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Editors

Climate Change Policies and Challenges in Indonesia

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Foreword

Recognizing climate change as one of the biggest threats we face, the Government of Indonesia has made several important contributions to addressing this issue. In 2007, we hosted the 13th Conference of the Parties to the United Nations Framework Convention on Climate Change in Bali. In 2009, the government announced a voluntary commitment to reduce its greenhouse gas emissions by 26 % below a business-as-usual scenario by 2020 using domestic resources and up to 41 % with international support. This was followed by the formulation and implementation of national and regional mitigation action plans. Indonesia is also accelerating adaptation efforts, as it is vulnerable to the impacts of climate change, such as the sea level rise and a change in the rainfall pattern. In this regard, the national adaptation action plan was officially launched in 2014. The Ministry of National Development Planning/National Development Planning Agency (BAPPENAS) has been coordinating with relevant line ministries and local governments for the implementation of these planned actions. We have integrated climate change mitigation and adaptation into the Medium-Term Development Plan. The Japan International Cooperation Agency (JICA) under the Project of "Capacity Development for Climate Change Strategies in Indonesia" has supported the mainstreaming process.

As part of the climate change mitigation and adaptation implementation plan, Indonesia recognizes the importance of human capacity. Therefore, human resource development is one of the important components of the above project, under which some young officials from Indonesia had opportunities to study at Hiroshima University, Japan. Contributions were made to this publication by those officials and professors at the university as well as experts of JICA, among others. The chapters in this publication present recent developments on climate change policy in Indonesia. The book also provides a collection of chapters that address the complexity of the relationship between climate and development policies in a range of sectors in Indonesia.

I would like to convey our gratitude to Professor Shinji Kaneko at the Graduate School for International Development and Cooperation of Hiroshima University, who has guided our young officials in completing their research works. Our sincere appreciation is also extended to Professor Akimasa Fujiwara, the Dean of the Graduate School. I wish to convey our many thanks to JICA. I hope that this book will contribute to better understanding and further discussion of the complex issues of climate and development.

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Preface

Background and Objective of the Book

The relationship between climate change and sustainable development has been a long-standing issue among researchers and practitioners. It was also considered at the latest assessment report of the Intergovernmental Panel on Climate Change (IPCC). The climate and development nexus is complex. While development policy regulates carbon emission paths, the resulting change in climate constrains possible development paths. While climate change mitigation and adaptation actions can alleviate negative effects on development, many of the determinants for the mitigative and adaptive capacities are shaped by the level of development. As capacities for effective climate actions have strong overlap with those for sustainable development, synergies and co-benefits exist between the two. There are potential trade-offs, however, since some climate responses may draw resources away from other developmental priorities, impose limitations on growth, or have adverse distributional effects. While the above findings are based on a high level of consensus among researchers, the latest IPCC report indicates that "the amount of supporting evidence is relatively limited as so many aspects of sustainable development and climate change mitigation and adaptation have yet to be experienced and studied empirically." Against this backdrop, this book provides empirical studies on the links between climate actions and development, using Indonesia as a case.

Indonesia has the second largest forest area in the world. It is one of the fastest-growing economies as well. According to the World Development Indicators, the population more than doubled and the real gross domestic product (GDP) increased by more than ten times during the period from 1965 to 2005. With a population of 240 million in 2010, Indonesia is the world's fourth most populous country after China, India, and the United States, and ranked at 16th in the world in terms of GDP. With this growth and scale, it also has become widely recognized as one of the largest greenhouse gas (GHG) emitters in the world. On the occasion of the G20 meeting in Pittsburgh (USA) in September 2009, the then Indonesian president announced a voluntary commitment to reduce its GHG emissions by 26 % by the year 2020 compared with the business-as-usual (BAU) level through its own national efforts and 41 % with international support. To follow this announcement, the National Action Plan for GHG Emission Reduction (*Rencana Aksi Nasional Penurunan Emisi Gas Rumah Kaca*; RAN-GRK) was issued as Presidential Regulation number 61/2011 in September 2011 to provide a policy framework. In addition, Presidential Regulation number 71/2011 was issued for the purpose of regulating regular submission of national GHG inventory (Chap. 2, this volume).

Indonesia is also prone to the impacts of climate variability and change. According to the latest National Communication of Indonesia, a substantial increase in temperatures, as well as a significant change in the volume and pattern of rainfall, has been observed across the country, and a number of climate models agree that these trends are projected to continue or even accelerate in the future. In response, the National Action Plan for Climate Change Adaptation (*Rencana Aksi Nasional untuk Adaptasi Perubahan Iklim*, RAN-API) was developed and officially launched in February 2014 with the aim of providing directions for mainstreaming climate change adaptation into national, local, and sectoral development planning (Chap. 4, this volume).

Indonesia has thus been making efforts to reconcile sustainable development and climate change policy. In this process, trade-offs as well as synergies between the two have been faced. Forest areas are where such conflicts are visible, with competing interests of oil palm plantations, mineral development, forest conservation, and the welfare of those who live there, among others (Chaps. 5 and 6, this volume). Energy subsidy is another example of controversy, with a potential to substantially and simultaneously affect the carbon emission paths, economic growth, and distribution between the rich and the poor (Chap. 7, this volume). This book compiles empirical studies on these and other similarly contentious issues, based on the experiences in Indonesia, as one of the most proactive on climate policy among developing countries. While it is mainly intended for practitioners, the editors hope that it will be also useful for researchers and students.

The plan to publish this book originated from the collaboration between Hiroshima University and the project “Capacity Development for Climate Change Strategies in Indonesia” of the Japan International Cooperation Agency (JICA). This project has been in operation since October 2010 to support the government of Indonesia in enhancing its capacity to tackle climate change. Under the project, some officials of the Indonesian government were provided with opportunities to study at Japanese universities, including Hiroshima University. Contributions to this book were made by those who received funding to study at the university, as well as JICA experts of the Project and other researchers in and outside Indonesia.

At the time of this writing, the new administration under President Joko Widodo has been established, with a mixture of continuity and change in policies relating to climate and development. The new president launched the National Mid-term Development Plan (*Rencana Pembangunan Jangka Menengah Nasional*, RPJMN) for 2015–2019, which retained both RAN-GRK and RAN-API. In the meantime, he issued a regulation concerning the merger of two formerly separate ministries to form the Ministry of Environment and Forestry. At the same time, he ordered the integration of the duties and functions of the REDD+ Agency and the National Council on Climate Change, both of which had been established under the previous administration, into the newly formed ministry. These recent institutional changes have not yet been reflected in some of the following chapters. Reconciliation of sustainable development and climate policy, however, will continue to be a challenge in Indonesia, and this is also the case for many other countries.

Outline of the Book

This book consists of two parts. Part I, from Chaps. 1, 2, 3 and 4, provides an introduction to climate change policies and institutions in Indonesia. While Chap. 1 reviews the economic development and carbon emission path in Indonesia, Chaps. 2, 3 and 4 address the climate change mitigation and adaptation policies. Kaneko (Chap. 1) provides an overview of the economic growth and trade, energy supply and demand, deforestation, and GHG emissions in Indonesia since 1990. The author employs a preliminary decomposition analysis of the energy-related CO_2 emissions over the last 40 years with data from the International Energy Agency (IEA).

Morizane, Enoki, Hase, and Setiawan (Chap. 2) introduce climate change mitigation policies and institutions in Indonesia. This chapter is descriptive in nature, but it has a comprehensive coverage of the relevant topics, such as GHG emissions status and trends; RAN-GRK and other mitigation-related initiatives, including those related to "reducing emissions from deforestation and forest degradation, conservation of forest carbon stocks, sustainable management of forests, and enhancement of forest carbon stocks (REDD+)"; institutional arrangements; and international cooperation, and funding mechanisms, including the Joint Crediting Mechanism (JCM).

Based on the results of a field survey, Ueda and Matsuoka (Chap. 3) demonstrate the scale of apparent changes in emission figures which may result from pure methodological improvement for GHG inventory preparation, not from actual mitigation actions. The implication of the apparent changes on policy formulation and evaluation is also discussed. The difficulty in establishing appropriate data and its policy implication is also addressed in Chap. 9.

Consideration of the monitoring and evaluation of climate change adaptation has expanded significantly in recent years among both researchers and practitioners. In Chap. 4, Kawanishi, Preston, and Ridwan evaluate national adaptation planning, using RAN-API as a case. The criteria and scoring system, developed by prior research, are applied to evaluate RAN-API, both as identified in its document and as viewed by stakeholders. A desktop review and questionnaires were undertaken to this end. This chapter also provides an overview of the climate variability, change, and impacts in Indonesia.

Part II is a collection of chapters that address climate change sectoral challenges. Chapters 5, 6, 7, 8, 9, 10, 11 and 12 address sectoral mitigation actions in Indonesia, analyzing their synergies and conflicts with development in Indonesia. The sectors were selected on the basis of their significance in the national economy and GHG emissions. Chapters 13 and 14, on the other hand, address climate impacts on rice production and response measures in Indonesia. Rice, the staple food of the country, is chosen because of its significance in national food security and rural development.

Chapters 5 and 6 address forestry and peatland, the largest sources of carbon emissions in Indonesia. In Chap. 5, Indarto analyzes the relationship between forest concessions and deforestation. After examining the role of various types of forest concessions, the author reveals that some types of concessions significantly contribute to deforestation. Quantitative analyses with official data at the provincial level are employed. With this result, the chapter discusses some implications on the current forest moratorium policy and proposes alternative ways to issue forest concessions, such as auction.

Yamamoto and Takeuchi (Chap. 6) discuss prevention of peatland fire as a part of REDD+. With Central Kalimantan as a study location, where peatland fire significantly contributes to the release of large amounts of carbon, the authors find that economic factors, such as the value of labor allocation for rubber production, and non-economic factors, such as traditional mutual assistance, can promote fire prevention, suggesting the necessity of a combination of economic and non-economic incentives for the effective implementation of REDD+.

The following two chapters address the energy issue. With a growing economy and increasing population, Indonesia has become a significant energy user as well as a net importer of oil. The oil subsidy, which accounts for one-fifth of the fiscal expenditure of the government, has been the source of a long-running controversy with high political stakes. In Chap. 7, Luthfi and Kaneko analyze the net impacts of international oil prices on the macro-economy of the country. The authors also assess the effects of the removal of the oil subsidy as climate change mitigation.

“Integrated Indonesian Energy and Environment Modeling” has been conducted by the Indonesian Institute for Energy Economics (IIEE) to support BAPPENAS in the formulation of the National Mid-term Development Plan for 2015–2019. In Chap. 8, Siahaan, Fitri, and Batih introduce the modeling results with particular attention to the energy mix in the power sector and its associated GHG emissions.

Armundito and Kaneko (Chap. 9) discuss environmental productivities and carbon abatement costs of manufacturing sectors. The chapter provides a review of the changes over the last 20 years in energy efficiency and carbon intensity of the manufacturing sector, and discusses the marginal abatement cost of CO_2 emissions. With firm-level data, the authors discuss the possible financial burdens for firms in different sectors in case carbon regulations are introduced.

In Chap. 10, Ghozali and Kaneko cover consumer behavior and eco-labeling. The chapter examines air conditioners, one of the fastest-growing home appliances in the market, which consume large amounts of electricity, without energy efficiency-labeling available yet. With data from an interview survey on consumer preferences in greater Jakarta, the chapter analyzes possible purchasing behavior changes of urban consumers in response to a hypothetical case where an authorized energy efficiency-labeling scheme is introduced.

The transport sector is the focus of Chap. 11. Mass Rapid Transit (MRT), under construction in Jakarta, is expected to mitigate traffic congestion and the associated GHG emissions. Using a consumer survey, Maimunah and Kaneko discuss the climate change mitigation effect of a possible modal shift from passenger vehicles and motorcycles to MRT and compare it with the potential impacts of other policies, such as road pricing under the Ministry of Transportation, fuel pricing under the Ministry of Energy and Mineral Resources, and tax reduction for compact cars under the Ministry of Industry.

The utilization of waste-to-energy (WTE) technologies is a long-standing strategy in developed countries in achieving the simultaneous objectives of sustainable waste management, reduction of GHG emissions, and development of energy from renewable sources. Previous studies, however, have dismissed such solutions for developing countries because of high costs, unsuitable wastes and climate, and inadequate human resources. New WTE technologies were developed that better fit tropical environments and waste with greater moisture and organic content. In Chap. 12, Johnson evaluates the feasibility of these adapted WTE projects and presents an accounting of the economic and environmental costs and benefits, using Bekasi municipality near Jakarta as a study location.

Chapters 13 and 14 shift their attention to climate impacts and responses in rice production in Indonesia. Anggarendra, Guritno, and Singh (Chap. 13) describe the "Integrated Cropping Calendar System (KATAM)" as a tool to provide climate information to farmers. In reference to the previous studies which indicate a capacity of information intermediaries and the extent of interaction as the factors that affect the use of climate information, this chapter also describes the status of agricultural extension workers and the "Climate Field School" as the government initiative to promote two-way communication.

Insurance is stipulated in Article 4.8 of the UNFCCC as one of the necessary actions "to meet specific needs and concerns of the developing country parties arising from the adverse effects of climate change." In recent years, increasing importance has been attached to risk management and insurance in international negotiations on climate change adaptation. In Chap. 14, Pasaribu and Sudiyanto present opportunities and challenges of crop insurance as one of the risk management instruments for rice farmers under a changing climate, based on the lessons learned from the pilot insurance provided by the government of Indonesia.

Hiroshima, Japan Shinji Kaneko
Tokyo, Japan Masato Kawanishi

Contents

Part I
Climate Change, Policies, and Institutions

Chapter 1
Economy, Energy, and CO_2 Emissions

Shinji Kaneko

Abstract The introductory chapter provides a historical overview on the nexus of economic development, energy use, and energy-related CO_2 emissions over the past 40 years in Indonesia. A logarithmic mean Divisia index (LMDI) decomposition analysis was employed to examine determinants for the changes in energy-related CO_2 emissions. The 40-year period was divided into three major periods of political regimes with available data: 1971–1997 for the Suharto regime, 1999–2004 for the transition to a democratic regime, and 2005–2011 for the Yudhoyono regime. The analysis found that (1) coal started to play an important role in exports and power generation, which have positive effects on CO_2 emissions; (2) the price of oil commodities increased due to the fuel subsidy removal, and the rise of international oil prices accelerated improvements in energy efficiency; and (3) the transportation sector became increasingly important to increasing CO_2 emissions. The chapter concludes with future perspectives related to other chapters in the book.

Keywords Economic growth • Energy-related CO_2 emissions • Decomposition analysis • LMDI

1.1 Introduction

The Suharto regime began in 1966 and successfully developed a national economy with an average GDP growth rate at 7.18 % for almost 30 years until the Asian financial crisis hit the country. The GDP per capita significantly increased from 280 US$ in 1966 to 1235 US$ in 1997. With rich natural resources and a large population with a relatively young demographic structure, the country was expected to continue to experience rapid economic growth before the financial crisis. The well-known report of the World Bank, East Asian Miracle (1994), included Indonesia as a highly performing Asian economy (HPAE), together with Japan, Korea, Taiwan, Hong Kong, Singapore, Malaysia, and Thailand. In 1998,

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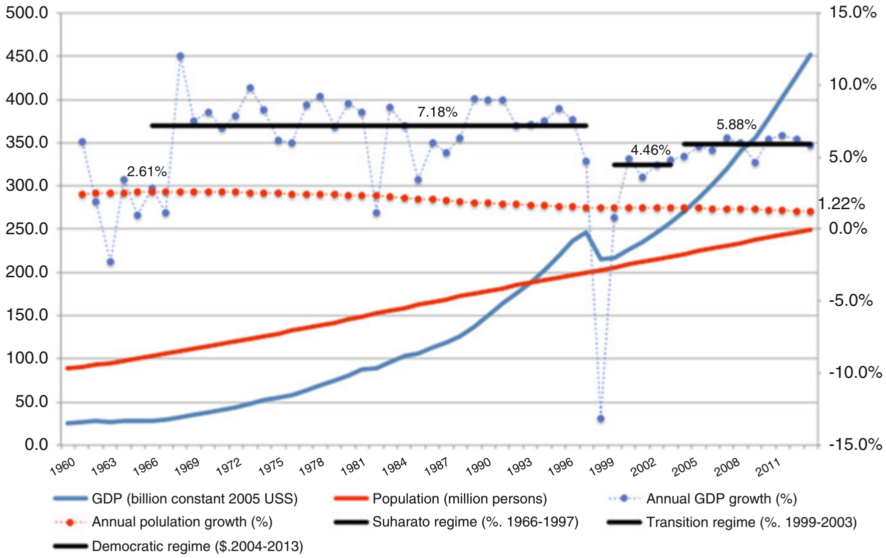

Fig. 1.1 GDP and population in Indonesia from 1960 to 2013 (Source: World Development Indicator)

Indonesia experienced an extremely serious economic crisis affected by the Asian financial crisis, which dropped its GDP growth to a large negative rate at −13.1 % (Fig. 1.1). As a result, the Suharto regime collapsed in May 1998, and Indonesia entered the political regime transition period from a developmental dictatorship to a democratic regime until 2004, when President Susilo Bambang Yudhoyono was elected. During the 6-year transition and economic recovery period after the Asian financial crisis, the country experienced much turbulence and many changes, which were evident by three different presidents and four revisions of the national constitution; however, there was steady progress toward ensuring freedom and human rights in the democratic regime. During the same period, a drastic decentralization policy was also introduced. The average GDP growth rate during the transition period was 4.46 %, which is almost two thirds of the average economic growth of the Suharto regime.

The 10 years of the Yudhoyono regime, from 2004 to 2014, demonstrated relatively steady economic growth, with an average GDP growth rate of 5.88 %. The figure was slightly lower than 6 %, which is an important economic growth target for Indonesia to annually absorb new and young laborers in order to maintain a low unemployment rate. During the Yudhoyono regime, several progresses and achievements were made toward law and order stability, anti-terrorism, anti-corruption, and improving the decentralization policy. It is worth noting that a symbolic achievement was the peace talks with the Aceh state after the earthquake and tsunami in December 2004. Since its national independence from the Dutch colonial period, regional independence movements have long been an important political agenda in Indonesia. The drastic 2001 decentralization that transferred the administrative authorities beyond state governments directly to provincial and city governments was modified in 2004 due to concerns of regional independence. The vertical hierarchy then resumed functioning. It was also during the Yudhoyono regime when Indonesia hosted COP13 of UNFCCC in Bali Island and established the Bali Action Plan in 2007.

As the fourth most populous country in the world after the United States, Indonesia's population is currently approximately 250 million. Since 1960, when the population was 89 million, the population has almost linearly grown, with average growth rate of 2.0 %. The annual growth rate peaked around the late 1960s at 2.61 % and gradually declined to 1.22 % as of 2013. However, Indonesia is still in the declining phase for the demographic-dependent ratio, and the number of productive laborers is predicted to increase until the mid-2020s (United Nations 2015).

Considering the historical economic development of Indonesia in terms of export performance, a structural change of economic development can be observed (Fig. 1.2). Before the Suharto regime, which began in 1962, export commodities mainly consisted of four categories: agricultural raw materials (45.6 %), fuels (31.7 %), food (16.8 %), and ores and metals (5.6 %), which are all from primary industries. In the first half of the Suharto regime, between 1966 and mid-1982, the share of agricultural raw materials significantly decreased to 5.8 %, while fuel (mineral oil and gas) shares expanded to 82.4 %, which shows that the economic development during the first half of the Suharto regime was largely driven by international sales of mineral oil and gas. There was the shift to industrialization in the mid-1980s. Consequently, the share of exports of non-high-tech

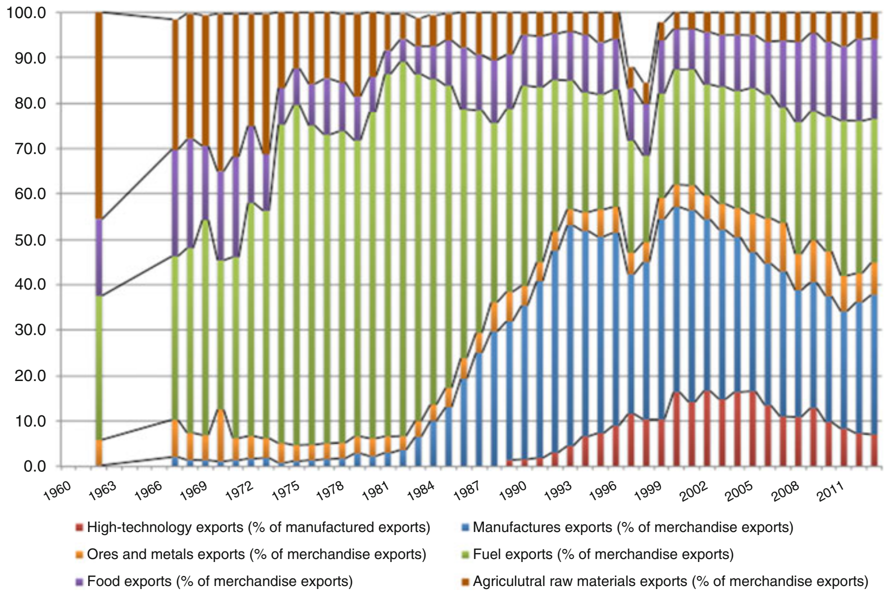

Fig. 1.2 Structural change in the merchandise exports of Indonesia from 1960 to 2013 (Source: World Development Indicator)

manufacturing commodities sharply expanded from 3.6 % in 1982 to 48.5 % in 1993, whereas the dependency on fuel exports dramatically decreased to 28.4 %. At the same time, the development of the high-tech manufacturing industry and its export began in 1989. The share of high-tech manufacturing exports increased thereafter, reaching more than 16 % four different times: in 2000, 2002, 2004, and 2005. One can observe that manufacturing exports drove the economy during the second half of the Suharto regime.

