawesi is middle risk to happen the water supply shortage. The main factors are land use condition (cultivation area) and geological condition which makes it difficult to infiltrate water into aquifers.

Figure 2.1 Water supply shortage hazards, SRA2 2000-2030 period

Based on the 30 year climate projection, a decrease of annual rainfall average and an increase of annual temperature is assumed. The highest decreasing of temperature is in February at Maluku Utara and decreasing again in November (Figure 2.2, left), otherwise the increasing of temperature is in North Sumatera Area and Northern Middle Sumatera (reach 20C) in March (Figure 2.2, right).

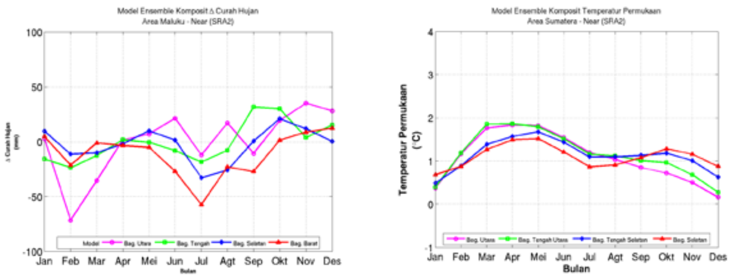


Figure 2.2 Model of rainfall change during normal condition in 30 years at Maluku region (left) and North Sumatera and Northern Middle (right)

Climate condition (Figure 2.2) is shown difference with the result of PKA calculation. Therefore, it shown here that the main factor which influenced to PKA is physical condition of those area (land use and lithology).

Based on 5 yearly periods analysis, PKA hazard happens in all time periods but not in a permanent area with hazard intensity increasing from 2010-2015 period to 2015-2020 period, decreasing in 2020-2025 period, and rebounding on 2025-2030 period; the distribution of hazard area in each period. Figure 2.1 illustrate the distribution of hazards and show that the Java-Bali and Sumatera regions are the regions most vulnerable to these hazards. Meanwhile, the regions with the lowest hazard threat are found in Papua and Maluku.

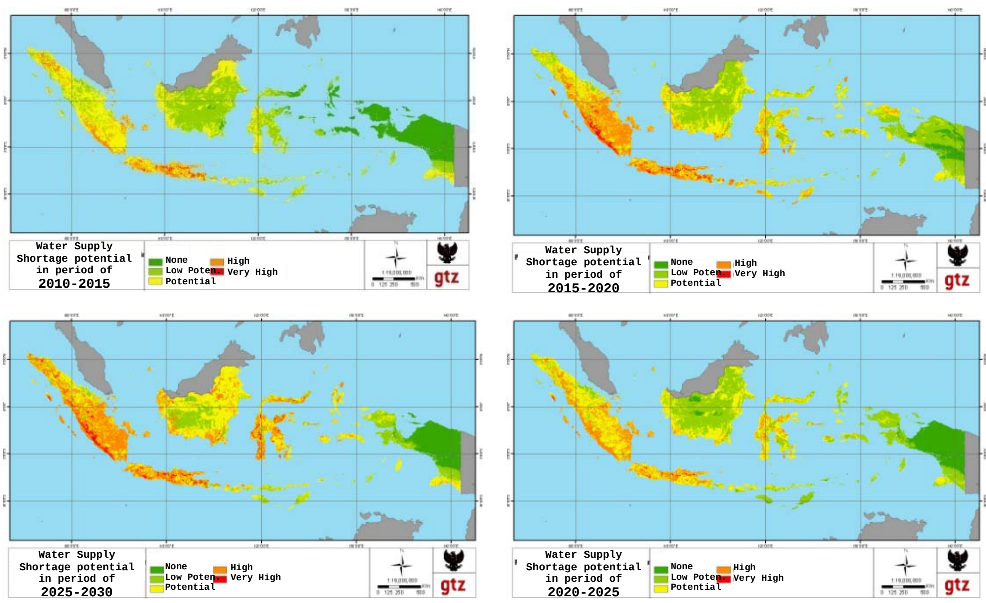


Figure 2. 3 Water supply shortage risk, SRA2, from top left clockwise: 2010-2015 period, 2015-2020, 2020-2025, and 2025-2030

Flood. There is a threat of flood hazard during periods with above normal rainfall (CH), temperature increase, and physical conditions with a slope gradient <3o and accumulation of water index 10,000 based on DEM analysis;. Based on CFD analysis on total TRO data from above normal average monthly CH (DROmax) and slope gradient of <3o, flood hazard is highest when DROmax for the projection period (DROmax, P) is bigger than CFD 50% of baseline condition or DROmax,CDF50,B (DROmax,P – DROmax,CDF50,B) occurs in land with slope <3o and accumulation of index flow >10,000. The maximum flood hazard happens when DROmax,P – DROmax,CDF 50,B equals 89 mm/month.

From result of 30 yearly analysis the flood occurs in the major rivers and the surrounding area and in lowlands particularly in Java Island, on Sumatra's East Coast, West and South Kalimantan and Southern Papua. The regions that are relatively safe from flood hazard are Sulawesi, Maluku and Nusatenggara (Figure 2.4)

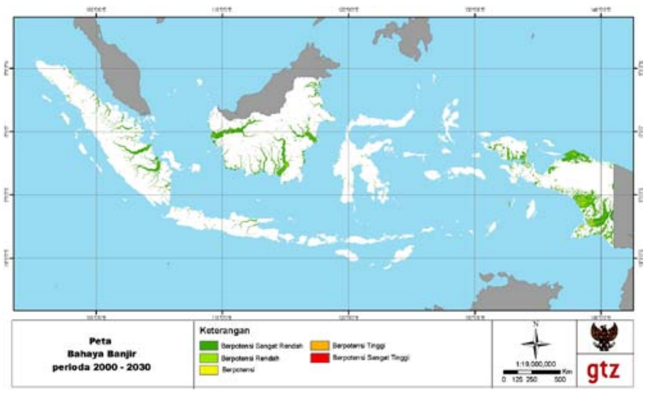


Figure 2. 4 Flood hazard, SRA2 2000-2030 period

Otherwise at western Kalimantan has increasing of rainfall in February and December, eastern Kalimantan has increasing rainfall in September (Figure 2.5, upper right). In the other side, Papua area has increasing rainfall in January, September, October and December and especially in January at West Papua 50 mm is reached (Figure 2.5, lower right). Otherwise, Sumatera region has potential of flood is middle Sumatera area both in north and south. Generally, in Sumatera region is not significance that rainfall influenced flood compare to others area, but big watershed and environmental degradation would be potential to increasing flood in this region (Figure 2.5, lower left).

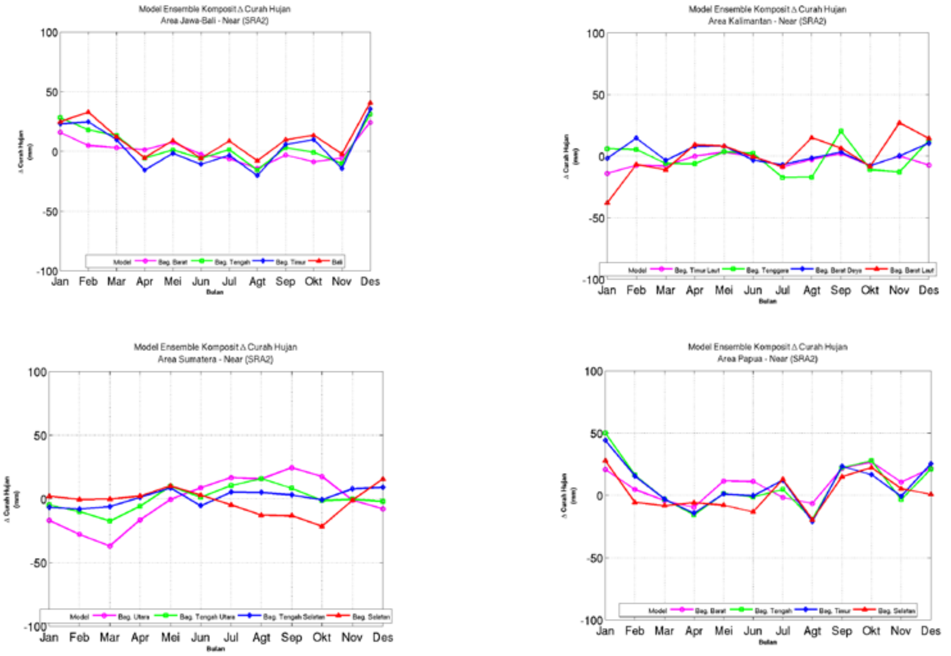


Figure 2. 5 Model of rainfall change during above normal condition in 30 yearly periods for Java-Bali (upper left), Kalimantan (upper right), Papua (lower right) and Sumatera (lower left)

Based on analysis of 5 year periods, flood hazard will occur in all period on the areas that are relatively the same but with different total area and intensity pattern varying from one period to another. The flood occurs in the major rivers and the surrounding area and in lowlands particularly in Java Island, on Sumatera's East Coast, West and South Kalimantan and Southern Papua. The regions that are relatively safe from flood hazard are Sulawesi, Maluku and Nusatenggara (Figure 2.6).

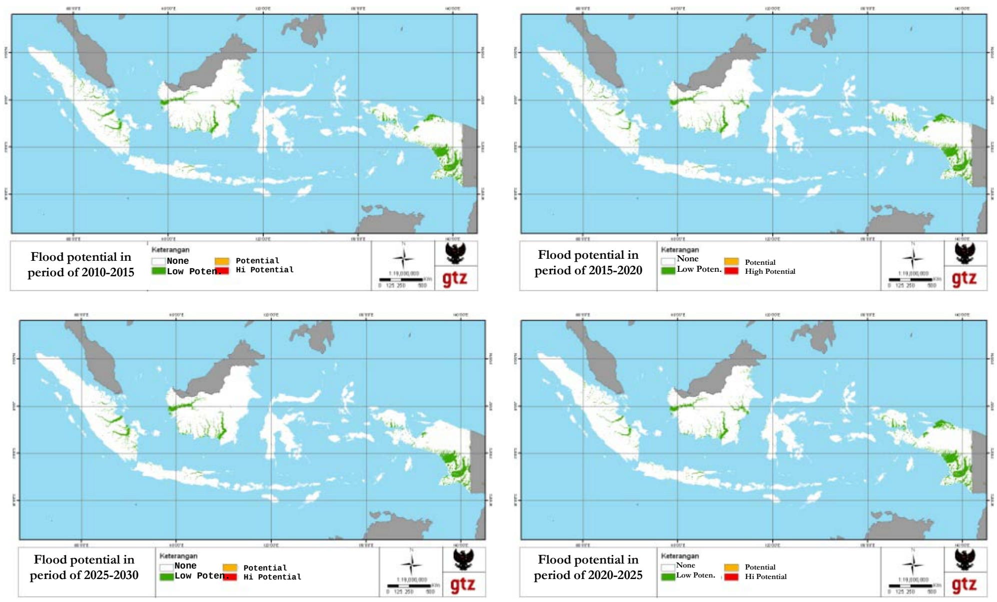


Figure 2.6 Flood risk, SRA2, from top left clockwise: 2010-2015 period, 2015-2020, 2020-2025, and 2025-2030

2) **Drought.** There is increased threat of drought hazard during periods when mean rainfall (CH) is below normal and temperature is increased. Drought hazard occurs in all periods but not in any single permanent area. Based on CFD analysis of CH TRO data from under normal conditions average annual (TROmin), the danger of drought in TROmin projection period (TROmin,, P) is smaller than 996 mm / year or less TROmin in CFD 50% of baseline condition (TROmin, CFD 50. Based on 30 yearly periods, the highest risk of drought is Nothern Sumatera, southern Java, middle and east Java and Nusa Tenggara (Figure 2.7)

Figure 2.7 drought hazard, SRA2 2000-2030 period

Based on 30 yearly climate projection (scenario SRA2), Northern Sumatera is the highest decreasing of rainfall (reach 50 mm) with increasing highest temperature (reach 20C) as shown in Figure 2.8 (upper). In Java Island, due to an increase in temperature and a decrease of rainfall as well as minimal levels of water after the monsoonal dry season, the probability of drought s highest in August. (June, July August) previously. Also in November there is a high probability of drought as shown by decreasing of rainfall and increasing of temperature (Figure 2.8, middle). In Nusa Tenggara, the highest decreasing of rainfall is in July following by increasing of temperature although not significant, but physically (land use and lithology) is dried area that influenced to more drought in increasing of temperature and decreasing of rainfall (Figure 2.8, lower).

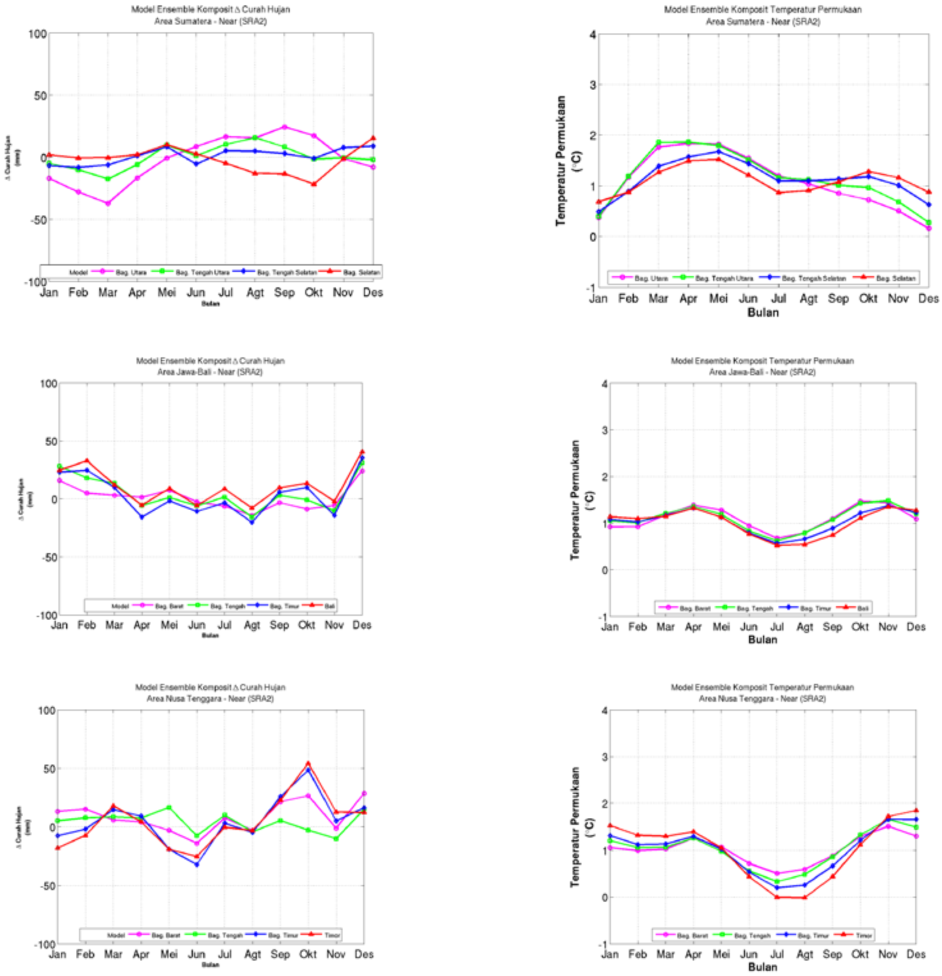


Figure 2. 8 Model of rainfall change (left) and temperature change (right) under normal for 30 years in Sumatera (upper), Java-Bali (middle) and Nusa Tenggara (lower)

Based on analysis of 5 yearly, there is increased threat of drought hazard during periods when mean rainfall (CH) is below normal and temperature is increased. Drought hazard occurs in all periods but not in any single permanent area. The hazard intensity tends to increase from 2010-2015 periods until 2025-2030; with distribution of affected area on each period as shown in Figure 2.9 and Appendix 2.3.2.3. Java-Bali, Sumatera, and Nusatenggara regions are the regions with relatively high hazard threat. On the other hand, Kalimantan, Sulawesi, Papua and Maluku are regions with relatively low hazard threat.

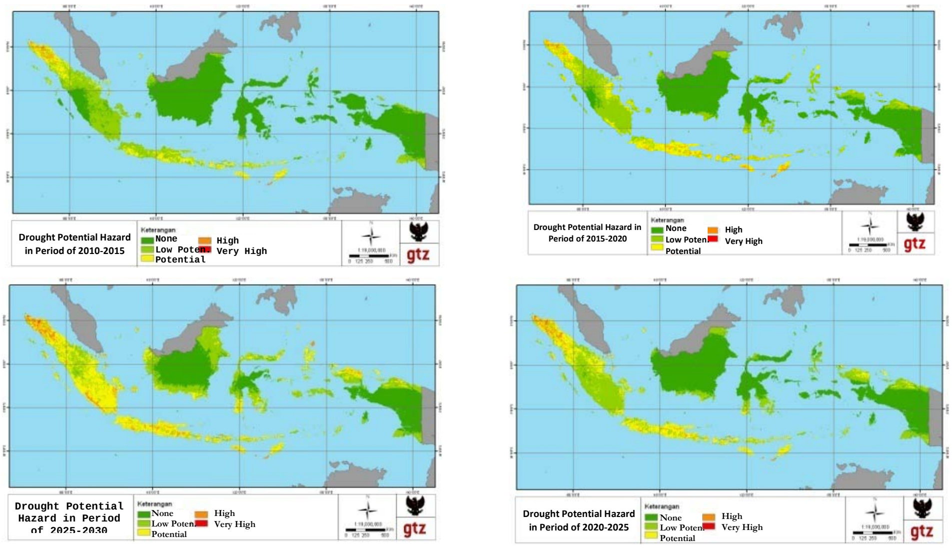


Figure 2. 9 Drought risk, SRA2, from top left clockwise: 2010-2015 period, 2015-2020, 2020-2025, and 2025-2030

3) **Landslide**. Landslide hazard occurs when mean rainfall (CH) is above normal, and slope gradient is high. Based on CFD analysis on total TRO data from above normal average annual (TROmax), landslide hazard is TROmax projection period (TROmax,) bigger than 89 mm / month or bigger than TROmax at CFD 50% of baseline condition (TROmax, CFD 50, B).

Based on analysis of 30 year periods, the areas with high hazard threat are NAD, West Sumatera, Bengkulu (Sumatera), central area of Papua, central and southern Sulawesi (Sulawesi), and the central to southern part of Java (Java-Bali). Other regions have relatively lower landslide hazard threat (Figure 2.10).

Figure 2.10 Landslide hazard, SRA2 2000-2030 period

Based on 30 year climate projection, North Sumatera area has increasing of landslide risk especially in September (Figure 2.11, upper left). Otherwise in Java-Bali, the increasing of landslide is in December, January and February, wherein it could be evaluated that in February due to rainfall accumulation (Figure 2.11, upper right). In Sulawesi, especially in North Sulawesi, the increasing of rainfall is in September, otherwise in Middle Sulawesi is in December which is not significant increase and reversal in another month (Figure 2.11, lower right). In the other hand, in Papua has high increasing rainfall especially in January (Figure 2.11, lower left).

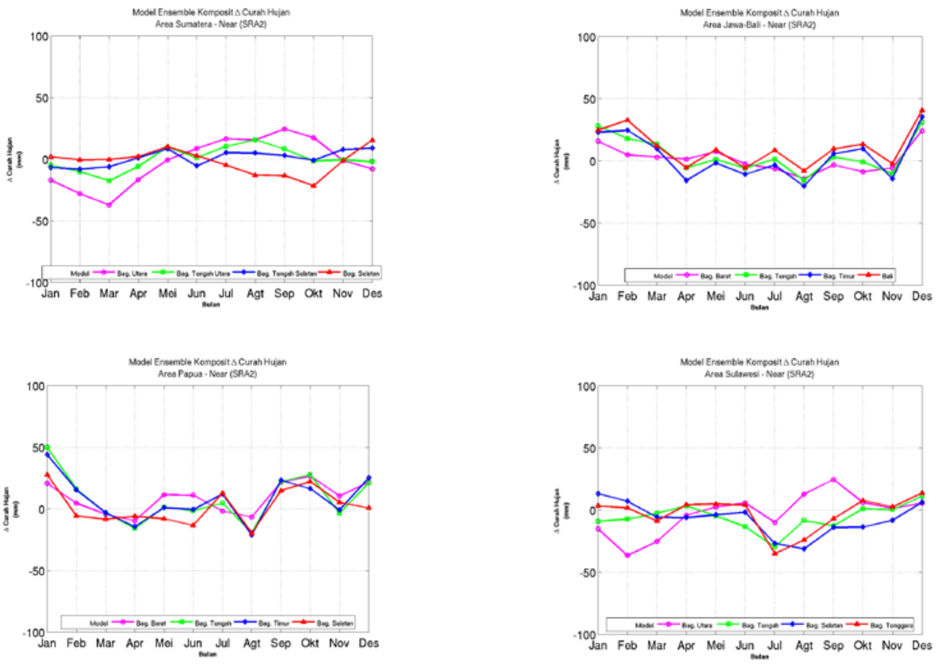


Figure 2.11 Model rainfall change during above normal condition in 30 years for Sumatera (upper left), Java-Bali (upper right), Sulawesi (lower right) and Papua (lower left)

Based on a 5 year analysis, landslide hazard is present throughout all periods of analysis but not in the same area with the highest hazard intensity occurs in 2015-2020 period and the intensity stays relatively the same in 2010-2015, 2020-2025, and 2025-2030; with distribution of hazard area on each period as shown in Figure 2.912 and Appendix 2.3.2.4..The areas with high hazard threat are NAD, West Sumatera, Bengkulu (Sumatera), central area of Papua, central and southern Sulawesi, and the central to southern part of Java. Other regions have relatively lower landslide hazard threat

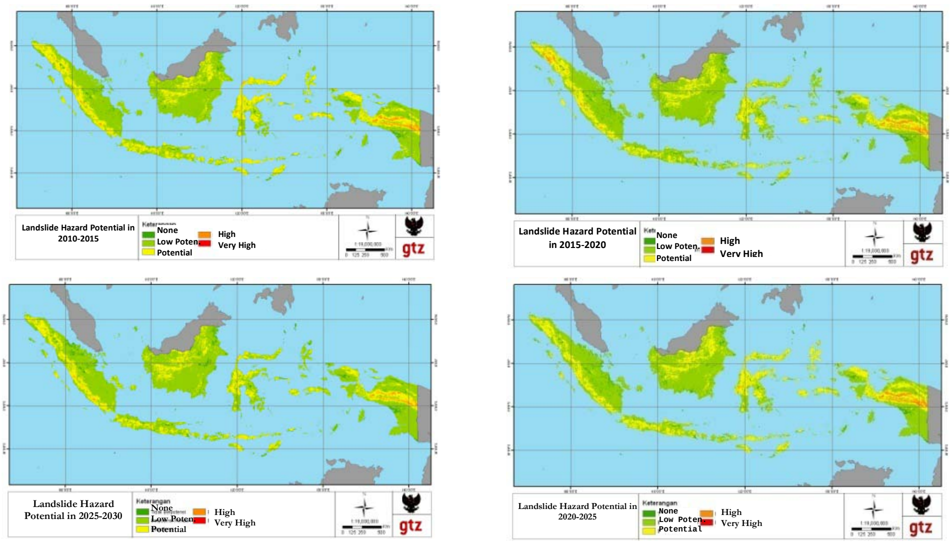


Figure 2.12 Landslide risk, SRA2, from top left clockwise: 2010-2015 period, 2015-2020, 2020-2025, and 2025-2030

4) **Seawater Intrusion**. Seawater intrusion hazard is primarily a function of excessive groundwater intake in coastal areas, but it is also affected by sea level rise (SLR). Based on groundwater and SLR data 1986-1994 on Jakarta coast (Java-Bali), seawater intrusion occurs whenever SLR exceeds 4-6 mm/year, water table (MAT) varies from 0-5 m below sea level (amsl) and hydraulic interface between 0.15%-53% for non-suppressed aquifer.; and MAT 0-50 m with a speed reduction BML 0,5-2,3 m/year and 0.1% slope hydraulic -1.33% for aquifer pressure (up to 250 m depth); capture groundwater 33.8 x 106 m3/year are rate 9.03% (Appendix 2.3.2.5).

2.3.3 Strategic Issues for the Water Resources Sector in Relation with Climate Change

Based on the current conditions, problems, and future challenges of water resources, eight water resources strategic issues in relation with climate change have been identified, comprising of three main water sector issues and five main cross-sectoral issues. All of the issues, while constituting threats, also contain potential benefit.

- *Main water resource sector issues*

The three main issues most relevant for the water sector are the following:

1) <u>Water balance between water supply and demand (water balance)</u>, be it its temporal or spatial aspect, or its distribution. Climate change creates a threat of water supply shortage, so the related vulnerability and risk needs to be understood to identify the necessary adaptation

steps. The demand of water from the residential sector should be the main priority, in every region on every season. For example, shallow groundwater and water springs in urban areas should be prioritized for residential water demand;

2) Adequate water infrastructure and provision of alternative water sources in special areas. The impact of climate change can be reduced through adequate provision and maintenance of water infrastructure function. On the contrary, inadequate or damaged water infrastructure can increase the risk for the water resource sector. Temporal and seasonal aspect of water availability is very important in relation to the operation of water infrastructure such as dams - both dams for irrigation and hydro power plants. Aside from that, special areas such as small islands, peatlands, and karsts area need breakthrough in water resource provision according to the characteristics of potentials in each area.
3) Database, technology, management, and research. The first three issues have arisen since the 1990s. In particular, databases related to climate change play a key role now. Technology—in this case intermediate technology—is supposed to provide affordable solutions to the problems and in the same time, opportunity from climate change. For all those reason, research is still lacking and needs to be prioritized.

- *Cross sectoral issues*

Basically, given the range of functions of water in society, policies in the water sector are connected with almost all the other development sectors. There is not any development activity that is detached from the availability of water. The solution to main issues of water resource as mentioned above still needs the role of other sectors. In several cases, several cross-sectoral solutions will be encountered, which is also a synergic effort between adaptation and mitigation efforts.

However, based on the priority scale of the following sectors, this is a prioritization for the water sector;

1) Water-agriculture-forestry and disasters. Flood, drought, and landslides will bring disaster when they strike society in a highly vulnerable area. The vulnerability of key areas and risk of the three hazards needs to be known well both in their spatial and temporal aspects in order to identify and implement the appropriate adaptation steps. Reserving adequate conservation forest will increase water resources security, helping to prevent flood, drought, and landslides; and can contribute to a climate change mitigation effort;

2) Water and health. The lack of clean water is given impact to people use low water quality in daily activities and water drinking, they could increase the sensitivity towards the illness as well as the decline in the health. The flood could trigger the outbreak and dengue fever of the diarrhoea illness. Clean water facilities in rural areas that were densely-populated and bordering with the forest could reduce the possibility of the illness outbreak malaria. Drought could cause the food shortage.
3) Water and energy. There are profit opportunities in understanding the mutual relation between water and energy in suitable areas. The greatest likelihood of commercial success lies in applying intermediate technology for water provision using alternative methods. is the use of intermediate technologies can reduce the need for burning coal or other fossil fuels, contributing to the global and national climate change mitigation effort. For this to happen, the right policy and strategy is needed;
4) Saving water. Improved water use efficiency can be achieved through integrated water resource management, particularly watershed management in the water source area or water capture area (DAS or SWS). Equally important is downstream management of water usage. The cohesiveness of various stakeholders on both parts is crucial for the successful implementation of policies.
5) Indonesia has a large and unique potential for water conservation and improved water resource management based on innovation, participation of community, local wisdom, and revitalization of existing infrastructure. Building infiltration wells or infiltration pools and water harvesting from rain fall are some of the alternatives of water provision, much of traditional local wisdom has been proven capable of maintaining the existence of water resource, but the knowledge of the system has not really been developed for optimal water use management

2.4 Concluding Remarks

This chapter explains conditions and problems of water resources, covering aspects of conservation, use of water and water hazards. This chapter also outlines future water sector hazards due to climate change and important issues in water sector and its implications.

Conservation of water is a crucial effort to maintain the continuity of the function of water resources. Water use is covered by availability, distribution, and quality of water. An analysis of the availability of surface water and ground water in Indonesia demonstrates that in Java-Bali the balance of water already shows a deficit. In Nusa Tenggara, Sulawesi, the Moluccas and Sumatra the availability is already critical, Kalimantan and Papua still being safe. Looking at the distribution of water resources in Indonesia, it could be stated that water resources are not equitably distributed. In Papua and Kalimantan the availability of water is the highest, the requirement for water is lowest with low populations, agriculture and also industry growth. On the other hand, Java-Bali has insufficient availability, because of very high demand and high population growth and growth of industry. The quality of water in Indonesia will need more attention, especially from the side of the provider of data and study. Water quality information generally is available in the region of cities western part in Indonesian especially in Java Island. The problems of the quality of water for the public are as follows: 1) Java-Bali region has experienced levels of relatively high pollution, especially in urban areas in Java Island; 2) Outside Java-Bali the quality of water is still good. Other problems for the water sector are flood, drought, landslide, and sea water intrusion.

The potential hazards due to impacts of climate change for the water sector are as follows:

- **Water Supply Shortage (PKA)** was identified by seeing the total runoff decreasing in the normal condition of climate (TRON) in the period of the projection (TRON,P). TRON is taken from water balance (WB) analysis and the decline in the availability of water is taken from Cumulative Distribution Frequency analysis against TRON. The results show that the hazard of water availability is decreasing of TRON in the projection period for which the value TRON,P is smaller than 0, that is 169 to 0 mm/year. Java-Bali-Sumatra is the area most hazard by decreasing of PKA, and lowest hazard level show Papua and Moluccas.

- **Flood hazard.** The extreme rainfall is potential to cause of flooding. In viewpoint of hydro-climatology, flood could happen if rainfall (CH) is above normal (> 400 mm/the month as encountered to CH projection). The analysis of flood counted also as a condition for the land cover and slope, and flow of river. The parameter used in the analysis of flood is direct runoff (DRO) with condition of rainfall above normal (DROmax). The flood hazard is formulated as the condition for rainfall above normal in the period of the projection that produced direct runoff (DROmax,P) > 89 mm/year with the slope of the land < 3o. The potential of flood hazard is in big rivers and their surroundings, and also the lowland area especially in Java Island, Eastern Sumatra, West and South Kalimantan, and southern parts of Papua. The regions which are relatively safe from flood hazard are Sulawesi, Moluccas, and Nusa Tenggara.

- **Drought hazard.** Hydrological drought comes from the extreme of PKA hazard, it has the potential to emerge in the period of projection. In this study, the physical aspect of drought as of climate is involved in the aspect of sensitivity. The identification of drought hazard is carried out from CDF analysis. It is found that the potential for drought hazard is relatively high in the region of Java-Bali, Sumatra, Nusa Tenggara, Kalimantan, and Sulawesi; whereas in Papua and Moluccas it is relatively low.

- **Landslide hazard.** Landslide hazard regarding rainfall above normal (> 400 mm/month was encountered to CH the projection), the slope of the land, as well as the porosity of the rock or the land. It is shown that landslide hazard of being the condition for the rainfall was supervised normal in the period of the projection that produced TRO min, P≥ 89 mm/year. The area with high potential landslide hazard is: Nangroe Aceh Darussalam, West Sumatra, Bengkulu (Sumatra), middle potential hazard is in Papua, South Sulawesi, and South Java.

There are 8 (eight) strategic issues (SDA) related to climate change as follows: 1) The balance between availability and requirement for water (the balance of water); 2) Water Infrastructure that has to be adequate and the provision of alternative sources of water to affected areas; 3) Database, technology, management and research, and five main cross-sector issue are following: 1) Water-agriculture-forestry, flood danger, drought, and landslide; 2) Water and health; 3) Water and energy; 4) Management water resources, and 4) Conservation of based water the innovation, community's participation and revitalization of local wisdom.

Chapter 3. Vulnerability of Water Sector against Climate Change

3.1 Identify the Vulnerability Components

The overall vulnerability of Indonesia's water sector has been analyzed using the GIS Analysis. The seven primary components of vulnerability (based on quantitative data) and five (based on qualitative data) additional vulnerability components are described below.

1. **River Basin and Land Use.** River basins damaged by development are vulnerable to floods, droughts, and landslide. The areal extent of damaged river basins is increasing every year. In the period from 1994/1995 until 1998/1999, 49 damaged river basins were identified as "super priority" areas. The number of such basins increased to 60 in the period of 1999/2000 – 20006 (excerpted from SLHI data, 2006). (See Appendix 3.1.1.)

2. **Population Density (PD)**. In general, Indonesia has a high population density (PD) with uneven distribution. Regions such as Java and Bali have the highest population and the highest density, followed by Sumatra. In 2005, Indonesia's total population was almost 219 million people and the PD was 112/km^2. The Government of Indonesia estimates that population growth until 2030 is estimated 1.4 million people/year (excepted from BPS, 2006). High population density increases Indonesia's vulnerability to all climate change hazards and is the largest contributor to the nation's elevated vulnerability level. (See Appendix 3.1.2).

3. **Land-use planning** Land-use patterns also make a major contribution to Indonesia's vulnerability component to climate change-related hazards. Based on poor land-cover patterns and the declining area of forest cover, regions such as Java, Bali, and Sumatra have the highest vulnerability level. Sulawesi and the Eastern part of Nusa Tenggara have a moderate vulnerability level in terms of land cover area. Areas like Kalimantan, Maluku islands, and Papua are relatively less vulnerable to climate change-related hazards. (See Appendix 3.1.3).

4. **Water demand** High levels of water demand contribute to Indonesia's vulnerability to water supply shortage and drought. At present (2005 – 2009), the highest demand is for water use in the agriculture sector. Agricultural water demand is estimated to be nearly 65 billion

m^3/year. This is equal to almost 75% of Indonesia's total water demand. The second largest water demand is for applications in the industrial sector, which consumes over 15 billion m^3/year, or almost 18% of the total. Among regions, Java-Bali has the highest water demand (over 50 billion m^3/year, or 58%), followed by Sumatera with more than 18 billion m^3/year, or 21% of the total water demand. Current projections indicate that Indonesia will experience an increasing water demand from 2010 to 2030. (See Appendix 3.1.4).

5. **Confined aquifer[1] and Aquifers (CAT) Potential.** Confined aquifers in Indonesia are largely in good condition and somewhat evenly distributed among regions. The total water resource inflow to confined aquifers is estimated to be nearly 18.841,37 x 10^6 m^3/year spread among 465 aquifers. (Data excerpted from Geological Body, 2005). Areas with the highest groundwater potential are Java-Bali, followed by Sumatera, Papua and Mollucas. Sulawesi and Nusa Tenggara have moderate groundwater levels. Kalimantan has the lowest level of confined aquifer. Since confined aquifers play an important role in the water supply because they are not rechargeable in short periods of rainfall, it is considered as a major vulnerability component to climate change hazard such as water-supply shortage and droughts. (See Appendix 3.1.5).

6. **Land Elevation** contributes to flood risk potential. Indonesian geological land elevation level can be divided into two categories of slope: high – very high level (5 - 36^o) and low – mid level (0^o- 5^o). Falling into high to very high level category are areas such as central and northern part of Papua, some parts of Mollucas and Sulawesi, central part of Nusa Tenggara, central part of Java-Bali, central and western part of Sumatera, and central part of Kalimantan. The remainder of Indonesia falls into low – mid level category, including, for example, the eastern coast of Sumatra. (See Appendix 3.1.6)
7. **Soil properties** are a permanent feature of the landscape and one of the major contributors to physical components of vulnerability to hazards such as landslides, floods and droughts. One of the land characteristics that contribute to risks of flood and drought hazard is the presence of clay sediments. It is important to identify the types and distribution of these rocks accurately based on information from reviewed geologic maps, landslide susceptibility maps, and reports of landslide disasters (Appendix 3.1.7)

[1] Confined aquifers is aquifer which is bounded by two impermeable layers and not related to free surface.

8. **Water quality** is a qualitative vulnerability component and contributes to the assessment of risks of water shortage. In general, Indonesia has relatively good water quality. The existing water supply can cover most of the water needs in several areas, especially in rural areas. Water quality in urban areas, particularly in big cities in Java-Bali has degraded in recent years. Water quality in some big cities in Sumatera, Kalimantan and a few in Sulawesi and Nusa Tenggara, particularly Nusa Tenggara Barat, have degraded significantly. (Appendix 3.1.8.)

9. **Water infrastructure** describes the variety of engineered assets and equipments needed to sustain water use and withdrawal. Water infrastructure includes irrigation systems, dams, pipelines, and other assets. When badly designed or in disrepair, water infrastructure can contribute to Indonesia's vulnerability to hazards related to water. Well-designed and in good state, water infrastructure becomes an important component of adaptive response which could reduce the impact of climate change in the water sector. In addition, especially in coastal areas, with drawl of freshwater from wells that have been contaminated with saltwater in coastal area becomes more exposed to the sea-water intrusion hazard, because freshwater withdrawn from wells that have been contaminated with saltwater. Information on the status of local irrigation systems is compiled from the available data on areas having access to irrigation facilities. Java-Bali and Sumatera have strong irrigation systems that are quite evenly distributed. (See Appendix 3.1.9.)

10. **Other Individual Components** of **Vulnerability are for instance the** National Action on Forest and Land Rehabilitation (*GNRHL*), the Clean River Program (*Prokasih*), lands subsidence in urban areas, and the Landslide Vulnerability Map, which is considered to be a vulnerability component related to water sector. Those components belong to qualitative vulnerability component and serve as adaptation measure except seawater intrusion. (See Appendix 3.1.10).

3.2 Overview of Water Sector Vulnerability

Based on GIS analysis of all major components of vulnerability to climate change in the water sector (See Chapter II), we can map Indonesia's current (2005-2010 to 2025-2030) and projected most vulnerable areas in a form of spatial information. This spatial information will be further augmented with qualitative vulnerability information to create a more comprehensive mapping of Indonesia's vulnerability to climate change in the water sector.

3.2.1 Vulnerability due to data resource and research

The main factors that contribute to vulnerability are: population density, land use or land cover, critical level land is interpreted from the critical watersheds, and water needs. Other factors can also increase the vulnerability of water quality. The study of water quality information is still qualitative (Appendix 3.2.1.1). In each region there are adaptations factors that can be developed to reduce vulnerability, including: 1) potential soil water stress, 2) the water infrastructure, 3) water bodies including rivers, lakes, and natural, 4) an appropriate morphology for the development of water infrastructure as check dams, and other artificial water structures, 5) type of soil or rocks that have a good potential to absorb water, and 6) culture and local wisdom that still function in water conservation. Factor 1) and 2) have been involved in the study of GIS for each of the quantitative data. The data factors 3 to 6 are not available in quantitative form so that only involved a qualitative (qualitative factors) or additional susceptibility components (Appendix 3.2.1.2).

Limitations of data and the very lack of research on the water sector's vulnerability to climate change in Indonesia is a constraint for this assessment. This condition of the data and information in dealing with the dangers of climate change is something that will give vulnerable a potential impact (See Appendix 3.2.1.3).

3.2.2 Vulnerability to Shortage of Water Supply

Shortage of water supply can occur in seasons with normal rainfall conditions. To assess this type of vulnerability involves understanding the role of population density, land-use planning, water demand as well as qualitative vulnerability components such as water infrastructure, groundwater potential, and water quality. The level of vulnerability (Figure 3.1 and Appendix 3.2.2) generally increased from 2010 to 2030 period is caused mainly by the increase in population, water requirement, and changes in land cover.

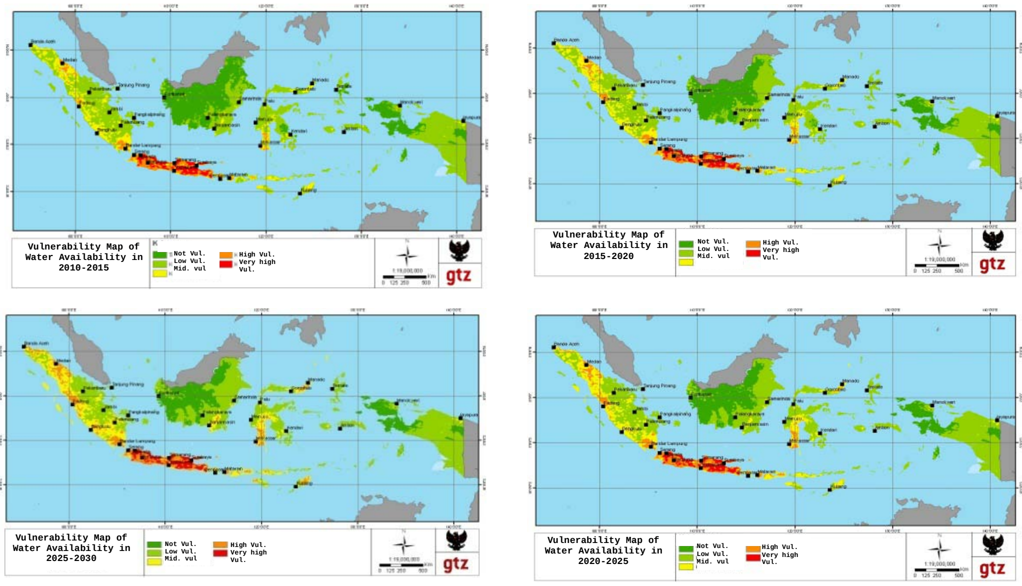


Figure 3.1 Map of vulnerability to water supply shortage, from left clockwise: 2010-2015 period, 2015-2020, 2020-2025, and 2025-2030

The level of vulnerability to shortage of water supply is generally divided into very high, high, medium, low, and not vulnerable, namely:

1. **Very High Vulnerability** of shortage of water supply's dangers applies for more than half of Java-Bali, small parts of Northern, West, and South Sumatera, this condition is caused by a population density of more than 3000 person/km2; the water consumption required by this populations, which amounts to 269,380,338 – 359,173,738 m3/year, and function/production of the farms or farm settlements, and agriculture that potentially increase impacts of disaster.. At the same time, another vulnerability reducing factor is potential of confined aquifer of ground water 5,313,740 – 7,084,987.20 m3/year), and the availability of water infrastructure and qualitative factors (Appendix 3.2.1.2)

2. **High Vulnerability** of shortage water supply's hazard take possession of almost half Java-Bali Region, small parts of northern, west, and south Sumatera, south of Sulawesi, and NTB. This condition is caused by population density between 400 – 3000 person/km2; the amount of water consumption required 269,380,338 – 359,173,738 m3/year and farm function or the form of farm and plantation generate more impact by the disaster. The another factor of reduced of vulnerability is potential of ground water pressed (5,313,740 – 7,084,987.20 m3/year); there're water infrastructure and qualitative factors (Appendix 3.2.1.2).

3. **Medium vulnerability** of shortage of water supply's dangers in territory parts of northern, west, and south Sumatera, part of Sulawesi and Nusa Tenggara. This condition is caused by population density between 50-400 person/km2; the amount of water consumption required 179.586.892 – 269.380.338 m3/year and farm function or the form of farm meadow, scrub, and empty land generate enough impact by the disaster. The factor of reducing vulnerability is the potential of ground water pressed (3,542,493.60 – 5,313,740.40 m3/year), and water infrastructure and qualitative factors (Appendix 3.2.1.2).

4. **Low vulnerability** of shortage of water supply dangers are found in East Sumatera region, Central to East Kalimantan, a half of Sulawesi and Maluku and part of East to Central in Papua. This condition is caused by a population density between 7– 50 person/km2; the amount of water consumption required by this population (89.793.446 – 179.586.892 m3/t), and farm function form of the form seasonal forest, mixed forest generate less impact by the disaster. The factor of reducing vulnerability is the potential of ground water pressed (1.771.246, 80 – 3.542.493, 60 m3/year), and there is no water infrastructure in place.
5. **Lowest Vulnerability** of shortage of water supply's dangers in middle-west parts of Kalimantan region, part in Papua and Halmahera Island. This condition is caused by population density between <7 person/km^2; the amount of water consumption required (< 89.793.446 m^3/year), and farm function form of the forest almost didn't have an impact by the disaster. The factor of reducing vulnerability is the potential of ground water pressed (<1.771.246, 80 m^3/year), and there is no irrigation infrastructure.

3.2.3 Vulnerability to Floods

Floods occur due to heavy rainfall above normal. Assessment of vulnerability to floods involves primary vulnerability components including population density, land-use planning, land stress or damaged river basins. The level of vulnerability (Figure 3.2 and Appendix 3.2.2) generally increases from 2010 to 2030 and this is caused mainly by the increase in population, water requirement, and changes in land cover.

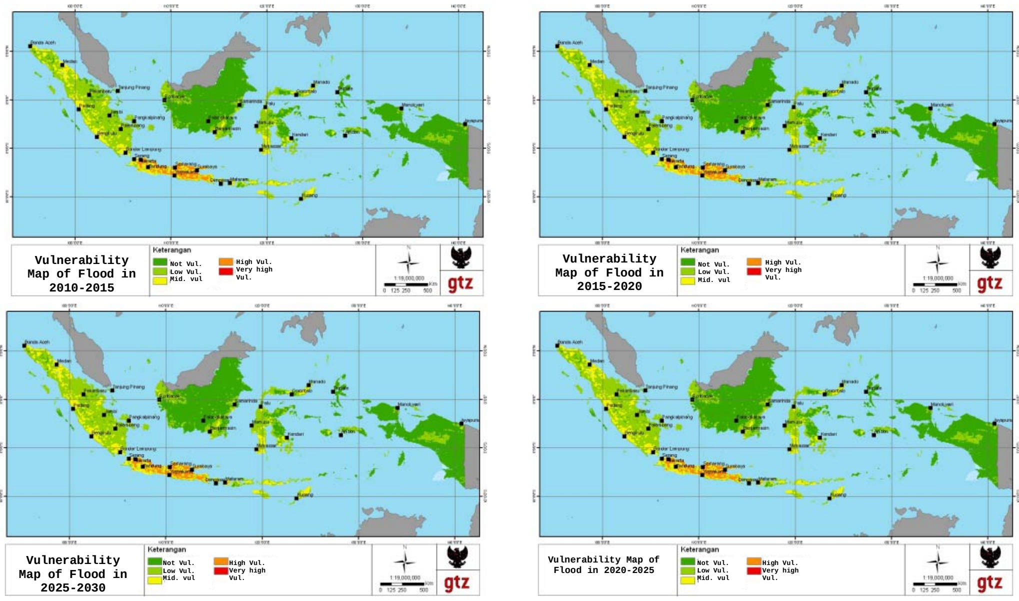


Figure 3.2 Map of vulnerability to floods ,from left clockwise: 2010-2015 period, 2015-2020, 2020-2025, and 2025-2030

The levels of vulnerability to floods are generally divided into very high, high, medium, low, and not vulnerable, namely:

1. **Very High Vulnerability** of flood's dangers applies for limited areas especially in the north of Java-Bali, covering some of the area's major cities through which the major rivers flow. This condition is caused by population density of more than – 3000 person/km2, farm function or the farm settlement, and agriculture that'll generate more impact in disaster, critical storey which is mirrored by the damage of DAS in ambient region above 0.8 critical index of DAS, and the vulnerability can be reduced if a good irrigation infrastructure and qualitative factors are in place (Appendix 3.2.1.2)

2. **High Vulnerability** of flood's dangers take possession of almost half in Java Region, in costal northern from west to east, this condition is caused by population density between 400 – 3000 person/km2, and farm function or the form of farm and plantation generate more impact in disaster. critical storey which is mirrored by the damage of DAS in ambient region above 0.6-0.8 critical index of DAS, and the vulnerability can be reduced if have a good infrastructure irrigation and qualitative factors .

3. **Medium vulnerability** of flood's dangers in territory parts of northern, west, and south Sumatera, in middle to south in Java island, in few east-west-south parts of Kalimantan region, southern, south-east, north and little in a middle Sulawesi. This conditions caused by population density between 50-400 person/km2; farm function or the form of farm

meadow, scrub, and empty land generate enough impact by the disaster. Critical storey which is mirrored by the damage of DAS in ambient region above 0.4-0.6 critical index of DAS, and the vulnerability can be reduced if have a good infrastructure irrigation and qualitative factors.

4. **Low vulnerability** of flood's dangers in most middle-east Sumatran regions, it's caused by population density between 7– 50 person/km2 and farm function form of the form seasonal forest, mixed forest generate less impact by the disaster, critical storey which is mirrored by the damage of DAS in ambient region above 0.2-0.4 critical index of DAS, and there are no of irrigation's infrastructure.

5. **Lowest Vulnerability** of flood's dangers is found in west parts of Kalimantan and Papua region, a little part in middle Sulawesi, and Maluku this condition is caused by population density between <7 person/km^2, farm function form of the forest almost did not have an impact by the disaster. Critical storey which is mirrored by the damage of DAS in ambient region above 0-0.2 critical index of DAS, and there're no of irrigation's infrastructure.

3.2.4 Vulnerability to Drought

Drought hazards occur if rainfall is below normal level. An assessment of vulnerability to drought involves major vulnerability components such as population density, land-use planning, water demand, and unused/underused land as well as qualitative or additional vulnerability components such as water infrastructure, groundwater potentials, and *GNRHL* (See Appendix 3.2.3.) The vulnerability (Figure 3.3 and Appendix 3.2.2) generally increases from 2010 to 2030, caused mainly by the increase in population, water requirement, and changes in land cover. The level of vulnerability to drought is generally divided into very high, high, medium, low, and not vulnerable, respectively.

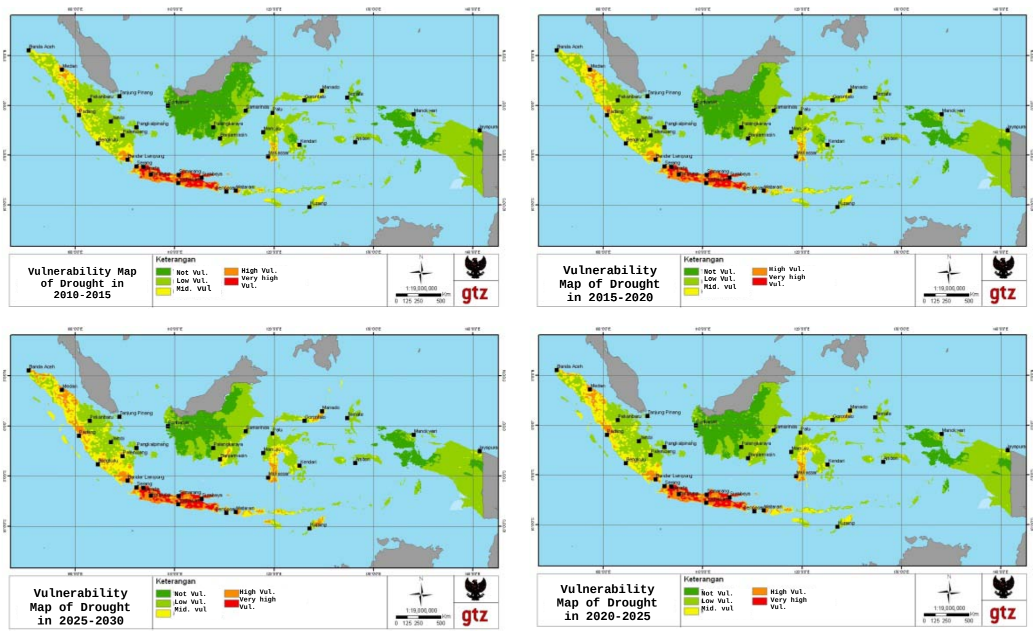


Figure 3.3 Map of vulnerability to drought, from left clockwise: 2010-2015 period, 2015-2020, 2020-2025, and 2025-2030

1. **Very High Vulnerability** to drought hazard is present in a few areas in Java, especially in the north, covering some of the area's major cities through which the major rivers flow. Very high levels of vulnerability are caused by factors similar to factors that cause vulnerability to hazards. Simultaneously, those factors can also reduce the level of vulnerability.
2. **High Vulnerability** to drought hazard is present in large areas of Java, especially on the north shore from west to east; in the middle for most of the eastern Java area and the middle, and partly in the western region includes several cities large and surroundings. High vulnerability due to population density, land use, and damage to watersheds with the same conditions as in the high vulnerability to hazards reduction in water availability. Similarly, factors that can reduce the level of vulnerability.
3. **Medium Vulnerability** is the danger of drought mainly in large areas of western and northern coast of Sumatra, south-central part of Java Island, just south-east western Kalimantan and Sulawesi region on the southern, southeastern, northern and some of the middle; and in most areas of Nusa Tenggara. The level of vulnerability was caused by factors similar to factors that cause vulnerability in danger of decline in water availability.
4. **Low Vulnerability** of drought exists in most parts of central-eastern Sumatra, Sulawesi, most of the region, especially in the middle and a small part in the Moluccas, Nusa Tenggara, and Papua. Low vulnerability is caused by population density, land use, and the critical area of damage reflected by the surrounding watersheds in the region each with a range of numbers as the low level of vulnerability to hazards reduction in water availability.