The manufacturing sector in Indonesia, including both non-high-tech and high-tech industries, continuously grew, except during the Asian financial crisis period, until 2000, reaching 57.1 %, which has been the highest value since that period. Instead, conventional commodities, including agricultural raw materials, food, fuels, and ores and metals, from the primary industry, started to expand their shares during the recent democratic period of Yudhoyono, even though Indonesia has become a net oil-importing country since 2004, as discussed later. Therefore, there is present concern about future sustainable economic development, in terms of environmental conservation and unemployment, if the dependency on the primary industry for exports continues.

Crude oil, one of the sources of economic growth in Indonesia, particularly in the first half of the Suharto regime, has declined in production since the late 1990s. Figure 1.3 compares the production energy values and exports of three major fossil fuels in Indonesia. One common feature is that the majority of energy produced in the country is exported, which is particularly true for coal. The other observation is the transitional shift in the production of fossil fuels around the late 1990s. While

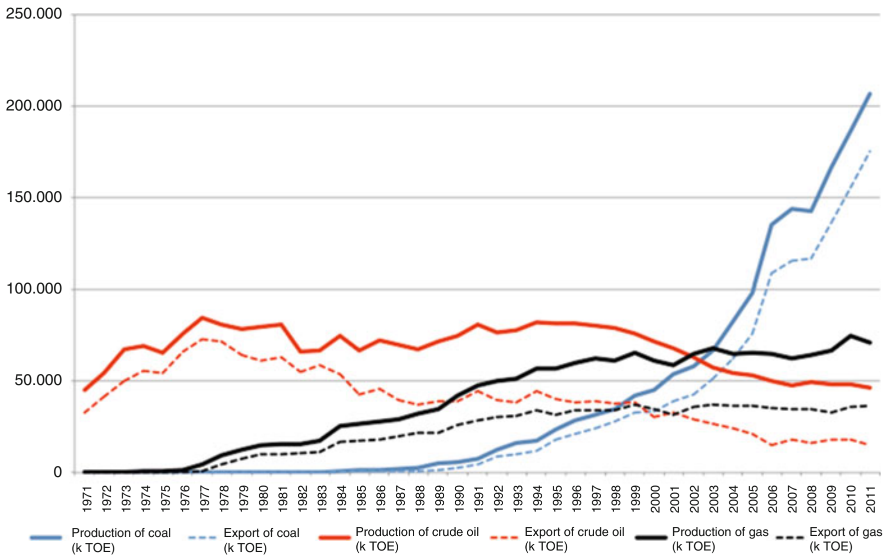

Fig. 1.3 Energy values of the production and export of coal, crude oil, and natural gas in Indonesia (Source: IEA/OECD (2013))

the production of crude oil declined, as mentioned above, coal production sharply increased, and natural gas production demonstrated a modest increase since 2000. The peak of crude oil exports occurred in 1977. Currently, the energy value of coal production is four times and three times larger than those of crude oil and natural gas, respectively. The economic implication for this shift is derived from the difference in economic values of those fossil fuels, where prices of crude oil and natural gas are relatively higher than that of coal. The environmental implication for this shift is derived from the difference in emission factors of carbon and other local pollutants, where natural gas is much cleaner than coal.

The domestic supply of energy is intertwined with the domestic production of fossil fuels. Figure 1.4 shows the historical trajectory of the total primary energy supply in Indonesia between 1971 and 2011. Approximately 35 million TOE was supplied to Indonesia in 1971: three quarters were in the form of traditional biomass, and the rest was crude oil. Since then, the primary energy supply increased by six times, reaching 200 million TOE in 2011. For the two major energies supplied in 1971, crude oil increased until the late 1990s, whereas traditional biomass continued to slowly grow until now, doubling from 1971 to 2011. Several new sources of energy appeared in the trajectory at different points in time: natural gas in the 1980s, coal in the 1990s, and hydropower and geothermal energy in the 2000s. Since the early 2000s, along with the transition to a net oil-importing country, refined petroleum products have been included in the primary energy supply and are imported mainly from Singapore. The recent rapid growth in coal production, which is mostly exported, began to be used for the domestic energy supply. As a consequence, the

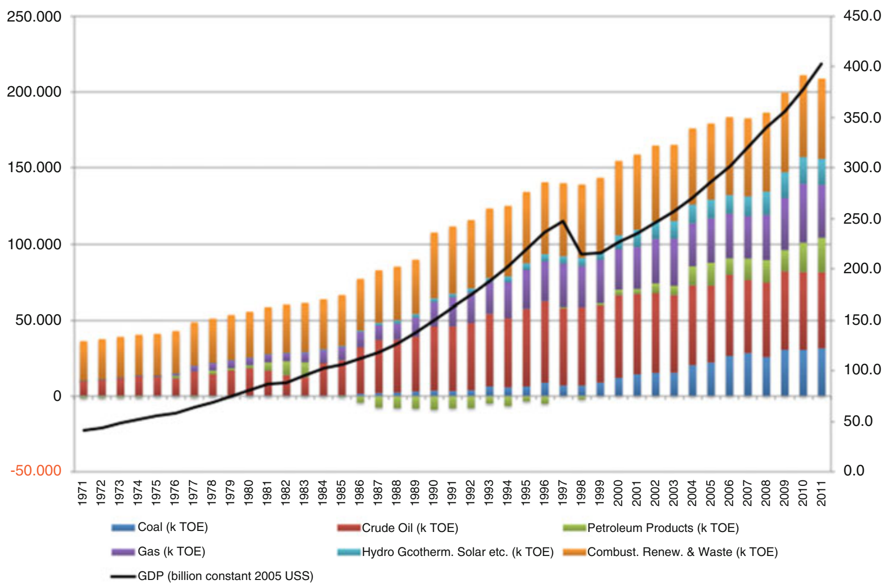

Fig. 1.4 Historical trajectory of the total primary energy supply in Indonesia (Source: IEA/OECD (2013); note: GDP is displayed in right axis)

current energy supply structure of Indonesia is diversified into six sources, although traditional biomass and crude oil are still the largest energy sources.

Passing through the energy transformation sectors of Indonesia, the primary supply energies are used either directly or in different forms of secondary energy. Because there are transformation and distribution losses, the amount of energy actually used is less than that of the primary supply. In 1971, 32 million TOE was used, and less than 10 % of the primary supply was lost, whereas in 2011, 158 million TOE was used, and nearly 20 % of the primary supply was lost (Fig. 1.5). The dominance of traditional biomass is apparent, as the energy loss from transformation and distribution was very limited. Two major energy categories were dominant in the final energy consumption: traditional biomass and petroleum products. Although traditional biomass lost and petroleum products gained in their individual shares, together, the combined share declined from 98.9 % in 1971 to 72.6 % in 2011. In 2008, the share of petroleum products surpassed that of traditional biomass for the first time in Indonesia's history. Three forms of energy have filled the remaining share: coal, natural gas, and electricity. It should be noted that despite the steady increase of the share of electricity in the final energy consumption, it began at less than 1 % during the 1970s and was only 8.7 % in 2011. The domestic use of coal and natural gas in industry is relatively recent (since the late 1990s), indicating that petroleum products, which have a labor-intensive input structure, have mostly driven the industrialization during the second half of the Suharto regime.

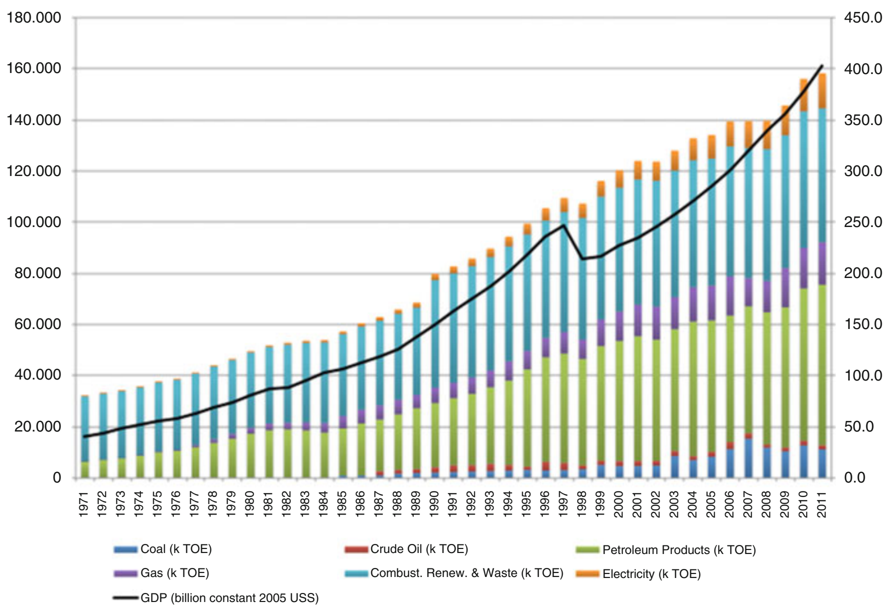

Fig. 1.5 Historical trajectory of final energy consumption by source in Indonesia (Source: IEA/OECD (2013), Note: GDP is displayed in right axis)

On the other side of the energy balance, Fig. 1.6 depicts historical changes in the demand structure by sector for energy uses as fuels, where nonenergy uses are excluded. Among others, the residential sector has been the dominant and largest energy-consuming sector, although its share has declined from 85.5 % in 1971 to 38.8 % in 2011. The start of the growth of the industrial sector in final energy consumption coincided with industrialization in the 1980s and continued until now. However, in recent years since 1999, the share of the industrial sector has remained at approximately 30 %, whereas the share of the transportation sector has grown from 18.1 % in 1999 to 26.4 % in 2011, and transportation has become a competitive sector with the industrial sector. The strong and robust demand for energy in the transportation sector is, in part, due to the successful development of the automobile and motorcycle manufacturing industry and to motorization. Considering that a large share of residential energy demand is supplied by traditional biomass and the share of commercial and public services is currently very limited, the future demand for electricity is expected to largely increase.

In Indonesia, the removal of energy subsidies was considered an extremely difficult political issue at the end of the Suharto regime and during the transition period between 1998 and 2003, with repeated withdrawals of government proposals due to strong resistance from energy users and the general public. Nevertheless, for the first time in the history of Indonesia, the policy was finally passed and put into action in March 2005. From this policy, Indonesia has already become a net oil-importing country; the demand for petroleum products has rapidly increased,

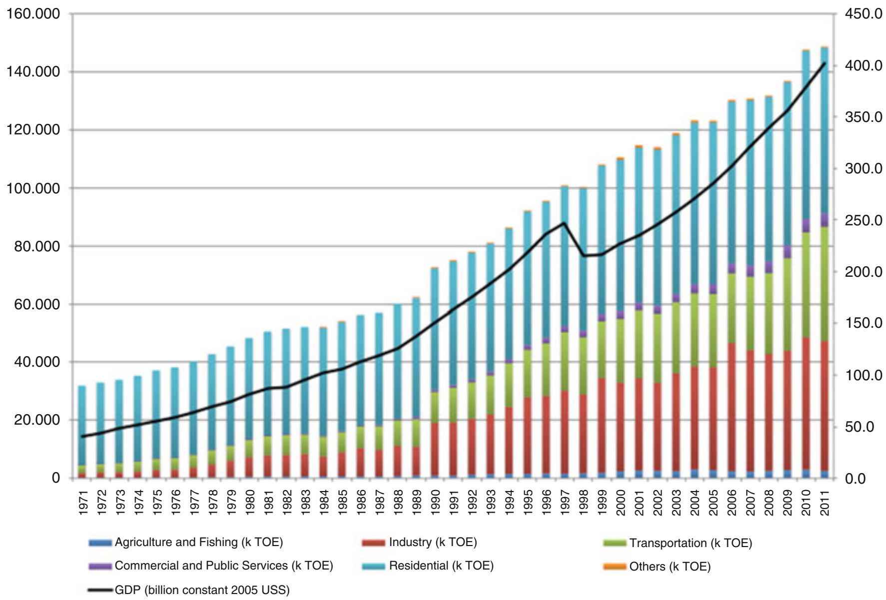

Fig. 1.6 Historical trajectory of final energy consumption by sector in Indonesia (Source: IEA/OECD (2013), Note: GDP is displayed in right axis)

and the international oil price has started to soar, remaining at a high price, which leads to a severe fiscal burden for the national budget. The increase in the international oil price brought additional revenue to Indonesia when the country was exporting crude oil. However, for an oil-importing country with energy subsidies, high international oil prices are extremely harmful to the national budget. Fortunately, during the democratic regime led by President Yudhoyono, with public trust and credibility, careful design, and a step-by-step and sector-by-sector phaseout strategy, the subsidy removal became a reality. The first step of this process was the removal of the energy subsidy in March 2005, when the international oil price increased to 40 US$, and kerosene use for residential needs was exempted. Then, the second step was in October 2005, when the international oil price reached 80 US $. The third step was in May 2008, followed by the fourth step in January 2013. In general, the first target of energy subsidy removal was industry and then the residential and transportation sectors. For the residential sector, the Zero Kero policy was implemented sequentially: its implementation started in Jakarta and then was spread to local cities, finally expanding to the entire country and promoting the shift of cooking fuel from kerosene to subsidized LPG. In 2015, the complete removal of the subsidy was implemented for regular gasoline.

Figure 1.7 compares the trade balance of oil commodities and macro energy efficiency. The net balance of trade for crude oil shows large surpluses and exports in the 1970s and 1980s. It started to decline in the 1990s and finally became negative (i.e., net import). While the net import of crude oil has been marginally limited, the net import of petroleum products has increased thereafter. Indonesia currently maintains a certain amount of crude oil exports, and it is known that sweet, higher-quality crude oil is exported due to contract restrictions and bitter, lower-quality crude oil is imported instead. Furthermore, refined petroleum products are much more costly than petroleum products domestically refined, which makes domestic prices of oil commodities expensive. Figure 1.7 also presents several macro indicators of energy efficiency, such as the total primary energy supply (TPES) per unit of GDP production (TPES/GDP), the total final energy consumption (TFEC) per unit of GDP production (TFEC/GDP), and the TFEC per unit of value added in the manufacturing sector (TFEC/GDP for manufacturing). While both TPES/GDP and TFEC/GDP steadily improved until the Asian financial crisis in 1997, TFEC/GDP for manufacturing fluctuated during that same period. After the crisis, TPES/GDP returned to the level in the early 1980s and took almost 10 years to recover to the level before the crisis. The gap between TPES/GDP and TFEC/GDP widened due to the gradual spread of secondary energy and the associated transformation losses. On the other hand, there has been no significant progress in energy efficiency in the manufacturing sector, despite the rise of energy costs due to energy subsidy reform and soaring international oil prices. This phenomenon could be explained by the shift from labor-intensive manufacturing industries to capital and energy-intensive ones.

As a result, energy-related CO_2 emissions largely increased over the past 40 years, which poses significant implications to the climate change mitigation policy of the country, though there are other important sources of greenhouse gas emissions, such as land use changes and peat fires. Figure 1.8 explains the available

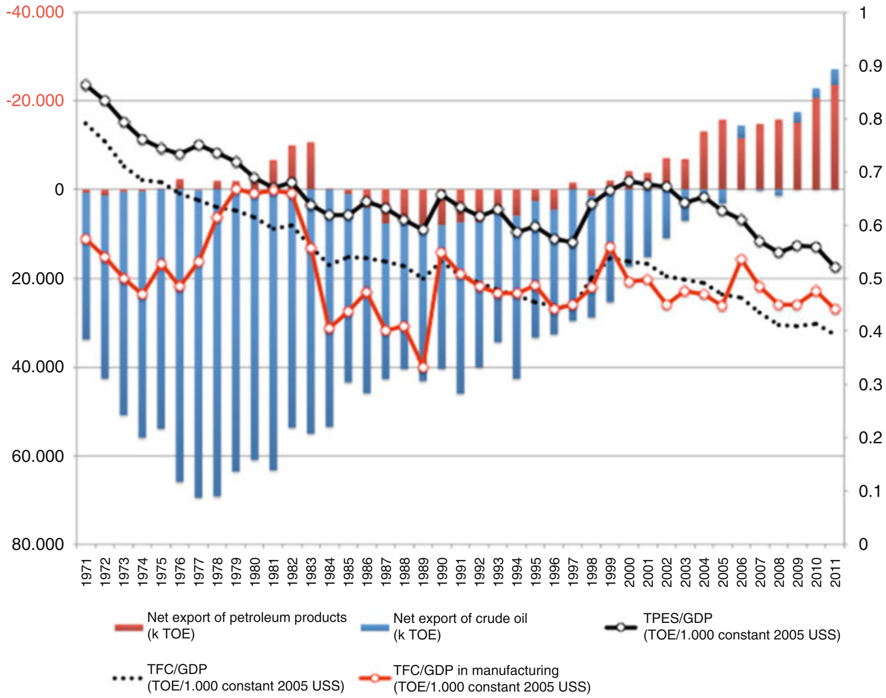

Fig. 1.7 Trade balance of oil commodities and macro energy efficiency (Source: World Development Indicator and IEA/OECD (2013))

estimates of energy-related CO_2 emissions in Indonesia that cover a sufficiently long term. One estimate was from the World Development Indicator, which contains an estimate of CO_2 emissions stemming from the burning of fossil fuels and the manufacturing of cement, compiled by the Oak Ridge National Laboratory, United States. The author computed the other two estimates with two simple accounting methods by applying the IEA/OECD publication on CO_2 emissions from fuel combustion to the energy balance tables for non-OECD countries provided by IEA/OECD. The emission factors used in these estimates were taken from the IPCC guideline on the GHG inventory in 2006. The first estimate corresponds to the reference approach, which uses primary energy supply data. The reference approach comprehensively captures the energy flow upstream but is unable to elucidate CO_2 emissions by sector. On the other hand, the second estimate corresponds to the sectoral approach, which uses final energy consumption data. Though the sectoral approach has the advantage of capturing CO_2 emissions by sector, indirect CO_2 emissions during the energy transformation process, such as conversion and distribution losses, are difficult to precisely and consistently compute. In addition, the sectoral approach in the present analysis does not consider nonenergy uses, while the reference approach does. These are two major possible causes of disparity between the reference approach and sectoral approach in Fig. 1.8.

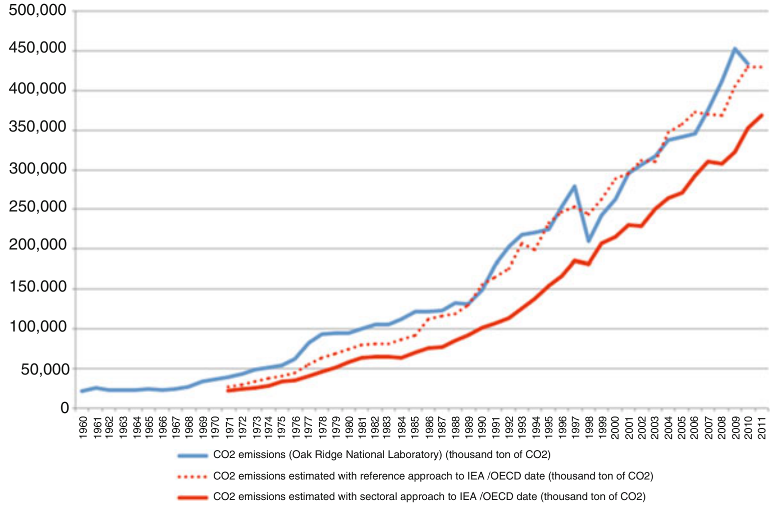

Fig. 1.8 Comparison of different estimates of energy-related CO_2 emissions in Indonesia (Source: World Development Indicator and IEA/OECD (2013))

Noncombustion emissions of CO_2 from cement production processes are considered to be negligible, as the scale of cement production in Indonesia is still small. Therefore, the disparity between the estimate by the Oak Ridge National Laboratory and that with the reference approach might be due to the level of breakdown of the energy sources. For example, the energy balance tables of IEA/OECD have aggregate energy values for petroleum products, while gasoline, diesel, kerosene, LPG, and other refined oil products are treated as similar energy sources with a common emission factor. The same approach is applied to coal-oriented energy sources. Considering this difference, these two estimates are in agreement, although the disparity between the two estimates is larger from 1971 to 1980. At the same time, the Oak Ridge National Laboratory estimate suggested a larger drop in energy consumption during the Asian financial crisis.

The increase in CO_2 emissions from 1971 to 2011 occurred much faster than that of energy use because the energy structure significantly changed to more carbon-intensive fossil fuels. The CO_2 emissions grew by more than 16 times over those 40 years, according to the author's estimates, whereas the total primary energy supply grew by six times, as mentioned earlier.

1.2 Method

Although large numbers of decomposition studies on energy and the environment have been reported, there is still a lack of accumulated empirical evidence in Indonesia. In this chapter, only highly aggregated levels of data are available for

Indonesia; the log mean Divisia index type I (LMDI-I) analysis, known as the "best" decomposition method, is conducted for Indonesia. The LMDI-I model has preferable attributes related to perfectness in terms of residual free and consistency in aggregation (Ang 2004).

1.2.1 Indicators and Data

The present study uses energy balance tables for Indonesia between 1971 and 2011 compiled by IEA/OECD (2013), the only publicly available and reliable data covering multiple years. The energy balance tables provide a matrix of 9 categories[1] of energy and 26 sectors of final consumers. Among the nine categories of energy, seven categories are used in Indonesia, except for nuclear and heat. For the final consumers, the 26 sectors – 13 subsectors of secondary industry, 8 subsectors of transportation, and 2 subsectors of primary industry, commercial and public services, residential, and nonspecified sector – are aggregated into 5 sectors[2] due to unavailability of consistent data.

From the energy balance tables with seven energy categories and five final consumption sectors, the energy consumption datasets by sector and by category over the 40 years are computed. Furthermore, with the carbon emission factors for coal, petroleum products, and natural gas taken from the IPCC guideline, corresponding datasets of CO_2 emissions by sector and by category over the 40 years are also computed. Note that for electricity, the information on the input and output structure of the sector for "electricity plants" is used to annually compute the CO_2 emissions per unit of electricity consumption.

The other data (the GDP in constant 2005 US$; the respective shares of primary, secondary, and tertiary sectors to GDP (%); the total population in millions; and the household final consumption expenditure in constant 2005 US$) are mostly taken from the World Development Indicators.[3] Data on the number of vehicles is available for the period between 2000 and 2011, and the data from 1971 to 2000 is supplemented by the data from the book compiled by the Japan Automobile Association. The number of vehicles includes not only privately owned passenger vehicles but also publicly owned passenger vehicles, trucks, and busses, while two wheelers are not included. Key variables are indexed to 1 in 1971 and compared in Fig. 1.9.

[1] (1) Coal, (2) crude oil, (3) petroleum products, (4) gas, (5) nuclear, (6) hydro, geothermal, solar, etc., (7) combust. renew. and waste, (8) electricity, and (9) heat.

[2] The "other miscellaneous sectors" are included in Commercial and Public Services.

[3] Household final consumption expenditure (formerly private consumption) is the market value of all goods and services, including durable products (such as cars, washing machines, and home computers) purchased by households. It excludes purchases of dwellings but includes imputed rent for owner-occupied dwellings. It also includes payments separately and fees to governments in order to obtain permits and licenses. Here, household consumption expenditure includes the expenditures of nonprofit institutions serving households, even when reported by the country.

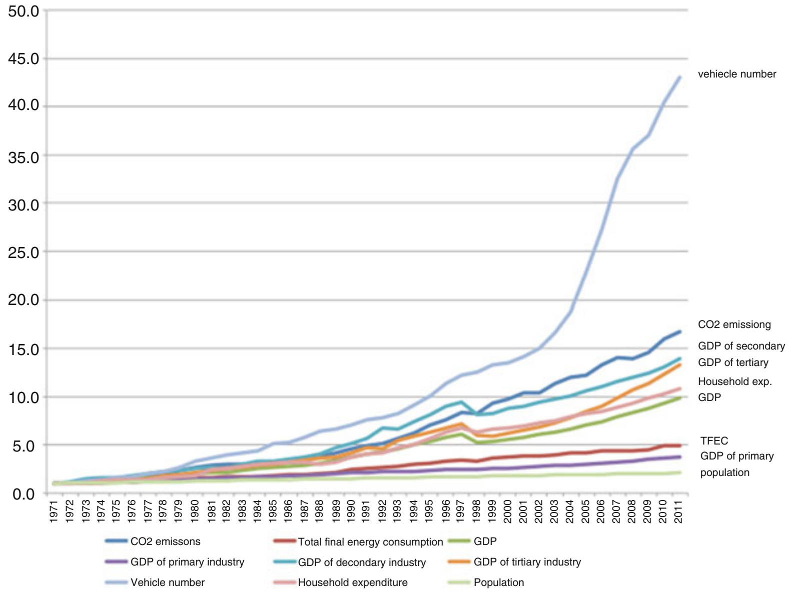

Fig. 1.9 Comparison of the key variables used for the decomposition analysis (Source: World Development Indicator and IEA/OECD (2013))

The vehicle number increased the most among these variables, followed by CO_2 emissions, and the GDP of the secondary industry. On the other hand, the population increased the least, followed by the GDP of the primary industry and the total primary energy consumption (TPEC).

1.2.2 Model

In the present analysis, total CO_2 emissions per year is calculated by the summation of 35 elements of CO_2 emissions, which are defined by 5 sectors and 7 energy categories in which each element is a product of predefined determinants. For the three production sectors, primary, secondary, and tertiary industries have six predefined determinants, whereas both the transportation sector and the residential sector each have five determinants, as seen in the following equations (Ang and Liu 2001).

$$
\begin{aligned}
CO_2 = {} & \sum_{i=1}^{3}\sum_{j=1}^{7} \frac{CO_{2_{ij}}}{TFC_{ij}} \frac{TFC_{ij}}{TFC_i} \frac{TFC_i}{GDP_i} \frac{GDP_i}{GDP} \frac{GDP}{POP} POP \\
& + \sum_{i=T}\sum_{j=1}^{7} \frac{CO_{2_{ij}}}{TFC_{ij}} \frac{TFC_{ij}}{TFC_i} \frac{TFC_i}{VN} \frac{VN}{POP} POP \\
& + \sum_{i=H}\sum_{j=1}^{7} \frac{CO_{2_{ij}}}{TFC_{ij}} \frac{TFC_{ij}}{TFC_i} \frac{TFC_i}{HEP} \frac{HEP}{POP} POP
\end{aligned}
$$

where CO_2 denotes total CO_2 emissions, and i and j represent the sector and energy category, respectively. While T and H represent the transportation sector and residential sector, respectively, the numbers from 1 to 3 for i denote the primary, secondary, and tertiary industry, respectively. TFC is the total final energy consumption, and VN and HEP denote vehicle number and total household expenditure, respectively. Finally, POP is the total population.

The first component on the right side of the above equation represents the CO_2 emission intensity from the use of the final energy in sector i for energy category j. The second component measures the structure of the energy categories for the total final energy consumption in sector i. The third component is the energy efficiency in reference to the scale of activities for each sector. In the production sectors, the respective value added is employed as a proxy for the scale of activities that demand energy. On the other hand, vehicle number and total household expenditures are used as the proxies for the scale of activities in the transportation and residential sectors, respectively. Due to data availability, the fourth component in the three production sectors captures the macro industrial structure. The transportation and residential sectors may be broken down to subsectors of activities, such as different transportation modes or the difference between passenger and freight transport for the transportation sector and urban and rural households or different social groups of households for the residential sector. However, due to data limitations, the present analysis does not include the structural component of energy-demanding activities in the transportation and residential sectors. The last two components, the per capita activity levels and the population, in all five sectors, are added.

With the use of indices, the aforementioned equation is converted to

$$
\begin{aligned}
CO_2 = {} & \sum_{i=1}^{3}\sum_{j=1}^{7} CI_{ij}\, ENS_{ij}\, ENE_i\, ECS_i\, INC\, POP \\
& + \sum_{i=T}\sum_{j=1}^{7} CI_{ij}\, ENS_{ij}\, ENE_i\, VI\, POP \\
& + \sum_{i=H}\sum_{j=1}^{7} CI_{ij}\, ENS_{ij}\, ENE_i\, HI\, POP
\end{aligned}
$$

By taking the logarithmic differentiation with respect to time t, the following differential equation is derived:

$$\frac{d\ln\mathrm{CO_2}}{dt}$$

$$= \sum_{i=1}^{3}\sum_{j=1}^{7}\frac{\mathrm{CI}_{ij}\,\mathrm{ENS}_{ij}\,\mathrm{ENE}_i\,\mathrm{ECS}_i\,\mathrm{INC}\,\mathrm{POP}}{\mathrm{CO_2}}$$
$$\times\left(\frac{d\mathrm{InCI}_{ij}}{dt}+\frac{d\mathrm{InENS}_{ij}}{dt}+\frac{d\ln\mathrm{ENE}_i}{dt}+\frac{d\ln\mathrm{ECS}_i}{dt}+\frac{d\ln\mathrm{INC}}{dt}+\frac{d\ln\mathrm{POP}}{dt}\right)$$
$$\times\sum_{i=T}\sum_{j=1}^{7}\frac{\mathrm{CI}_{ij}\,\mathrm{ENS}_{ij}\,\mathrm{ENE}_i\,\mathrm{VI}\,\mathrm{POP}}{\mathrm{CO_2}}$$
$$\times\left(\frac{d\mathrm{InCI}_{ij}}{dt}+\frac{d\mathrm{InENS}_{ij}}{dt}+\frac{d\ln\mathrm{ENE}_i}{dt}+\frac{d\ln\mathrm{VI}}{dt}+\frac{d\ln\mathrm{POP}}{dt}\right)$$
$$\times\sum_{i=H}\sum_{j=1}^{7}\frac{\mathrm{ENS}_{ij}\,\mathrm{ENE}_i\,\mathrm{HI}\,\mathrm{POP}}{\mathrm{CO_2}}$$
$$\times\left(\frac{d\mathrm{InCI}_{ij}}{dt}+\frac{d\mathrm{InENS}_{ij}}{dt}+\frac{d\ln\mathrm{ENE}_i}{dt}+\frac{d\ln\mathrm{HI}}{dt}+\frac{d\ln\mathrm{POP}}{dt}\right)$$

Then, integrating over the time interval [0, T] yields

$$\mathrm{In}\left(\frac{\mathrm{CO_2}_T}{\mathrm{CO_2}_0}\right)$$
$$=\sum_{i=1}^{3}\sum_{j=1}^{7}\int_0^T w_{ij}\left(\frac{d\mathrm{InCI}_{ij}}{dt}+\frac{d\mathrm{InENS}_{ij}}{dt}+\frac{d\ln\mathrm{ENE}_i}{dt}+\frac{d\ln\mathrm{ECS}_i}{dt}+\frac{d\ln\mathrm{INC}}{dt}+\frac{d\ln\mathrm{POP}}{dt}\right)dt$$
$$+\sum_{i=T}\sum_{j=1}^{7}\int_0^T w_{ij}\left(\frac{d\mathrm{InCI}_{ij}}{dt}+\frac{d\mathrm{InENS}_{ij}}{dt}+\frac{d\ln\mathrm{ENE}_i}{dt}+\frac{d\ln\mathrm{VI}}{dt}+\frac{d\ln\mathrm{POP}}{dt}\right)dt$$
$$+\sum_{i=H}\sum_{j=1}^{7}\int_0^T w_{ij}\left(\frac{d\mathrm{InCI}_{ij}}{dt}+\frac{d\mathrm{InENS}_{ij}}{dt}+\frac{d\ln\mathrm{ENE}_i}{dt}+\frac{d\ln\mathrm{HI}}{dt}+\frac{d\ln\mathrm{POP}}{dt}\right)dt$$

Here, we employ the logarithmic mean for deriving the average share of each element of CO_2 emissions over the time interval [0, T] as the weight function $w_{ij}{}^{*}$, which is mathematically expressed as

$$w_{ij}^{*}=\frac{L\left(\mathrm{CO_2}_{ij,0,},\mathrm{CO_2}_{ij,T}\right)}{L\left(\mathrm{CO_2}_{0,},\mathrm{CO_2}_{T}\right)}$$

Thus, we obtain the following model known as the log mean Divisia index I (LMDI-I) method (Ang and Liu 2001):

$$\begin{aligned}\frac{CO_{2_T}}{CO_{2_0}} = & \exp\left[\sum_{i=1}^{3}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{CI_{ij,T}}{CI_{ij,\ 0}}\right] \times \exp\left[\sum_{i=1}^{3}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{ENS_{ij,T}}{ENS_{ij,\ 0}}\right] \\ & \times\exp\left[\sum_{i=1}^{3}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{ENE_{i,T}}{ENE_{i,\ 0}}\right] \times \exp\left[\sum_{i=1}^{3}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{ECS_{i,T}}{ECS_{i,\ 0}}\right] \\ & \times\exp\left[\sum_{i=1}^{3}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{INC_T}{INC_0}\right] \times \exp\left[\sum_{i=1}^{3}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{POP_T}{POP_0}\right] \\ & \times\exp\left[\sum_{i=T}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{CI_{ij,T}}{CI_{ij,\ 0}}\right] \times \exp\left[\sum_{i=T}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{ENS_{ij,T}}{ENS_{ij,\ 0}}\right] \\ & \times\exp\left[\sum_{i=T}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{ENE_{i,T}}{ENE_{i,\ 0}}\right] \times \exp\left[\sum_{i=T}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{VI_T}{VI_0}\right] \\ & \times\exp\left[\sum_{i=T}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{POP_T}{POP_0}\right] \times \exp\left[\sum_{i=H}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{CI_{ij,T}}{CI_{ij,\ 0}}\right] \\ & \times\exp\left[\sum_{i=H}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{ENS_{ij,T}}{ENS_{ij,\ 0}}\right] \times \exp\left[\sum_{i=H}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{ENE_{i,T}}{ENE_{\mathrm{i},\ 0}}\right] \\ & \times\exp\left[\sum_{i=H}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{HI_T}{HI_0}\right] \times \exp\left[\sum_{i=H}\sum_{j=1}^{7} w_{ij}^{*}\ln\frac{POP_T}{POP_0}\right]\end{aligned}$$

Reorganizing the factors by type, the total change in CO_2 emissions over the time interval [0, T], denoted by D_{TOT}, is decomposed into six types of factorial effects, D_{CI} (carbon intensity effects), D_{ENS} (energy structure effects), D_{ENE} (energy efficiency effects), D_{ECS} (economic structure effects), D_{INT} (activity intensity effects), and D_{POP} (demographic effects), in the following multiplicative form:

$$D_{TOT} = D_{CI} \cdot D_{ENS} \cdot D_{ENE} \cdot D_{ECS} \cdot D_{INT} \cdot D_{POP}$$

where each factor is defined as follows:

$$D_{\mathrm{TOT}} = \frac{\mathrm{CO}_{2_T}}{\mathrm{CO}_{2_0}}$$

$$D_{\mathrm{CI}} = \exp\left[\sum_{i=1}^{3}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{CI}_{ij,T}}{\mathrm{CI}_{ij,\,0}}\right] \times \exp\left[\sum_{i=T}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{CI}_{ij,T}}{\mathrm{CI}_{ij,\,0}}\right] \times \exp\left[\sum_{i=H}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{CI}_{ij,T}}{\mathrm{CI}_{ij,\,0}}\right]$$

$$D_{\mathrm{ENS}} = \exp\left[\sum_{i=1}^{3}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{ENS}_{ij,T}}{\mathrm{ENS}_{ij,\,0}}\right] \times \exp\left[\sum_{i=T}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{ENS}_{ij,T}}{\mathrm{ENS}_{ij,\,0}}\right] \times \exp\left[\sum_{i=H}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{ENS}_{ij,T}}{\mathrm{ENS}_{ij,\,0}}\right]$$

$$D_{\mathrm{ENE}} = \exp\left[\sum_{i=1}^{3}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{ENE}_{i,T}}{\mathrm{ENE}_{i,\,0}}\right] \times \exp\left[\sum_{i=T}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{ENE}_{i,T}}{\mathrm{ENE}_{i,\,0}}\right] \times \exp\left[\sum_{i=H}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{ENE}_{i,T}}{\mathrm{ENE}_{i,\,0}}\right]$$

$$D_{ECS} = \exp\left[\sum_{i=1}^{3}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{ECS}_{i,T}}{\mathrm{ECS}_{i,\,0}}\right]$$

$$D_{\mathrm{INT}} = \exp\left[\sum_{i=1}^{3}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{INC}_T}{\mathrm{INC}_0}\right] \times \exp\left[\sum_{i=T}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{VI}_T}{\mathrm{VI}_0}\right] \times \exp\left[\sum_{i=H}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{HI}_T}{\mathrm{HI}_0}\right]$$

$$D_{\mathrm{POP}} = \exp\left[\sum_{i=1}^{3}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{POP}_T}{\mathrm{POP}_0}\right] \times \exp\left[\sum_{i=T}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{POP}_T}{\mathrm{POP}_0}\right] \times \exp\left[\sum_{i=H}\sum_{j=1}^{7} w_{ij}^{*} \ln \frac{\mathrm{POP}_T}{\mathrm{POP}_0}\right]$$

1.3 Results

The LMDI-I model is applied in two ways: (A) by comparing the three periods of different political regimes, namely, the Suharto regime from 1971 to 1997, the transition regime from 1999 to 2003, and the Yudhoyono regime from 2004 to 2011 and (B) by fixing the initial year as 1971 and determining annual changes over the following 40 years sequentially.

1.3.1 Results of Periodical Analysis

During the Suharto regime, the CO_2 emissions increased by more than eight times over 26 years, which corresponds to an 8.53 % annual growth rate (Figs. 1.10 and 1.11). Four factors positively contributed to the growth of CO_2 emissions: energy structure effects, economic structure effects, activity intensity effects, and demographic effects. Two factors negatively contributed to the growth: carbon intensity effects and energy efficiency effects. Among the positive factors, activity intensity effects contributed the most by more than a factor of 4, followed by energy structure effects and demographic effects. A further breakdown of the activity intensity effects by sector reveals that the transportation sector has the largest positive effects on increasing CO_2 emissions, followed by the residential and secondary industry

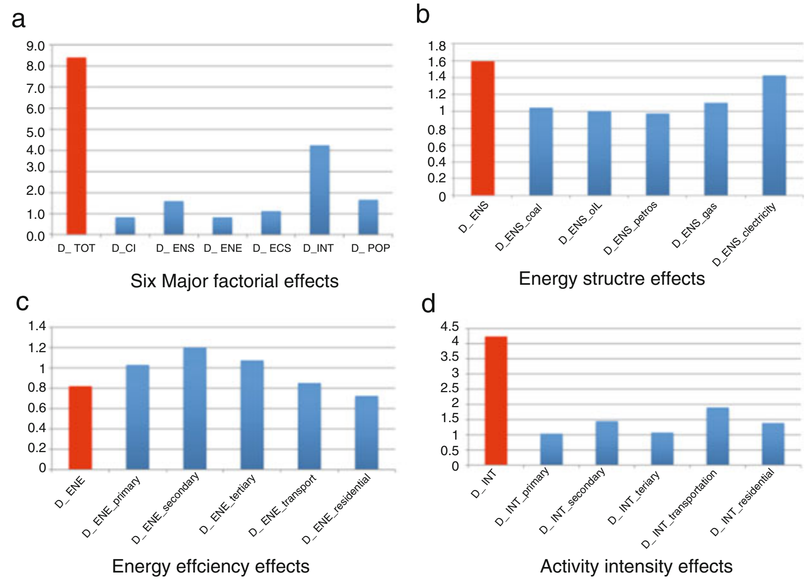

Fig. 1.10 Results of the decomposition analysis during the Suharto regime

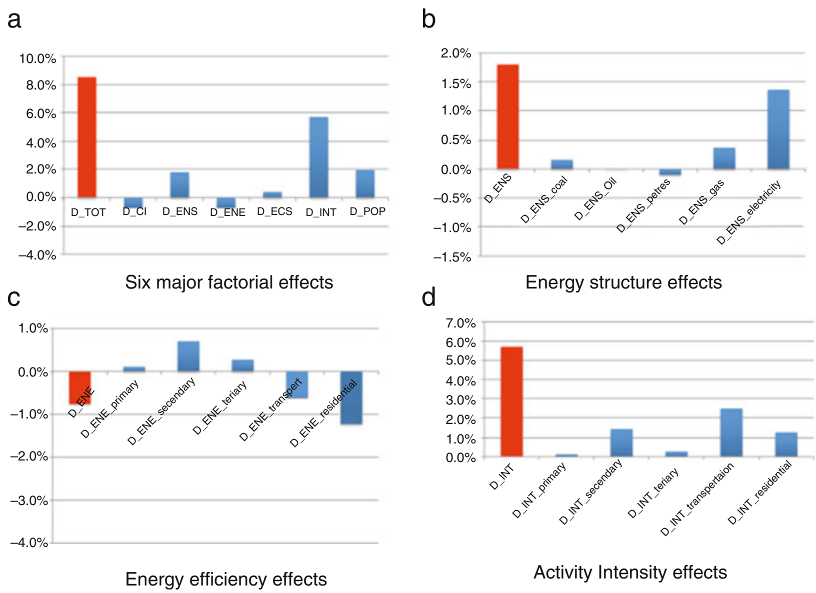

Fig. 1.11 Results of the decomposition analysis during the Suharto regime (Average annual change in percentage)

sectors. Other than activity intensity effects, electrification played an important role in explaining the changes in overall CO_2 emissions during the Suharto regime. The energy structure effects had the largest positive effects on increasing electricity consumption among the other energy categories. On the other hand, the carbon intensity effects, which are exclusively explained by carbon intensity in electricity because the other emission factors are assumed to be unchanged, had a negative contribution by a factor of 0.82 due to the significant use of natural gas. Regarding the energy efficiency effects, the aggregate effects show a negative effect on increasing CO_2 emissions. However, further breakdown by sectoral contributions reveals mixed effects. While the three production sectors had positive effects by worsening the energy efficiency, the energy efficiency of the transportation and residential sectors were improved. Because the activity intensity of transportation is calculated from the vehicle number (stocks) per person, care should be taken when interpreting these results because not only fuel efficiency but also per person transported and/or per ton transported might also affect the stocks per person. In the residential sector, wide deployment of various modern fuels that substitute for traditional biomass might have improved the efficiency.

For the transition regime, the CO_2 emissions increased by 21 % during the 4 years, which corresponds to a 4.99 % annual growth rate (Figs. 1.12 and 1.13). The energy efficiency factor continued to negatively contribute to the growth of CO_2 emissions, mainly due to the decline of the secondary industry, whereas economic structure effects changed from a positive to a slightly negative contributor during the transition regime. Unlike in the Suharto regime, the energy efficiency in the transportation and residential sectors did not largely contribute to the mitigation of the increase in CO_2 emissions. On the other hand, carbon intensity became a positive factor, as coal used for power generation increased, and natural gas used actually decreased during the period. For the energy structure effects, coal, natural gas, and electricity consistently had large positive effects, but petroleum products had negative effects due to a decrease in the dependency on petroleum products. Another clear difference of the transition regime was that the intensity effects were half of those observed in the Suharto regime due to the economic slowdown.