5. **Lowest vulnerability** or no vulnerability at all generally applies for most of Central in Kalimantan and Papua, small parts of Central Sulawesi, and the Moluccas. Lowest levels of vulnerability are caused by the same factors as lowest vulnerability levels to PKA hazards.

3.2.5 Vulnerability to Landslides

The types of landslide hazards analyzed here are limited to landslide occurrences caused or triggered primarily by water. Other factors triggering landslides such as earthquakes cannot be considered here. Having said that, such hazards can occur throughout the year when rainfall conditions are above normal. Contributing factors to vulnerability include such factors as population density, land-use planning, land elevation, unused/underused land. Land characteristics and land elevation have been identified as additional factors that influence landslide hazards. Figure 3.4 below and Appendix 3.2.4 illustrate a Map of Landslide Vulnerability. The following is a brief description of the distribution of landslide vulnerability in Indonesia:

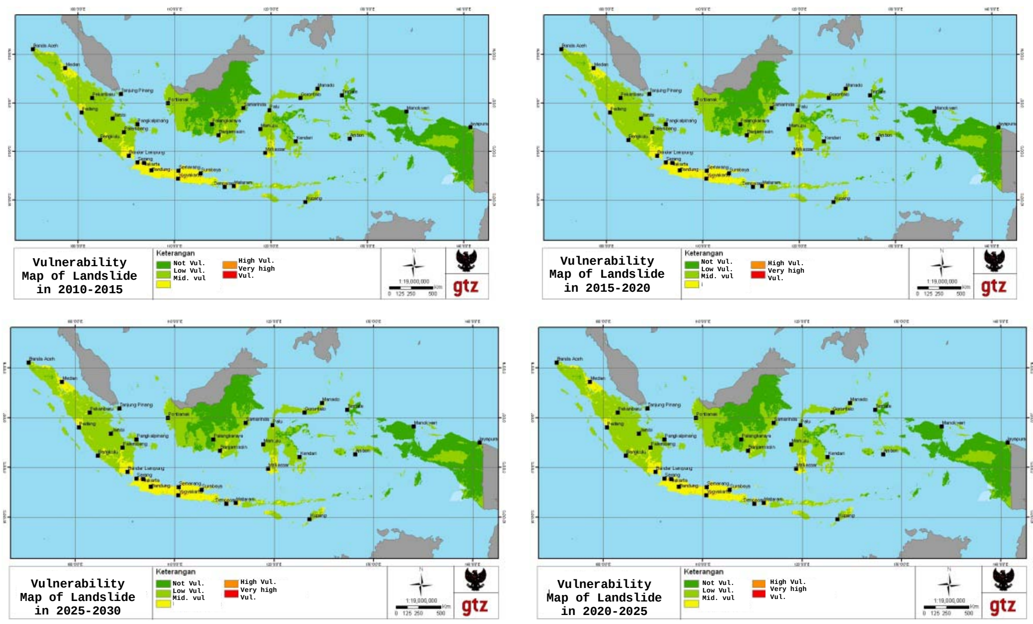


Figure 3.4 Map of vulnerability to landslide, from left clockwise: 2010-2015 period, 2015-2020, 2020-2025, and 2025-2030

1. **Very High Vulnerability** of landslides exists only in certain areas in Java, and it is not even visible in 1:1,000,000 scale maps. The very high level of vulnerability is due to population density, land use or land cover, the level of damage to watersheds as a cause of very high levels of vulnerability have been discussed previously.

2. **High vulnerability** towards landslides is spread in limited areas in Java, especially in the Central part of Banten, West Java, Central Java and East Java. Very high level of vulnerability due to population density, land use or land cover, critical level of land or damage to the watershed as a cause of high levels of vulnerability have been discussed earlier.

3. **Medium Vulnerability** towards the danger of landslides exists in almost all areas in Java, part of NAD and North Sumatra (Sumatra); most Sulses (Sulawesi), a small part of South Kalimantan (Borneo); most of the NTB, and some NTT (Nusa Tenggara). Very high level of vulnerability due to population density, land use or land cover, watershed damage level as in the previous discussion hazard vulnerability.

4. **Low Vulnerability** to landslide is found in Sumatra, Sulawesi, except the middle-east, the west and east Kalimantan, Maluku and Papua in part. Low vulnerability due to population density, land use or land cover, and damage to watersheds such as the discussion of low vulnerability levels.
5. **Lowest vulnerability** or no susceptibility to landslide hazards ise in the center of Kalimantan, Sulawesi, the middle-east, some of area in Maluku and Papua. Very low level of vulnerability due to population density, land use or land cover, watershed damage level as in the discussion of very low levels of vulnerability before.

3.2.6 Vulnerability to Seawater Intrusion

The following vulnerability components are involved in the qualitative assessment: population density, land-use planning related to ground-water infiltration, extent of reliance on artesian wells, groundwater withdrawal rates for residential and industrial use, recreational and tourism use, and identification of alternative fresh water resources other than ground water in assessed coastal area. The regional vulnerability to seawater intrusion can be described as follows (Appendix 3.2.6):

A. **High vulnerability** exists in coastal areas of Java-Bali, in particular along the coast north of Jakarta plus Semarang except along the western, southern and eastern part of Denpasar, which have moderate vulnerability levels.

B. **Moderate to Low Vulnerability** accounts for Sulawesi, Kalimantan, Nusa Tenggara, and Sumatera can be found in coastal area of Makassar (Sulawesi), Balikpapan (Kalimantan), Mataram (Nusa Tenggara); Palembang and Padang (Sumatera).

C. **Low to Lowest Vulnerability** exists in urban coastal area in Mollucas and Papua.

3.3 Unassessed Important Vulnerability Components

Due to limited data availability, this assessment does not involve all the important vulnerability components that will affect Indonesia's future. Several important vulnerability components that have not been assessed to date are:

1. Type of other water infrastructure or freshwater or clean water with drawl;
2. Other use of water such as for transportation, sport, recreation, religious use, and others;
3. National action of reforestation other than *GNRHL* in river basin;
4. Land characteristics;
5. Land cover in potential landslide zone; and
6. Freshwater and seawater interface, artesian well and the frequency of groundwater withdrawn in coastal area, particularly in big cities.

Qualified data for the vulnerability components that has been taken into account (such as water quality, *GNRHL*, and *Prokasih)* also needs to be improved in order to create spatial information. Vulnerability component 1) and 2) above are used to assess regional vulnerability to water supply shortage and droughts. Vulnerability components 4) and 5) above are used to asses regional vulnerability to landslides. Component 6) is used for assessing regional vulnerability to seawater intrusion. Appendix 3.2.5 shows more details on the vulnerability components which have not been taken into account in this study. Use of spatial information concerning vulnerability components should improve the accuracy and usefulness of vulnerability assessments for the impacts of climate change.

Vulnerability and climate change risks cover not only physical aspect but also socio-cultural aspects in the studied communities. Besides the issue of population growth, other issues such as information on how people treat water resource and how they make use of it, local initiatives and their impacts, as well as economical capacity of water supply, and other socio-cultural aspects of water, remain to be studied.

3.4 Reliability Level of Vulnerability Study

Having a macro level approach, the reliability level of this study is of course limited. It is difficult to use an analysis at this level as a basis for choosing adaptation measures to implement at regional or local level. However, for the national level, this study provides good results and a high level of reliability as policy guidance.

Based on this analysis, a certain level of reliability can be assumed in terms of assessing the following factors:

1. Moderate reliability level for all kind of hazards
2. High reliability level for information about population density
3. Moderate reliability level for information about land-use planning, unused/underused river basin, and water for individual and agricultural use.
4. Low reliability level for information about industrial water use, water quality, and water infrastructure.

3.4.1 Sumatera Region

In Sumatra, there are all types of vulnerability towards climate change for the water sector, medium vulnerability being prevailing in some areas it is even very high to high. The profile of vulnerability for each hazard is as follows: 1) Vulnerability to hazard PKA is generally low to highly vulnerable with a high area is relatively small; 2) vulnerability to flood hazards is generally low to high with balanced proportions of width of the area; 3) vulnerability to drought hazards generally low to high prone areas with a high area narrower; 4) vulnerability to landslide hazards is generally low and little medium; 5) vulnerability to seawater intrusion hazards is medium to low. Based on the review of sub-regions and regions, the level of vulnerability in the region of Sumatera can be divided as follows:

1. Major cities such as Medan (North Sumatra), Palembang (South Sumatra), Pekanbaru (Riau), Padang (West Sumatra), Bandar Lampung (Lampung) and each has a level of vulnerability of the surrounding high to very high for all types of hazards, except for sea water intrusion in Palembang.
2. The northern part of Sumatera, especially North Sumatra and Aceh; central-western region, especially West Sumatra and around Bengkulu; southern region, especially Lampung has a medium level to high vulnerability to all types of hazards, except the danger of seawater intrusion;
3. The bulk of the region, especially from the centre to the east and from north to south, shows very low to low vulnerability levels and some of them are against all types of hazards. Vulnerability is generally high and some areas up to very high in the region of Sumatra (with population density of an average 96/ km^2 with an average growth of 1.5%, the total water consumption is 18,376,141 x 10^3 m^3/year (21.20%), this is the

highest after Java-Bali and which is dominated by land cover types that are not functioning properly for water conservation. Soil and water quality in some major cities tend to decrease; and 16 watersheds are severly damaged, 37 watersheds are damaged, and 52 watersheds are slightly damaged. The factors that can reduce the potential vulnerability of ground water pressure of 6.671,57 x 10^6 m^3/year at 86 CAT m^3/years, is fairly evenly spread throughout the region; irrigation infrastructure covers 1,809,000 hectares of rice fields (27% of the national rice fields), among other factors which can't be quantified, including the factor of local wisdom, see also Appendix 3.4.1.

3.4.2 Java-Bali

In Java-Bali region, particularly in Java all types of vulnerabilities to dangers of climate change in the water sector exists with a general level of high to very high. The profile of vulnerability for each hazard is as follows: 1) vulnerability to PKA hazards is generally high to very high; 2) vulnerability to flood hazards are generally medium to high; 3) vulnerability to drought hazards are high to very high; 4) vulnerability to landslide hazards is generally low and high to very high in a few areas; 5) vulnerability to seawater intrusion is medium to high. Based on the review of sub-region and regions, the levels of vulnerability in Java-Bali can be divided as follows:

1. The big cities like Jakarta (DKI Jakarta), Bandung (West Java), Semarang (Central Java), Yogyakarta (DIY), and Surabaya (East Java) and the satellite towns in the surrounding, are highly vulnerable to hazards of shortage of water supply, floods and droughts; and highly susceptible to the dangers of sea water intrusion specifically for Jakarta and Semarang;
2. The other largest area outside major cities and satellite cities around it have a very high level to high vulnerability to shortage of water supply, floods, and droughts; and medium to high level susceptibility to landslide hazards;

The level of vulnerability is usually high to very high in Java-Bali, particularly in Java because of an average population density of at least 990/ km^2 (high in Indonesia); a total water consumption of 50,175,395 x 10^3 m^3/years (57.43% total water consumption in Indonesia), land cover of about 70% -80% of the water less able to absorb properly, and a declining water quality, especially in urban areas; another factor is the critical level of land that was mirrored by the damage to watersheds, namely: 17 with major damages, 95 damaged, and 31 slightly damaged watersheds or 50% of all watersheds in Indonesia are major damaged and there's so damaged in Java. The factors that can reduce the potential vulnerability of ground water pressure of 1,973 x

10^6 m^3/year, spread fairly evenly in 99 CAT; adequate of water infrastructure, in addition to dams also have irrigation infrastructure covering 3,283,000 ha of rice fields or 49 % of all rice fields in Indonesia; and qualitative factors as mentioned, including local wisdom in this study can't be quantified.

3.4.3 Kalimantan Region

Kalimantan generally shows a low to very low vulnerability for all types of dangers on climate change, except in provincial capitals and limited areas in the Southeast. The profile of general vulnerability to all types of hazards are: 1) at both the level of vulnerability of region in general was medium to high, except for landslide danger which was medium; 2) half of the West, South and East have a low level of vulnerability, and 3) almost half of the region in the Center has a very low level or is not vulnerable at all.

The level of vulnerability is generally very low to low due to an average population density of 21/ km^2, a low total water consumption is 5,636,082 x10^3 m^3/years (6.96% of the total national consumption), land cover about 60% -70% still of forests, soil water potential which relatively small depression (1,095.50 x10^6 m^3/years); condition of watersheds: 4 basins major damaged, 12 basins was damaged, and 24 basins damaged and water infrastructure covering 402,000 ha (6% of national rice fields). The factors that reduce vulnerability are the relatively good water quality, and the qualitative factors including local wisdom.

3.4.4 Sulawesi

In Sulawesi vulnerability to all kinds of dangers of climate change with the level of water sector is generally medium to low, except in South Sulawesi (Sulawesi), where it is moderate to high. The profiles of vulnerability for each hazard are as follows: 1) vulnerability to PKA hazards is generally low to moderate; 2) vulnerability to flood hazards is generally low; 3) vulnerability to drought hazard is generally low to moderate, 4) susceptibility to landslide hazards is generally low to moderate; 5) vulnerability to sea water intrusion danger of moderate to low in Makassar. Based on the review of sub-regions and regions, the vulnerability can be divided as follows: (1) The capital and surrounding provinces, especially in South Sulawesi, North Sulawesi and South Sulawesi region have a level of medium to high vulnerability to all types of hazards, except for sea water intrusion which is only present in Makassar and (2) Overall, except for Sulawesi, North Sulawesi partly in relation to landslide hazard, and the middle-east have high levels of medium to low to all types of vulnerability of hazards, except the danger of seawater intrusion.

Vulnerability in the Sulawesi region is generally medium to low caused by: the population density of 74/ km^2, the total water demand of 8,211,338 x 10^3 m^3/year (9.47% of total national water demand); a land cover of 60% to 70% dominantly good forests; potential confined aquifer of ground water on 96 CAT is 37,778 x 10^6 m^3/year. Factors that increase the vulnerability are the condition of irrigation infrastructure which only covers a land area of 804,000 ha of rice fields (12% of the national rice area) and damages to watersheds, namely: 12 considerably damaged watersheds, 43 watersheds are damaged; and 37 DAS in slightly damaged condition. The factors that reduce the vulnerability are the relatively good water quality and qualitative factors including local social still functioning in water conservation.

3.4.5 Nusa Tenggara Islands

Nusa Tenggara's vulnerability to all types of dangers of climate change in the water sector is generally medium to low, except in NTB where it is medium to high. Profile of vulnerability for each hazard are: 1) vulnerability to shortage of water supply hazards are generally low to high; 2) vulnerability to flood hazards are generally medium to low; 3) vulnerability to drought hazards are generally low to high, 4) vulnerability to landslide hazards are generally low to medium; 5) vulnerability to seawater intrusion dangers are low on the coast Senggigi, Mataram, NTB. The vulnerability profile can be divided by region as follows: 1) region of West Nusa Tenggara (Lombok and Sumbawa), medium to high vulnerability, and 2) the vulnerability of East Nusa Tenggara region is medium to low.

Vulnerability is generally moderate to low due to the following factors: a population density of 125/ km^2, total water needs of 3,454,136 x 10^3 m^3/year (3.99% of total national water demand); a dominant land cover which is still a forest, groundwater potential 41,404 x 10^6 m^3/year on 46 CAT. Another factor is the only irrigation infrastructure covers an area of 335,000 ha of rice fields (5% of the national rice area) and damage to watersheds, namely: 5 major damaged watersheds, 26 watersheds are damaged, and watersheds are minor damaged. The factors that reduce the vulnerability of the water quality is relatively good, and qualitative factors including the local wisdom.

3.4.6 Mollucas Islands

Maluku region's vulnerability to all kinds of dangers of climate change in the water sector is generally low to very low or not existing, except in some limited areas in Ambon and surrounding areas; island of Buru and Seram. Low-level vulnerabilities are not vulnerable because the 28/ km^2 of population density, very low water consumption (299,944 x 10^6 m^3/year (0.35% of national demand), land use is 65% - 75% of the wood, water quality is still good, depressed ground water potential is huge (1,231 x 10^6 m^3/year on 68 CAT). Factors that can increase the vulnerability are the irrigation infrastructure that includes only 0.5% of the national rice area, and watershed conditions, namely: 2 DAS considerably damaged, 9 watersheds damaged, and 16 watersheds slightly damaged.

3.4.7 Papua Region

Papua vulnerability to all kinds of dangers of climate change in the water sector are generally low to very low or not susceptible to all kinds of danger, except in some limited areas in Jayapura and Manokwari are medium to low levels. Low level vulnerabilities are not vulnerable because the 6/ km^2 population density, very low water needs (523,175 x 10^6 m^3/years or 0.6% of national demand), the dominant land use of forest; water quality, but water surface around Timika; potential depressed ground water large (7,018 x 10^6 m^3/years on 45 CAT). Factors that can increase the vulnerability of irrigation infrastructure that includes only 0.5% of the national rice area, and damage to watersheds are: severely 4 watersheds are major damaged, 1 watershed is damaged, and 14 watersheds are minor damaged.

3.5 Cross-cutting Vulnerability Issues

3.5.1 Cross-cutting Information

In accordance with the scope of the study conducted at the macro level or Indonesian national level, the level of reliability of this study in general terms is medium on a national scale, and low when used for the purpose of adaptation actions at regional or local level. However, the degree of confidence in the results of the study for use is at the national level (Appendix 3.5.1).

In summary, the degree of reliability of this study for spatial or map information obtained from the assessment of vulnerability following information: (1) the level of reliability of the information is for all types of hazards, except the danger of seawater intrusion, (2) a high level of reliability for the information within the vulnerability component "population density"; (3) the reliability of the information for land use, the level of critical watersheds, and water demand of the population and agriculture; (4) low reliability of the information on industrial water, water quality information, and water infrastructure.

3.5.2 Future research is needed

Further research is needed including research on hazards and climate change and water in Indonesia. Several studies presented information required in Appendix 3.5.2 and most important includes:

1. The research on the dangers of trust limits the water sector based on CDF analysis of the data the total runoff and direct runoff water balance analysis in this study which used 50% CDF value; and flood hazard analysis based on rainfall data daily average;
2. Review the vulnerability based on the vulnerability of other important components such as the way residents get water or water infrastructure is more complete; and water needs closer to actual conditions;
3. Land-use change and its relation to water demand.

3.6 Concluding Remark

Water Sector Vulnerability to Climate Change was analyzed using an overlay of the components of the GIS analysis. There are seven primary components of vulnerability and in this study five additional components of vulnerability have been included. The seven components are as follows: River Basin and Land Use, Population Density, Land-use planning, water demand, Confined aquifer, Land Elevation, and Water infrastructure. The five additional vulnerability components are: Soil Properties, Water quality, Other Individual Components of Vulnerability National Action on Forest and Land Rehabilitation (GNRHL), Clean River Program (PROKASIH), Land Subsidence in urban areas, and the Landslide Vulnerability Map.

Identification of the components of vulnerability and the dangers produces:

1) **Vulnerability to Shortage of Water Supply (PKA) hazard,** which is a function of the normal climate TRO decline in the projection (TRO_{NP}) and variations land use, population density, water demand, and potential ground water.

   Vulnerability level to Shortage of Water Supply (PKA) are (1) Very High: Vulnerability applies for more than half of Java-Bali, small parts of northern, west, and south Sumatera. (2) High Vulnerability: exists in almost half of Java-Bali, small parts of northern, west, and south Sumatera, south of Sulawesi, and NTB. (3) Medium vulnerability to shortage of water supply: present in territories of north, west, and south Sumatera, part of Sulawesi and Nusa Tenggara. (4) Low vulnerability: exists in east Sumatera region, Central to East Kalimantan, half of Sulawesi and Maluku and parts of East to Central Papua. (5) Lowest Vulnerability: this is the case for Central-West Kalimantan, parts of Papua and Halmahera Island.

2) **Vulnerability to Flood Hazard** is a function of the total direct runoff in the projection condition ($DRO_{AN\ P}$) which exceeds the value of 0 169 mm / year (50% CDF) and the variation of population density, land use and level of critical watershed land or damage.

   Vulnerability levels to Flood are : (1) Very High Vulnerability of flood dangers covers limited areas in Java-Bali, especially in the north, (2) High Vulnerability of flood dangers apply for almost half of Java, on the northern coast from West to East, (3) Medium vulnerability of flood dangers exist in parts of the northern, western, and southern territory of Sumatera, from Central to South Java, in a few parts of East-, West and South Kalimantan, and in Southern, Southeast, North- and to a minor extent also in Central Sulawesi. (4) Low vulnerability of flood dangers are present in most Central-Eastern Sumatra, and (5) Low Vulnerability of flood dangers apply for the Western parts of Kalimantan and Papua, and to a minor extent also to Central Sulawesi and Maluku.

3) **Vulnerability to** Drought hazards can be formulated as a function of hazard reduction in the total runoff ($TROmin,_{P}$) and the variation of population density, land use, water needs, the level of critical land, water infrastructure, and water potential for the drought hazard.

   Vulnerability levels to drought are: (1) Very High Vulnerability to drought hazards are present in limited areas in Java, especially in the North, covering some of the area's major cities through which the major rivers flow. (2) High Vulnerability to drought hazards are present in large areas of Java, especially on the north shore from West to East; in the middle for most of the eastern Java area and the middle, and partly in the western region includes several large cities and their surroundings. (3) Medium Vulnerability is the danger of drought and it is mainly present in large areas of the Western and Northern coast of Sumatra, south-central part of Java Island, just South-east and Western

Kalimantan and in Sulawesi on the southern, southeastern, northern and partly also in the Center as well as in most areas of Nusa Tenggara (4) Low Vulnerability of drought applies for most parts of central-eastern Sumatra, Sulawesi, most of the region, especially in the center and also small parts of the Moluccas, Nusa Tenggara, and Papua. (5) Lowest vulnerability or no risk vulnerability to drought is generally found in the biggest areas in Central Kalimantan and Papua, a small parts in Central Sulawesi, and parts of the Moluccas.

4) **Vulnerability to landslide hazards** can be formulated as a function of hazard reduction in the total runoff ($TRO_{min, P}$) population density, land use and land critical.

   <u>Vulnerability levels to landslide are</u> (1) Very High Vulnerability to landslides are found only limited in Java, (2) High vulnerability to landslides is spread in limited areas in Java, especially in the Central part of Banten, West Java, Central Java and East Java; (3) Medium Vulnerability to landslides spread in almost all areas in Java, part of NAD and North Sumatra (Sumatra); most Sulawesi, a small part of South Kalimantan (Borneo); most of NTB, and parts of NTT (Nusa Tenggara). (4) Low Vulnerability to landslide is found in Sumatra, Sulawesi, except the middle-east, the west and east Kalimantan, Maluku and Papua in parts. (5) Lowest vulnerability or no susceptibility to landslide hazards is in the center of Kalimantan, Sulawesi, the middle-east, some of area in Maluku and Papua.

5) **Vulnerability to seawater intrusion hazards** can be formulated as a qualitative analysis due to data limitations, the vulnerability of components of population density, land use, groundwater level retrieval, as well as potential alternative water sources other than groundwater.
   Based on qualitative analysis of the level of vulnerability to intrusion of sea water are:
   - **High vulnerability** in coastal areas of Java-Bali, in particular along the coast north of Jakarta plus Semarang except along the western, southern and eastern part of Denpasar, which have medium vulnerability levels.
   - **Moderate to Low Vulnerability exist** in Sulawesi, Kalimantan, Nusa Tenggara, and Sumatera and can be found in coastal areas near Makassar (Sulawesi), Balikpapan (Kalimantan), Mataram (Nusa Tenggara); Palembang and Padang (Sumatera).

- **Low to Lowest Vulnerability** are found in urban coastal areas in Mollucas and Papua.

Based on the vulnerability analysis, regions in Indonesia are indeed very vulnerable to climate change hazard with regard to the water sector, with vulnerability levels as follows:

1. Highest to high for Java-Bali and cities in Sumatra like Medan (South Sumatra), Pekanbaru (Riau), Padang (West Sumatra), Banda Lampung (Lampung) and Sulawesi;
2. Medium to high for northern parts of Sumatra, especially North Sumatra and NAD, middle-western regions especially West Sumatra and around Bengkulu, Southern regions especially Lampung, and South Sulawesi territory (South Sulawesi),
3. Low to medium for Nusa Tenggara and Timur territory, and Sulawesi territory except South Sulawesi;
4. Low to lowest in the middle-east of north to south Sumatra, most Kalimantan territories, and the Moluccas and Papua.

Chapter 4. Potential Climate Change Impact on the Water Resource Sector

The result for the potential impact or risk of climate change on the water resource sector in this study is the integrated result of hazard and vulnerability of the water sector. In this chapter, five types of climate change risk on the water sector are discussed, based on five types of hazard and five types of vulnerability previously identified.

The first section discusses the spatial dimension of climate change risk for each danger and vulnerability. The next section discusses the spatial dimension of risk for each area and some further examples of risks.

4.1 Illustration of Climate Change Risk on Water Sector

Based on the analysis of climate hazard and water sector vulnerability, Indonesia will experience risks of climate change in the water sector that may take several forms. These include water supply shortage, flood, drought, landslide, and seawater intrusion (Appendix 4.1). GIS analysis will be used to map the extent and spread of the risk.

Climate change risk in the water sector arises in all scenarios, from year 2010 to 2030. During 2015-2020, the risks decrease slightly and then increase again during the 2025-2030 period, when risk levels range from very high to low or no risk. For the purposes of this analysis, only scenario SRA2 will be evaluated in detail. The confidence level of this risk information analysis is low to moderate following the level of the study that is macro-scale or national-scale and the information levels for the hazard and vulnerability are respectively, moderate and low- to moderate levels.

4.1.1 Water Supply Shortage Risk

GIS analysis has been used to evaluate the areal extent and distribution of expected risks of water supply shortage (PKA) from 2010-2015 to 2025-2030. The results are shown in Figure 4.1 and Appendix 4.1.1. PKA indicates, risk is obtained from PKA hazard as a function of total runoff (TRO). TRO decreases from average annual rainfall over the projection period of 0 to 169 mm/yr from baseline condition in areas with related vulnerability levels (Appendix 4.1.1). In Java-Bali region, most areas in Sumatera, parts of Nusa Tenggara and Sulawesi experience significant PKA risks.

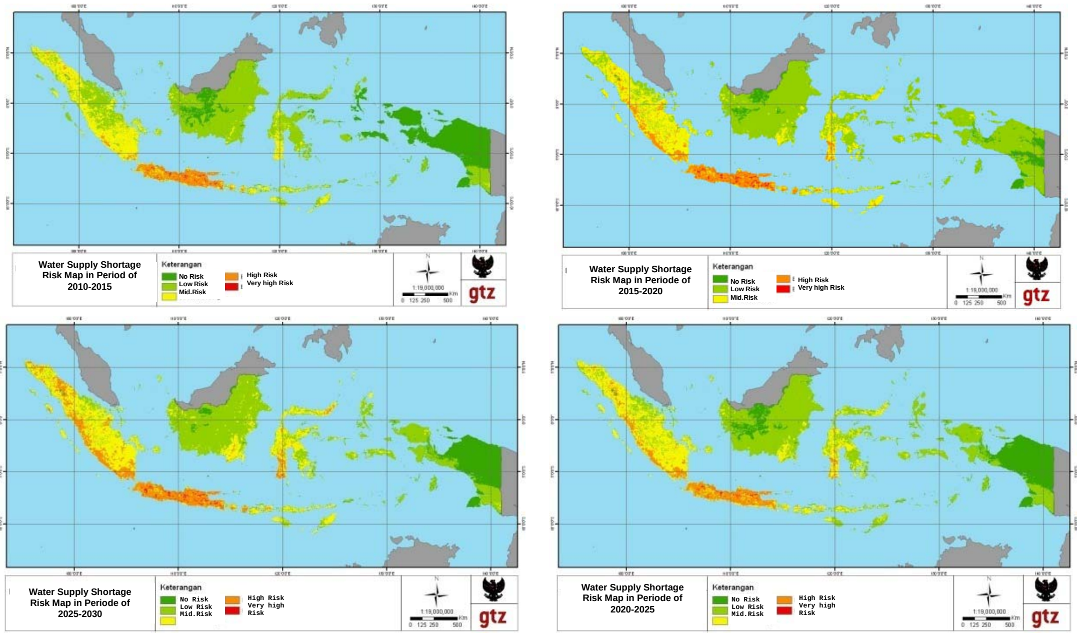


Figure 4.1 Water supply shortage risk, SRA2, from top left clockwise: 2010-2015 period, 2015-2020, 2020-2025, and 2025-2030

Based on the risk map generated, there are five risk levels, each with its own spatial distribution. The five levels are:

1. **Very high PKA risk** occurs in small areas of the Java-Bali region, particularly in Northern and Southern West Java, Central and Southern Central Java and East Java, as well as in the capital of North Sumatera, West Sumatera, Bengkulu and Lampung (Sumatera); Bali; Nusa Tenggara Barat (Nusa Tenggara) and South Sulawesi (Sulawesi);
2. **High PKA risk** is observed in 75% of Java-Bali region; a small area in Northern, Western, and Southern Sumatera region, part of Lombok area (Nusa Tenggara) and South Sulawesi (Sulawesi);
3. **Moderate PKA risk** occurs in 20% of Java Island region, particularly in central region of West Java, in around 70% of Sumatera region, except in its central to eastern areas;
4. **Low PKA risk** in general is found in around 80% of Kalimantan, and in a small part of Maluku and Papua;
5. **Very low PKA risk** or **no PKA risk** in general is located in 80%-90% of Maluku and Papua region.

Further impacts or risks of PKA hazard can be seen in the water balance condition, which ranges from critical to almost critical deficits in areas with overall risk levels ranging from very high to high (Figure 4.2). In urban areas, water deficit will cause more pressure on water resources and create other impacts as outlined in Appendix 4.1.1.

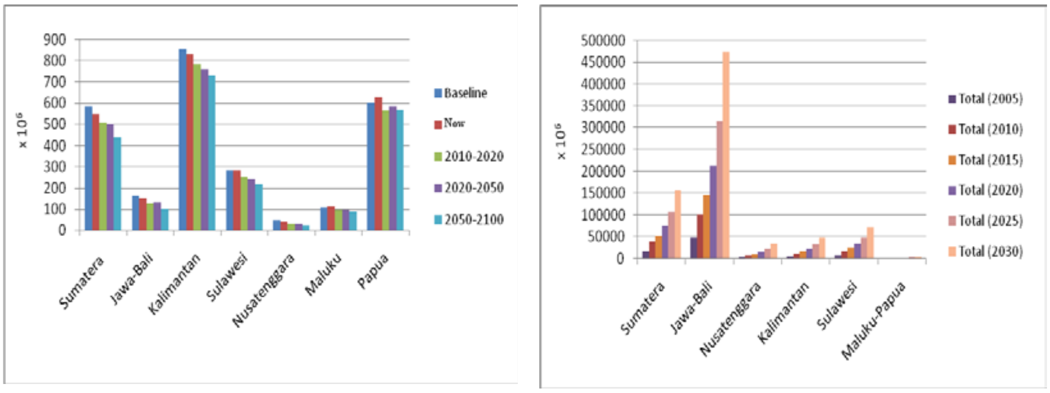


Figure 4.2 Water supply (*left*) and water demand (*right*) per area

4.1.2 Flood risk

Floods can cause loss of lives, material wealth and livelihood, increase reparation and rebuilding of infrastructure damaged by floods, decrease of clean water supply, harvest failure, and diseases such as dengue fever and other further impacts (See Appendix 4.1.2).

Figure 4.3 illustrates a comparison of flood risks between the 2010-2015 periods and the 2025-2030 periods, based on GIS analysis. Flood risk is obtained from flood hazard as a function of direct run-off during above normal rainfall condition on projection period (which is more than 89 mm/month), where it occurs in areas with slope gradient < 3^{o} that are exposed to related vulnerability levels (See Appendix 4.1.2). Areas with significant risk of flood are lowland areas, particularly in the downstream zones of major rivers in Java, Sumatera, Kalimantan, Sulawesi and Papua.

There are five levels of flood risk, distributed as follows:

1. **Very high flood risk** is located exclusively along major rivers, particularly in their downstream areas in Java Island; eastern Sumatera; western, southern, and eastern Kalimantan; eastern Sulawesi, and southern Papua.
2. **High flood risk** is experienced in areas similar to areas with very high flood risk, but with larger extent.

3. **Moderate flood risk** is experienced in areas similar to areas with high flood risk, but in even larger areas;
4. **Low flood risk** is experienced in areas similar to areas with moderate flood risk, but in even larger areas;
5. **Very low flood risk or no flood risk** applies for very large areas in each region.

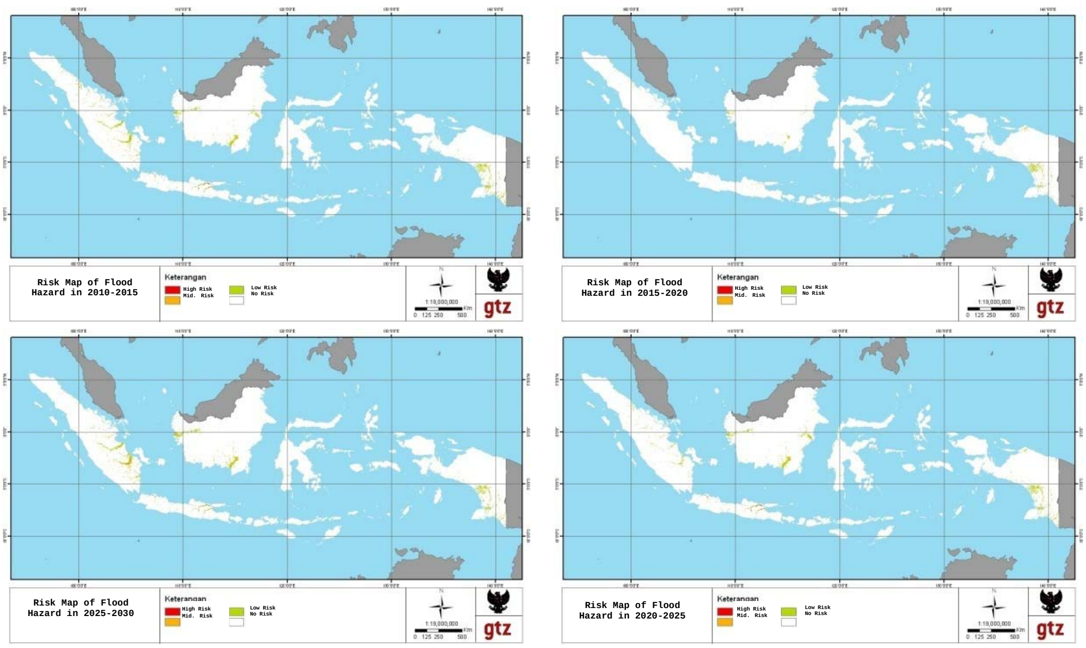


Figure 4.3 Flood risk, SRA2, from top left clockwise: 2010-2015 period, 2015-2020, 2020-2025, and 2025-2030

4.1.3 Drought Risk

Figure 4.4 provides a GIS analysis and comparative illustration of the areal distribution of drought risks in Indonesia, comparing the risk during the 2010-2015 period with projected risks during 2025-2030 as shown in Figure 4.4. Drought risk is obtained from drought hazard as a function of total runoff. The risk is significant when rainfall falls below normal annual average value during the projection period. (See Appendix 4.1.3). Drought risk is significant for the Java-Bali region, most areas in northern Sumatera, part of Nusa Tenggara and Sulawesi.

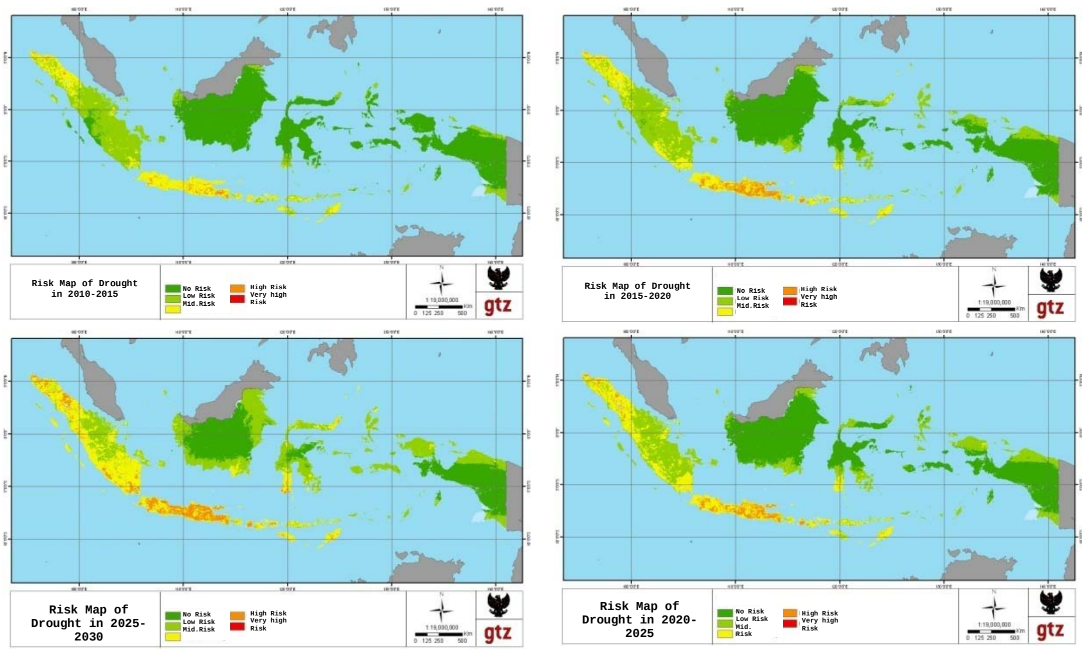


Figure 4.4 Drought risk, SRA2, from top left clockwise: 2010-2015 period, 2015-2020, 2020-2025, and 2025-2030

The drought risk can be divided into five levels of exposure:

1. **Very high drought risk** is found in limited areas in Central Java, Northern Sumatra, and small part of Nusa Tenggara.
2. **High drought risk** is encountered in a larger area in Central Java, Sumatera, and Nusa Tenggara, small part of South Sulawesi;
3. **Moderate drought risk** is generally encountered in around 80% of Java island area, 30% of Sumatra region, particularly in northern area and in a small area in its southern part; as well as in around 75% of the Nusa Tenggara region;
4. **Low drought risk** is observed in 60% of Sumatera region, particularly in central-southern areas, in a small part of the southern area, and in the northern tip of Sulawesi; as well as in small areas in Kalimantan, Maluku and Papua;
5. **Very low drought risk** or no drought risk is found in 80%-90% of Kalimantan, Sulawesi, Mollucas and Papua region.

Further risk of drought and more severe risk of water supply shortage exist, both in intensity and areal affected (See Appendix 4.1.3). Many agricultural areas in Indonesia are vulnerable to planting and harvesting failure due to drought onset or to shifting of the start of the dry season.

4.1.4 Landslide risk

Figure 4.5 illustrates the results of the GIS analysis and provides a comparative illustration of landslide risk in the 2010-2015 periods, as compared to the 2025-2030 periods. Landslide risk is estimated from the landslide hazard overlay of total decrease in maximum rainfall than base line projections of 278 mm /month.

Towards various related vulnerability level (See Appendix 4.1.4). Landslide risk is observed significantly in the Java-Bali region, and also in Sumatera, Sulawesi, Nusa Tenggara, and Papua.

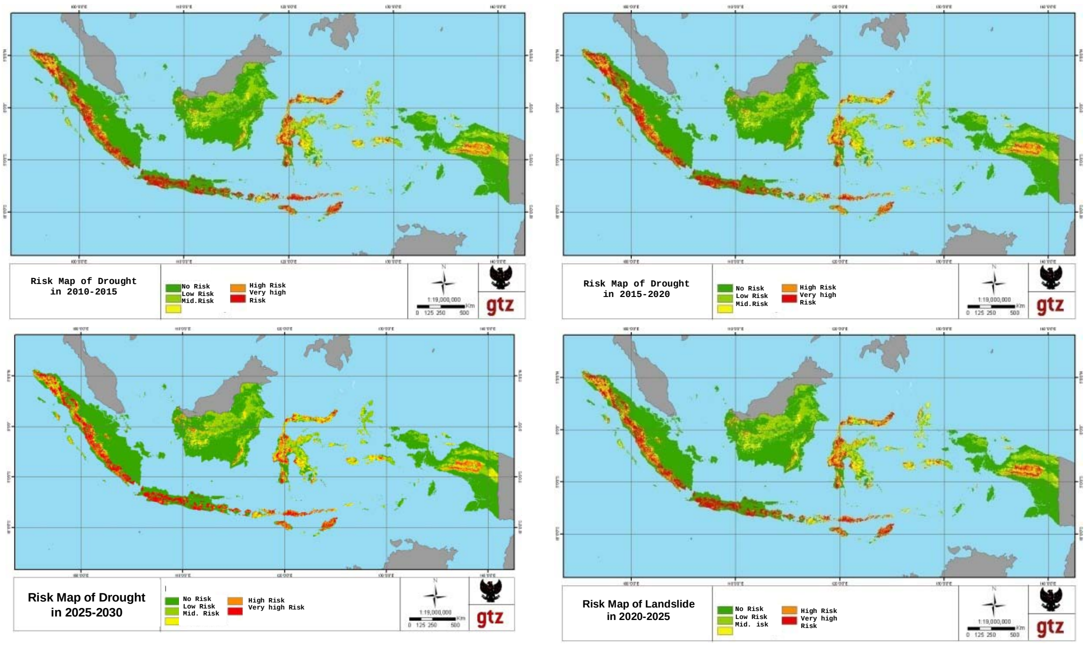


Figure 4.5 Landslide risk, SRA2, from top left clockwise: 2010-2015 period, 2015-2020, 2020-2025, and 2025-2030

The levels of landslide risk can be described as follows:

1. **Vey high landslide risk** is found in central to southern areas of Java-Bali, central to western areas of Sumatera, most parts of Nusa Tenggara; and Sulawesi, and central Papua;
2. **High landslide risk** is encountered at the edge of the very high risk band, but with a smaller area;
3. **Moderate landslide risk** is observed in nearby areas of high-very high risk in the central to eastern area of Sulawesi, limited areas of central Kalimantan, and in parts of Maluku and Papua;
4. **Low landslide risk** occurs in several areas in Sumatera and Java, in large areas of central Kalimantan; central to eastern area of Sulawesi, parts of Nusa Tenggara, Maluku, and Papua;

5. **Very low or no landslide risk** is generally located in the northern half of Java-Bali area, in the northern and eastern half of Sumatera region, in the largest part of Kalimantan, several areas in Sulawesi, Nusa Tenggara, and the largest part of Maluku and Papua.

Landslides have diverse impacts, from loss of lives and material wealth to disturbance or damages in public facilities and infrastructures such as road, and agricultural irrigation (See Appendix 4.1.4).

4.1.5 Seawater Intrusion risk

The potential impact of seawater intrusion is limited in several coastal areas, particularly in Java-Bali area (Jakarta, Semarang, and Denpasar) and Sumatera (Palembang and Padang). Seawater intrusion is caused by the interface of the water table-seawater layer that gets shallower in coastal area and compounded by the vulnerabilities caused by population density, land use, water demand, and groundwater intake level. Seawater intrusion makes water supply decrease as the quality of water declines and soil or building foundations are damaged (See Appendix 4.1.5).

4.2 Climate Change Risk by Region

The risks of climate change for the water sector are encountered throughout Indonesia facing the hazard of water supply decrease, flood, drought, and landslide and its respective related vulnerabilities. The risk level is determined by the hazard and vulnerability level. The risk levels in general are:

1) Very high to high for the Java-Bali region, small parts of Sumatera and Nusa Tenggara;

2) Moderate to low for parts of Sumatra, Nusa Tenggara, Sulawesi and Kalimantan region; and

3) Low to very low for Maluku and Papua region.

4.2.1 Sumatra Region

Sumatra is divided by Barisan Mountains into three areas whose biogeophysics determine the most prominent potential impact. The Western part of Sumatra is characterized by small watershed and short rivers, with small potential for surface water storage so generally the flood risk is smaller, but the water supply shortage, drought, and landslide risks are quite high. The central area is mountainous and has larger landslide risk potential, especially in Lahat (South Sumatera), Sitinjau Laut (West Sumatera), and Bengkulu. The central to eastern area of Sumatera is characterized by the great length and areal extent of large rivers so the flood risk is higher.

In general, the integrated risk level of Sumatera area varies from **high** to **low.** The wide variation is caused by the high threat level for individual hazards and related vulnerability factor. The risk profile for each hazard type is: very high to moderate risk of PKA, flood, and drought; very high risk of landslide; and moderate to low risk of seawater intrusion.

Based on the GIS analysis the profile of climate-related risks in the Sumatera area can be categorized as follows: (See Appendix 4.2.1):

(1) Kota Medan (North Sumatera), Palembang (South Sumatera), Pekanbaru (Riau), Padang (West Sumatera), and Bandar Lampung (Lampung) has very high to high risk towards PKA and drought;

(2) The northern area to northern central area (North Sumatera, NAD, and West Sumatera) and a small part of the southern tip (Lampung) have a moderate-high risk towards PKA and drought, while the flood hazard is limited to big flood; (3) the third of Sumatera that is in the central-western area beyond a north-south line has a very high-high risk of landslide;

(3) Two thirds of the area, central part eastwards has a high risk towards flood, particularly in lowlands along Major River in eastern area, and has low-very low risk of PKA, drought, and landslide. As for seawater intrusion risk, available quantitative analysis is limited to the coastal area in Palembang (South Sumatera) and Padang (West Sumatera).

In areas with a very high-high risk, there may be further, derived impacts of each risk. Some of these follow-on risks are:

(1) pressure on water sources that can trigger social conflicts, planting failure or harvest failure, as well as forest fire, declining performance due to PKA and drought by hydro power plants (e.g., Asahan) and both natural water reserve (Toba Lake and other lakes) and artificial reserves;

(2) destruction of settlement and cultivation area particularly agriculture area that includes plantation, and the spreading of several diseases due to lack of water, such as diarrhea and dengue fever due to flood; and

(3) damage to settlements, infrastructure, and public facilities; this poses obstacles for the logistics of goods, especially for the agricultural sector from West to East (for vegetables, plantation commodities) and vice versa (for production goods supply).

4.2.2 Java-Bali Region

The intensity of climate change risk in the Java-Bali region is also strongly influenced by the physiography of the area. In the northern area of Java Island, the most prominent risks are flood and drought, particularly in lowlands near the coast and the farmland, and seawater intrusion for coastal areas such as Jakarta and Semarang. In both of these cities and in other cities in the coastal area, local flood can also occur, triggered by high rainfall, land subsidence, or caused by failures of water infrastructure, such as old water storage sites. In central and southern areas of the Java-Bali region, the risk of water supply shortage, drought, and landslide is prominent, particularly in Java Island. Flood risk in the central area is limited to big cities.

GIS analysis illustrates that Java-Bali in general has a **very high** to **high** risk level for all hazard types, corresponding to the threat level of each hazard and to related vulnerability factors. The risk profile is generally high-very high and moderate in several areas for PKA; the risk is generally high for flood; moderate-high for drought, very high risk in general for landslide, and moderate to low risk of seawater intrusion. (See Appendix 4.2.2)

Based on GIS analysis, the risk profile in the Java region can be categorized as follow:

(1) Kota Jakarta (DKI Jaya), Bogor, Bandung and surrounding area (West Java), Yogyakarta (DIY), Semarang, Solo (Central Java), and Surabaya and its surrounding area (East Java) have very high to high risk for water supply shortage (PKA); some of the large cities and medium city in the areas passed by major rivers (Citarum, Ciliwung, Bengawan Solo, Kali Brantas and other rivers) have high-moderate risk for flood;

(2) central to southern area in West, Central, and East Java have high-very high risk of landslide;

(3) central areas, particularly in East and Central Java have moderate to high risk of drought; and

(4) Based on qualitative analysis, it is known that northern coast area of Jakarta and Semarang has high-very high risk of seawater intrusion.

One of the characteristic of the Java-Bali region, particularly in Java Island, is the advance level of artificial water resource storage and development activities. In the area located in very high-to-high risk zone area, some of the risks are:

(1) The impact of PKA and drought; pressure on water sources that are easy to access by the inhabitants and by industry (such as water springs and shallow groundwater in urban

areas) can lead to social conflicts planting failure or paddy harvest failure in northern coast, central and eastern area; declining performance of hydropower plants that can result in decreasing electric energy supply, irrigation and residential enterprise that rely on dams (e.g., Saguling, Ciarata, Jatiluhur, Kedungombo, Wadaslintang, and others); and other reservoirs both natural and artificial such as lakes and water sites; and decrease in water quality. Other risks include increasing damages to water supply infrastructure, such as hydropower plants facilities, dams, water sites, and irrigation networks;

(2) Impact of flood: damages and disturbance in settlement and land cultivation patterns, particularly paddy fields, road infrastructure, public facilities, and settlement areas; spreading of infectious diseases, (e.g., diarrhea and dengue fever); damage of watershed or river bodies due to erosion, particularly in the riverhead; planting failure or harvest failure that affect vast area, loss of lives and material and wealth, and disruption of daily activities of the residents;

(3) Impact of landslide: trauma caused by loss of lives, obstruction of infrastructure function such as road, a remote area become more isolated, increase of expense for relocation or reparation of damaged settlement and infrastructure;

(4) Impact of seawater intrusion: health problem, expense for provision of clean water becomes more expensive and high cost for restoration, and damages to building foundation in northern coast of Jakarta and Semarang.

4.2.3 Kalimantan Region

Kalimantan region is characterized by its coastal lowlands. Almost all its big cities are facing the sea and are located on major rivers. Other characteristics of this region include its long wide rivers river. The region is dominated by low lands, except in the central area which is mountainous; it provides opportunity of enough water availability, but the threat of flood is high.

Based on GIS analysis result, Kalimantan region in general has **very low** to **moderate** risk for all hazards, corresponding to the low threat level of each hazard and its related vulnerability factors. Risk profiles for each hazard are: the risk in general is moderate for PKA and flood, the risk in general is very low for drought and landslide, and the risk is moderate-low for seawater intrusion in major cities in coastal area. Based on sub regional or area observation of GIS analysis result, the risk profiles are: (1) big cities in coastal area have moderate to high risk for PKA, and lowlands have similar risks for floods; (2) hill region has moderate risk for landslide; (3) most of the region has very low or no risk for drought except for a small area in the northwest that has a low risk for drought. (See Appendix 4.2.3)

The more prominent risk related to climate change in Kalimantan is flood risk. The flood risk will be exacerbated by the degradation level of river banks as happened in Samarinda in 2008. The flood risk in coastal urban areas and lowlands along the major river paths can further result in damages to settlements, infrastructure, disruption of the residents' daily activities, damages to farmland, as well as epidemics of diarrhea and dengue fever. Severe drought in several areas can trigger land fires or forest fires along with coal or peat fires.

4.2.4 Sulawesi Region

Sulawesi Region is characterized by wavy hill morphology with steep cliffs and narrow plateaus in all areas of the region. Big cities are generally located in coastal areas. In general, all types of climate change risk, except seawater intrusion, can be expected to occur in this region.