For the Yudhoyono regime, the CO_2 emissions increased by 39 % during the 7 years, which corresponds to a 4.83 % annual growth rate (Figs. 1.14 and 1.15). A noteworthy finding is the large and comprehensive improvement of energy efficiency across all sectors due to the rise in energy prices, which mitigates the strong increase of CO_2 emissions during the same period because of the recovery of the intensity effects to the level of the Suharto regime. For the energy structure effects, the dependency on petroleum products continued to decline and thus negatively contributed the growth of CO_2 emissions. Similarly, coal and electricity use continued to increase, which had positive impacts on CO_2 emissions. Because motorization rapidly developed and the stocks per capita increased, the activity effects of the transportation sector increased. On the other hand, because the increase in energy demand did not grow as fast as that of stocks per capita, the energy

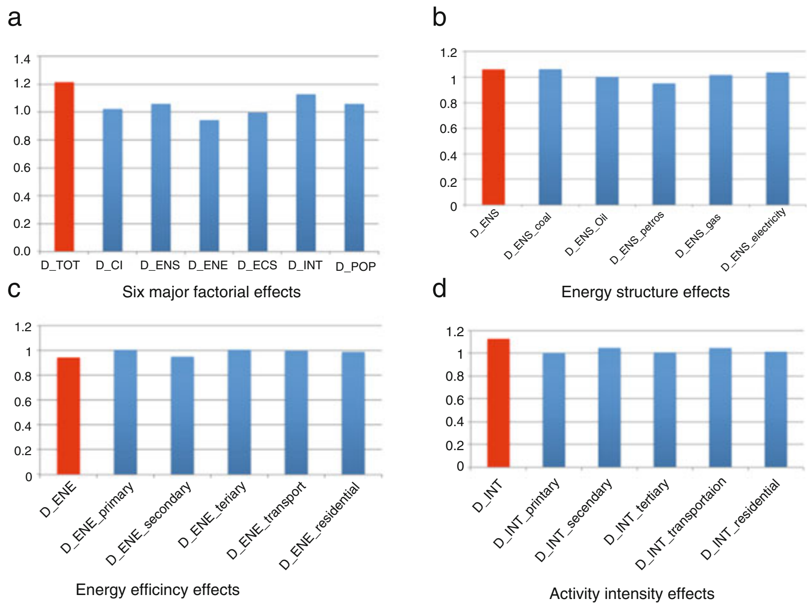

Fig. 1.12 Results of the decomposition analysis during the transition regime

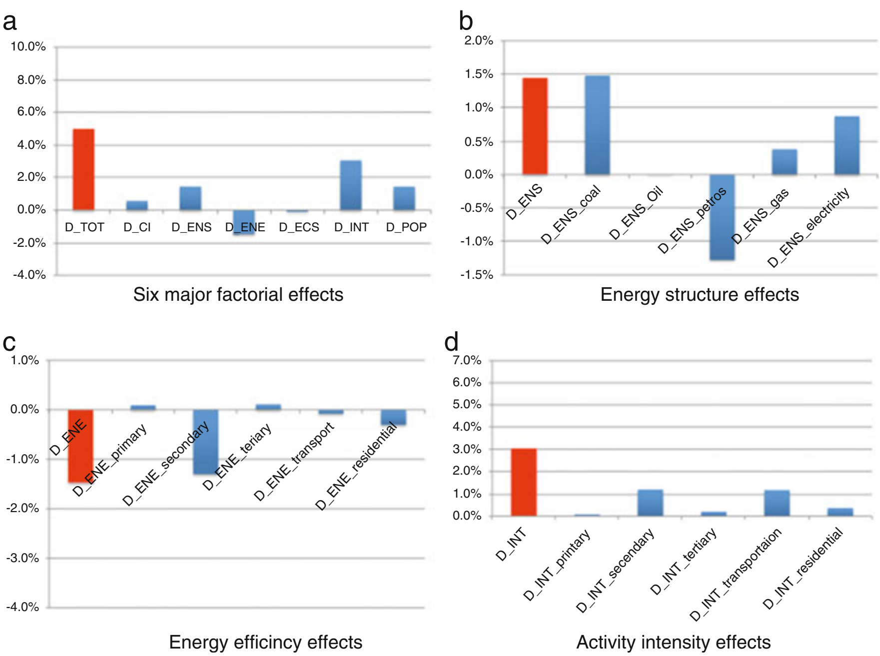

Fig. 1.13 Results of the decomposition analysis during the transition regime (Average annual change in percentage)

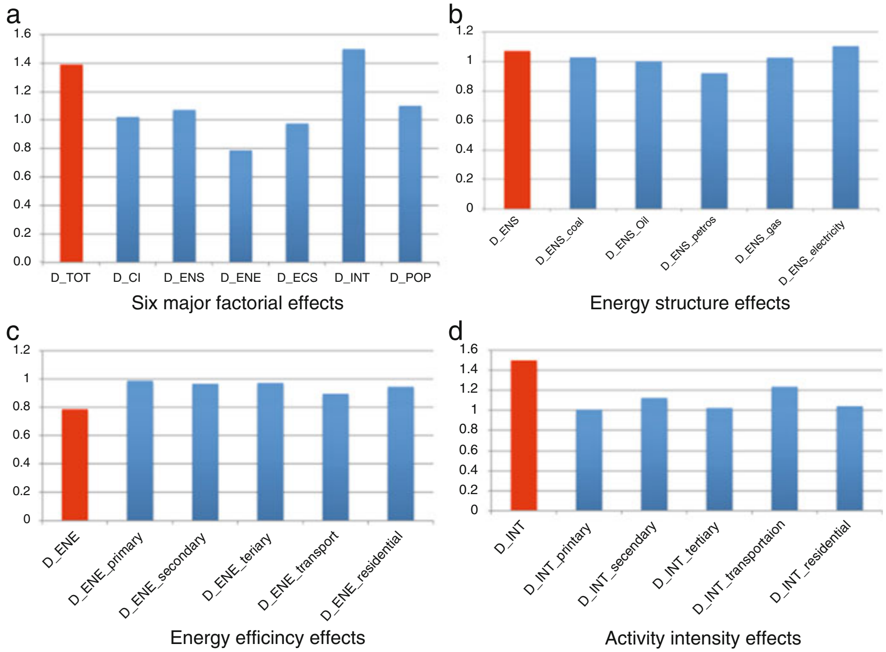

Fig. 1.14 Results of the decomposition analysis during the Yudhoyono regime

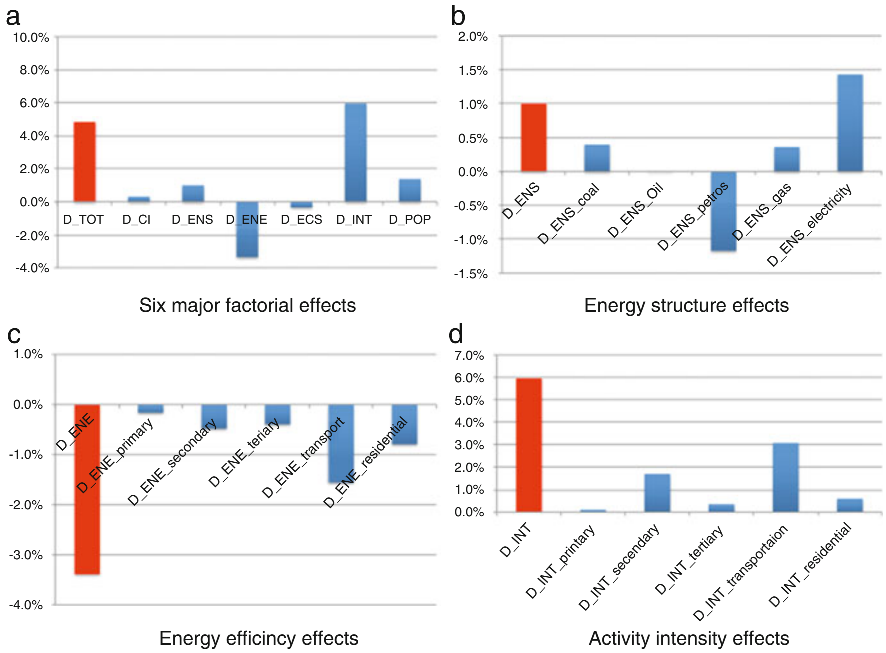

Fig. 1.15 Results of the decomposition analysis during the Yudhoyono regime (Average annual change in percentage)

efficiency effects in the transportation sector had negative effects to a large extent on the growth of CO_2 emissions.

1.3.2 Results of the Sequential Analysis and the Counterfactual Analysis

When the decomposition model is annually applied by fixing the initial year, cumulative changes in the effects of determinants on CO_2 emissions over time can be examined. Figure 1.16 shows the cumulative changes of the effects for key determinants. Because the intensity effects have a different scale for their impacts (positive), they are shown on the right axis. The trend of the intensity effects is similar to that of GDP growth. Among the other determinants, the energy structure effects contribute to increasing CO_2 emissions throughout the analysis period, except for the early 1990s and the recent period after 2005, when they did not have much impact. The second determinant is the demographic effects, which have constant positive effects on CO_2 emissions. The economic structure effects have weak positive effects on CO_2 emissions, although since 2000, no impact or even slightly negative impacts have been observed. The other two factors, carbon intensity effects and energy efficiency effects, have moved in the negative region. The carbon intensity effects, which represent the carbon intensity of electricity mentioned earlier, declined due to the increase in natural gas until the 1990s, when the trend stopped because of the increase in coal use for power generation. Compared to the fuel mix used for power generation in 1971, the current fuel mix has a 20 % less carbon intense structure. On the other hand, the energy efficiency effects demonstrate a fluctuating trend over the last 40 years. The first sharp drop was in the early 1980s, with a worsening trend until around the regime shift in 1998. After the regime shift, the energy efficiency started and continued to improve until now. Compared to the energy efficiency in 1971, the current energy efficiency is higher, which reduced CO_2 emissions by 30 %.

As in the energy efficiency market report by IEA, the results of the decomposition analysis can be further utilized for analyzing hypothetical cases, which is known as a counterfactual analysis. The IEA energy efficiency market reports evaluate the energy savings from energy efficiency (IEA 2014). Similarly, the present study evaluates what would be the CO_2 emissions if the carbon intensity, the energy efficiency, and the energy structure had not changed using a counterfactual analysis. In reference to the actual CO_2 emissions in 2011 of 368 million tons, the CO_2 emissions in the counterfactual case, under the assumption of unchanged energy efficiency throughout the analytical period, would be 464 million tons, representing a 25 % increase in the total cumulative CO_2 emissions. In particular, the gap between the actual emissions and the emissions for unchanged energy efficiency has widened since 2000. Assuming unchanged carbon intensity, the case shows a 20 % increase in the total cumulative CO_2 emissions. On the other hand, the impact of changes in the

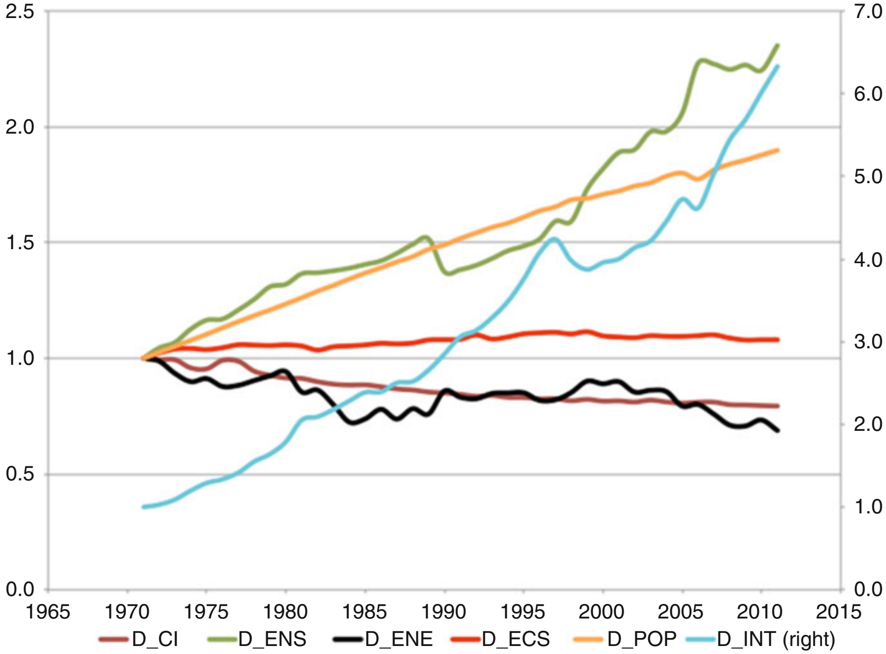

Fig. 1.16 Results of the decomposition analysis with sequential approach (1971 = 1)

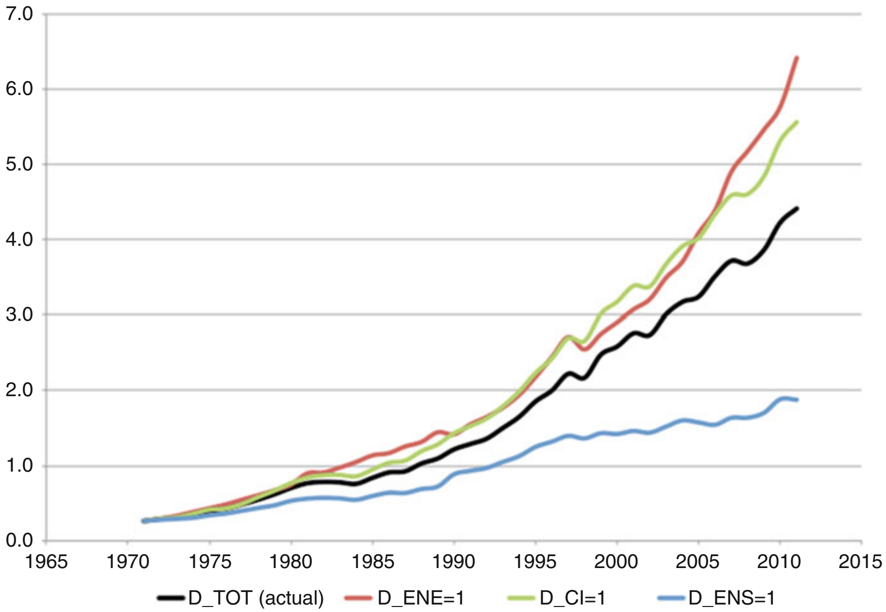

Fig. 1.17 Results of the counterfactual analysis using the results of the decomposition analysis (Million TOE)

energy structure on CO_2 emissions can also be evaluated by the counterfactual analysis. If the energy structure was fixed as in 1971, when approximately 80 % of the final energy consumption was from conventional renewable energy, the CO_2 emissions would be less than half in 2011, even though the carbon intensity for electricity increased, which results in a 43 % decrease in the total cumulative CO_2 emissions. Although the energy structure effects are much more significant than those of the carbon intensity and energy efficiency effects, it is noted that the results of the counterfactual analysis depend on the condition of initial year (Fig. 1.17).

1.4 Concluding Remarks

In this chapter, the nexus of economic growth, energy use, and CO_2 emissions over the last 40 years is examined by LMDI-I decomposition analysis. The 40 years are divided into three different regimes, during which a developmental dictatorship was transformed to a more democratic regime. Also during this period, Indonesia, known as one of the oil resource-rich countries, became a net oil-importing country in 2004 and withdrew its membership from OPEC in 2008. This transition from oil producer to oil consumer largely affects the CO_2 emissions of Indonesia.

Major findings of the analyses in this chapter are summarized as follows: (1) coal started to play an important role in exports and power generation, which have positive effects on CO_2 emissions; (2) the price increase of oil commodities due to the fuel subsidy removal and the rise of international oil price accelerated improvements in energy efficiency; and (3) the transportation sector became increasingly important to increasing CO_2 emissions.

For future perspectives, several considerations can be noted. (1) As the export structure dependency on the primary industry increases, increased productivity and environmental efficiency in the manufacturing sector are important for employment and international competitiveness (Chap. 9 of this book further explores this concept). (2) The commercial and public administration sector is relatively small at the moment and is expected to expand, for which electricity consumption would be a major category of their energy demand. Therefore, reducing the energy demand and saving electricity in the sector, together with the residential sector, would be important (Chap. 10 of this book further explores this concept by studying the case of air conditioners used by residents of Jakarta). (3) Because motorization is expected to continue, energy savings in the transportation sector have significant effects on CO_2 emissions. Thus, the prices of fuels for vehicles should be properly managed (Chap. 11 of this book further explores this concept by studying the case of Jakarta). (4) The carbon intensity of power generation plays an important role and the promotion of renewable energy should be considered (Chap. 12 of this book further explores this concept by studying the case of waste-to-energy technology).

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Chapter 2
Government Policies and Institutions for Climate Change Mitigation and Its Monitoring, Evaluation, and Reporting

Junko Morizane, Takeshi Enoki, Noriko Hase, and Budhi Setiawan

Abstract This chapter will introduce climate change mitigation policies and institutions in Indonesia. In September 2009, the president of Indonesia stated that Indonesia would reduce emissions by 26 % unilaterally and up to 41 % with international support by 2020 compared to business as usual emission level. The Presidential Regulation No. 61/Year 2011 on the National Action Plan on GHG emission reduction (RAN-GRK) was issued to achieve this voluntary commitment. In addition, the Presidential Regulation No. 71/Year 2011 on national GHG inventory was issued with the objective of providing regular information on status and trend of GHG emissions and removals. The institutional arrangement related to climate change mitigation, including several funding mechanisms such as the Joint Crediting Mechanism (JCM), has also been developed in Indonesia. These initiatives are linked with international reporting requirements. To comply with the more regular and frequent reporting requirement, Indonesia will need to make a transition from a temporary project-based approach to a more permanent and institution-based approach.

Keywords GHG emissions • Mitigation actions • GHG inventory • NAMA • MRV • REDD+

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2.1 Introduction

While Indonesia is widely recognized as one of largest greenhouse gas (GHG) emitters in the world, it has been making efforts to reconcile sustainable development and climate change policy. The government has legalized the National Action Plan on GHG emission reduction (*Rencana Aksi Nasional Penurunan Emisi Gas Rumah Kaca*, RAN-GRK) and the national GHG inventory as the Presidential Regulations. These progressive national initiatives have a close linkage with international efforts, such as reporting obligation under the United Nations Framework Convention on Climate Change (UNFCCC).

This chapter will give an overview concerning Indonesia's policies and institutional arrangement of climate change mitigation. It will start with presenting the GHG emissions status and trend and provide an overview of policies and institutions related to climate change mitigation in Indonesia. It will then describe international cooperation and funding mechanisms for mitigation actions.

2.2 GHG Emission Status and Trend

A national GHG inventory identifies and quantifies a country's anthropogenic sources and sinks of GHGs to serve as input to developing climate change mitigation policy and tracking its progress. The national GHG inventory adheres to a set of methodologies for estimating sources and sinks of GHGs established by the Intergovernmental Panel on Climate Change (IPCC) and a common and consistent mechanism that enables Parties to the UNFCCC to compare their emission sources and sinks.

The IPCC defines five sectors for the national GHG inventory, namely, energy; industrial processes and product use; agriculture; land use, land-use change, and forestry (LULUCF); and waste sectors. The major gases covered by the national GHG inventory are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and three groups of fluorinated gases: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). All Parties to the UNFCCC have an obligation to prepare GHG inventories that cover all sectors and gases to the best of their capabilities.

Indonesia has submitted its national GHG inventory to the UNFCCC in 1999 and 2011, as a part of their Initial National Communications (INC) and Second National Communications (SNC), respectively. The figures in this section are adopted from the Indonesian SNC, which includes emission/removal estimates from 2000 to 2004 for all sectors and emissions for 2005 without LULUCF (Tables 2.1 and 2.2).

In 2004, total GHG emissions were 663,770 gigagrams (1,000 tons) (Gg) CO_2 equivalent (eq.) without LULUCF and 1,721,193 Gg CO_2 eq. with LULUCF (including peat fire). This represents a significant emission increase of 19.3 % compared to 2000 without LULUCF and 24.9 % with LULUCF. In 2004, GHG

Table 2.1 Trend of GHG emissions in Indonesia by sector (Ministry of Environment 2010)

	2000	2001	2002	2003	2004	2005
Energy	280,938	306,774	327,911	333,950	372,123	369,800
Industrial processes	42,814	49,810	43,716	46,118	47,985	48,733
Agriculture	75,420	77,501	77,030	79,829	77,863	80,179
LULUCF	821,254	754,546	1,965,495	591,489	1,057,423	–
Waste	157,328	160,818	162,800	164,074	165,799	166,831
Total GHG emissions (without LULUCF)	556,499	594,903	611,457	623,971	663,770	665,544
Total GHG emissions (with LULUCF)	1,377,753	1,349,449	2,576,952	1,215,460	1,721,193	–

Unit: Gg CO_2 equivalent

Table 2.2 Trend of GHG emissions in Indonesia by gas (Ministry of Environment 2010)

	2000	2001	2002	2003	2004	2005
GHG emissions without LULUCF	**556,354**	**594,758**	**611,312**	**623,826**	**663,625**	**665,399**
CO_2	291,705	326,111	343,526	351,171	391,648	390,478
CH_4	236,332	238,815	238,167	241,981	240,151	242,299
N_2O	28,317	29,831	29,618	30,674	31,825	32,622
PFCs	145	145	145	145	145	145
GHG emissions with LULUCF	**1,377,608**	**1,349,304**	**2,576,807**	**1,215,315**	**1,721,048**	–
CO_2	1,112,879	1,080,518	2,309,001	942,642	1,449,040	–
CH_4	236,388	238,955	238,181	241,994	240,173	–
N_2O	28,341	29,832	29,624	30,679	31,835	–
PFCs	145	145	145	145	145	–

Unit: Gg CO_2 equivalent

emissions from the LULUCF sector amounted to 1,057,423 Gg CO_2 eq., being the most dominant sector in the Indonesian GHG inventory. GHG emissions from the energy sector amounted to 372,123 Gg CO_2 eq., which represents 56.1 % of total GHG emissions without LULUCF, followed by waste sector (165,799 Gg CO_2, 25.0 %), agriculture sector (77,863 Gg CO_2 eq., 11.7 %), and industrial processes and product use sector (47,9585 Gg CO_2 eq., 7.2 %). In terms of gases, CO_2 was the main GHG emitted with 391,648 Gg CO_2 eq., followed by CH_4 of 240,151 Gg CO_2 eq. and N_2O of 31,825 Gg CO_2 eq. representing 59.0 %, 36.2 %, and 4.8 % of total GHG emissions, respectively, without LULUCF.