Based on GIS analysis, the Sulawesi region has **low** to **moderate** risk for all types of climate--related hazards, corresponding to the threat level of each hazard and its related vulnerability factor. The risk profiles for each hazard (Appendix 4.2.4) are: the risk generally is moderate-low for PKA and flood; and the general risk is very low-low for drought; for landslide the risk is moderate-high. Based on sub regional or area observation of GIS analysis result, the profiles in Sulawesi region are: (1) big cities in South and North Sulawesi and their surrounding areas has high-moderate risk for PKA and drought; (2) central area from southern to northern part has moderate to high risk toward landslide; (3) southern-eastern area along the river flow and several limited area in the central and northern part has risk ranging from low-high towards flood.

Furthermore, the risk of flood coincides with landslide risk. The joint danger is greatest in the case of big floods spreading in the western, southern, and part of northern Sulawesi and in Jeneberang River (South Sulawesi). For PKA and drought risk, key areas are southeastern area (South East Sulawesi) and in the south (South Sulawesi), from the Center to the West (Central and West Sulawesi)

4.2.5 Nusa Tenggara Islands Region

Nusa Tenggara Islands Region is characterized by big and small islands, each with its unique characteristics. The more prominent risks in Nusa Tenggara region are drought and water supply shortage, as well as landslides during the peak rainy season. However, particularly for western area (NTB) that is characterized by generally wet climate, the risk of flood can still be encountered at any time with above normal precipitation.

GIS analysis shows that Nusa Tenggara region has low to moderate risk for all types of hazard, except for landslide, (which is moderate to high, which corresponds to the threat level of each hazard and related vulnerability factors. The risk profile for each hazard is: the risk is generally moderate-low for PKA and drought; very low to low risk for flood, and moderate to high risk for landslide. The area profiles are: (1) big cities in NTB and NTT has high-moderate risk for PKA and drought, and moderate risk for flood; (2) all area outside big cities has moderate to low risk for PKA and drought, very low for flood, and moderate to high risk for landslide. The risk for seawater intrusion is moderate-low for limited area in the western coast of Mataram (NTB). (See Appendix 4.2.5)

Among the secondary impacts of climate change, the most important is planting failure and harvest failure in farmland, particularly paddy fields and horticulture, due to season shifting or water supply shortage. Aside from that, the pressure on water sources due to drought can cause performance decline of regional *embung* as a conservation medium and water supplier this will result in decreasing agriculture production. On the eastern area (NTT), prolonged drought will have a great impact on agricultural productivity.

4.2.6 Maluku Island Region

Maluku Islands Region is characterized by small and medium islands characterized by a narrow plateau, with relatively moderate to high slope gradient. Because of the good land cover condition in relation to water conservation, the small population and limited agriculture, climate-related risk in the water sector is low to very low in this region.

GIS analysis shows similar result, i.e. Maluku region in general has low to very low risk for all hazards (Appendix 4.2.6). Several areas with significant risks are: 1) Kota Ambon and surrounding area, 2) Seram and Buru Island, and 3) part of Halmahera, Ternate, and Morotai Islands. Of importance is the risk of big flood from Gamalama volcano lava in Ternate Island during periods of above-normal rainfall.

4.2.7 Papua Region

Papua region is divided by Jaya Wijaya Mountains, which strongly affects the water resource potential. The northern coast of Papua is a narrow area characterized by the short length of the river, which means it receives and channels water quickly so the surface water potential is not very high. There is limited flood risk, but the drought risk is quite high. This is different from the situation on the southern coast of Papua, which is characterized by long rivers and large area of river bank, making the potential of water availability and hence greater risk of flood than drought. Meanwhile, the central part of Papua has quite a high risk of landslide. However, the general risk condition is similar to that of the Maluku region.

GIS analysis supports similar findings, namely: Papua region in general has **low** to **very low** risk level for all climate-related hazards. Several areas that needs attention are: 1) Kota Jayapura and its surrounding area in relation to drought and landslide; 2) central area in relation to landslide risk, 3) southern coast area in relation to flood, water supply shortage, and drought; and 4) specifically in Timika lowlands and surrounding area in relation to flood risk and water pollution potential due to gold mining activities in riverhead area (See Appendix 4.2.7).

4.3 Concluding Remark

This chapter covers the following topics: in the first section the spatial dimension of climate change risk for each danger and vulnerability has been discussed, whereas the second part discussed the spatial dimension of risk for area in Indonesia.

Risk on climate change is an overlay of dangers from lowest levels to very high with each vulnerability:

- **Water Supply Shortage Risk (PKA)**
  PKA indicate, risk is obtained from PKA hazard as a function of total runoff (TRO). TRO decreases from average annual rainfall over the projection period of 0 to 169 mm/yr from baseline condition in areas with related vulnerability levels. Java-Bali region, most areas in Sumatera, parts of Nusa Tenggara and Sulawesi experience significant PKA risks.

  Five risk levels are generated with its own spatial distribution. The five levels are:

1. **Very high PKA risk** occurs in small areas of the Java-Bali region, particularly in Northern and Southern West Java, Central and Southern Central Java and East Java, as well as in

the capital of North Sumatera, West Sumatera, Bengkulu and Lampung (Sumatera); Bali; Nusa Tenggara Barat (Nusa Tenggara) and South Sulawesi (Sulawesi);

2. **High PKA risk** is observed in 75% of Java-Bali region; a small area in Northern, Western, and Southern Sumatera region, part of Lombok area (Nusa Tenggara) and South Sulawesi (Sulawesi);
3. **Moderate PKA risk** occurs in 20% of Java Island region, particularly in central region of West Java, in around 70% of Sumatera region, except in its central to eastern areas;
4. **Low PKA risk** in general is found in around 80% of Kalimantan, and in a small part of Maluku and Papua;
5. **Very low PKA risk** or **no PKA risk** in general is located in 80%-90% of Maluku and Papua region.

- **Flood risk**

  Flood risk is obtained from flood hazard as a function of direct runoff during above normal rainfall condition on projection period (which is more than 89 mm/month), where it occurs in areas with slope gradient $< 3^o$ that are exposed to related vulnerability levels. Areas with significant risk of flood are lowland areas, particularly in the downstream zones of major rivers in Java, Sumatera, Kalimantan, Sulawesi and Papua.

  Distribution of five levels of flood risk, are as follows:

1. **Very high flood risk** is located exclusively along major rivers, particularly in their downstream areas in Java Island; eastern Sumatera; western, southern, and eastern Kalimantan; eastern Sulawesi, and southern Papua.
2. **High flood risk** is experienced in areas similar to areas with very high flood risk, but with larger extent.
3. **Moderate flood risk** is experienced in areas similar to areas with high flood risk, but in even larger areas;
4. **Low flood risk** is experienced in areas similar to areas with moderate flood risk, but in even larger areas;
5. **Very low flood risk or no flood risk** in very large areas in each region

- **Drought Risk**

  Drought risk is obtained from drought hazard as a function of total runoff. The risk is significant when rainfall falls below normal annual average value during the projection period. Drought risk is significant for the Java-Bali region, most areas in northern Sumatera, part of Nusa Tenggara and Sulawesi.

The drought risk can be divided into five levels of exposure:

1. **Very high drought risk** is found in limited areas in Central Java, Northern Sumatra, and small part of Nusa Tenggara.
2. **High drought risk** is encountered in a larger area in Central Java, Sumatera, and Nusa Tenggara;
3. **Moderate drought risk** is generally encountered in around 80% of Java island area, 30% of Sumatra region, particularly in northern area and in a small area in its southern part; as well as in around 75% of the Nusa Tenggara region;
4. **Low drought risk** is observed in 60% of Sumatera region, particularly in central-southern areas, in a small part of the southern area, and in the northern tip of Sulawesi; as well as in small areas in Kalimantan, Maluku and Papua;
5. **Very low drought risk** or no drought risk is found in 80%-90% of Kalimantan, Sulawesi, Maluku and Papua region.

- **Landslide risk**

  Landslide risk is estimated from the landslide hazard overlay of total decrease in maximum rainfall from base line projections of 278 mm /month towards various related vulnerability level Landslide risk is observed significantly in the Java-Bali region, and also in Sumatera, Sulawesi, Nusa Tenggara, and Papua.

The levels of landslide risk can be described as follows:

1. **Vey high landslide risk** is found in central to southern areas of Java-Bali, central to western areas of Sumatera, most parts of Nusa Tenggara; and Sulawesi, and central Papua;
2. **High landslide risk** is encountered at the edge of the very high risk band, but with a smaller area;
3. **Moderate landslide risk** is observed in nearby areas of high-very high risk in the central to eastern area of Sulawesi, limited areas of central Kalimantan, and in parts of Maluku and Papua;

4. **Low landslide risk** occurs in several areas in Sumatera and Java, in large areas of central Kalimantan; central to eastern area of Sulawesi, parts of Nusa Tenggara, Maluku, and Papua;
5. **Very low or no landslide risk** is generally located in the northern half of Java-Bali area, in the northern and eastern half of Sumatera region, in the largest part of Kalimantan, several areas in Sulawesi, Nusa Tenggara, and the largest part of Maluku and Papua.

- **Seawater intrusion**

  The potential impact of seawater intrusion is limited in several coastal areas, particularly in Java-Bali area (Jakarta, Semarang, and Denpasar) and Sumatera (Palembang and Padang).

The risks of climate change for the water sector are encountered throughout Indonesia in facing the hazard of water supply decrease, flood, drought, and landslide and its respective related vulnerabilities. The risk level is determined by the hazard and vulnerability level. The risk levels in general are:

1. Very high to high for the Java-Bali region, small parts of Sumatera and Nusa Tenggara;
2. Moderate to low for parts of Sumatra, Nusa Tenggara, Sulawesi and Kalimantan region; and
3. Low to very low for Maluku and Papua region.

Chapter 5. Mainstreaming Climate Change into the National Development Programme: Policies for the Water Sector

5.1 Long-term National Development Planning in the Water Resource Sector 2010-2030

The main policy for water resource management in Law No. 7 of year 2004 are: conservation of water resources, efficiency of water use and the reduction of water hazards. The law clarifies responsibilities of the respective line ministries relevant for the water sector which are the Agency of National Water Resource (Dewan Nasional Sumber Daya Air) for Coordinating all ministries related to water resources. Several important legal articles related to water management have not yet been followed up with operational and special regulation in detail by the Ministry of Public Works.

A first step in this regard is the Long-term National Development Plan for 2010 – 2030 (RPJP). A summary of the relevant RPJP policies is given here:

1. Water resource management is carried out with due attention to the balance between conservation and utilization, upstream and downstream, between the utilization of surface water and groundwater, between demand and supply management, and the fulfillment of long-term and short-term interests.
2. Conservation will be given priority in order to maintain the balance between efforts to satisfy the short-term and long-term demands for water
3. The pattern of upstream-downstream relations will be further developed in order to reach a level of water management that is appropriate to meet the demand for water.
4. The development and the application of a system of conjunctive use between utilization of surface water and ground water will be promoted in order to create synergies and maintain continued ground water availability.
5. Efficiency in the use of water for irrigation will be achieved through optimizing irrigation techniques and improved irrigation management, rehabilitation and improvement of operation and management, especially outside Java.
6. Efficiency in terms of supply with clean water focuses on domestic use, especially in areas where clean water is scarce.
7. If ground water is used to meet the demand for clean water, this needs to be carried out in a controlled way (because seduction of ground water has impacts on the environment) and in close coordination between the institutions in charge, here which are the Center of

Environmental Geology, Ministry of Energy and Mineral Resources (for technical recommendation) and the Local Government (for permit). At the same time efforts need to be increased to provide quality water from surface water, given that ground water levels are already significantly lowered.

8. The control of water hazards, especially flood control, is given priority to a holistic approach ("non-construction approach") through capacity building for neighboring communities and local wisdom, conservation of water resources and river basin management by paying attention to the integrity with the layout of the territory.
9. The protection of coastal zones from abrasion especially is carried out to the area of the border, the small islands as well as to the centre of economic activity.
10. Increasing community development and partnership among stakeholders are long-term goals not only for the time of disasters such as flood incidents, but also in the prevention stage as well as in the restoration and post-disaster phase. In flood control, priority is given to highly populated and strategic areas.
11. Development and management of water resources is also carried out through institutional arrangement such as rescheduling of authority and responsibility of the respective stakeholders.

The RPJP policy 2010-2030 on the water resource sector and climate change is based on the future challenges and strategic issues for the water sector resulting from climate change. As this study has shown, in the future, the climate change related hazards for the water sector in Indonesia are as follows: decreasing water availability, drought, flood, landslide and saltwater intrusion. Regarding these hazards seven strategic issues are currently key for the water sector: 1) The balance between water availability and water need should be achieved both spatially and temporally with priority given to domestic water need; 2) decreasing vulnerability and risk of flood, drought and landslide; 4) finding synergetic solutions for cross cutting issues, especially water and agriculture, energy, industry, health and forestry; 4) good water infrastructure and alternative water supply for areas where water is already scarce; 5) water conservation through participatory approach and with the help of local wisdom; 6) integrated water resource management and flood control; 7) database, technology and research of water resources and impacts of climate change.

The RPJP 2010-2030 programme for mainstreaming climate change impacts into the water sector is carried out as a step in finding strategic solutions for the key issues the water sector will be facing in the future resulting from climate change. This policy therefore is part of the adaptation program for the water sector, covering strategic issues such as sensitivity towards and risks resulting from climate change. The sensitivity towards climate change impacts and risks resulting from climate change in the water sector show a great regional diversity. The Java-Bali area and Sumatra show generally highest sensitivity and very high risks of all the threats analyzed. Nevertheless, our findings show very clearly, that adaptation action in due course is necessary. The next paragraph elaborates possible adaptation policies and measure.

5.1.1 Policy Recommendations for Adaptation for the period 2010 – 2030

A long-term policy for the water sector for Indonesia should take into account the climate change pattern that has been identified for Indonesia and which shows an increase in temperature between 2010-2020, a temperature decrease during 2020-2025 and again an increase for the period 2025-2030.

A development policy for the water resources sector should aim at an efficient use of water resources to meet demands of households, urban areas and the industry, by consideration of the following points:

(1) Give priority to the demands of households, developed areas, and strategic areas of the hazard of the water deficit;
(2) Control of the utilization of the ground water to meet demands for standard water and, in line with that, increased efforts in the provisions of standard water from surface water;
(3) Increase of development of water capacity as the source of standard water, and the optimization of the source of standard water available by improved management;
(4) Increased participation of private enterprises in funding infrastructure development for standard water (*conveyance system).*

Following the vulnerability assessment it can be stated that the period 2015-2020 bears the highest vulnerability and risk, whereas the period 2025-2030 shows decreasing risk, although risks and vulnerability prevail. However, all in all vulnerability and risk increase, although fluctuating, during the period 2015-2030. In order to achieve the results needed in the water sector, the following should be pursued:

(1) Creating a momentum as a follow-up to the Law No 7 at 2004 in term of its implementing regulations as the technical guidance for the management of water resources;

(2) Increasing communication capacity, co-operation, inter-institutional co-ordination and inter-stakeholder co-ordination on the management of water resources;
(3) Increasing institutional capacity, management and empowerment as well as community participation of water resources especially in the level of regency/city;
(4) Supporting of participatory approach and community involvement at each stage of water resources management through assistance, counseling and management;
(5) Strengthening of management efforts on water resources in partnerships between the Government and communities.

Apart from national policy making, what is needed here is regional policy making in each territory, based on the intensity of the hazard, the vulnerability, and the risk. Results could take the form of legislation other measures or technical infrastructure. As was shown in the analysis in the last chapters, a sound and integrated policy adaptation is needed. The policy direction of the Water Sector adaptation was aimed at reducing the potential for the impact of the danger resulting from climate change and the related sensitivity of the water sector. Against the background of the finding of the Vulnerability and Impact Assessment in this study, an integrated and sound adaptation policy has to follow the directions listed below:

1. Carry out study of the hazard, sensitivity, impact of climate change in water resource sector that is more specific;
2. Increase data capacity and water resources information, cover the availability, the requirement, the source, and the inhabitants' method received water; through updating, the increase, the provisions and the community's access towards the data and Water Sector information;
3. Increase the source capacity of water in order to increase the provisions situation of water;
4. Increase or apply the concept of conjunctive use to the area that the potential for surface water not all that;
5. Increased the provisions as well as the community's access towards the data and information about the related disaster water and the change in the climate like the flood, the drought, and the landslide,
6. The regulation (the regulation) further from SDA UU in the national level and the area that considered issues of the change in the climate;
7. Appoint or pacify the area or the arrest of water or the protection of the protected region the source of water as well as

8. The socialization and the adaptation campaign of the change in the climate of the sector of water.

The policy recommendations given here can be divided into three main programs, that is: 1) data inventory, information system, research and *capacity building*; 2) regulation and policy; and 3) implementation or action program of adaptation of climate change in water sector.

As a result of the stakeholder consultations with the Ministry of Public Works, Climate Change has already been mainstreamed into the national development planning for the water sector for the next years: (See Appendix 5.1 for details):

5.2 Medium National Development Planning in water resource sector

Following the intense stakeholder consultations, mainstreaming of climate change into the national development planning for the water sector has been achieved. The Ministry of Public Works will create the policies in line with the findings of the Roadmap and give special consideration to the regions with the highest vulnerability in each of the three planning periods, based on the results of this study.

5.2.1 Stage I (2010-2015)

5.2.1.1. Priority Program for Adaptation

With the results of study based on vulnerability, the first state priority programs for adaptation focuses on a particular area with reference to region in Java: BBWS Bengawan Solo and Pemali Juwana; Sumatra: Sumatra I and BWS Mesuji Sekampung; Borneo: BWS II Kalimantan; Sulawesi: BWS Jeneberang and Pompengan; Nusa Tenggara: BWS I Nusa Tenggara; Maluku: BWS Maluku and Papua: BWS Papua. Priorities program are as follows:

1. Vulnerability and risk assessment in regional level (based on Balai Wilayah Sungai – River Basin Agency)
2. Increase of catchment capacity and water infrastructure to water balance safety and reducing water hazard
3. Increasing of water availability at very vulnerable area using good technology and increasing local water resources
4. Increase of water resource conservation anda reducing hazard intensity in water.
5. Revitalisation of local wisdom, increasing capacity and people participation in adaptation of climate change in water resource

5.2.2 Stage II (2015-2020)

5.2.2.1 Priority Program for Adaptation

With the results of study based on vulnerability, the second state priority programs for adaptation focuses on specific areas according to region in Java: BBWS Brantas and Ciliwung-Cisedane; Sumatra: Sumatra BWS II and V; Borneo: BWS III; Kalimantan Sulawesi: BWS II Sulawesi; Nusa Tenggara: BWS Nusa Tenggara II; Maluku: BWS Maluku and Papua: BWS Papua. Priorities program are as follows:

1. Vulnerability and risk assessment in regional level (based on Balai Wilayah Sungai – River Basin Agency)
2. Increase of catchment capacity and water infrastructure to water balance safety and reducing water hazard
3. Increase of water availability at very vulnerable area using good technology and increasing local water resources
4. Increase of water resource conservation and reducing hazard intensity in water.
5. Revitalization of local wisdom, increasing capacity and people participation in adaptation to climate change in water resource

5.2.3 Stage III (2021-2025)

5.2.3.1 Priority Program for Adaptation

1. Vulnerability and risk assessment in regional level (based on Balai Wilayah Sungai – River Basin Agency)
2. Increasing of catchment capacity and water infrastructure to wáter balance safety and reducing water hazard
3. Increasing of water availability at very vulnerable area using good technology and increasing local water resources
4. Increasing of water resource conservation and reducing hazard intensity in water.
5. Revitalization of local wisdom, increasing capacity and people participation in adaptation of climate change in water resource

5.2.4 Stage IV (2026-2030)

5.2.4.1. Priority Program for Adaptation

With the results of this study based on vulnerability, the fourth state priority programs for adaptation focused on specific areas according to the region in Java, namely Java: BBWS

Citarum-Citanduy and Ciujung-Cidanau-Cidurian; Sumatra: BBWS Sumatra , BWS VIII Sumatra and III; Kalimantan: BWS I Kalimantan and Sulawesi: BWS Sulawesi. Priorities program are as follows:

1. Vulnerability and risk assessment in regional level (based on Balai Wilayah Sungai – River Basin Agency)
2. Increase of catchment capacity and water infrastructure to water balance safety and reducing water hazard
3. Increase of water availability at very vulnerable area using good technology and increasing local water resources
4. Increase of water resource conservation anda reducing hazard intensity in water.
5. Revitalization of local wisdom, increasing capacity and people participation in adaptation of climate change in water resource

5.3 Summary

Conditions and problems in the water resource sector include aspects of water use and destructivity. Water use includes water supply, water distribution and water quality. Destructivity of water includes floods, droughts, landslide, and seawater intrusion. The Roadmap is based on a scientific basis (i.e. climate projection and sea level rise modeling) using vulnerability assessment at a macro level. This means a simplification of the risk assessment approach due to availability of data, time, and depth or scope of study.

Water Sector hazard, vulnerability and risk assessment to climate change were analyzed using an overlay of the components of the GIS analysis. Identification of the components of hazard and vulnerability each produces: shortage of water supply, flood, drought, landslide and seawater intrusion. The main finding of this identification based on region which is divided into 7 regions as follows: Sumatera, Jawa-Bali, Kalimantan, Sulawesi, Nusa Tenggara, Maluku and Papua. The current capacity building challenge to be addressed is how to improve the responses and policies in relation to risks and hazards directly caused by climate change in the water sector and other related important implications for the water sector result from climate-related risks and hazards.

A development policy for the water resources sector should aim at an efficient use of water resources to meet demands of households, urban areas and the industry, by consideration of the following points: a) give priority to the demands of households, developed areas, and strategic areas of the hazard of the water deficit; b) control of the utilisation of the ground water to meet demands for standard water and in line with that increased efforts in the provisions of standard water from surface water: c) Increase of development of water capacity as the source of standard water, and the optimisation of the source of standard water available by improved management; d) Increased participation of private enterprises in funding infrastructure development for standard water (*conveyance system)*.

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Appendix 2.3.2.1. Water Supply Shortage Hazard

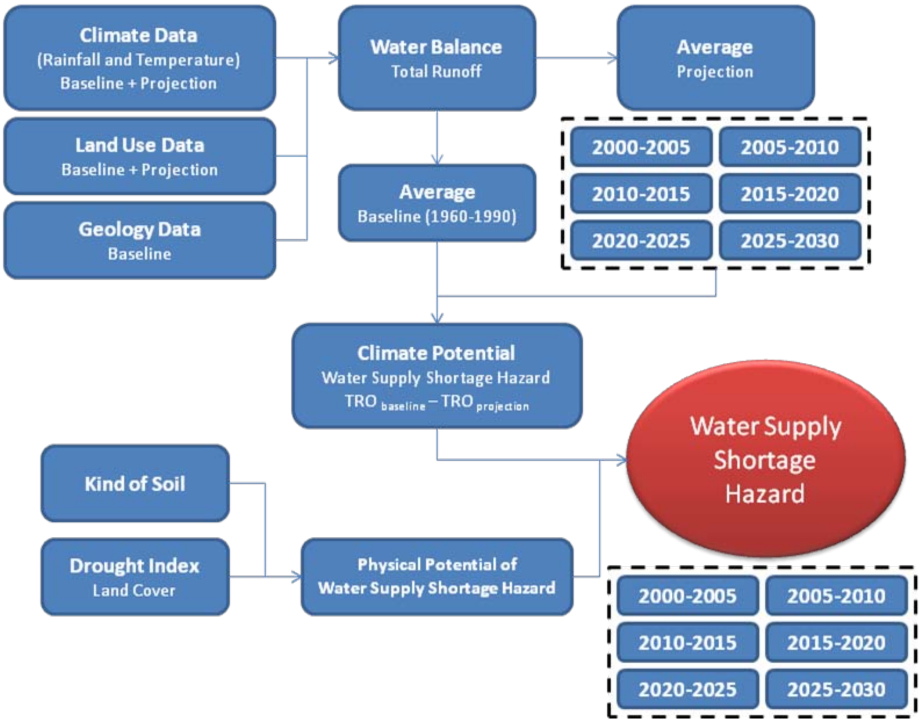
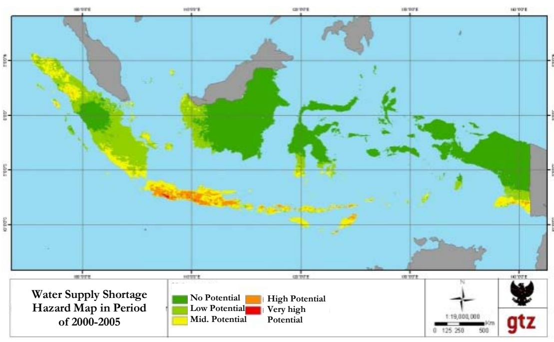
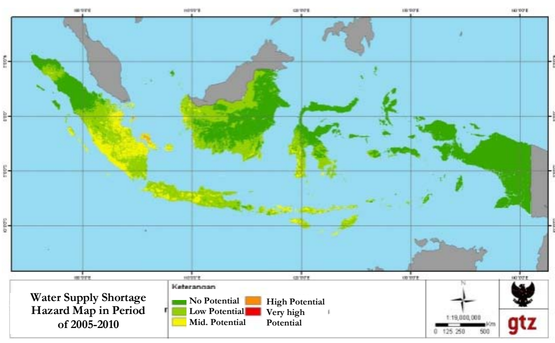
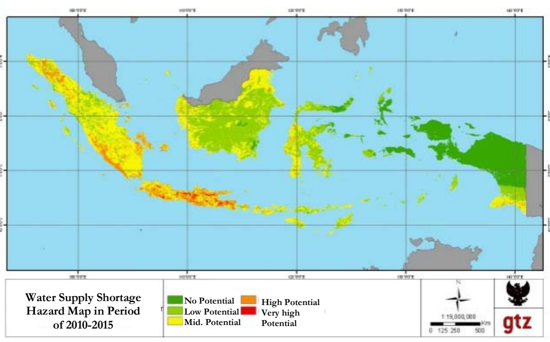
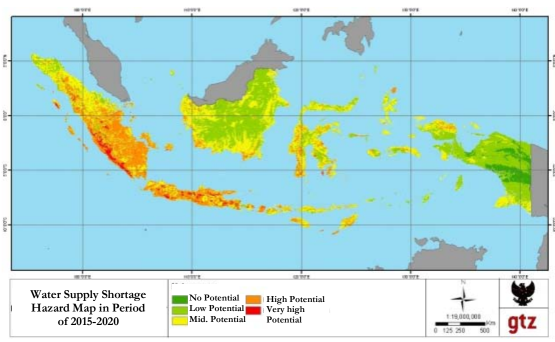


Figure L. 1 Flow Chart of Water Supply Shortage Hazard









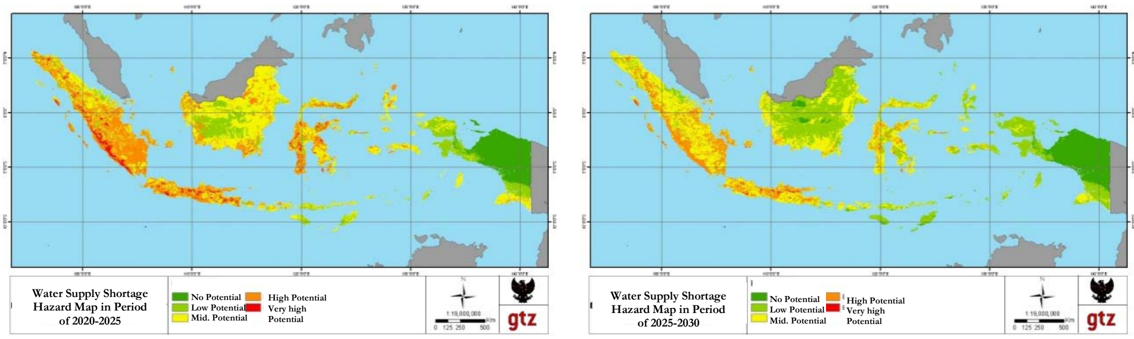


Figure L. 2 Water Supply Shortage Risk Map, SRA2, for: period 2000-2005, 2005-2010-2010-2015, 20150-2020, 2020-2025, and 2025-2030.

Appendix 2.3.2.2. Flood Hazard

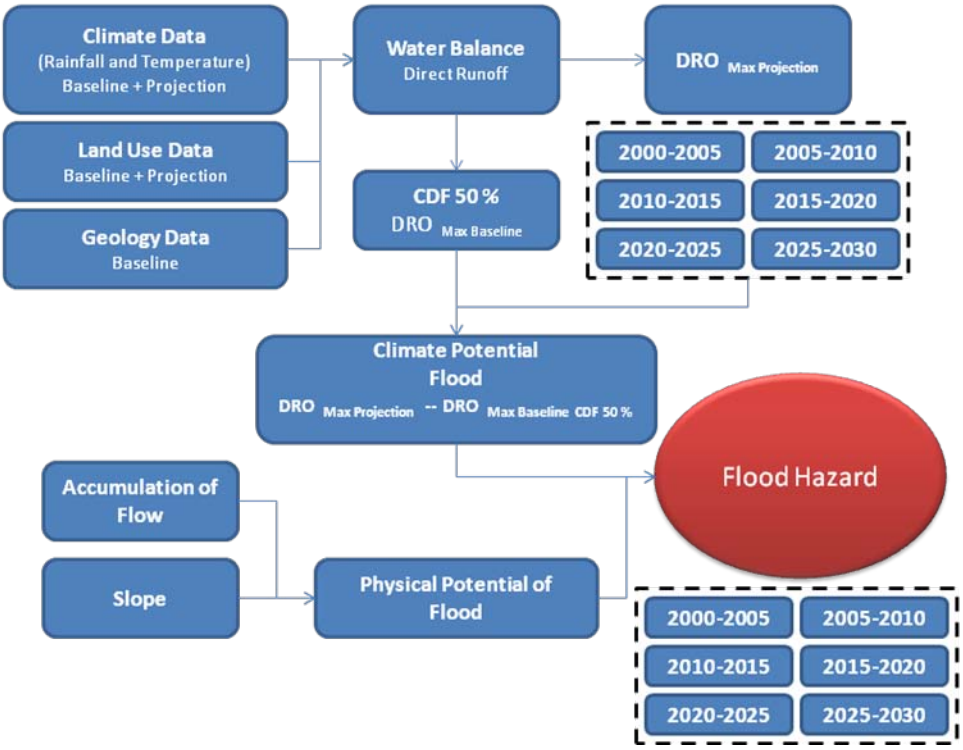


Figure L. 3 Flow Chart of Flood Hazard

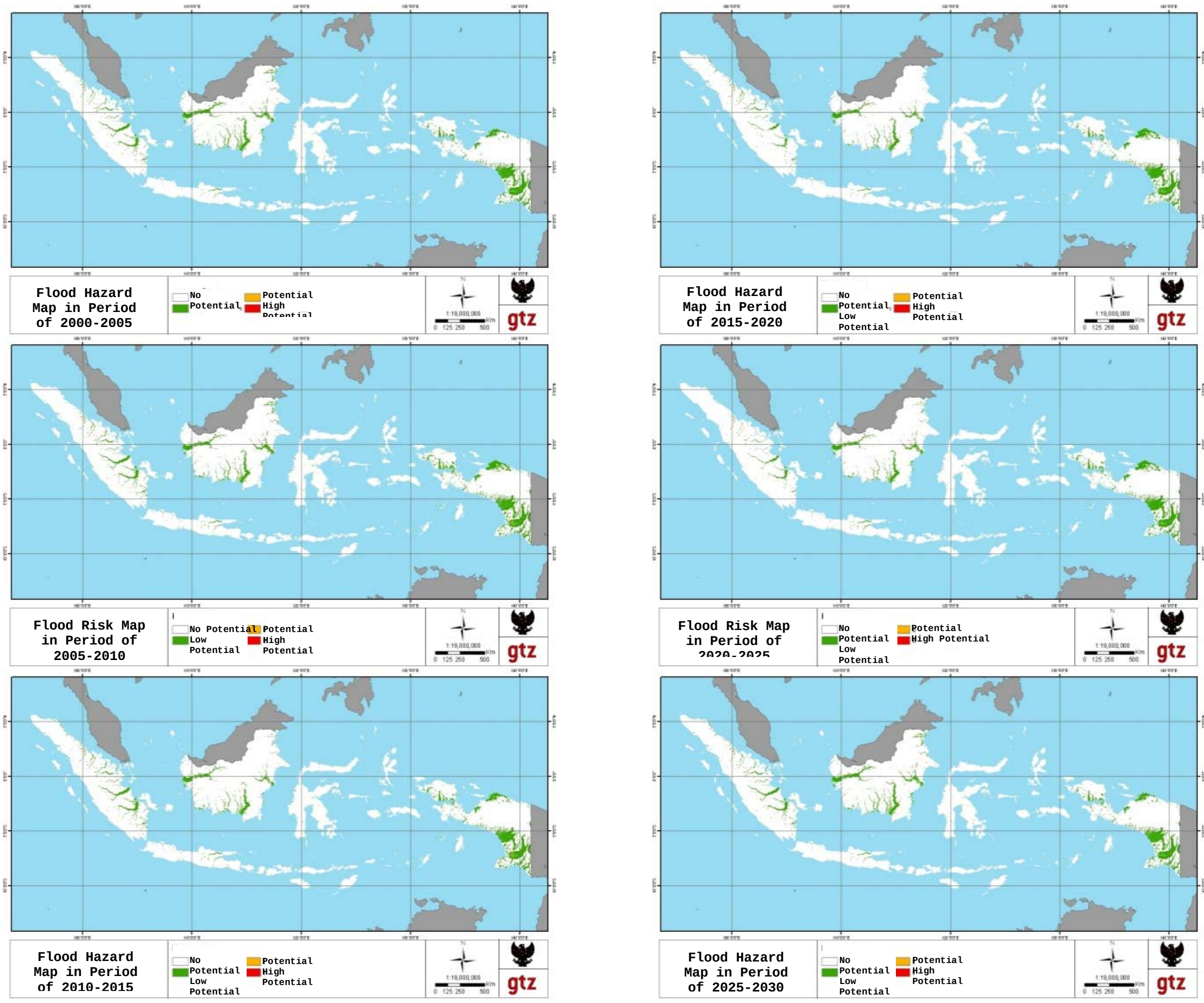


Figure L. 4 Flood Hazard Map, SRA2, for: period 2000-2005, 2005-2010-2010-2015, 2015-2020, 2020-2025, and 2025-2030

Appendix 2.3.2.3. Drought Hazard

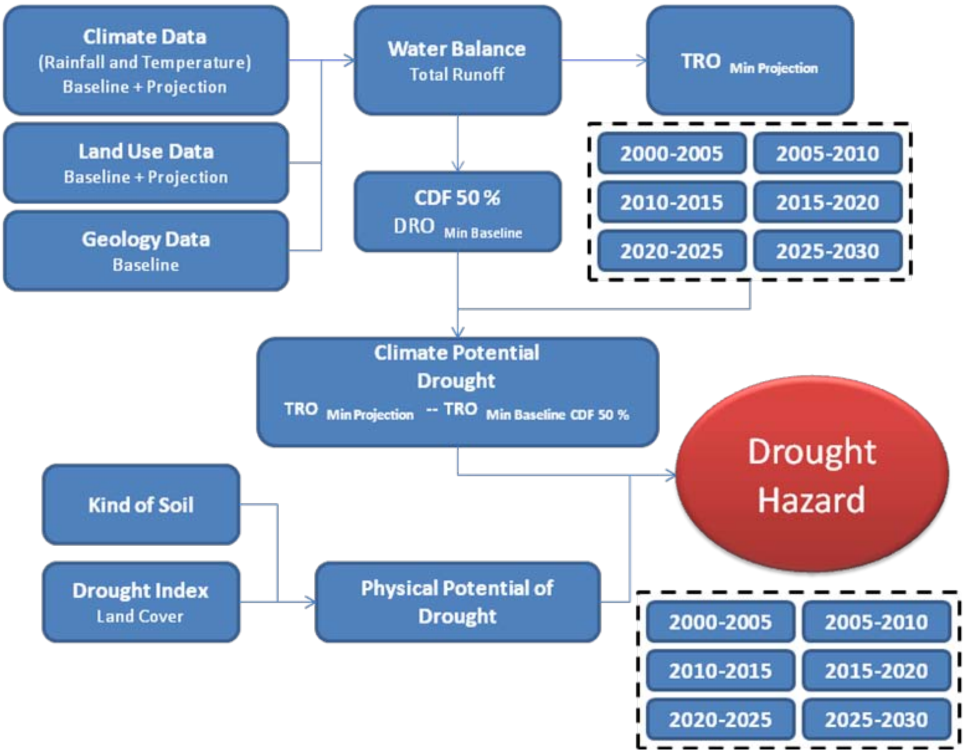
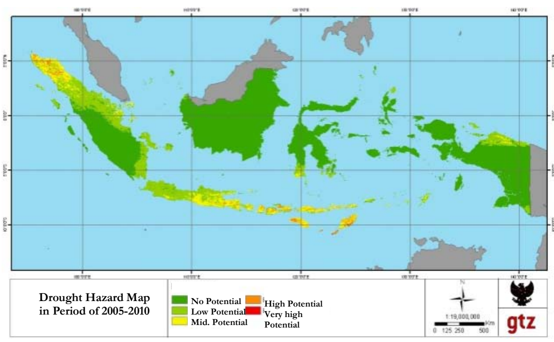
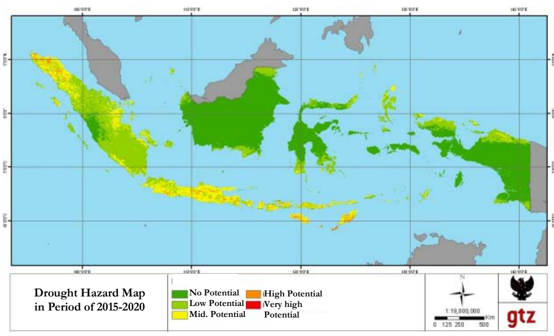


Figure L. 5 Flow Chart of Drought Hazard





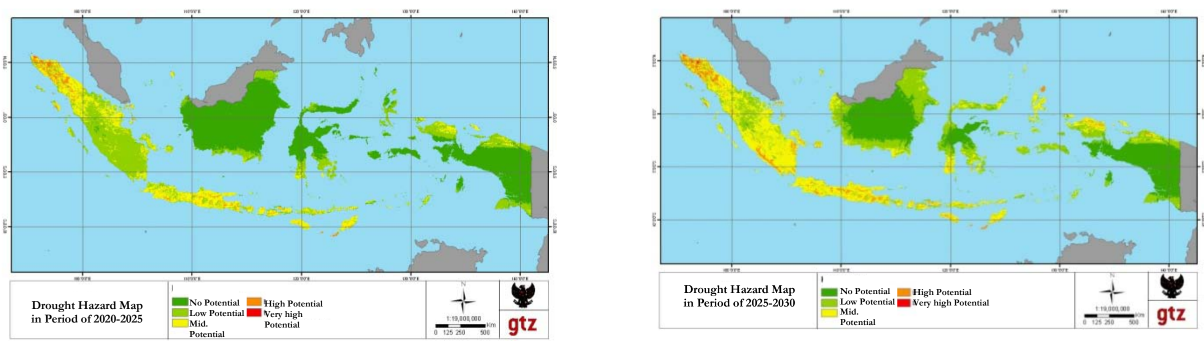


Figure L. 6 Drought Hazard Map, SRA2, for: period 2000-2005, 2005-2010-2010-2015, 20150-2020, 2020-2025, and 2025-2030.

Appendix 2.3.2.4. Landslide Hazard

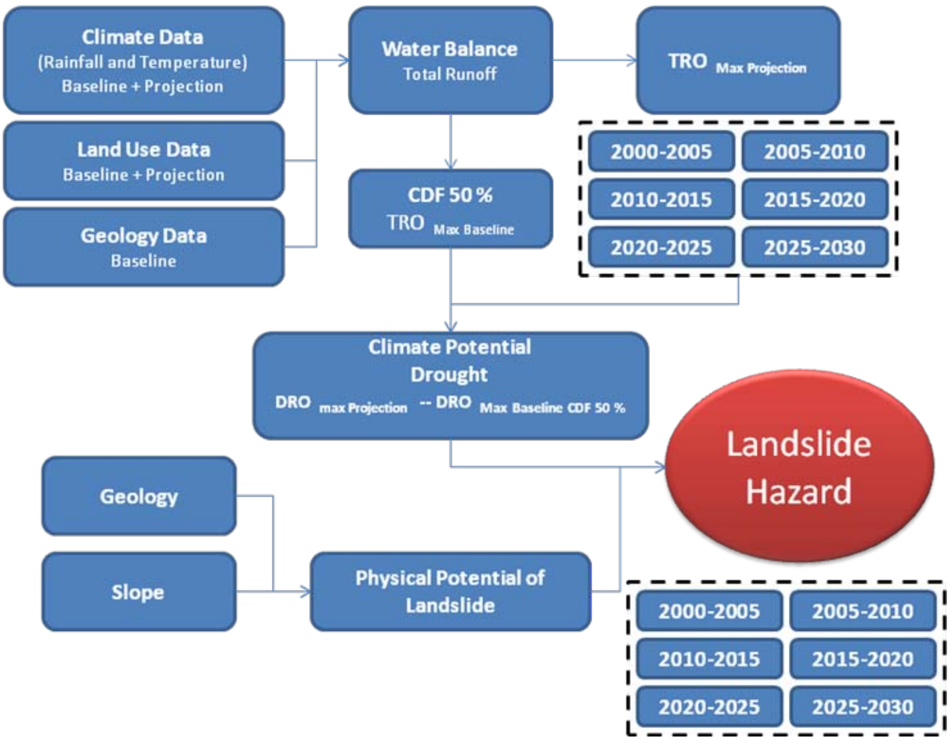


Figure L. 7 Flow Chart of Landslide Hazard

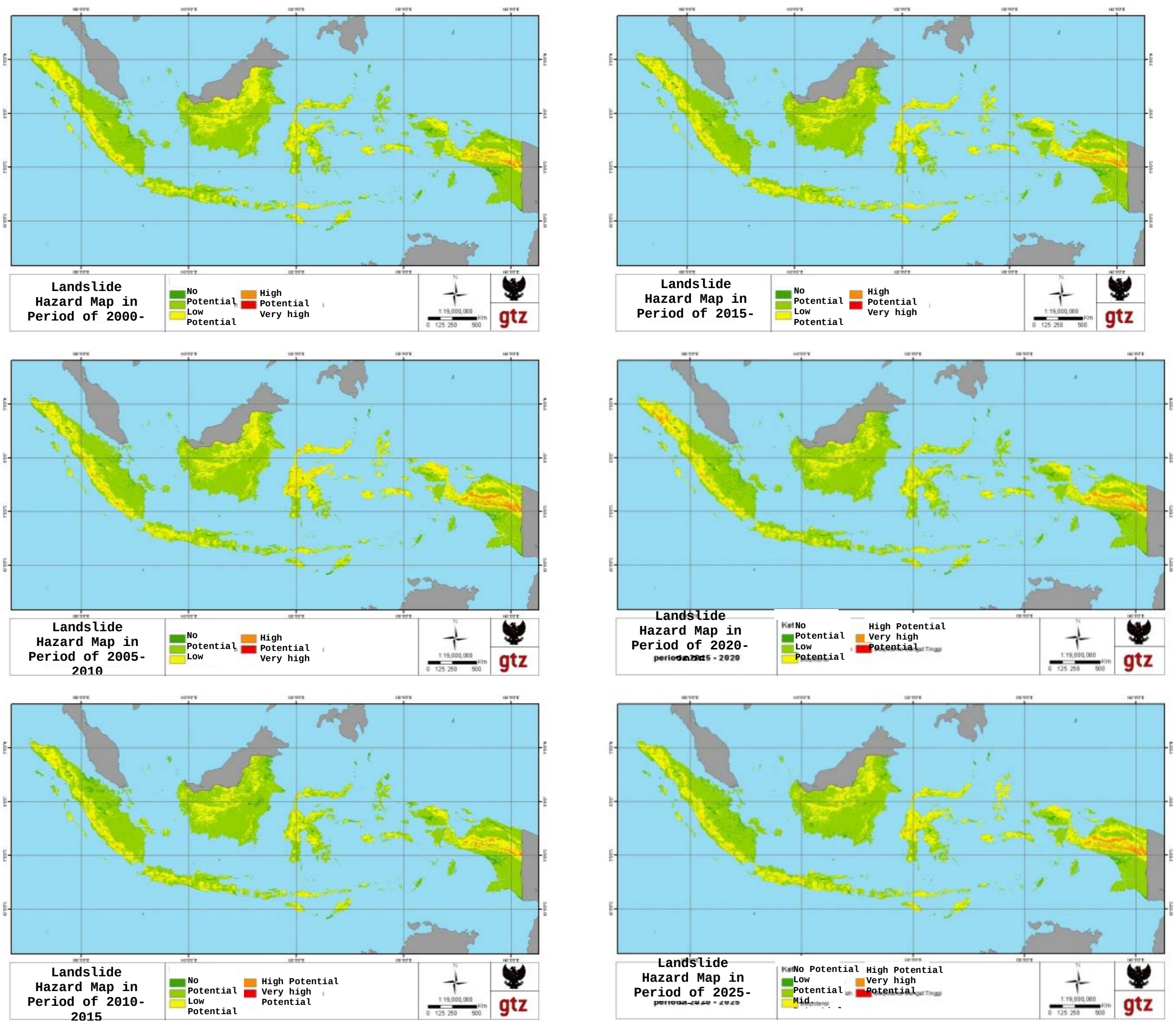


Figure L. 8 Landslide Hazard Map, SRA2, for: period 2000-2005, 2005-2010-2010-2015, 20150-2020, 2020-2025, and 2025-2030.

Appendix 3.2.1.1. Air Factor of Water Quality Vulnerability

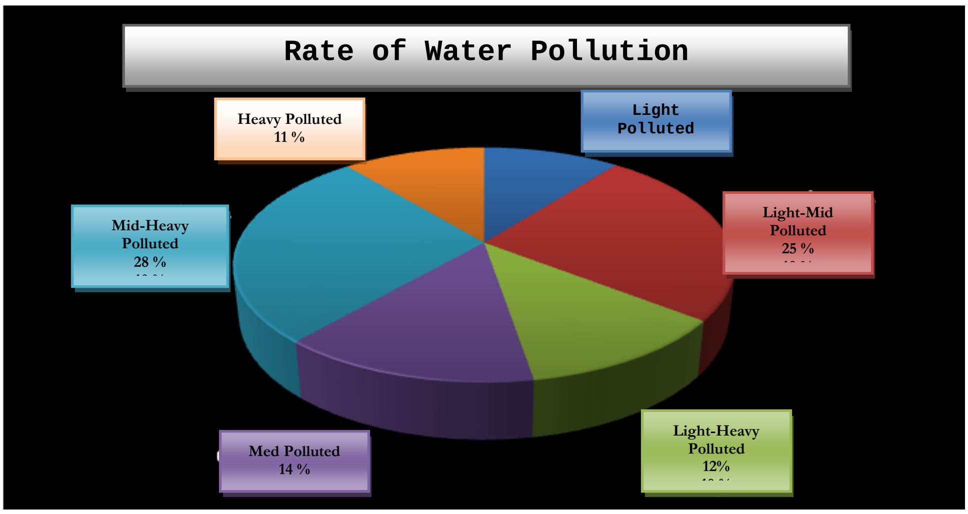


Figure L. 9 Level Of Water Pollution in Indonesia (percent)

Appendix 3.2.2. Vulnerability to Water Supply Shortage Hazard

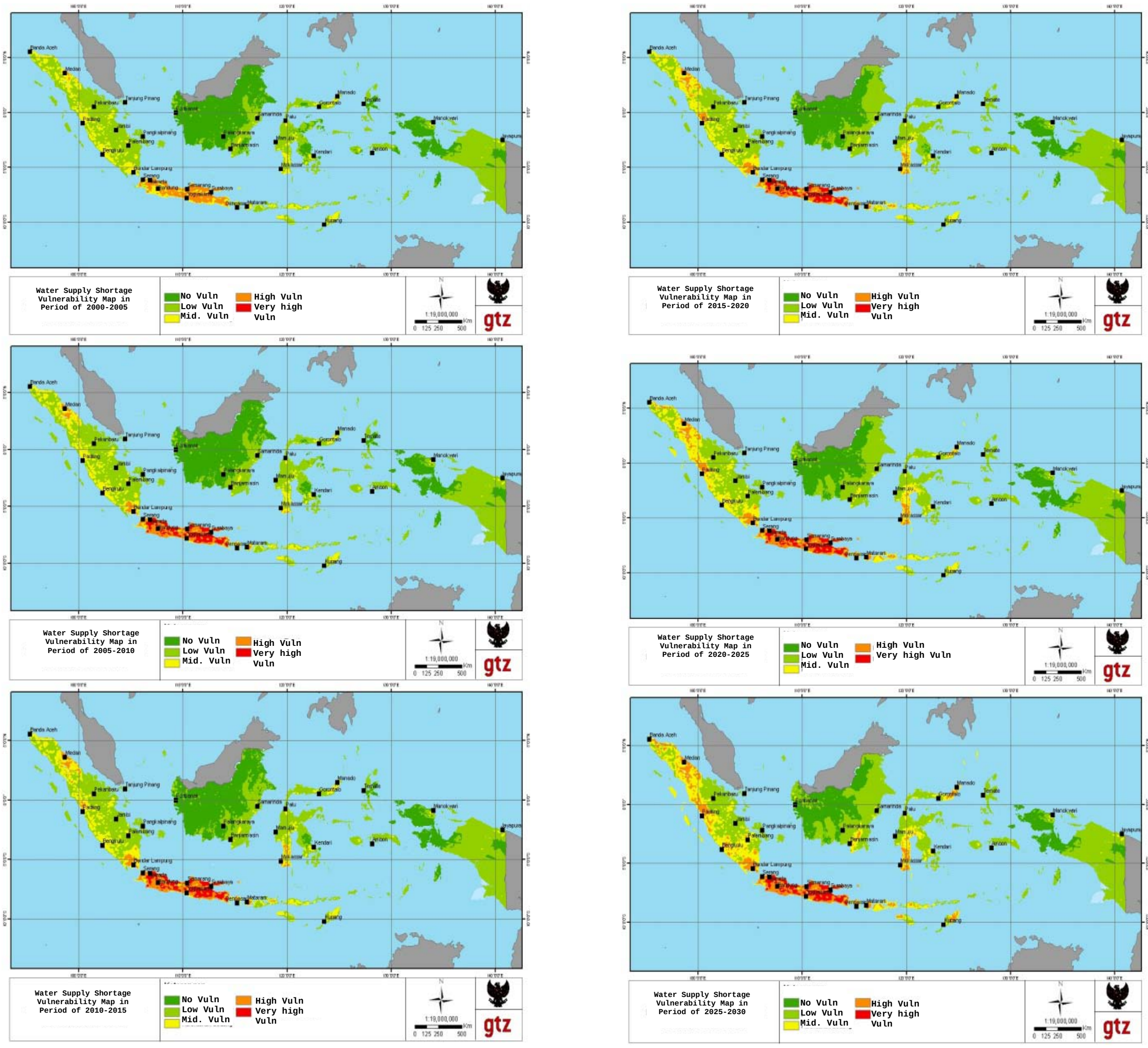


Figure L. 10 Water Supply Shortage Vulnerability Map, SRA2, for: period 2000-2005, 2005-2010-2010-2015, 20150-2020, 2020-2025, and 2025-2030.