The GHG emissions fluctuate over the years mostly due to the LULUCF sector, which is the most uncertain of all the sectors in the Indonesian GHG inventory. High emissions tend to occur when El Niño events are observed (e.g., in 2002–2003, 2004–2005, and 2006–2007). According to the SNC, a 2007 study by Pelangi Energi Abdi Citra Enviro, World Bank, and the United Kingdom Department for International Development estimated land-use change and forestry

(LUCF) emissions to be 2,563,000 Gg CO_2 (approximately twice the amount reported in the SNC), while another study conducted by the National Council on Climate Change (*Dewan Nasional Perubahan Iklim*, DNPI) in 2009 suggested that the total GHG emissions from LUCF in 2005 reached 1,880,000 Gg CO_2 eq. The SNC includes information on these and other studies and acknowledges the high uncertainty of the GHG inventory. An important challenge for Indonesia is to improve the quality of emission and removal estimation of the LULUCF sector.

While the GHG inventory data submitted to the UNFCCC is considered the "official" dataset for a country's GHG emissions and removals, international organizations and research institutions independently estimate GHG emissions of countries. The International Energy Agency (IEA) is one such agency that estimates GHG emissions from countries on an annual basis. In IEA (2013), GHG emissions and removals are estimated using IEA energy databases, as well as the default methods and emission factors provided by the IPCC. Figure 2.1 shows the GHG emissions in Indonesia estimated by the IEA for the years 1990, 2000, 2005, 2008, and 2010. In 2010, total GHG emissions including LULUCF were 1,926,000 Gg CO_2 eq., increasing by 75 % and 33 % compared to 1990 and 2000, respectively. Like the results of the Indonesian SNC, a significant fluctuation can be observed due to the LULUCF sector. According to the IEA, the GHG emissions from the LULUCF sector in 2005 were almost three times that of 1990 and over twice the amount of 2000 (from 731 Gg CO_2 eq emissions in 1990, 920 Gg CO_2 in 2000, and 2188 Gg CO_2 eq. in 2005).

According to the IEA, in 2010, Indonesia was the fifth largest GHG-emitting country in the world, higher than developed countries such as Japan, Germany, and Canada (Table 2.3). In a year where there were high emissions from the LULUCF sector in Indonesia, like in 2005, it was the third highest GHG-emitting country in the world, only behind China and the United States. As a fast growing economy with increasing trend of total GHG emissions, it is important for Indonesia to enhance its mitigation actions. However, a better understanding of GHG emission levels, specifically in the LULUCF sector, is critical, as this data is the fundamental input into projection and mitigation models.

2.3 Policies and Initiatives Regarding Mitigation Actions

2.3.1 National and Local Mitigation Action Plans

Climate change issue has been recognized as one of the critical challenges to be prioritized in national development in Indonesia since the 1990s, as shown in Table 2.4. A significant momentum was built at the thirteenth Conference of Parties (COP13) of the UNFCCC, which was hosted by the government of Indonesia in December 2007. In September 2009 at the G20 meeting in Pittsburg, the president

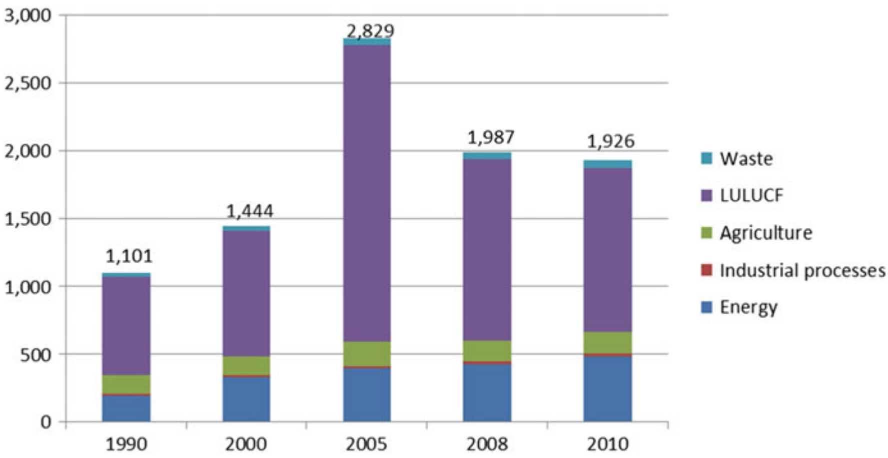

Fig. 2.1 GHG emissions in Indonesia (IEA 2013)

Table 2.3 Top 10 GHG-emitting countries (IEA 2013)

		1990	2000	2005	2008	2010
1	People's Republic of China	3873	5271	8074	9627	10,756
2	United States	6101	6926	7031	6872	6715
3	India	1354	1854	2104	2443	2776
4	Russian Federation	3517	2598	2528	2520	2481
5	**Indonesia**	**1101**	**1444**	**2829**	**1987**	**1926**
6	Brazil	1604	1451	2548	1464	1604
7	Japan	1298	1399	1431	1369	1351
8	Democratic Republic of Congo	1377	1037	949	1072	1113
9	Germany	1231	1037	995	991	949
10	Canada	597	730	781	740	717
	Other countries	15,947	16,496	18,051	19,330	19,441
	World total	38,000	40,242	47,321	48,415	49,829

Unit: Gg CO_2 equivalent

stated that Indonesia would be committed to voluntarily reduce its GHG emissions by 26 % by the year 2020 compared with business as usual (BAU) level with its own national efforts and 41 % with international support. This target was submitted in January 2010 to the UNFCCC in responding to the Copenhagen Accord adopted at COP15 in December 2009. Seven nationally appropriate mitigation actions (NAMA) were specified in order to achieve 26 % emission reduction by 2020: (1) sustainable peatland management, (2) reduction in deforestation and land degradation, (3) development of carbon sequestration projects in forestry and

Table 2.4 Chronology of climate change policy in Indonesia (by the authors)

August 1994	Ratification of the UNFCCC (signature in 1992)
October 1999	Submission of the First National Communications
December 2004	Ratification of Kyoto Protocol (signature in 1998)
January 2005	National Mid-term Development Plan (RPJMN 2004–2009)
February 2007	National Long-Term Development Plan (RPJPN 2005–2025)
November 2007	National Action Plan for Climate Change (RAN-PI)
December 2007	National Development Planning: Indonesia Responses to Climate Change
	UNFCCC COP13 in Bali
July 2008	Establishment of DNPI
September 2009	Indonesia Climate Change Trust Fund (ICCTF)
	Announcement of 26 % emission reduction target at G20 meeting in Pittsburg
December 2009	Indonesia Climate Change Sectoral Roadmap
	Announcement of 26 % reduction target at UNFCCC/COP15 in Copenhagen
January 2010	Submission of Indonesia NAMAs to the UNFCCC
March 2010	Revision of National Development Planning: Indonesia Responses to Climate Change (Yellow Book)
May 2010	RPJMN 2010–2015
November 2010	Submission of the Second National Communications
September 2011	Presidential Regulation No. 61/Year 2011 concerning RAN-GRK
October 2011	Presidential Regulation No. 71/Year 2011 concerning GHG Inventory

agriculture, (4) promotion of energy efficiency, (5) development of alternative and renewable energy sources, (6) reduction in solid and liquid waste, and (7) shifting to low-emission transportation mode.

To follow up this target, RAN-GRK was established to provide a policy framework to guide the central government, local governments, private sector, and other key stakeholders. It was issued as the Presidential Regulation No. 61/Year 2011 in September 2011. The Presidential Regulation No. 71/Year 2011 was also issued in October 2011 to regulate regular submission of national and regional GHG inventories developed by respective line ministries, agencies, and local governments. RAN-GRK includes sectoral target as shown in Table 2.5.

According to the Presidential Regulation No. 61/Year 2011, the provincial governments should develop their Local Action Plan for GHG emission reduction (*Rencana Aksi Daerah Penurunan Emisi Gas Rumah Kaca*, RAD-GRK). Most of the provinces have finalized respective RAD-GRK.

Table 2.5 Target by sector under RAN-GRK (Drawn from Presidential Regulation No. 61/Year 2011)

Sector	Emission reduction target (Giga ton CO_2e)		Core activity
	26 %	41 %	
Forestry and peatland	0.672 (87.6 %)	1.039 (87.4 %)	Forest and land fire control, network system management, water management, forestry and land rehabilitation, industrial plantation forest, community forest. Illegal logging eradication, deforestation prevention, community empowerment
Agriculture	0.008 (1.0 %)	0.011 (0.9 %)	Introduction of low-emission paddy varieties, irrigation water efficiency, organic fertilizer use
Industry	0.001 (0.1 %)	0.005 (0.4 %)	Energy efficiency, utilization of renewable energy
Energy and transportation	0.038 (5.0 %)	0.056 (4.7 %)	Biofuel use, engines with higher fuel efficiency standard, improvement in transportation demand management, improvement of public transportation and road, demand-side management, energy efficiency, renewable energy development
Waste	0.048 (6.3 %)	0.078 (6.6 %)	Use of final landfill site, 3R, urban integrated wastewater management
Total	0.767	1.189	

2.3.2 Monitoring, Evaluation, and Reporting of Mitigation Actions

The mechanism for monitoring, evaluation, and reporting (MER) of mitigation actions at both national and regional levels has been developed by the National Development Planning Agency (*Badan Perencanaan Pembangunan Nasional*, BAPPENAS), with support by donors. In this respect, BAPPENAS has been utilizing the existing monitoring and reporting system for the implementation of development plans. In 2013, BAPPENAS published the MER guideline, which consists of general and technical elements. It has also developed "MER online" as an effort to achieve effective and efficient coordination between central and local governments (RAN-GRK Secretariat 2014).

The general guideline is intended (1) to serve as a reference for ministries and other institutions in implementing MER of RAN-GRK at the national level, (2) to serve as a reference for local governments in implementing MER of RAD-GRK, and (3) to harmonize report on mitigation actions and GHG inventory. The guideline also contains information on goals, approach, and timeframe of MER. The template is provided by the guideline to accommodate information on a mitigation action, such as its reduction target, BAU, schedule, cost, and so forth.

The technical guideline is aimed at providing a reference especially for local government and other relevant institutions to identify and collect information about the implementation of RAD-GRK and providing instructions for the formulation and implementation mitigation actions as well as the calculation of GHG emission reductions. It is divided into (1) land-based sector including agriculture, forestry, and peatland; (2) energy sector including energy, transportation, and industry; and (3) waste management. The activities are also categorized into (1) core activities with direct impacts on emission reductions and (2) supporting and enabling activities with indirect impact on GHG emission reduction.

The MER online is based on the templates from the general and technical guidelines, as described above. The guideline for the MER online was also produced to support reporting by provincial governments and line ministries. This online system is also used for the evaluation of the progress of RAN-GRK and RAD-GRK.

2.3.3 GHG Inventory

Along with the GHG emission reduction's target of 26 % by 2020, the government also issued Presidential Regulation No. 71/Year 2011 regarding "Conducting National GHG Inventory" with the objective of providing regular information about the level, the status, and the trend of GHG emissions and removals, including carbon stock at national, provincial, and district levels, and to provide information on GHG emission reduction achievements of national climate change mitigation actions. Presidential Regulation No. 71/Year 2011 is the legal basis for the annual development of national and regional GHG inventories in Indonesia. The scope of the GHG inventory as described in Presidential Regulation No. 71/Year 2011 are the same as the UNFCCC inventory scope in terms of the sectors covered, the gases covered, and other requirements such as quality control/quality assurance activities, uncertainty analysis, and key category assessments. The Presidential Regulation No. 71/Year 2011 stipulates that the GHG inventories shall be prepared annually by relevant stakeholders. It also sets out general roles and responsibilities for the key stakeholders, as shown in Table 2.6. Indonesia has prepared two national GHG inventories to be submitted to the UNFCCC as part of its National Communications.

Table 2.6 Stakeholders and their roles and responsibilities in preparing the GHG inventory (Drawn from Presidential Regulation No. 71/Year 2011)

Stakeholder	Roles and responsibilities
Minister of Environment	Coordinate the preparation of GHG inventory
	Prepare guideline for the development and implementation of GHG inventory
	Monitor and evaluate GHG inventory processes and results
Relevant minister and/or non-ministry government institutions related to the GHG inventory	Prepare the relevant sectors of the GHG inventory
	Arrange GHG emission and removal of a trend of GHGs including carbon stock in accordance with the scope of roles and responsibilities
	Develop inventory methodologies and emission factor or removal of GHG in coordination with the stakeholders. The respected minister and/or head of non-ministry government institution assign responsible party to conduct the GHG inventory in the institution working unit
Governor	Prepare the GHG inventory at the provincial level; and coordinate the implementation of GHG inventory at the district and municipal levels. The governor appoints a local technical implementing unit to carry out the tasks
Regent and mayor	Responsible for GHG inventory implementation at the district and city. The regent or the mayor appoints local technical implementing unit to carry out the tasks

2.4 Institutional Arrangement for Climate Change Mitigation

2.4.1 Institutional Arrangement on Mitigation Actions

The institutional arrangement for climate change mitigation, including GHG inventory reporting, has evolved in Indonesia. This section presents roles and responsibilities of relevant ministries and institutions, including those related to reducing emissions from deforestation and forest degradation (REDD+).

Role and responsibility of relevant ministries/institutions were stipulated in the Presidential Regulation No. 61/Year 2011 regarding RAN-GRK and defined further in the subsequent relevant guidelines, as illustrated in Fig. 2.2. BAPPENAS is designated as a leading coordinating ministry. It is responsible for reviewing RAN-GRK in coordination with line ministries on the relevant sectors including forestry, agriculture, peatland, energy, industry, transportation, and waste. The review results shall be reported to the Coordinating Ministry for Economic Affairs. BAPPENAS is also responsible for setting the guidelines concerning RAD-GRK,

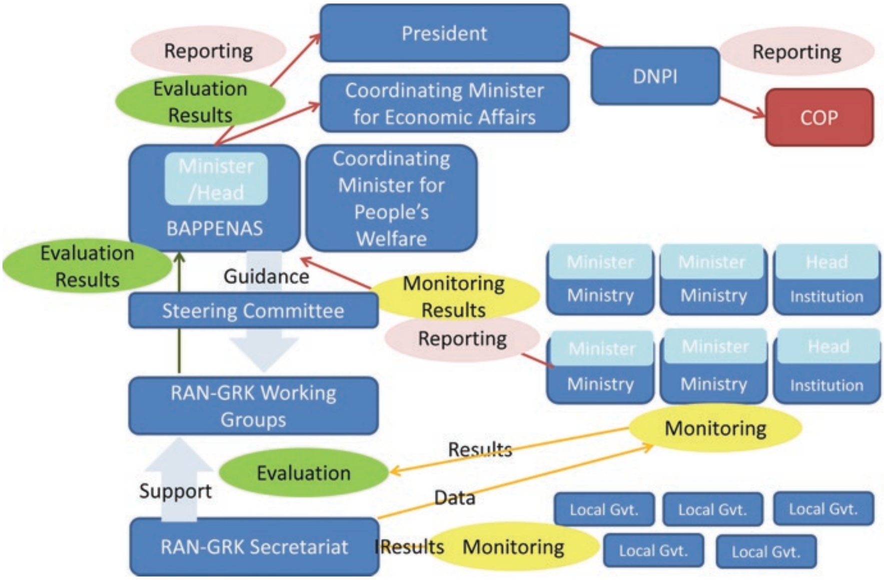

Fig. 2.2 Organizations of RAN-GRK and RAD-GRK (Drawn from the Presidential Regulation No. 61/Year 2011 regarding RAN-GRK)

in collaboration with the Ministry of Home Affairs (MOHA) and the Ministry of Environment (*Kementerian Lingkungan Hidup*, KLH).

A Coordination Team on Climate Change was established by the Decree of BAPPENAS Minister No. 38/M. PPN/HK/03.2012 in April 2012 in order to facilitate coordination between the ministries. The Coordination Team is responsible to develop policy recommendations on climate change mitigation and adaptation in line with the national development planning and RAN-GRK and to submit progress report to the Minister of BAPPENAS. There are six working groups under the Coordination Team, as shown in Fig. 2.3.

Indonesia has its own national mid-term (5 years) development plan (*Rencana Pembangunan Jangka Menengah Nasional*, RPJMN) and long-term (25 years) development plan (*Rencana Pembangunan Jangka Panjang Nasional*, RPJPN). BAPPENAS is in charge of developing development plans based on consultations with other ministries and various stakeholders. BAPPENAS is also responsible for monitoring the progress of these national development plans. Mainstreaming of climate change mitigation and adaptation has been taken into consideration in the drafting process of RPJMN for 2015–2019.

The RAN-GRK Secretariat was established in early 2012 by BAPPENAS with support by donors such as JICA, GIZ, and AusAID. The Secretariat is aimed at facilitating the implementation of RAN-GRK as well as its MER. The Secretariat supports the Coordination Team on Climate Change in planning and monitoring of RAN-GRK and RAD-GRK.

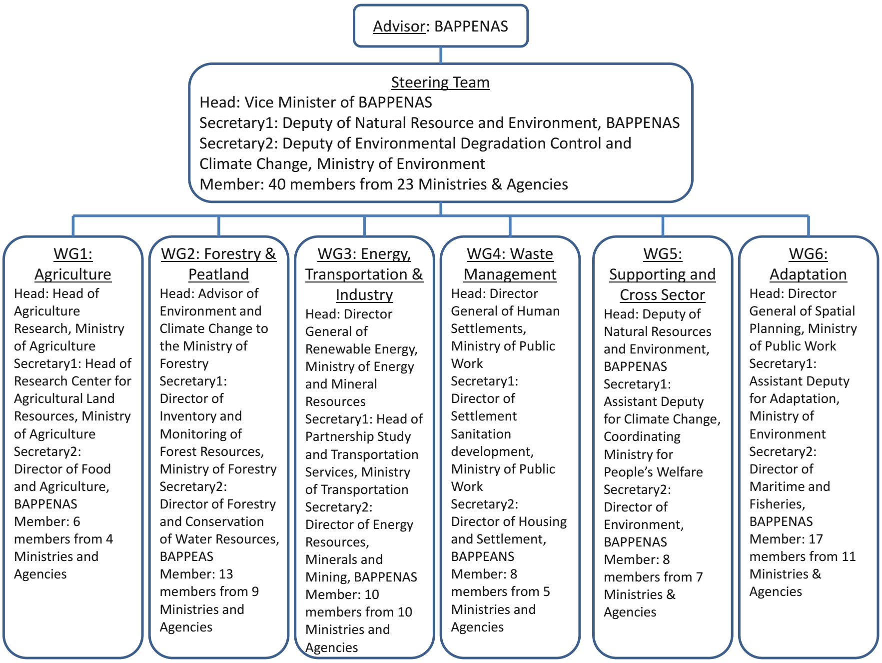

Fig. 2.3 Climate Change Coordination Team and Working Groups (BAPPENAS 2012)

The MOHA supports coordination between central and regional governments in developing and implementing RAD-GRK. Line ministries are responsible for mitigation actions under their respective jurisdictions. Progress report should be submitted periodically to the Coordinating Minister for Economic Affairs. The Presidential Regulation states that governors are responsible for developing RAD-GRK for their respective provinces in line with RAN-GRK and regional development priorities. The Regulation stipulates that funding of RAN-GRK is derived from state budget (*Anggaran Pendapatan dan Belanja Negara*, APBN), regional budget (*Anggaran Pendapatan dan Belanja Daerah*, APBD), and other sources. The Ministry of Finance is in the process of developing financial and fiscal incentive in order to ensure effective and efficient implementation of mitigation actions.

Indonesia has the second largest forest area in the world, which functions as carbon sinks in absorbing CO_2. Due to active forest exploitation, illegal logging, peatland fire, and other problems, however, LUCF is the biggest emission source in Indonesia. The Government of Indonesia and Government of the Kingdom of Norway signed a Letter of Intent (LoI) in May 2010 to establish a partnership for REDD+. Norway is committed to contribute up to 1 billion USD toward Indonesia's REDD+ efforts, and actual funds will be disbursed based on verified emission reductions. REDD+ Task Force was established by the Presidential Regulation No. 19/Year 2010. It is chaired by the Head of Presidential Unit for

Development Monitoring and Oversight (*Unit Kerja Presiden Bidang Pengawasan dan Pengendalian Pembangunan*, UKP4) and comprises high-level officials from key ministries and agencies as well as nongovernmental experts. The 2-year moratorium on the "Suspension of New Permits and Improvement of Governance on Primary Forest and Peatlands" (Presidential Instruction No. 10/Year 2011) was issued on 20 May 2011. In the meantime, the efforts for improvement on forest and peatland strategies and governance, including an initiative on a unified "One Map" of forests, are taken. REDD+ Agency was launched by the Presidential Regulation No. 62/Year 2013 in order to achieve emission reduction from deforestation and forest degradation and peatland and to ensure that these efforts are managed in an effective, efficient, equitable, and sustainable manner (Cabinet Secretariat 2013).

DNPI was established through the Presidential Regulation No. 46/Year 2008 in July 2008, to serve as a national focal point of the UNFCCC. In addition, DNPI also serves as focal point of Article 6 of the UNFCCC concerning educational and training on climate change. Before the above Presidential Regulation was issued, KLH had served as the national focal point for the UNFCCC as well as the designated national authority (DNA) under the Clean Development Mechanism (CDM), which is one of the flexible mechanisms under the Kyoto Protocol. Since 2008, however, DNPI has served as both a national focal point and DNA.

2.4.2 Institutional Arrangement on GHG Inventory

Since the enactment of the Presidential Regulation No. 71/Year 2011, KLH, relevant ministries, and provincial governments have taken steps to institutionalize the GHG inventory and implement the requirements set out in the Regulation. In December 2012, the National GHG Inventory System (*Sistem Inventarisasi Gas rumah kaca Nasional*, SIGN) Center was established under KLH. The members of the Center are mandated to lead all GHG inventory activities within KLH. In 2012, KLH drafted GHG inventory guidelines, along with a step-by-step manual for completing emission/removal estimation worksheets. Interministerial working groups, made up of technical experts from the relevant ministries, have met to discuss the process of preparing the sectoral national GHG inventories. In addition, KLH has held numerous workshops and seminars in Jakarta and the provinces to present the Presidential Regulation No. 71 requirements and to train staff of line ministries and provincial government agencies on the methods to prepare the GHG inventory.

At the time of this writing, many provinces have submitted their regional GHG inventories. However, a national GHG inventory has yet to be compiled by KLH, due to several challenges described in the section below.

The Presidential Regulation No. 71/Year 2011 provides legal basis for developing the annual regional and national GHG inventories. However, the inventory alone is not sufficient for the agencies' partnership to take place. Many organograms, like Fig. 2.4, have been developed to show the flow chart of Indonesian GHG Inventory National System. The challenge, however, is how to clearly define

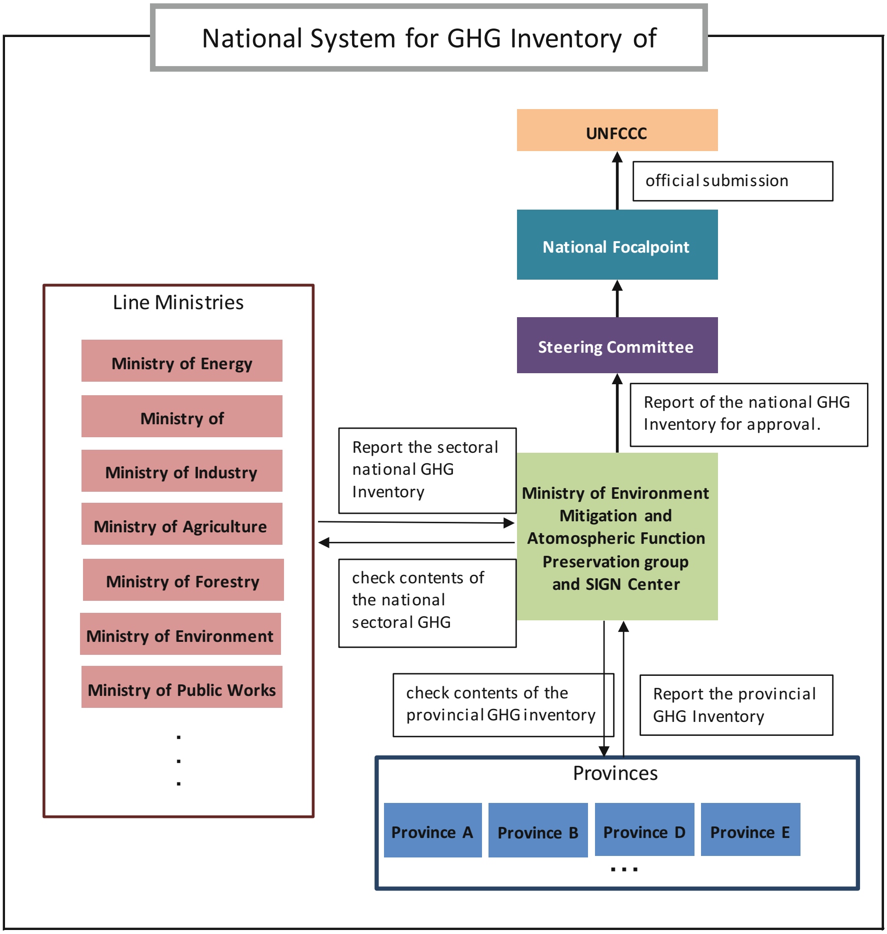

Fig. 2.4 Organizations of the GHG inventory preparation for the UNFCCC (Drawn from Presidential Regulation No. 71/Year 2011 "Conducting National GHG Inventory")

the elements in the institutional arrangements and formalizing them. For example, the Regulation No. 71/Year 2011 stipulates that KLH coordinates the preparation of GHG inventory. However, the Regulation does not clearly define what kind of coordinating activities that KLH is to undertake, especially for the activities that require collaboration with other relevant ministries. In addition, the Regulation does not specify which ministries are responsible for which categories. The GHG inventory contains several hundred emission/removal categories, many of which require coordination among ministries so that there is no duplication of emissions/removals' estimation.

The Presidential Regulation No. 71/Year 2011 is often described as two national GHG inventory preparation processes: a top-down (national level) approach and a bottom-up (subnational level) approach. However, there are many technical and practical challenges in developing a national GHG inventory as a sum of regional inventories. The role and purpose of the two inventories will need to be clarified so that relevant agencies can properly allocate resources for the two approaches. Although the SIGN Center was established in KLH, reliance on the advice of consultants is inevitable in the first stages of developing the GHG inventory system. It is necessary, however, to establish sustained national technical teams and retain their capacity and expertise. One way to address this is to prioritize the documentation of all methods and data sources used in the GHG inventory process to maintain a consistent process and institutional memory.

As GHG inventory preparation is relatively a new process in Indonesia, technical challenges like the lack of reliable activity data and emission factors are expected to be issues in the process. However, it is important to keep in mind that one of the key principles of the IPCC is “continuous improvement.” A GHG inventory that is fully transparent, accurate, comparable, complete, and consistent (the TACCC principles of the GHG inventory) is desirable, but the key priority in developing a good GHG inventory preparation cycle is to develop the national arrangements that serve as the foundation for all relevant work. Indonesia has several LULUCF estimates from different entities. The key is not for Indonesia to produce another LULUCF emission/removal estimate, but to efficiently coordinate with the existing experts to produce the best results using the resources available.

2.5 Linkage with International Efforts

All Parties to the UNFCCC have an obligation to report about the steps they are taking or envisage undertaking. Based on the principle of “common but differentiated responsibilities” in the Convention, the required information to be reported and the timetable to be submitted are different between Annex I and non-Annex I Parties. However, the provisions for reporting have evolved in recent years, resulting in enhanced reporting and more frequent reporting to be submitted by all Parties. This section presents main reporting requirements for non-Annex I Parties under the UNFCCC and describes the implications in Indonesia.

2.5.1 National Communications

Article 4, paragraph 1, and Article 12, paragraph 1, of the UNFCCC state that each Party should report to the COP about the emissions by sources and removals by sinks of all GHGs which are not included in the Montreal Protocol, the national or, where appropriate, regional programs that contain measures to mitigate climate change and to facilitate adequate adaptation to climate change and any other information that the Party considers relevant for the achievement of the objectives of the Convention. This report is known as the National Communications (Table 2.7). In 2010 in Cancun, the COP decided that non-Annex I Parties would

Table 2.7 Reporting elements for the National Communications (Drawn from UNFCCC 2003)

Elements	Details
National circumstances	Description of national and regional development priorities, objectives, and circumstances
	Description of existing institutional arrangements relevant to the preparation of their NCs on a continuous basis
National GHG inventory	Information on GHG emissions and removals
	Year: 1st NC=1994 or 1990, 2nd NC=2000
	Methodologies: Revised 1996 IPCC good practice guidance
	Gas: CO_2, CH_4, N_2O (shall), HFCs, PFCs, SF_6 (encourage)
General description of steps taken or envisage to implement the Convention	Adaptation measures
	Vulnerability assessment
	Mitigation measures
Other information considered relevant to the achievement of the objective of the Convention	Technology transfer
	Research and systematic observation
	Education, training, and public awareness
	Capacity-building activities
	Information and networking
Constraints and gaps and related financial, technical, and capacity needs	Constraints and gaps; financial, technical, and capacity needs; and activities for overcoming the constraints and gaps
	Financial resources and technical support provided by GEF, Annex II Parties, or multilateral/bilateral institutions
	Proposed project for financing
	Information on implementing adaptation measures
	Country-specific technology needs and assistance received from developed country Parties and the financial mechanism of the Convention
Other information	Additional or supporting information

submit their National Communications every 4 years (Decision 1/CP.16) (UNFCCC 2011a). The reporting elements of the National Communications have not changed since 2002, but an update of the required information can be expected in the near future.

Indonesia submitted its INC to the UNFCCC in 1999. The INC provided information on GHG inventories for the years 1990–1994, a preliminary assessment of the vulnerabilities, policies, and measures to reduce GHG emissions for four sectors, energy, agriculture, forestry, and waste, including a proposed timeframe for their implementation. During the preparation of the INC, the involvement of the key sectors was still very limited. In 2011, Indonesia submitted its SNC to the UNFCCC. According to the SNC, a number of gaps in the INC were filled, thanks in part to an increased involvement of stakeholders in the process. Indonesia is currently preparing its Third National Communication with a view of submission in 2016.

2.5.2 *Biennial Update Report*

The Cancun Agreements stipulate that developing countries, consistent with their capabilities and the level of support provided for reporting, should submit biennial update reports (BURs), including a national inventory report and information on mitigation actions, needs, and support received. This additional reporting requirement for non-Annex I Parties is a product of intense negotiations on how the COP can understand how the mitigation actions in developing countries were being implemented and monitored, how they were being funded, what the results of the actions were, and so forth. The BUR is a tool to explain the extent of the "measureable, reportable, verifiable (MRV)" manner of developing countries' NAMAs, as originally described by the Bali Action Plan. The first BUR deadline for non-Annex I Parties is December 2014, with an exception for Small Island States (SIDS) and Least Developed Countries (LDCs) which may submit BURs at their discretion. The details of the reporting elements for the BUR are as shown in Table 2.8.

As the name of the report suggests, the BUR is a report that contains updated information from its previous report (the National Communications or the BUR) and does not contain new reporting elements. However, some of the information that is required for the BUR is more specific in nature than that of the National Communications. Also, unlike the National Communications, the BURs will undergo a process where the reported information will be analyzed and discussed. The following are some elements that may be viewed as additional or more specific than that of the National Communications.

2.5.2.1 REDD+

Although not mandatory, non-Annex I Parties may report sector-specific information including information on REDD+ in a technical annex to the BUR as additional or supplemental information. This is especially important for non-Annex I Parties seeking to obtain and receive payments for result-based actions. These Parties are requested to report the following data and information as part of a technical annex of the BUR: estimation of anthropogenic forest-related emissions by sources and removals by sinks, forest carbon stocks, and forest carbon stock and forest-area changes. The information and data should be transparent and consistent over time and with the established forest reference emission levels and/or forest reference levels.

Table 2.8 Reporting elements for the biennial update report (Drawn from UNFCCC 2011b)

Elements	Details
(a) National circumstances	Information on national circumstances and institutional arrangements relevant to the preparation of the NCs on a continuous basis
(b) National GHG inventory, including a national inventory report	Update of national GHG inventories according to the guidelines for the preparation of NCs
	Inventory years: calendar year no more than 4 years prior to the date of submission or more recent years. Consistent time series back to the years reported in the previous NCs
	Methodologies: Revised 1996 IPCC guidelines and IPCC good practice guidance
(c) Mitigation actions and their effects	(a) Name and description of the mitigation action
	(b) Methodologies and assumptions
	(c) Objectives of the action and steps taken or envisaged to achieve that action
	(d) Progress of implementation of the mitigation actions and the underlying steps taken or envisaged and the results achieved
	(e) Information on international market mechanisms
(d) Constraints and gaps and related financial, technical, and capacity needs	Updated information on financial resources, technology transfer, capacity-building needs
	Updated information on financial resources, technology transfer, capacity building, and technical support received from GEF, developed country Parties, and multilateral institutions
(e) Information on the level of support received to enable the preparation and submissions of BURs	Information on support received for the preparation of the BURs
(f) Information on domestic measurement reporting and verification	–
(g) Any other information	Any other information that the non-Annex I Party considers relevant to the achievement of the objective of the Convention and suitable for inclusion in its BURs

2.5.2.2 Domestic MRV

Developing countries are encouraged to utilize existing domestic processes, arrangements, or systems, including domestically available information, methodologies, experts, and other aspects, or voluntarily establish these for domestic MRV for domestically supported NAMAs. Developing countries may indicate the general approach adopted: (1) to establish, when appropriate, and/or recognize, where relevant, inter alia, the institutions, entities, arrangements, and systems involved in the domestic MRV of NAMAs; (2) to measure domestically supported NAMAs, including the collection and management of relevant and available information and the documentation of methodologies; and (3) to verify domestically supported NAMAs, including the use of domestic experts using domestically developed processes, thereby enhancing the cost-effectiveness of the verification process. There are no specific reporting requirements regarding domestic MRV of domestically supported NAMAs; this is up to the Party to determine the information best suited for reporting.

2.5.2.3 International Consultation and Analysis

In 2011, the COP decided that all BURs would undergo an international consultation and analysis (ICA) process. The ICA will be nonintrusive, nonpunitive, and respectful of national sovereignty and has the objective to improve the transparency of mitigation actions and their effects of non-Annex I Parties. The ICA will be made up of two stages, the technical analysis of the BUR, and a facilitative exchange of views. During the technical analysis stage, a team of technical experts will conduct an analysis of the BURs and any additional technical information provided by the Party, if any. The output of this process is a summary report, drafted by the experts and reviewed by the Party, which will serve as input to the second facilitative sharing of views stage. In this stage, an open-to-all-Party workshop will be held under the Subsidiary Body for Implementation (SBI). During the workshop, an oral presentation will be delivered by the non-Annex I Parties to explain the contents of the BUR, followed by an oral question and answer among Parties. The ICA process is new to non-Annex I Parties, in that information reported by them to the UNFCCC has never been under any analysis or scrutiny by a team of experts under the UNFCCC, and it has never had to explain the reported information in an official workshop.

2.5.3 Implications to Indonesia

To comply with the more regular and frequent reporting requirements, Indonesia will need to make a transition from a temporary project-based approach to a more permanent institution-based approach to support the new cycle of activities related to reporting under the UNFCCC. This is especially important for GHG inventories, which needs a strong institutional arrangement as a basis for collecting data, estimating emissions/removals, carrying out QA/QC procedures, and approving the results. National arrangements will also be important in addressing the ICA process, where a technical team of experts may request Indonesia for additional information and draft a summary report for their review. More importantly, a government official will need to orally present the BUR and participate in a discussion during the SBI workshop. For addressing the voluntary reporting of

REDD+ and domestic MRV, Indonesia will need to establish an entity or department which will determine the country's positions on each of the issues, establish necessary arrangements, implement plans to carry out the country positions, and finally compile a paper to be included in the BUR. The roles and responsibilities of the abovementioned tasks need to be clarified in addition to the actual compilation of the reports. These are some major challenges that must be addressed in the near future in Indonesia.

2.6 International Cooperation for Mitigation Actions

Various activities and initiatives related to climate change mitigation are supported by multilateral and bilateral cooperation agencies, as introduced in section below.

2.6.1 JICA

JICA has been working with Indonesia through comprehensive financial cooperation "Climate Change Program Loan" and technical assistance "Project of Capacity Development for Climate Change Strategies in Indonesia," among others. The former was a pioneering approach to coordinate several donors' financial sources with policy dialogue, where a so-called Policy Matrix, a list of policy actions in each sector, was set based on agreement between Indonesia and the relevant donors, including Japan, in line with the Indonesian development plan. The latter contains three subprojects which cover, among others, supporting RAN-GRK and RAD-GRK as well as capacity development for national GHG inventory (JICA 2014).

2.6.2 GIZ

Climate change is one of the priorities. It covers policy advice under the programs "Policy Advice for Environment and Climate Change (PAKLIM)" and "Forests and Climate Change Programme (FORCLIME)," as well as sector-specific technical cooperation (e.g., "TRANSfer" for transport sector and "V-NAMA" for building and waste sectors (ECN and Ecofys 2013; GIZ and Ecofys 2013; ECN 2009; GIZ 2014; GIZ PAKLIM 2014; GIZ SUTIP 2014)).

2.6.3 USAID

USAID is supporting Indonesia through the global partner partnership programs: "Enhancing Capacity for Low Emission Development Strategies (EC-LEDS)" and "Low-Emissions Asian Development (LEAD) Program." LEDS is country-specific national strategic analysis and planning process, and LEAD is a capacity building program using LEDS in four interrelated areas: (1) analysis and modeling of economic development pathways, emissions trajectories, and technology options; (2) GHG inventories and accounting; (3) carbon market development; and (4) regional cooperation (USAID 2013; USAID 2014a, b, c).

2.6.4 UNDP

"Low Emission Capacity Building Programme (LECB)" is the global partnership program. LECB Indonesia aimed to formulate finance-ready NAMAs and credible MRV system in the transport sector and industrial subsector (European Union and UNDP 2011; UNDP 2014a, b).

2.6.5 World Bank

"Partnership for Market Readiness (PMR)" is a worldwide partnership program for sharing experience on market-based mitigation measures. In its first year (2011), PMR was participated by 11 donor countries (Australia, European Commission, Denmark, Germany, Japan, Netherlands, Norway, Spain, Switzerland, United Kingdom, United States). In Indonesia, energy sector programs, such as "Reducing emissions from fossil fuel burning" (REFF-burn program), and stakeholder consultations on market instruments are supported (World Bank 2014a, b, c).

Apart from the abovementioned activities focused on NAMA, MRV, and LEDS, there are many REDD+ support projects and programs. The World Bank and Australia are providing readiness process (reference emission level, MRV system, etc.) at the national level. UN-REDD program is supporting provincial and district levels. Norway is also playing significant role for national policy coordination and capacity building through the establishment of REDD+ Agency as well as MRV system (IGES 2012; Mitigation Partnership 2014; Norway 2010) (Table 2.9).

Table 2.9 List of projects and programs related to GHG mitigation in Indonesia (Mitigation Partnership 2014; IGES 2012)

Title	Activity	Additional sectors	Implementing organization	Funding source	Budget	Duration
Climate Change Program Loan	General	General	JICA, AFD, World Bank	JICA, AFD, World Bank	–	–
Capacity Development for Climate Change Strategies	General	General	JICA	JICA	–	October 2010–October 2015
ASEAN-German Programme on Response to Climate Change: Agriculture, Forestry and Related Sectors (GAP-CC)	General	Forest, agriculture	GIZ	German Federal Ministry for Economic Cooperation and Development (BMZ)	–	2012–2015
Policy Advice for Environment and Climate Change (PAKLIM I)	LEDS, NAMA	Energy, education	GIZ	BMZ	–	2009–January 2013
Bringing a Range of Supported NAMAs to the Next Level	NAMA	General, buildings, waste	Ecofys, Energy Research Centre of the Netherlands (ECN)	Germany – International Climate Initiative (ICI)	1.914.207 EUR	March 2012–December 2014
Enhancing Capacity for Low Emission Development Strategies (EC-LEDS)	LEDS	Capacity building	USAID, US Department of State	USA	1.459.359 EUR per country	January 2010–2013
Feasibility Study for Sustainable Peatland Management in Indonesia under NAMAs	NAMA	Agriculture, forests	Ministry of the Environment, Japan; Global Environment Center Foundation (GEC)	Ministry of the Environment (Japan – MOEJ); Global Environment Center Foundation (GEC)	–	–
Forest and Climate Change Programme (FORCLIME)	REDD+	Forest	GIZ	BMZ	13.05 million USD	2009–2020
Forest Investment Programme (FIP)	REDD+	Forest	FIP	FIP	80 million USD	2010–2012

(continued)

Table 2.9 (continued)

Title	Activity	Additional sectors	Implementing organization	Funding source	Budget	Duration
Global Support Project for the Preparation of Intended Nationally Determined Contributions (INDCs)	General	General	GIZ	BMU; Federal Ministry for the Environment (Germany – BMU)	2.500.000 EUR	June 2014–August 2015
IFCA and Support for REDD+	REDD+	Forest	International Forest Carbon Initiative (IFCI, Australia)	IFCI, Australia	3 million USD	2007–2012
Improving Governance, Policy and Institutional Arrangements to REDD	REDD+	Forest	Australian Centre for International Agricultural Research (ACIAR, Australia)	ACIAR	4.1 million USD	September 2008–December 2011
Indonesia Climate Change Trust Fund (ICCTF)	General	General	UNDP (interim fund manager)	DFID, AusAID, SIDA	5.5 million USD	2010-
Indonesia Sustainable Urban Transport Program Indonesia	NAMA	Transport	GIZ	BMU	14.000.000 USD	January 2014–2018
Indonesia's National Carbon Accounting System	MRV	Forest	AusAID	AusAID	2 million USD	June 2008–2012
International Climate and Forest Initiative	REDD+	Forest	Norway	Norway	1000 million USD	2010–2016
Kalimantan Green Growth Planning	LEDS	General	Global Green Growth Institute (GGGI)	GGGI	–	January 2011–December 2011
Low Carbon Development Country Studies	LEDS	General	Energy Sector Management Assistance Program (ESMAP)	World Bank	–	January 2009–December 2020

Low Carbon Growth Project	LEDS	General	DFID	DFID	1,500,000 GBP	July 2010–March 2012
Low Emission Capacity Building (LECB) Programme	LEDS, other	Capacity building	UNDP	Australian Government; European Commission; German Federal Ministry for the Environment Nature Conservation Building and Nuclear Safety (BMUB)	32.000.000 EUR	Duration: January 2011–December 2016
Low-Emissions Asian Development (LEAD) Program	LEDS, MRV	General	USAID	USAID	–	October 2011–2016
Mitigation Action Implementation Network (MAIN): A Multi-National Climate Change Initiative to Advance NAMAs	NAMA	General	Center for Clean Air Policy (CCAP)	Environment Canada, BMU (Germany), Ministry of Foreign Affairs (Denmark)	–	January 2011–September 2013
NAMA-Programme for the Building Sector in Asia	NAMA	Buildings, energy	UNEP	BMU	4.999.642,96 EUR	January 2013–August 2017
Partnership for Market Readiness (PMR)	General	Capacity building	World Bank	World Bank and others	–	April 2011–2015
TRANSfer – Towards Climate-Friendly Transport Technologies and Measures	NAMA	Transport	GIZ	Federal Ministry for the Environment (Germany – BMU)	1.471.804 EUR	November 2010 – September 2013
UN-REDD	REDD	Forest	UN-REDD	UN-REDD	5.6 million USD	2010
V-NAMAs – Involving Sub-National Actors into National Mitigation Strategies Through Vertically Integrated NAMAs	NAMA	Buildings, waste	GIZ	BMU	1.8 million EUR	May 2012–April 2015

2.7 Funding Mechanisms for Mitigation Actions

2.7.1 Funding Mechanisms in Indonesia

Two funding mechanisms, the Indonesia Climate Change Trust Fund (ICCTF) and the "Fund for REDD+ Indonesia" (FREDDI), are presented in this section.