Appendix 3.2.3. Vulnerability to Flood Hazard

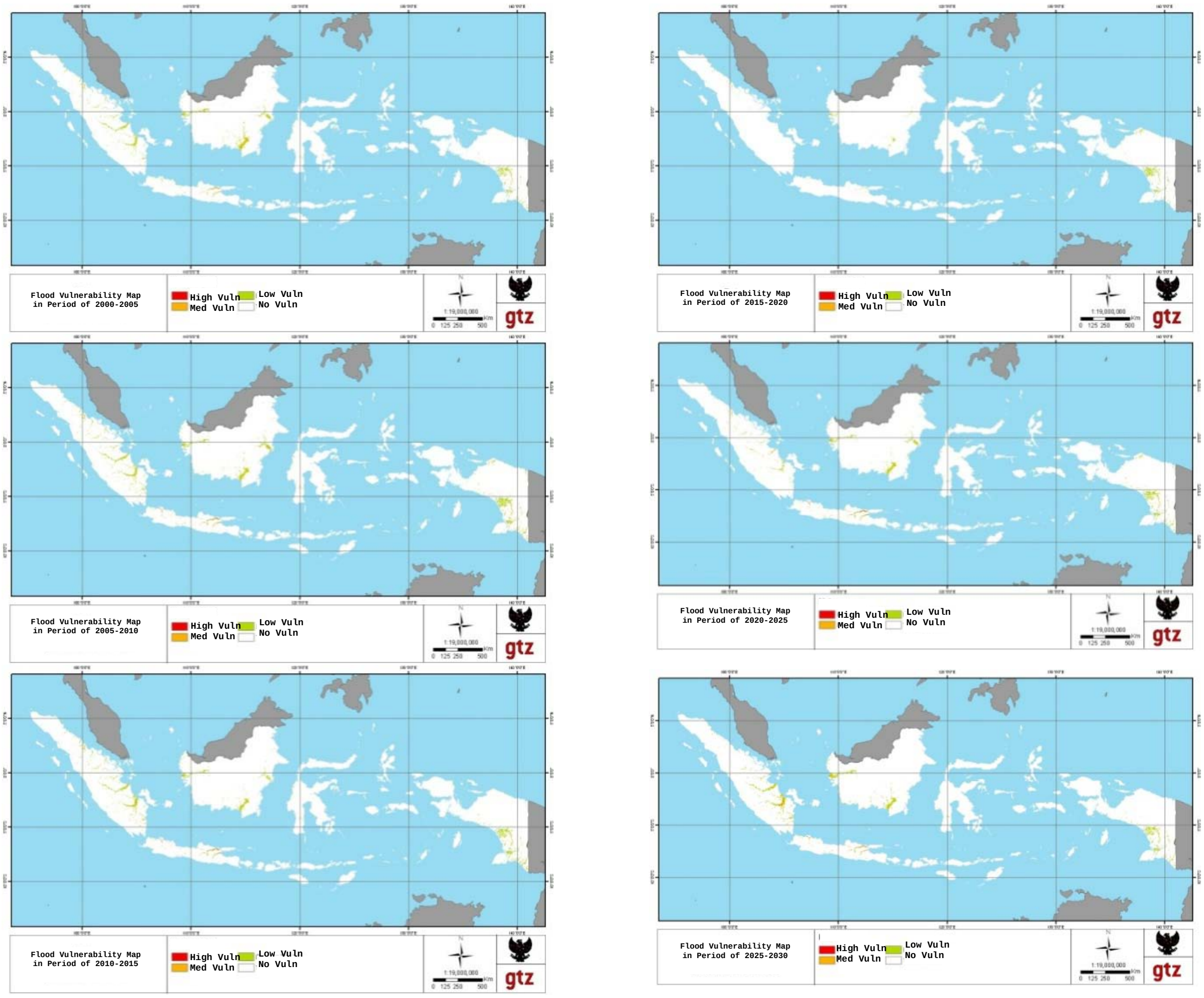


Figure L. 11 Vulnerability Map of Flood Hazard, SRA2, for: period 2000-2005, 2005-2010-2010-2015, 20150-2020, 2020-2025, and 2025-2030

Appendix 3.2.4. Vulnerability to Drought Hazard

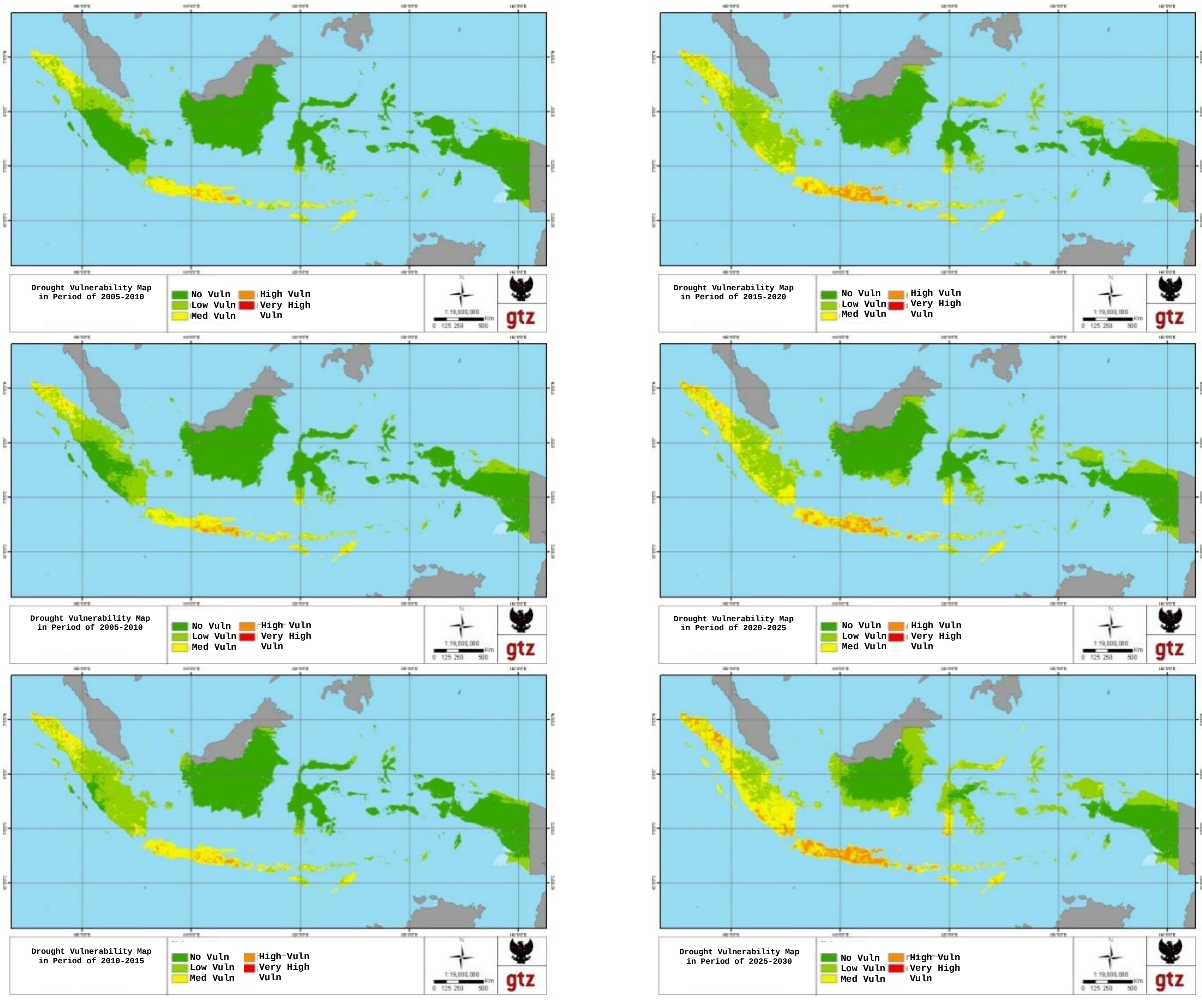


Figure L. 12 Vulnerability Map of Drought Hazard, SRA2, for: period 2000-2005, 2005-2010-2010-2015, 20150-2020, 2020-2025, and 2025-2030.

Appendix 3.2.5. Vulnerability to Landslide Hazard

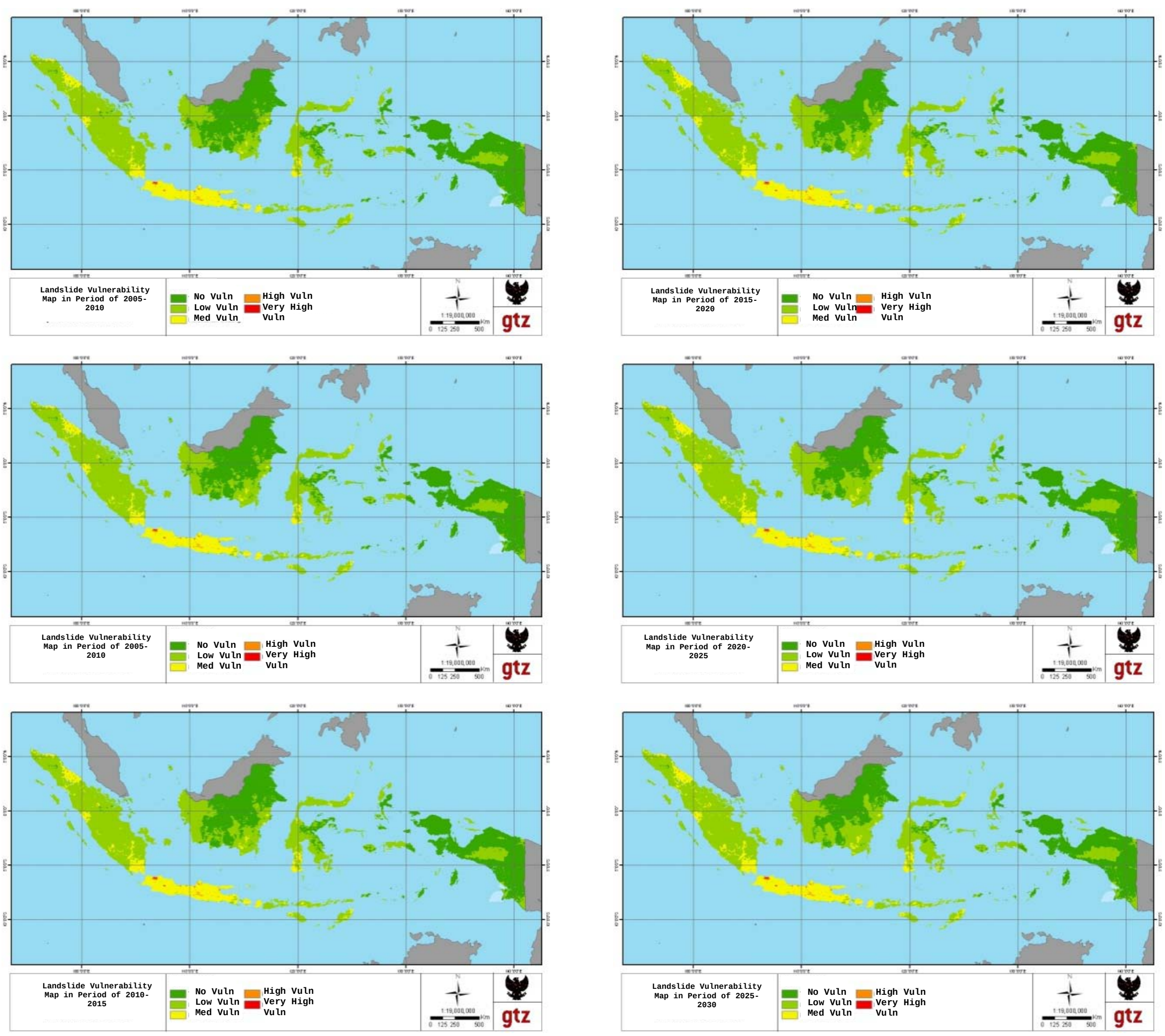


Figure L. 13 Vulnerability Map of Landslide Hazard, SRA2, for: period 2000-2005, 2005-2010-2010-2015, 20150-2020, 2020-2025, and 2025-2030

Appendix 3.4.1. Vulnerability factor of Water Quality and Quantitative Factor of Local Wisdom per Region

Table L. 1 Local Wisdom

Local Study	Activity	Location
Anjir and Handil	Converting swamp area into Agriculture	Banjarmasin (South Kalimantan)
Rimbo larangan	forest, land, and water preservation	Sumatera Barat
Banda larangan		
Lubuk larangan	Determine river basin	Tapanuli Selatan (Sumatera Utara)
Awing-awing	Forest management and preservation	Bali
Repong damar		Lampung
Rimbo penghulu		Jambi
Hutan tutupan		Kalimantan Selatan
Hutan kemenyan		Sumatera Utara
Hutan nagari		Sumatera Barat
Awig-awing	Water resources Protection	Lombok
Eras geniut		

Appendix 3.5.1 Level of Confidence of information

Table L. 2 Five Approaches in Climate Change Assessment (Modified from IPCC, 2007)

Approach					
	Impact	**Vulnerability**	**Adaptation**	**Integrated**	**Risk**
Scientific Objective	Impact and risk under future climate	Processes effecting vulnerability to climate change	Processes effecting adaptation and adaptive capacity	Interaction and feedbacks between multiple driver and impacts	Risk and Policy Response Assessment
Practical alms	Actions to reduce risks	Action to reduce vulnerability	Action to improve adaptation	Global policy options and costs	Mainstreaming into Policy Making
Research methods	Standard approach to CIAV Driver-pressure-	Vulnerability indicators and profiles Past and present climate risk Livelihood analysis		Integrated assessment modeling Cross-sectoral	Risk Assessment Procedures Risk composed

Approach					
	Impact	**Vulnerability**	**Adaptation**	**Integrated**	**Risk**
	state-impact-response (DPSIR) methods Hazard-driven risk assessment	Agent-based methods Narrative methods Risk perception including critical threshold Development/sustainability policy performance Relationship of adaptive capacity to sustainable development		interactions Integration of climate with other drivers Stakeholder discussions linking models across types and scales Combining assessment approaches/methods	of Hazards and Vulnerability
Motivation	Research Driven	Research Driven		Research Driven	Policy Driven

Sumber: Suroso, D.S (2008)

Table L. 3 Different Level of Vulnerability Analysis

Level/Scale	Data and Analysis	Area of Study	Level of Planning	Accuracy	Cost study per Area
Macro	Qualitative	National	Adaptation Policy	Low	Low
Messo	Combination between qualitative and quantitative	Regional (Province to district/city)	Adaptation Strategy	Medium	Medium
Macro	Quantitative	Local	Adaptation measurement	High	High

Source: modified from Messner (2005) in Suroso, D.S. (2008)

Appendix 4.1. Climate Hazard and Water Sector Vulnerability

Appendix 4.1.1. GIS Risk Analysis of Water Supply Shortage

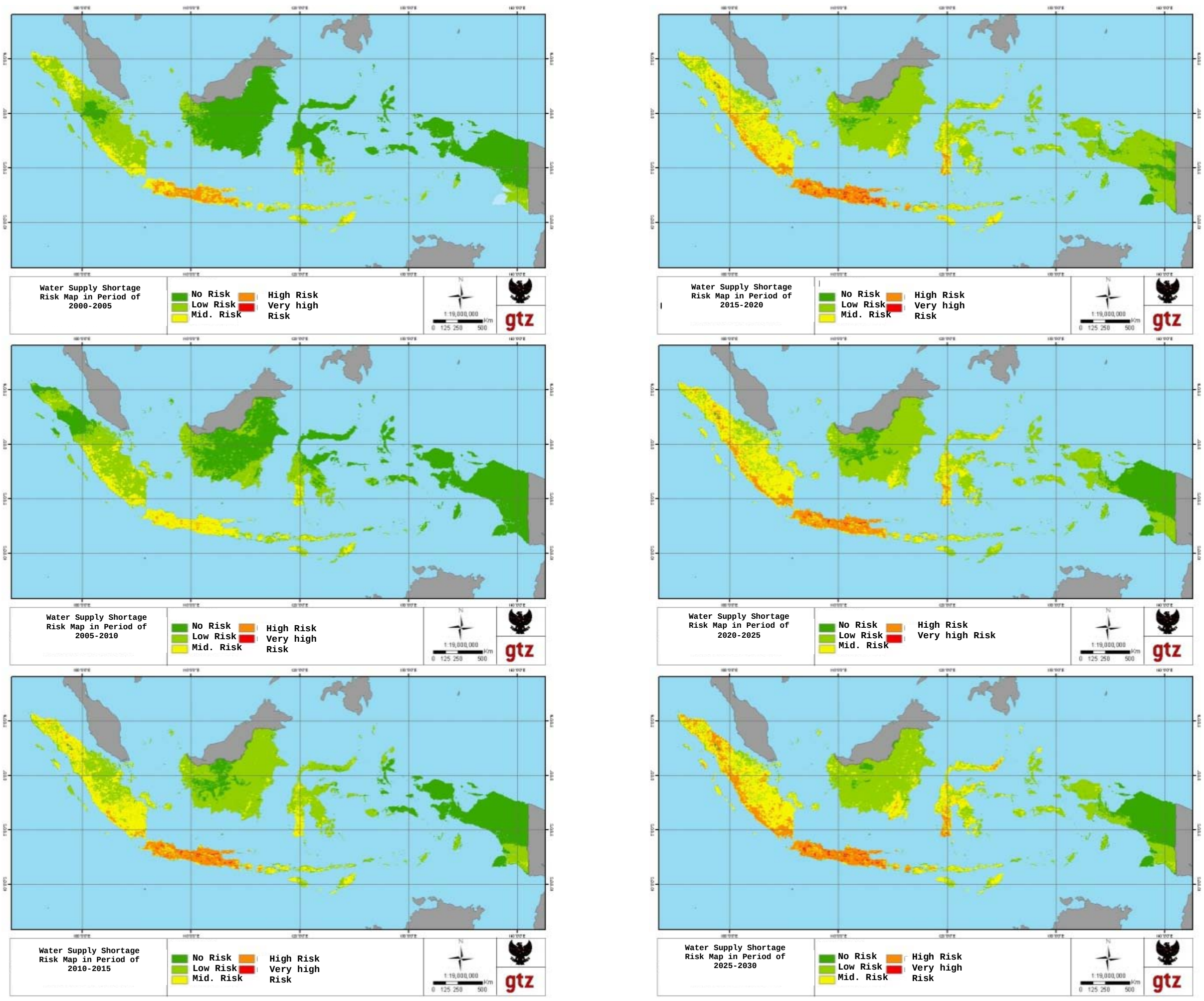


Figure L. 14 Water Supply Shortage Risk, SRA2, for: period 2000-2005, 2005-2010-2010-2015, 20150-2020, 2020-2025, and 2025-2030.

Table L. 4 Water Supply Shortage Risk per Region

Islands	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Bali	No risk		289,68	289,68	289,68	289,68	289,68
	Low Risk	1518,00	3316,01	651,74	318,45	965,09	646,76
	Medium Risk	3823,83	2146,53	3039,66	2825,97	3949,97	2906,48
	High Risk	120,71		1771,13	2318,12	547,48	1909,29
	Very High Risk						
Java	No risk		2943,22	2943,22	2943,22	2943,22	2943,22
	Low Risk	1311,85	7292,86	53,19	14,17	228,30	22,27

Islands	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
	Medium Risk	59672,12	116902,30	24214,03	16015,12	29551,69	16199,00
	High Risk	70406,24	7342,79	101393,41	104431,70	98212,14	105748,72
	Very High Risk	147,74		5877,32	11076,96	3545,83	9567,96
Kalimantan	No risk	479365,00	369391,93	90069,37	54081,95	82341,85	24033,38
	Low Risk	46674,14	167196,28	438566,82	458000,53	430481,24	452744,90
	Medium Risk	531,82	1848,09	9800,10	26168,81	25489,86	59422,14
	High Risk				185,00	123,35	2235,87
	Very High Risk						
Maluku	No risk	58299,74	65119,78	43129,06	8753,55	8835,35	8742,08
	Low Risk	11619,40	13652,93	35546,19	64505,89	64658,41	58396,25
	Medium Risk	113,90	1,23	98,70	5462,71	5229,63	11571,50
	High Risk				51,79	50,56	64,12
	Very High Risk						
Nusa Tenggara	No risk	23709,33	4944,20	4930,35	4930,35	4949,57	4930,35
	Low Risk	37853,54	35837,97	25797,10	9751,98	31569,99	16683,06
	Medium Risk	974,17	26685,22	34698,08	45591,81	29345,88	40780,68
	High Risk			2041,85	7193,25	1601,96	5073,30
	Very High Risk						
Papua	No risk	342416,52	411535,16	363171,74	84350,68	269801,89	256870,64
	Low Risk	38959,09		46236,51	324406,06	140990,99	150910,24
	Medium Risk	1500,78		2126,91	2778,42	742,29	3754,28
	High Risk						
	Very High Risk						
Sulawesi	No risk	139306,68	93638,05	11278,72	6308,77	6305,91	6305,91
	Low Risk	33779,23	79260,99	135983,90	98531,57	87319,60	51600,80
	Medium Risk	7533,82	14026,60	39076,27	71593,22	83812,13	106201,20
	High Risk			586,74	10492,08	9488,00	22617,65
	Very High Risk						200,07
Sumatera	No risk	44567,24	96623,41	10173,70	10166,22	10129,83	10129,83
	Low Risk	332211,21	293856,34	173913,74	89035,92	85640,88	48553,08
	Medium Risk	89199,00	85719,92	277746,97	315801,64	322755,66	303240,63
	High Risk	93,64	1,23	14366,50	61178,63	57653,57	113844,12
	Very High Risk				18,50	20,97	433,26

Appendix 4.1.2. GIS Risk Analysis for Flood

Table L. 5 Flood Risk per Region

Islands	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Bali	No risk	5752,22	5752,22	5752,22	5752,22	5752,22	5752,22
	Low Risk						
	Medium Risk						
	High Risk						
	Very High Risk						
Java	No risk	130811,89	129982,14	129993,32	133772,42	129944,30	130489,59
	Low Risk	2046,15	2075,87	2039,68	681,46	2050,85	2074,62
	Medium Risk	1265,78	1543,50	1418,31	27,29	1452,29	1448,03
	High Risk	357,34	839,98	890,91		910,89	468,94
	Very High Risk		39,68	138,95		122,84	
Kalimantan	No risk	522841,76	523834,85	527170,76	535462,94	525723,16	525731,57
	Low Risk	12790,84	12527,62	10291,18	2782,38	11119,00	11011,85
	Medium Risk	2660,79	1981,48	942,34	187,27	1532,57	1620,23
	High Risk	142,90	84,96	32,02	3,69	60,33	68,95
	Very High Risk		7,39			1,23	3,69
Maluku	No risk	78729,82	78689,27	78702,23	78770,24	78703,67	78760,08
	Low Risk	39,19	69,89	64,32	3,70	62,88	13,86
	Medium Risk	4,93	12,33	7,39		7,39	
	High Risk		2,47				
	Very High Risk						
Nusa Tenggara	No risk	64597,70	64643,22	64580,39	64663,78	64582,83	64613,48
	Low Risk	62,35	20,56	77,17		78,45	50,30
	Medium Risk	3,73		6,22		2,50	
	High Risk						
	Very High Risk						
Papua	No risk	402512,33	396435,02	398651,58	401245,97	398907,72	400954,79
	Low Risk	8790,39	14196,55	11901,58	9667,27	12081,83	10218,32
	Medium Risk	275,80	943,47	1023,12	656,50	586,71	404,94
	High Risk		3,47	2,24	8,78	2,25	0,47
	Very High Risk						
Sulawesi	No risk	186011,07	185602,86	185959,39	186917,00	185963,76	186512,37
	Low Risk	781,56	1050,31	816,03	8,64	810,23	360,21
	Medium Risk	129,31	247,81	141,58		143,02	53,05

Islands	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
	High Risk	3,70	24,66	8,63		8,63	
	Very High Risk						
Sumatera	No risk	462496,25	460591,77	459741,60	475123,52	469947,19	460740,56
	Low Risk	12215,55	13812,97	14117,09	853,48	6008,88	11842,59
	Medium Risk	1437,63	1747,18	2219,28	191,03	248,81	3345,65
	High Risk	55,46	52,97	126,92	30,68		272,39
	Very High Risk				6,17		3,70

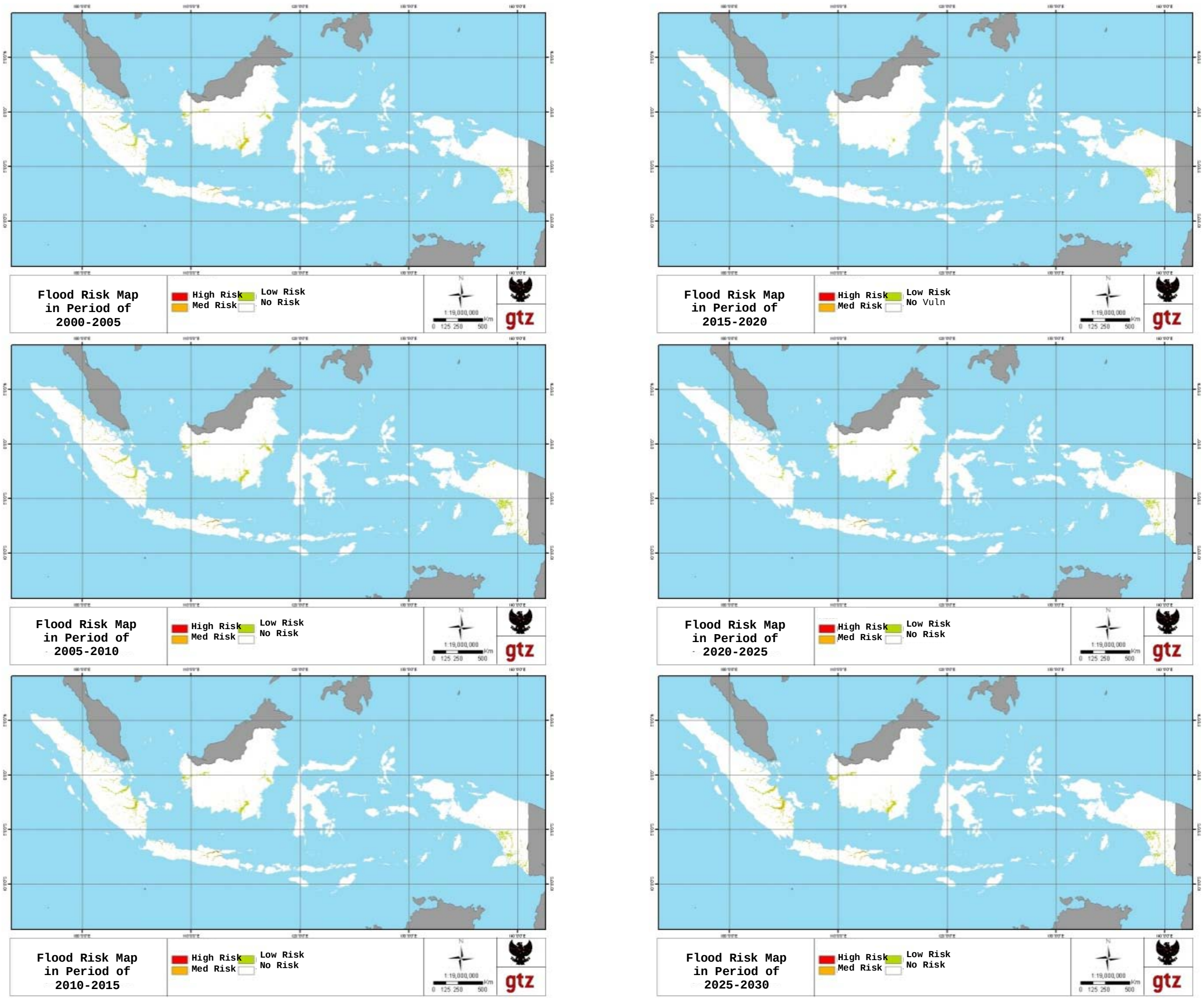


Figure L. 15 Flood Risk, SRA2, for: period 2000-2005, 2005-2010-2010-2015, 20150-2020, 2020-2025, and 2025-2030.

Appendix 4.1.3. GIS Risk Analysis for Drought

Table L. 6 Drought Risk per Region

Islands	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Bali	No risk						
	Low Risk	1981,19	1171,16	1261,62	951,54	1039,15	950,75
	Medium Risk	3421,61	3939,21	3949,54	3891,32	4031,41	3778,10
	High Risk	59,74	352,17	251,38	619,68	391,97	733,69
	Very High Risk						
Java	No risk	2,12					
	Low Risk	14782,55	13987,63	4065,83	1271,44	1293,15	738,59
	Medium Risk	107196,95	96685,70	110874,36	74486,36	79751,81	55504,49
	High Risk	9556,34	20864,63	16597,77	55780,15	50493,00	75253,92
	Very High Risk						40,95
Kalimantan	No risk	525261,40	525315,50	507833,06	475786,87	465090,57	293398,91
	Low Risk	1309,56	1255,45	18721,89	50309,09	60539,37	220852,89
	Medium Risk			16,00	474,99	941,02	12261,16
	High Risk						57,99
	Very High Risk						
Maluku	No risk	62299,24	58339,41	56445,12	36321,71	38390,32	3940,71
	Low Risk	7733,79	11682,44	13587,91	33491,16	31642,71	63542,17
	Medium Risk		11,18		220,16		2550,16
	High Risk						
	Very High Risk						
Nusa Tenggara	No risk						
	Low Risk	22253,44	13890,06	23379,49	12101,30	14714,88	8797,41
	Medium Risk	39622,54	45777,55	38322,84	45833,70	43583,34	46803,90
	High Risk	661,07	2869,43	834,72	4602,04	4238,82	6935,74
	Very High Risk						
Papua	No risk	362824,99	334316,26	343584,63	308910,97	273745,18	253435,18
	Low Risk	20051,40	48436,01	39202,22	73674,48	107458,30	126889,83
	Medium Risk		124,11	89,54	290,94	1672,90	2551,37
	High Risk						
	Very High Risk						
Sulawesi	No risk	170498,51	150533,65	161046,29	111247,02	112807,61	30608,72
	Low Risk	9517,68	24855,61	18469,87	59384,33	53015,72	107918,70
	Medium Risk	603,54	5230,47	1103,57	9969,90	14589,93	38207,03

Islands	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
	High Risk				18,47	206,47	3885,28
	Very High Risk						
Sumatera	No risk	232365,38	138099,92	32435,77	4722,89	148,66	4,43
	Low Risk	179118,64	261842,35	337985,98	325538,79	261425,70	141670,50
	Medium Risk	53959,49	63625,67	91633,36	131905,31	191241,53	285378,46
	High Risk	627,57	2503,14	4015,97	3904,09	13252,73	38996,73
	Very High Risk					2,47	20,97

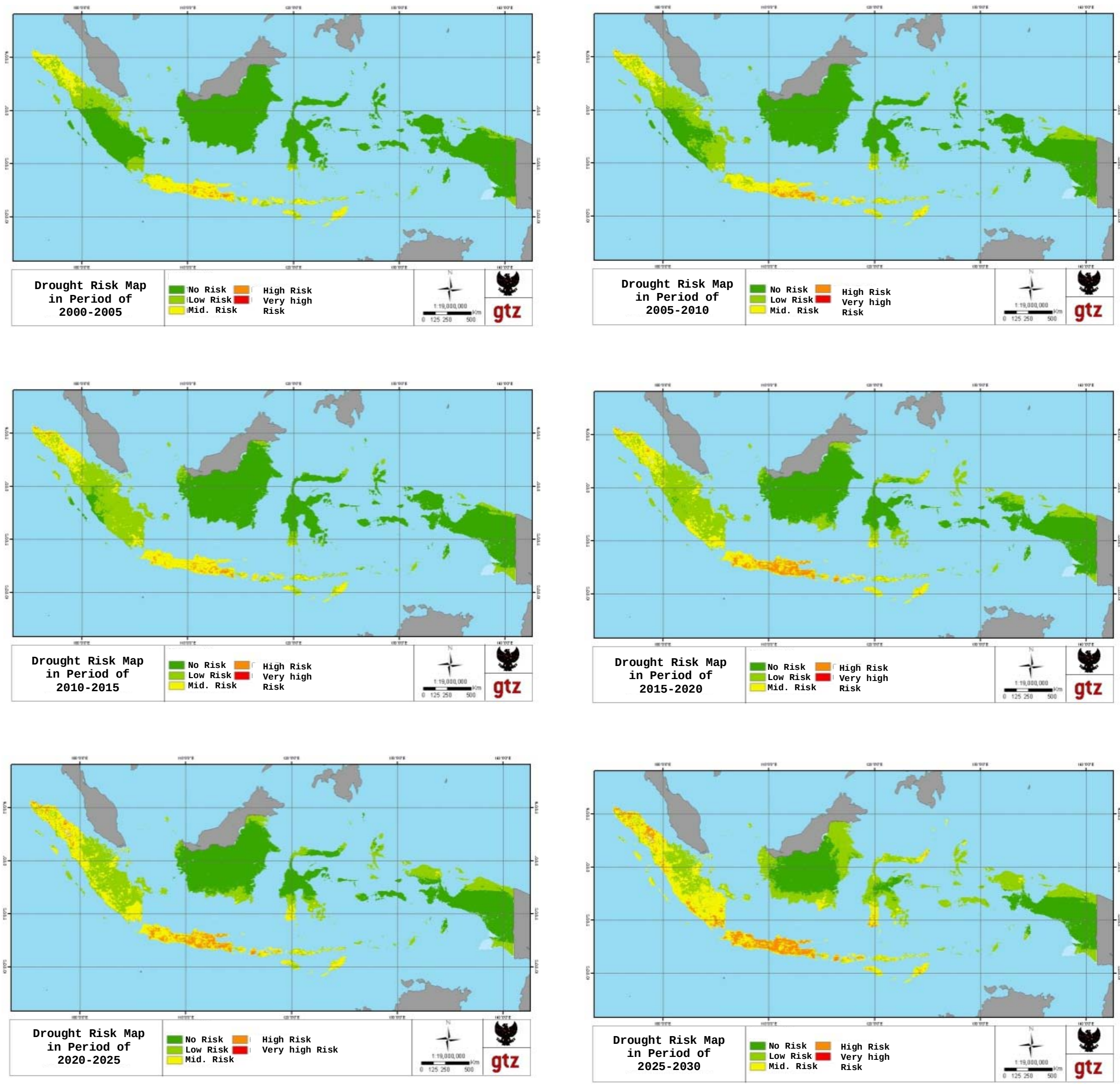


Figure L. 16 Drought Risk, SRA2, for: period 2000-2005, 2005-2010-2010-2015, 20150-2020, 2020-2025, and 2025-2030.

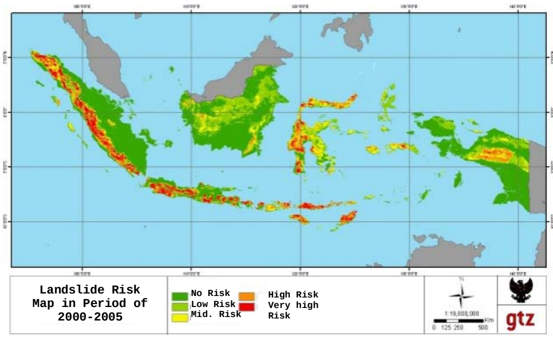
Appendix 4.1.4. GIS Risk Analysis for Landslide

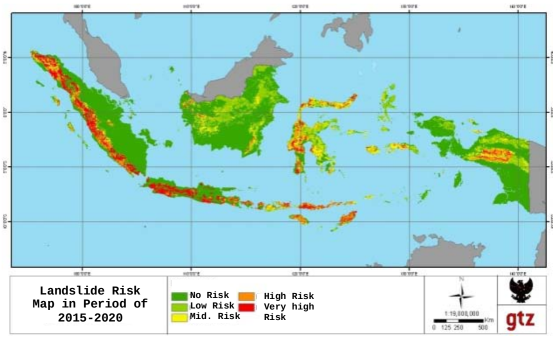
Table L. 7 Landslide Risk per Region

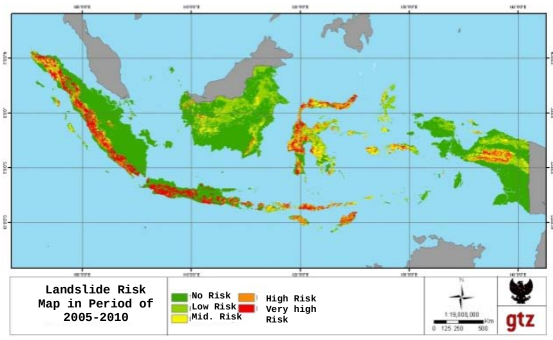
Islands	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Bali	No risk						
	Low Risk	1981,19	1171,16	1261,62	951,54	1039,15	950,75
	Medium Risk	3421,61	3939,21	3949,54	3891,32	4031,41	3778,10
	High Risk	59,74	352,17	251,38	619,68	391,97	733,69
	Very High Risk						
Java	No risk	2,12					
	Low Risk	14782,55	13987,63	4065,83	1271,44	1293,15	738,59
	Medium Risk	107196,95	96685,70	110874,36	74486,36	79751,81	55504,49
	High Risk	9556,34	20864,63	16597,77	55780,15	50493,00	75253,92
	Very High Risk						40,95
Kalimantan	No risk	525261,40	525315,50	507833,06	475786,87	465090,57	293398,91
	Low Risk	1309,56	1255,45	18721,89	50309,09	60539,37	220852,89
	Medium Risk			16,00	474,99	941,02	12261,16
	High Risk						57,99
	Very High Risk						
Maluku	No risk	62299,24	58339,41	56445,12	36321,71	38390,32	3940,71
	Low Risk	7733,79	11682,44	13587,91	33491,16	31642,71	63542,17
	Medium Risk		11,18		220,16		2550,16
	High Risk						
	Very High Risk						
Nusa Tenggara	No risk						
	Low Risk	22253,44	13890,06	23379,49	12101,30	14714,88	8797,41
	Medium Risk	39622,54	45777,55	38322,84	45833,70	43583,34	46803,90
	High Risk	661,07	2869,43	834,72	4602,04	4238,82	6935,74
	Very High Risk						
Papua	No risk	362824,99	334316,26	343584,63	308910,97	273745,18	253435,18
	Low Risk	20051,40	48436,01	39202,22	73674,48	107458,30	126889,83
	Medium Risk		124,11	89,54	290,94	1672,90	2551,37
	High Risk						
	Very High Risk						

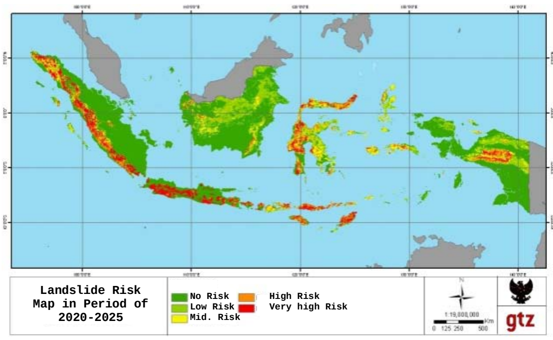
Islands	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Sulawesi	No risk	170498,51	150533,65	161046,29	4722,89	112807,61	30608,72
	Low Risk	9517,68	24855,61	18469,87	325538,79	53015,72	107918,70
	Medium Risk	603,54	5230,47	1103,57	131905,31	14589,93	38207,03
	High Risk				3904,09	206,47	3885,28
	Very High Risk						
Sumatera	No risk	232365,38	138099,92	32435,77	4722,89	148,66	4,43
	Low Risk	179118,64	261842,35	337985,98	325538,79	261425,70	141670,50
	Medium Risk	53959,49	63625,67	91633,36	131905,31	191241,53	285378,46
	High Risk	627,57	2503,14	4015,97	3904,09	13252,73	38996,73
	Very High Risk					2,47	20,97

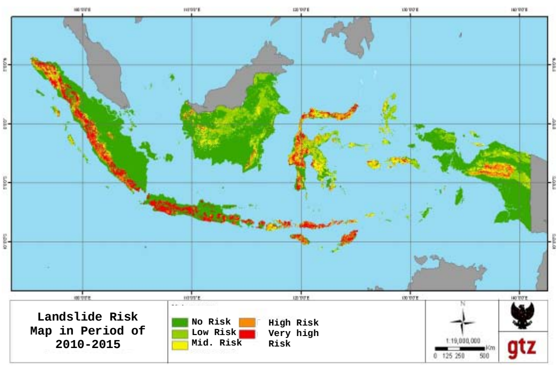
Appendix 4.1.5. Landslide Risk











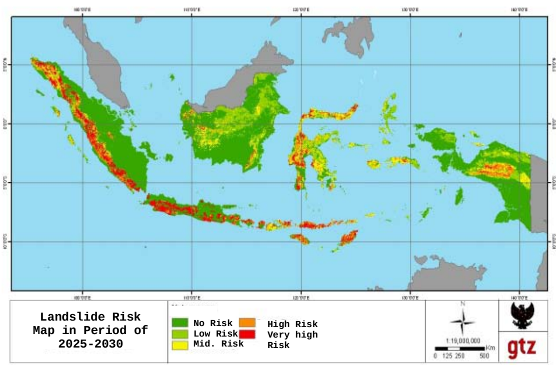


Figure L. 17 Landslide Risk, SRA2, for: period 2000-2005, 2005-2010-2010-2015, 20150-2020, 2020-2025, and 2025-2030.

Appendix 4.2. Climate Change Risk per Region

Table L. 8 Risk level in Sumatera

	Risk level	**Area (Km2)**					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Water Supply Shortage	No risk	44567,24	96623,41	10173,70	10166,22	10129,83	10129,83
	Low Risk	332211,21	293856,34	173913,74	89035,92	85640,88	48553,08
	Medium Risk	89199,00	85719,92	277746,97	315801,64	322755,66	303240,63
	High Risk	93,64	1,23	14366,50	61178,63	57653,57	113844,12
	Very High Risk				18,50	20,97	433,26
Flood Risk	No risk	462496,25	460591,77	459741,60	475123,52	469947,19	460740,56
	Low Risk	12215,55	13812,97	14117,09	853,48	6008,88	11842,59
	Medium Risk	1437,63	1747,18	2219,28	191,03	248,81	3345,65
	High Risk	55,46	52,97	126,92	30,68		272,39
	Very High Risk				6,17		3,70
Drought	No risk	232365,38	138099,92	32435,77	4722,89	148,66	4,43
	Low Risk	179118,64	261842,35	337985,98	325538,79	261425,70	141670,50
	Medium Risk	53959,49	63625,67	91633,36	131905,31	191241,53	285378,46
	High Risk	627,57	2503,14	4015,97	3904,09	13252,73	38996,73
	Very High Risk					2,47	20,97
Landslide	No risk	232365,38	138099,92	32435,77	4722,89	148,66	4,43
	Low Risk	179118,64	261842,35	337985,98	325538,79	261425,70	141670,50
	Medium Risk	53959,49	63625,67	91633,36	131905,31	191241,53	285378,46
	High Risk	627,57	2503,14	4015,97	3904,09	13252,73	38996,73
	Very High Risk					2,47	20,97

Table L. 9 Risk level in Java

	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Water Supply Shortage	No risk		2943,22	2943,22	2943,22	2943,22	2943,22
	Low Risk	1311,85	7292,86	53,19	14,17	228,30	22,27
	Medium Risk	59672,12	116902,30	24214,03	16015,12	29551,69	16199,00
	High Risk	70406,24	7342,79	101393,41	104431,70	98212,14	105748,72
	Very High Risk	147,74		5877,32	11076,96	3545,83	9567,96
Flood Risk	No risk	130811,89	129982,14	129993,32	133772,42	129944,30	130489,59
	Low Risk	2046,15	2075,87	2039,68	681,46	2050,85	2074,62
	Medium Risk	1265,78	1543,50	1418,31	27,29	1452,29	1448,03
	High Risk	357,34	839,98	890,91		910,89	468,94
	Very High Risk		39,68	138,95		122,84	
Drought	No risk	2,12					
	Low Risk	14782,55	13987,63	4065,83	1271,44	1293,15	738,59
	Medium Risk	107196,95	96685,70	110874,36	74486,36	79751,81	55504,49
	High Risk	9556,34	20864,63	16597,77	55780,15	50493,00	75253,92
	Very High Risk						40,95
Landslide	No risk	2,12					
	Low Risk	14782,55	13987,63	4065,83	1271,44	1293,15	738,59
	Medium Risk	107196,95	96685,70	110874,36	74486,36	79751,81	55504,49
	High Risk	9556,34	20864,63	16597,77	55780,15	50493,00	75253,92
	Very High Risk						40,95

Table L. 10 Risk level in Bali

	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Water Supply Shortage	No risk		289,68	289,68	289,68	289,68	289,68
	Low Risk	1518,00	3316,01	651,74	318,45	965,09	646,76
	Medium Risk	3823,83	2146,53	3039,66	2825,97	3949,97	2906,48
	High Risk	120,71		1771,13	2318,12	547,48	1909,29
	Very High Risk						
Flood Risk	No risk	5752,22	5752,22	5752,22	5752,22	5752,22	5752,22
	Low Risk						
	Medium Risk						
	High Risk						
	Very High Risk						

	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Drought	No risk						
	Low Risk	1981,19	1171,16	1261,62	951,54	1039,15	950,75
	Medium Risk	3421,61	3939,21	3949,54	3891,32	4031,41	3778,10
	High Risk	59,74	352,17	251,38	619,68	391,97	733,69
	Very High Risk						
Landslide	No risk						
	Low Risk	1981,19	1171,16	1261,62	951,54	1039,15	950,75
	Medium Risk	3421,61	3939,21	3949,54	3891,32	4031,41	3778,10
	High Risk	59,74	352,17	251,38	619,68	391,97	733,69
	Very High Risk						

Table L. 11 Risk level in Kalimantan

	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Water Supply Shortage	No risk	479365,00	369391,93	90069,37	54081,95	82341,85	24033,38
	Low Risk	46674,14	167196,28	438566,82	458000,53	430481,24	452744,90
	Medium Risk	531,82	1848,09	9800,10	26168,81	25489,86	59422,14
	High Risk				185,00	123,35	2235,87
	Very High Risk						
Flood Risk	No risk	522841,76	523834,85	527170,76	535462,94	525723,16	525731,57
	Low Risk	12790,84	12527,62	10291,18	2782,38	11119,00	11011,85
	Medium Risk	2660,79	1981,48	942,34	187,27	1532,57	1620,23
	High Risk	142,90	84,96	32,02	3,69	60,33	68,95
	Very High Risk		7,39			1,23	3,69
Drought	No risk	525261,40	525315,50	507833,06	475786,87	465090,57	293398,91
	Low Risk	1309,56	1255,45	18721,89	50309,09	60539,37	220852,89
	Medium Risk			16,00	474,99	941,02	12261,16
	High Risk						57,99
	Very High Risk						
Landslide	No risk	525261,40	525315,50	507833,06	475786,87	465090,57	293398,91
	Low Risk	1309,56	1255,45	18721,89	50309,09	60539,37	220852,89
	Medium Risk			16,00	474,99	941,02	12261,16
	High Risk						57,99
	Very High Risk						

Table L. 12 Risk level in Sulawesi

	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Water Supply Shortage	No risk	139306,68	93638,05	11278,72	6308,77	6305,91	6305,91
	Low Risk	33779,23	79260,99	135983,90	98531,57	87319,60	51600,80
	Medium Risk	7533,82	14026,60	39076,27	71593,22	83812,13	106201,20
	High Risk			586,74	10492,08	9488,00	22617,65
	Very High Risk						200,07
Flood Risk	No risk	186011,07	185602,86	185959,39	186917,00	185963,76	186512,37
	Low Risk	781,56	1050,31	816,03	8,64	810,23	360,21
	Medium Risk	129,31	247,81	141,58		143,02	53,05
	High Risk	3,70	24,66	8,63		8,63	
	Very High Risk						
Drought	No risk	170498,51	150533,65	161046,29	111247,02	112807,61	30608,72
	Low Risk	9517,68	24855,61	18469,87	59384,33	53015,72	107918,70
	Medium Risk	603,54	5230,47	1103,57	9969,90	14589,93	38207,03
	High Risk				18,47	206,47	3885,28
	Very High Risk						
Landslide	No risk	170498,51	150533,65	161046,29	4722,89	112807,61	30608,72
	Low Risk	9517,68	24855,61	18469,87	325538,79	53015,72	107918,70
	Medium Risk	603,54	5230,47	1103,57	131905,31	14589,93	38207,03
	High Risk				3904,09	206,47	3885,28
	Very High Risk						

Table L. 13 Risk level in Nusa Tenggara

	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Water Supply Shortage	No risk	23709,33	4944,20	4930,35	4930,35	4949,57	4930,35
	Low Risk	37853,54	35837,97	25797,10	9751,98	31569,99	16683,06
	Medium Risk	974,17	26685,22	34698,08	45591,81	29345,88	40780,68
	High Risk			2041,85	7193,25	1601,96	5073,30
	Very High Risk						
Flood Risk	No risk	64597,70	64643,22	64580,39	64663,78	64582,83	64613,48
	Low Risk	62,35	20,56	77,17		78,45	50,30
	Medium Risk	3,73		6,22		2,50	
	High Risk						

	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
	Very High Risk						
Drought	No risk						
	Low Risk	22253,44	13890,06	23379,49	12101,30	14714,88	8797,41
	Medium Risk	39622,54	45777,55	38322,84	45833,70	43583,34	46803,90
	High Risk	661,07	2869,43	834,72	4602,04	4238,82	6935,74
	Very High Risk						
Landslide	No risk						
	Low Risk	22253,44	13890,06	23379,49	12101,30	14714,88	8797,41
	Medium Risk	39622,54	45777,55	38322,84	45833,70	43583,34	46803,90
	High Risk	661,07	2869,43	834,72	4602,04	4238,82	6935,74
	Very High Risk						

Table L. 14 Risk of Landslide in Maluku

	Risk level	Area (Km²)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Water Supply Shortage	No risk	58299,74	65119,78	43129,06	8753,55	8835,35	8742,08
	Low Risk	11619,40	13652,93	35546,19	64505,89	64658,41	58396,25
	Medium Risk	113,90	1,23	98,70	5462,71	5229,63	11571,50
	High Risk				51,79	50,56	64,12
Flood Risk	No risk	78729,82	78689,27	78702,23	78770,24	78703,67	78760,08
	Low Risk	39,19	69,89	64,32	3,70	62,88	13,86
	Medium Risk	4,93	12,33	7,39		7,39	
	High Risk		2,47				
	Very High Risk						
Drought	No risk	62299,24	58339,41	56445,12	36321,71	38390,32	3940,71
	Low Risk	7733,79	11682,44	13587,91	33491,16	31642,71	63542,17
	Medium Risk		11,18		220,16		2550,16
	High Risk						
	Very High Risk						
Landslide	No risk	62299,24	58339,41	56445,12	36321,71	38390,32	3940,71
	Low Risk	7733,79	11682,44	13587,91	33491,16	31642,71	63542,17
	Medium Risk		11,18		220,16		2550,16
	High Risk						
	Very High Risk						

Table L. 15 Risk of Landslide in Papua

	Risk level	Area (Km2)					
		2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Water Supply Shortage	No risk	342416,52	411535,16	363171,74	84350,68	269801,89	256870,64
	Low Risk	38959,09		46236,51	324406,06	140990,99	150910,24
	Medium Risk	1500,78		2126,91	2778,42	742,29	3754,28
	High Risk						
	Very High Risk						
Flood Risk	No risk	402512,33	396435,02	398651,58	401245,97	398907,72	400954,79
	Low Risk	8790,39	14196,55	11901,58	9667,27	12081,83	10218,32
	Medium Risk	275,80	943,47	1023,12	656,50	586,71	404,94
	High Risk		3,47	2,24	8,78	2,25	0,47
	Very High Risk						
Drought	No risk	362824,99	334316,26	343584,63	308910,97	273745,18	253435,18
	Low Risk	20051,40	48436,01	39202,22	73674,48	107458,30	126889,83
	Medium Risk		124,11	89,54	290,94	1672,90	2551,37
	High Risk						
	Very High Risk						
Landslide	No risk	362824,99	334316,26	343584,63	308910,97	273745,18	253435,18
	Low Risk	20051,40	48436,01	39202,22	73674,48	107458,30	126889,83
	Medium Risk		124,11	89,54	290,94	1672,90	2551,37
	High Risk						
	Very High Risk						