The ICCTF is operated by the government aiming to pool and coordinate funds from various financial sources, both from public and private, for Indonesia's climate change policy actions. Three windows are open for the priority areas: land-based mitigation, energy, and adaptation and resilience. UNDP, an interim fund manager, had received from 2010 to 2012 about 11.7 million USD in total (9.5 million USD from DFID, 1.4 million USD from AusAID, 309,000 USD from SIDA, 180,000 USD from UNDP, and others). In 2010–2013, total allocated budget amounted to about 8.9 million USD, out of which 72 % was allocated for project funding and 28 % for indirect costs. 33.3 % of the project funds were spent on Energy Conservation with the Ministry of Industry, 31.9 % on Sustainable Peatland Management with the Ministry of Agriculture, 18.7 % on Public Awareness and Education with Agency for Meteorology, Climatology, and Geophysics (*Badan Meteorologi*, *Klimatologi*, *dan Geofisika*, BMKG), 8.8 % on Health Vulnerability Assessment with the Ministry of Health, and 7.3 % on Community Forest Management with the Ministry of Forest (ICCTF Secretariat 2014).

The FREDDI is a trust fund for REDD+, which has been developed in accordance with the Presidential Decree No. 80 in 2011. It aimed to promote the financing paradigm from budget to investments, to expand the sources of funding including private investments. The subsequent Presidential Regulation No. 62/Year 2013 (regarding REDD+ Agency) suggested direction and mandate of the FREDDI as "transparent, accountable and effective" management and as "REDD+ funding safeguards" (Sari 2013b). There are three modalities for financing. Modality 1 is pure grant mainly for readiness, infrastructure, and capacity building. Modality 2 is performance aggregator. Modality 3 is investment. The funds may be mobilized in the form of fund placement through joint corporate or project financing. The target amount of fund mobilization is assumed to be about 10 billion USD, mainly from private sector. Currently four funding windows are prepared: national initiatives and emergencies, subnational initiatives, competitively selected initiatives, and small grants (Sari 2013a). It is equipped with the "Principles, Criteria, and Indicators for REDD+ Safeguards in Indonesia (*Prinsip*, *Kriteria*, *Indikator Safeguards Indonesia*: PRISAI"), a safeguard protocol to consider potential social and environment impacts. The protocol has been already in pilot stage by the REDD+ Task Force in four project sites (Indonesia REDD+ Task Force and United Nations Development Programme 2013).

2.7.2 Joint Initiative Between Japan and Indonesia: Joint Crediting Mechanisms

The Joint Crediting Mechanism (JCM) is one of the most materialized activities among "various approaches," which is developed in line with the Decision 1/CP18 (UNFCCC 2012). JCM is an innovative mechanism for carbon offsetting, being expected to mobilize further involvement of private sector as well as financing and transfer of advanced technologies. Japan has been working on consultations for JCM since 2011. As of August 2014, 12 countries have signed the agreements with Japan (Mongolia, Bangladesh, Ethiopia, Kenya, Maldives, Viet Nam, Lao PDR, Indonesia, Costa Rica, Palau, Cambodia, and Mexico).

The JCM scheme is operated by a joint committee, which is established based on an agreement between Japanese government and each developing country. Its mandates are (1) to develop/revise the rules, guidelines, and methodologies, (2) to register projects, and (3) to discuss on implementation of JCM. The project submitted by a project participant will be validated and verified by third-party entities who are accredited under ISO 14065 or Designated Operational Entity (DOE) under the CDM. The certification body is called "Third Party Entity" (TPE). The main character of JCM is its decentralized structure. It is operated by the concerned governments, unlike the CDM which is guided by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP). The eligibility criteria are established based on the two principles. One is to accelerate the deployment of low-carbon technologies, products, and services, which will contribute to achieving net emission reductions; and the other is to facilitate NAMAs in host countries. The eligibility criteria include the requirements for the project registration and methodologies. The eligibility criteria are provided in a checklist format in each methodology. Methodologies also provide monitoring and calculation parameters as well as default values, such as emission factors, for specific countries and sectors.

The Japanese Ministry of Economy, Trade and Industry (METI) and the New Energy and Industrial Technology Development Organization (NEDO) provide three support schemes: JCM demonstration projects (six projects in three countries for FY2013), JCM feasibility studies (30 projects in 13 countries for FY2013), and capacity building programs. The Japanese Ministry of Environment (MOE) also operates several schemes: feasibility studies (37 projects in 10 countries for FY2013), an outreach program called New Mechanisms Information Platform (New Mechanisms Information Platform 2014), and capacity building programs. In addition, "Financing Programme for JCM Model Projects" and the program called "Leapfrog Development" started in 2014. The former is intended to finance a part of investment costs. The latter is aimed at supporting transfers of advanced - low-carbon technologies with funding support by the Japanese government as well as ADB trust fund.

The bilateral document between Indonesia and Japan was signed in August 2013, and the first Joint Committee was held in October 2013 in Jakarta. The

Rules of Implementation (a fundamental framework), project cycle documents (project cycle procedure, as well as guidelines for methodologies and project design documents), documents for a third-party entity (guidelines for designation of TPE and for validation and verification), and the Rules of Procedures for the Joint Committee have been documented. The first proposed methodologies “Power Generation by Waste Heat Recovery in Cement Industry” and “Energy Saving by Introduction of High Efficiency Centrifugal Chiller” were in the public hearing process in May 2014. The further development of methodology will be expected based on the agreement between the two countries.

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Chapter 3
Importance of Accurate GHG Estimation for the Effective Promotion of Mitigation Policies

Hiroyuki Ueda and Natsuko Matsuoka

Abstract This chapter explains the importance of accurate estimation of greenhouse gas (GHG) emissions for effective promotion of mitigation policies at the national and regional levels. Between 2011 and 2014, the Ministry of Environment of Indonesia and Japan International Cooperation Agency (JICA) conducted a pilot project in the provinces of North Sumatra and South Sumatra to enhance the quality of their GHG inventory in the waste sector. Through the pilot project, methodologies for developing accurate activity data were developed, resulting in a decrease of GHG emissions from solid waste disposal sites (SWDSs) by approximately 30 %. Methane emissions from SWDSs in other provinces are also expected to decrease by approximately 30 % because their GHG estimation methods are similar to what had been the case in North Sumatra and South Sumatra before the pilot project started. This indicates the necessity of updating the national action plan for GHG emission reduction (RAN-GRK) along with the improvement of the GHG inventory.

Keywords GHG inventory • Mitigation action • Methodology • Tier • Waste sector • Waste composition survey • Dry matter content survey • Waste stream survey

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3.1 Introduction

This chapter will discuss the importance of accurate estimations of greenhouse gas (GHG) emissions for the development of effective mitigation policies at national and regional scales on the basis of the results from pilot projects in Indonesia conducted by the Ministry of Environment of Indonesia (*Kementerian Lingkungan Hidup*, KLH) and Japan International Cooperation Agency (JICA) between 2011 and 2014.

A GHG inventory can provide the following information about GHG emissions at national and regional scales:

- Amount of GHG emissions by sources and gases
- Time-series trends in GHG emissions by sources and gases
- Methodologies used for estimating GHG emissions
- Information about the sources of the activity data and parameters used for estimating GHG emissions

The abovementioned scientific information from the GHG inventory can provide policy makers with the following bases for planning mitigation actions:

- GHG emission sources that require mitigation
- Potential reductions in GHGs and targets for future reductions to be met through mitigation activity
- Prioritization of mitigation activities
- Development of monitoring methods for evaluating mitigation activity progress

Therefore, a GHG inventory is an essential tool for mitigation policy planning at national and regional scales. A national GHG inventory must be developed in line with the international GHG inventory guidelines published by the Intergovernmental Panel on Climate Change (IPCC). The IPCC guidelines provide fundamental information on the estimation of GHGs. This information includes methodologies for GHG estimation, default emission factors, default parameters, and definitions of activity data. The IPCC guidelines also introduce the concept of "tier" to represent methodological complexity levels. The newest guidelines, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories ("2006 IPCC Guidelines"), outline three methodology tiers (tiers 1, 2, and 3) for each GHG emission source. A tier 1 methodology comprises the basic method, tier 2 comprises the intermediate, and tier 3 is the most demanding in terms of complexity and data requirements. Tiers 2 and 3 are sometimes referred to as higher-tier methods and are generally considered to be more accurate.

Tier 2 and 3 methodologies, which use activity data directly connected with GHG-producing activities, can provide more accurate GHG emission data than a tier 1 methodology. Policy makers utilize GHG emission data in GHG inventories for the development of mitigation policies. If they have access to more accurate GHG emission data, more effective mitigation actions can be taken. In addition, as tier 2 and 3 methodologies use activity data that are directly connected with

GHG-producing activities, the progress achieved as a result of each mitigation action will be automatically reflected in the GHG inventory under these methodologies. Therefore, to ensure effective mitigation policy planning, the development of a GHG inventory based on tier 2 and 3 methodologies is recommended.

It may be difficult to apply tier 2 or 3 methodology in developing countries, because the related statistics are not sufficiently established and the parameters necessary for their methodologies are not well developed. For example, in the solid waste disposal category in the waste sector, tier 2 or 3 methodology requires information on the amount of landfilled domestic and industrial solid waste (ton or m^3) as activity data, which must be monitored by a weighbridge on a landfill site or estimated by using the number of waste collection vehicles entering the landfill site. Currently, most developing countries have no such data. This means that effective mitigation policy planning may be difficult in developing countries because of the lack of accurate GHG emission data.

This paper will start with an overview of the pilot activity on GHG inventory in North Sumatra and South Sumatra, as well as general information on GHG inventory for the waste sector. It will then provide detailed description on the methodologies applied in the pilot activity, which will be followed by results and discussion.

3.2 Pilot Project on GHG Inventory in the Waste Sector: Overview

In 2011, Indonesia established the Presidential Regulation No. 71/Year 2011 to promote the preparation of a GHG inventory in the provinces. To facilitate the development of these GHG inventories, KLH prepared a GHG inventory manual that accords with the 2006 IPCC Guidelines (Ministry of Environment 2012). On the basis of this manual, each province developed an initial provincial GHG inventory and submitted it to the KLH between 2011 and 2012. Because of limited time, a lack of available activity data and parameters, and a lack of understanding by staff about the methodologies to be used in a GHG inventory, tier 1 methodology was used in each province. To improve this situation, particularly with respect to the limited availability of activity data and insufficient staff training for conducting GHG inventories, KLH and JICA conducted pilot projects between 2011 and 2014 in three provinces.

As listed in Table 3.1, the pilot projects were implemented in the provinces of North Sumatra (2011–2014), South Sumatra (2011–2014), and East Java (2014) to enhance the quality of provincial GHG inventories in the waste sector and to develop human capacities. In North Sumatra and South Sumatra provinces, several surveys were conducted to obtain the necessary activity data and parameters in the waste sector to apply higher-tier methodologies. In East Java province, the activities mainly focused on staff training in GHG inventory activity on the basis of the experiences in North Sumatra and South Sumatra.

Table 3.1 Outline of pilot project (JICA 2014a)

Location (province)	Duration	Main activities
North Sumatra	2011–2014	Activity data and parameter development for accurate GHG estimation
South Sumatra	2011–2014	Training for GHG estimation methodology and developing provincial GHG inventory
East Java	2014	Training for improving quality of provincial GHG inventory

3.3 GHG Estimation Methodologies in the Waste Sector

Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions from solid waste disposal on land, wastewater, waste incineration, and other waste management activities are reported in the waste sector. All types of waste are considered, including municipal solid waste, sludge, industrial waste, and other wastes, as illustrated in Fig. 3.1.

3.3.1 GHG Emissions from Solid Waste Disposal Sites

Solid waste disposal includes “landfill” and “open dump.” CH_4 is produced from anaerobic microbial decomposition of organic matter in solid waste disposal site (SWDS). CO_2 emissions are not included in the estimation because carbon is biogenic in origin, and thus its net emissions are estimated as part of the agriculture, forest, and land-use (AFOLU) sector.

There are three methodology tiers in the SWDS category, as shown in Fig. 3.2. A tier 1 methodology uses population data or GDP data as the driver for estimating activity data. Tier 2 uses good quality country-specific activity data. Typically, the amount of monitored waste disposed at an SWDS is used as the activity data. If country-specific key parameters are available, a tier 3 methodology can be applied.

The amount of CH_4 formed from decomposable material is determined by multiplying the CH_4 fraction in generated landfill gas with the CH_4/C molecular weight ratio. CH_4 is emitted over a long period of time rather than instantaneously. As such, a kinetic approach must be considered for the factors that influence the rate and extent of CH_4 generation and release from SWDSs. The first-order decay (FOD) method can be used to model the rate of CH_4 generation over time. Countries, without historical statistical data, or any equivalent data on solid waste disposal that spans the last 50 years, will have to formulate methods to estimate historical data. To classify its waste sites into four categories, a country must describe its methods of waste management (unmanaged or managed) and the environmental effects of its site structures.

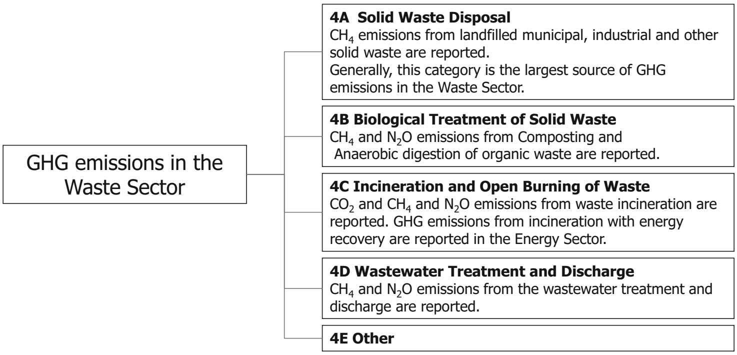


Fig. 3.1 GHG emission sources in the 2006 IPCC guidelines (IPCC 2006)

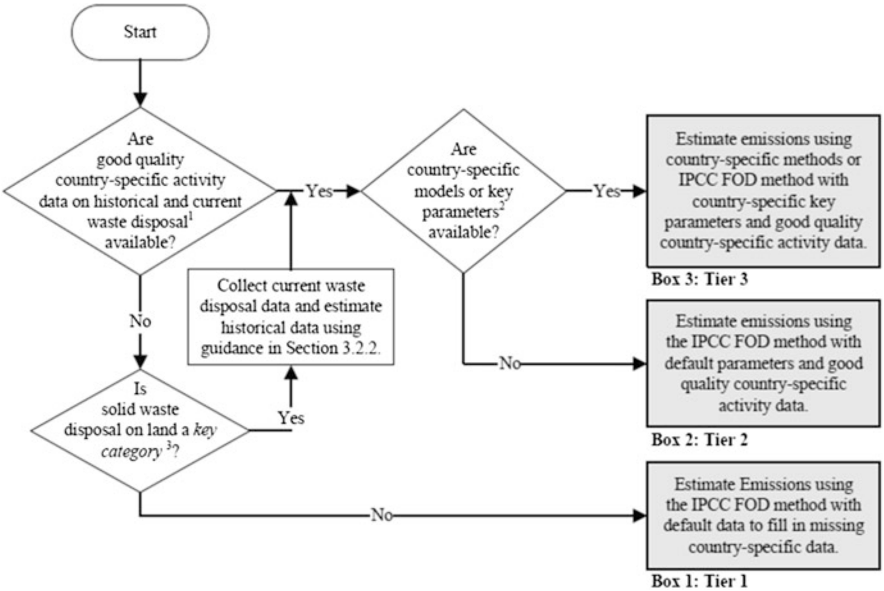


Fig. 3.2 Decision tree for GHG emissions from SWDS (IPCC 2006)

3.3.2 Biological Treatment of Solid Waste

CH_4 and N_2O emissions from composting and the anaerobic digestion of organic waste are reported as biological treatments of solid waste.

- Composting: an aerobic process in which CH_4 and N_2O are formed in anaerobic areas of the compost. These emissions must be estimated.
- Anaerobic digestion: CH_4 emissions from anaerobic digestion because of unintentional leakages must also be estimated. Since CH_4 generated by

anaerobic digestion can be used to produce heat and/or electricity, GHG emissions from generated CH_4 are usually reported in the energy sector.

- Mechanical–biological (MB) treatment: waste materials undergo a series of mechanical and biological operations, of which the biological operations include composting and anaerobic digestion. Therefore, CH_4 and N_2O emissions from MB treatment can be estimated for this category.

If emission factors are based on facility- or site-specific measurements, a tier 3 methodology can be selected. If emission factors based on representative measurements are available, a tier 2 methodology can be selected. If country-specific emission factors are not available, the IPCC default emission factors can be used in a tier 1 methodology. Activity data for this category is the mass of organic waste treated biologically, which can be derived on the basis of national statistics. Data on biological treatment can be collected from the municipal or regional authorities responsible for waste management, or from waste management companies. Where possible, data on composting and anaerobic treatment should be collected separately.

3.3.3 Waste Incineration and Open Burning of Waste

Waste incineration is defined as the combustion of solid and liquid waste in controlled incineration facilities. The types of waste incinerated include municipal solid waste (MSW), industrial waste, hazardous waste, clinical waste, and sewage sludge. Open burning of waste can be defined as the combustion of unwanted combustible materials in nature (open air) or in open dumps, where smoke and other emissions are released directly into the air without passing through a chimney or stack. Open burning can also include incineration devices that do not control combustion air to maintain an adequate temperature and do not provide a sufficient residence time for complete combustion. GHG emissions from waste incineration without energy recovery are reported in the waste sector of the GHG inventory, while emissions from waste incineration with energy recovery are reported in the energy sector. The methodology described for this category is generally applicable to incineration practices with and without energy recovery. CO_2, CH_4, and N_2O emissions are reported under this category. Only CO_2 emissions from the combustion of fossil-fuel wastes (e.g., plastics, certain textiles, rubber, liquid solvents, and waste oil) are considered to be net emissions, and these should be included in the national CO_2 emission estimate. CH_4 emissions from incineration and the open burning of waste result from incomplete combustion. Important factors affecting these emissions include temperature, residence time, and air ratio. N_2O is emitted in combustion processes at relatively low combustion temperatures between 500 and 950° C. Other important factors affecting emissions are the type of air pollution control device in use, the type and nitrogen content of the waste, and the fraction of excess air.

In case of incineration and open burning of solid waste, if this is a key category, it is good practice to estimate emissions using a tier 2 or 3 methodology. If plant-specific data is available, a tier 3 methodology should be selected. If country-specific data is available, a tier 2 methodology should be selected, as shown in Fig. 3.3.

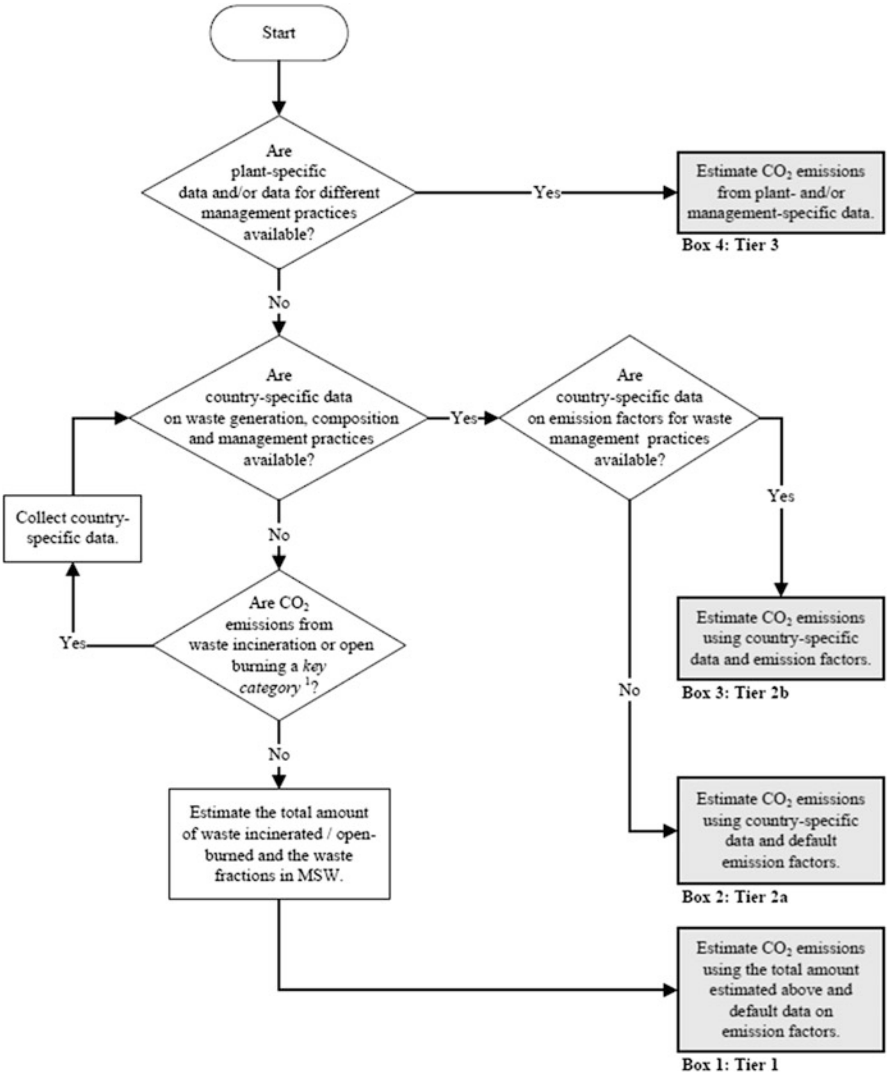


Fig. 3.3 Decision tree for GHG emissions from the incineration and open burning of solid waste (IPCC 2006)

- Tier 1: Data on the amount of waste is required.
- Tier 2a: Country-specific waste composition data and default data for other MSW parameters are required. For other types of waste, country-specific data on waste amounts is required.
- Tier 2b: Country-specific data on the amount of waste by waste type or MSW composition, dry matter content, carbon content, fossil carbon fraction, and oxidation factor is required, in addition to country-specific composition data.
- Tier 3: Plant-specific data is required. It is good practice at this tier level to consider parameters affecting both the fossil carbon content and oxidation factor.

Fossil liquid waste is defined here as industrial and municipal residues that are based on mineral oil, natural gas, or other fossil fuels. It includes waste products formerly used as solvents and lubricants. It does not include wastewater unless it is incinerated (e.g., due to a high solvent content).

3.3.4 Wastewater Treatment and Discharge

Wastewater and its sludge components can produce CH_4 if it degrades anaerobically. The extent of CH_4 production depends primarily on the quantity of degradable organic material in wastewater, temperature, and the type of treatment system being used. With increases in temperature, the rate of CH_4 production increases. Common parameters used to measure the organic components of wastewater are biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The BOD concentration only indicates the amount of carbon that is aerobically biodegradable. The COD concentration indicates the total material available for chemical oxidation (both biodegradable and non-biodegradable). N_2O is associated with the degradation of nitrogen components in wastewater, e.g., urea, nitrate, and protein. N_2O emissions occur as direct emissions from treatment plants or as indirect emissions from wastewater after the disposal of effluent into waterways, from lakes to seas (Fig. 3.4).

GHG emissions from sludge treatment at wastewater treatment facilities fall into this category. If sludge is removed for incineration, disposal in landfills, biological treatment, or as fertilizer on agricultural lands, the amount of organic material removed as sludge should be subtracted from the total organics in the wastewater. The amount of organic material removed as sludge should be consistent with the data used in the relevant categories and sector.

In case of domestic wastewater treatment and discharge, if this is a key category, it is good practice to estimate the emissions using a tier 2 or 3 methodology. If country-specific bottom-up data is available, then a tier 3 methodology should be selected. If country-specific emission factors are available, then a tier 2 methodology should be selected. In all tiers, data on the percentage of wastewater being treated or discharged in each pathway is required, as shown in Fig. 3.5.

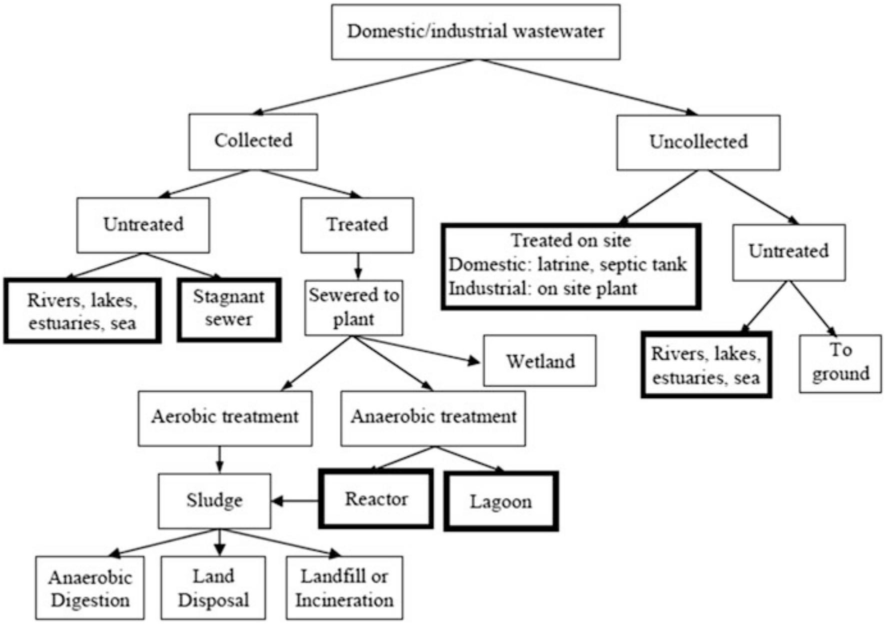


Fig. 3.4 Wastewater treatment systems and discharge pathways (IPCC 2006)

- Tier 1: Use default values for the emission factor and activity parameters.
- Tier 2: Requires the incorporation of country-specific emission factors and country-specific activity data.
- Tier 3: Country-specific method with bottom-up data is required.

In case of industrial wastewater treatment and discharge, if this is a key category, it is good practice to estimate the emissions using a tier 2 or 3 methodology. If country-specific bottom-up data is available, then a tier 3 methodology should be selected. If country-specific emission factors, as well as COD and waste flow data, are available, the tier 2 methodology should be selected. In all tiers, information from major industrial sectors having a large potential for CH_4 emissions is required (Fig. 3.6).

- Tier 1: Estimate wastewater outflow for each industrial sector using industrial production data and default emission factors.
- Tier 2: COD and wastewater outflow data for each industrial sector is required, as are country-specific emission factors.
- Tier 3: Country-specific bottom-up data from individual facilities or companies is required.

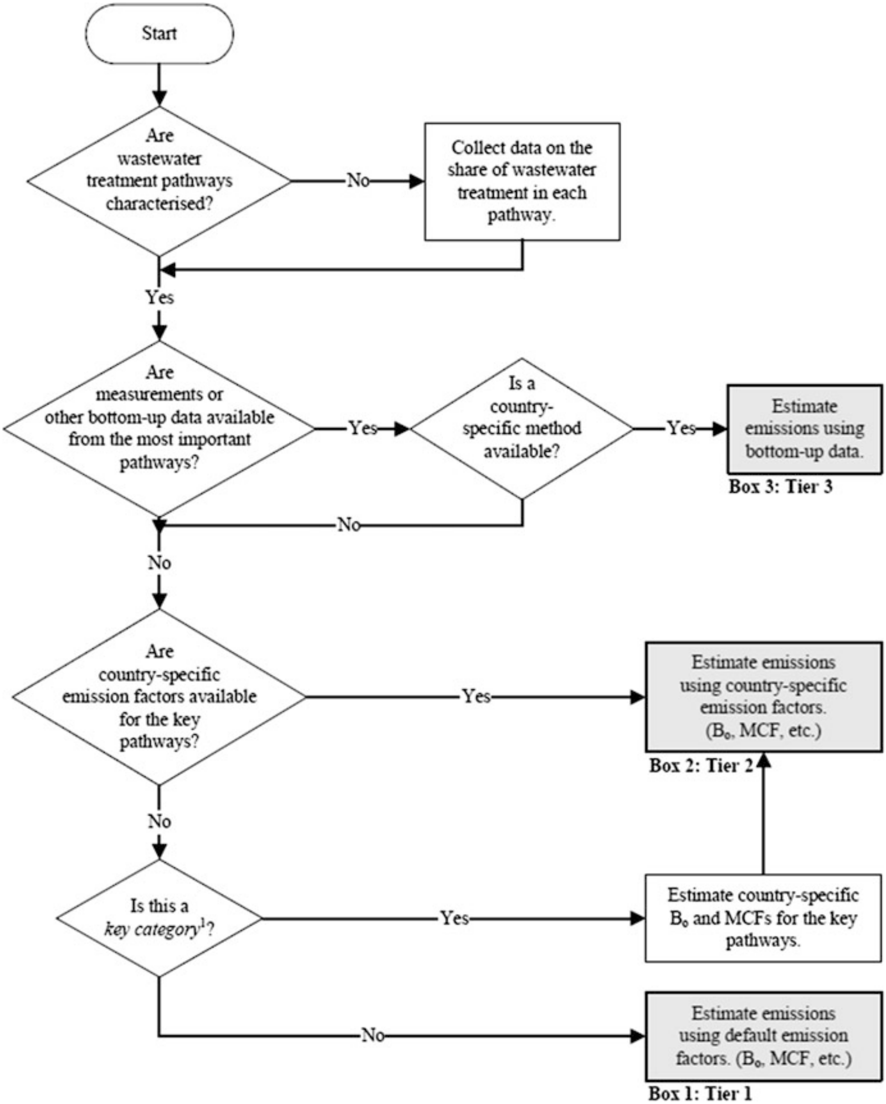


Fig. 3.5 Decision tree for GHG emissions from domestic wastewater treatment and discharge (IPCC 2006)

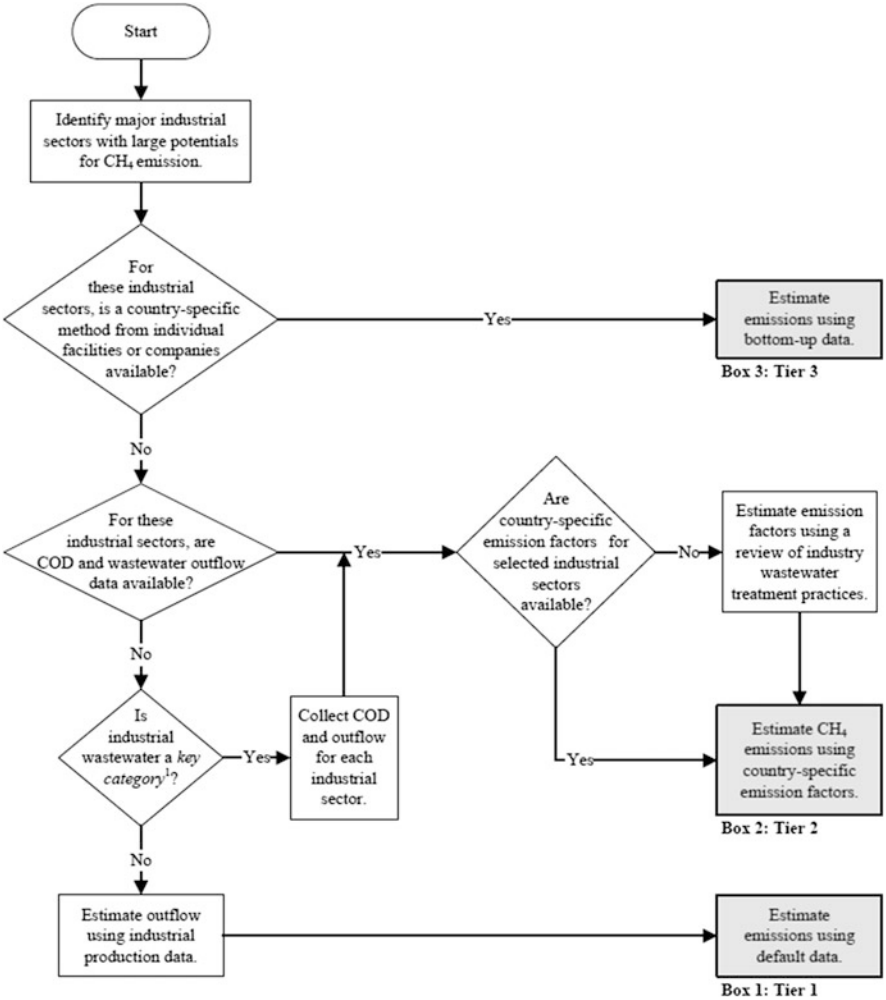


Fig. 3.6 Decision tree for GHG emissions from industrial wastewater treatment and discharge (IPCC 2006)

3.4 Methodology for Developing Country-Specific Parameters and Activity Data Under the Pilot Project

3.4.1 Methodology for Applying Higher Tiers

To develop the necessary activity data and parameters for applying tier 2 or 3 methodology, activity data collection and estimation method, waste composition survey, and dry matter content survey are conducted in North Sumatra and South Sumatra provinces. The methodology used for each activity is explained below.

To obtain accurate activity data for CH_4 emissions from SWDSs, it is best to weigh landfilled waste with a weighbridge at the site. However, at SWDSs which are not equipped with weighbridges, the amount of landfilled waste can be determined by calculating the number of waste collecting vehicles on a volume basis. Using a tier 1 methodology, the amount of solid waste disposed to SWDS is estimated by using population data multiplied by a waste generation ratio (kg waste/per person/day) and the fraction of waste disposed to an SWDS. This estimation method is widely used where data on actual amounts of landfilled waste is not available. However, the waste generation ratio and the fraction of waste disposed to an SWDS contain large uncertainties, which result in large uncertainties in the estimated GHG emissions for the waste sector. In Indonesia, middle- to large-scale SWDSs are generally equipped with a logbook for recording amounts of landfilled waste or the number of waste collection vehicles. Logbook data is useful for collecting data on the amount of landfilled waste. If a logbook only contains records on the number of waste collection vehicles, the amount of waste must be estimated by multiplying bulk-density data (kg waste/m^3) with the volume capacity of the waste collection vehicle (m^3/vehicle). Such bulk-density data was used in the South Sumatra survey.

Waste composition data will differ by region because this data is affected by the waste management and recycling policies in each municipality and by local parameters, such as seasonal temperatures, foods grown, crops farmed, and local cultural and religious practices. A waste composition survey is the only way to obtain waste composition data for tier 2 and tier 3 methodologies. On the basis of the abovementioned local parameters, classifications of waste type should be made by each country.

The 2006 IPCC guidelines suggest that the amount of degradable organic waste (DOC) be estimated as the product of the amount of waste disposed at the SWDS, the dry matter content of the bulk waste, and the waste composition. However, as waste compositions and their associated dry matter content data differ, the amount of DOC must be estimated from the waste composition and associated dry matter content data to obtain a more accurate GHG estimation.

3.4.2 Methodology for Obtaining Activity Data of Waste Stream Survey

3.4.2.1 Household Waste Methodology

There are two types of waste stream surveys: the waste composition survey and the waste disposal method survey. For waste composition surveys, surveyed households are provided with plastic disposal bags, which are collected after approximately 24 h. After collection, the amount of waste is scaled one by one, and then the bags are opened and classified into 12 waste types.

Points that need be taken into consideration while conducting surveys are as follow:

- Write a household code number on each plastic disposal bag for identification. The waste generation per capita can be calculated by combining this data and the results from the waste disposal method survey.
- Require surveyed households to include in the bag all household wastes produced, including wastes they normally burn or bury in the backyard or throw into the river, in order to obtain accurate waste generation data.
- Two plastic bags are provided for each house, so that one is used for waste generated within the house and the other for outside waste.

In the waste disposal method survey, project staff visits the respective surveyed households to conduct interviews about their daily waste disposal methods, according to the questionnaire. The waste disposal methods should be addressed separately with respect to five waste types: food waste, yard and garden waste, paper waste, plastic waste, and other wastes. The interviewees choose their disposal methods from a list of waste disposal methods in the questionnaire and provide a rough percentage of waste amounts that apply to each method. For example, if one interviewee reports that 30 % of food waste is collected in front of the house and 70 % is buried in the back yard, the data is reported as shown in Table 3.2.

In selecting samples for both surveys, several geographical features that influence life styles with respect to waste amounts and disposal methods must be considered. First, regions under a local government are divided into areas according to their level of urbanization. Some areas are more occupied by houses and stores than others. Most occupied areas are categorized as "city areas," less occupied areas

Table 3.2 Example of household waste questionnaire response (JICA 2015a)

Disposal method	Food	Plastic	Paper	Garden	Other
Collected in front of house	30 %	%	%	%	%
Collected at waste collection point, TPS	%	%	%	%	%
Dump in a backyard: bury	70 %	%	%	%	%
Dump in a backyard: burn	%	%	%	%	%
Dump in a backyard: put (in a hole, no treatment)	%	%	%	%	%
Dump in a backyard: put (no holes, no treatment)	%	%	%	%	%
Dump in a backyard: other	%	%	%	%	%
Feed animals	%	–	–	–	–
Compost at home	%	–	%	%	%
Biogas at home	%	–	%	%	%
Throw outside the house: drain, river, lake, sea	%	%	%	%	%
Throw outside the house: open space, road side	%	%	%	%	%
Throw outside the house: put in a hole	%	%	%	%	%
Throw outside the house: burn					
Throw outside the house: sell to the junk buyer	%	%	%	%	%
Throw outside the house: other	%	%	%	%	%
Total	100 %	100 %	100 %	100 %	100 %

as “suburban areas,” and least occupied areas as “rural areas.” With respect to the population’s purchasing and discarding behaviors, this categorization also reflects income level to some extent.

Second, the availability of waste collection services and the geographical features that influence people’s waste disposal tendencies must be considered. According to the results of a waste stream survey conducted in Lahat (JICA 2014b), in areas where the availability of waste collection services is high, approximately 90 % of the inhabitants use the service. On the other hand, in areas where there are no waste collection services, the percentage of waste that is disposed of by the inhabitants themselves increases, and the employed methods tend to be influenced by the distance from a big local river (Fig. 3.7). People living near the big river tend to throw their waste into the river, whereas people living far from it tend to burn or bury their waste in or around their backyard, as shown in Fig. 3.8.

There has been no standard sample number for waste disposal method surveys because this type of survey has not been conducted broadly in Indonesia, although the Indonesian National Standard (*Standar Nasional Indonesia*, SNI) defines a standard sample number for waste composition surveys. Therefore, a tentative standard sample number for waste stream surveys is established, using the SNI standard as a minimum number, through discussion with local academic experts, as shown in Table 3.3. The tentative standard is 15–20 samples per district for the waste composition survey and 20–30 samples for the waste disposal method survey (JICA 2015a).

Fig. 3.7 River running through Lahat (JICA 2014b)

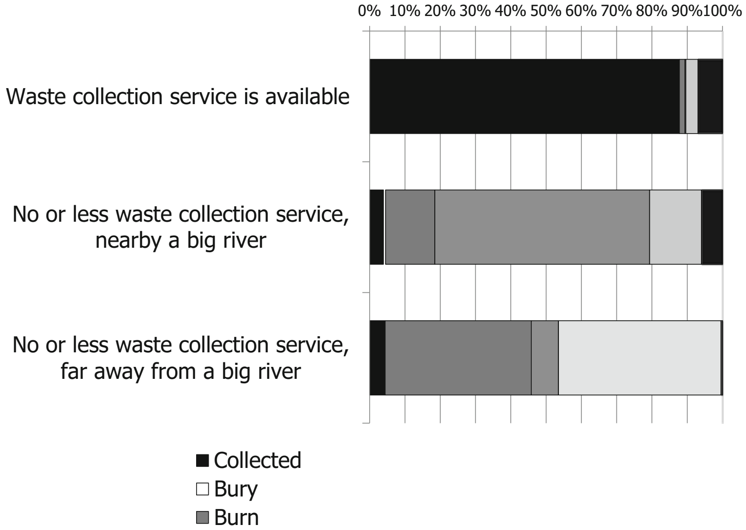


Fig. 3.8 Waste disposal methods in Kabupaten Lahat (JICA 2014b)

Table 3.3 Survey locations in Prabumulih (JICA 2015a)

Area	District			Number of sample	
	Code	Waste collection availability	Distance from a river	Composition	Disposal method
City	A	Available	15–20	20–30	
	B	Not available	Nearby a big river	15–20	20–30
	C		Far away from a river	15–20	20–30
Suburb	A	Available	15–20	20–30	
	B	Not available	Nearby a big river	15–20	20–30
	C		Far away from a river	15–20	20–30
Rural	A	Available	15–20	20–30	
	B	Not available	Nearby a big river	15–20	20–30
	C		Far away from a river	15–20	20–30
Total				135–180	180–270

On the basis of the data obtained from those two surveys, Fig. 3.9 shows the data analysis methods for calculating GHG emissions. First, the total waste amount is calculated by obtaining the waste amount per household in the designated area—obtained from the waste composition survey—and the number of family members, obtained by the waste disposal method survey. Population data by area is required for this calculation. Secondly, the waste amount (dry based) in relation to the GHG emissions must be calculated. Specifically, this includes food waste, yard and

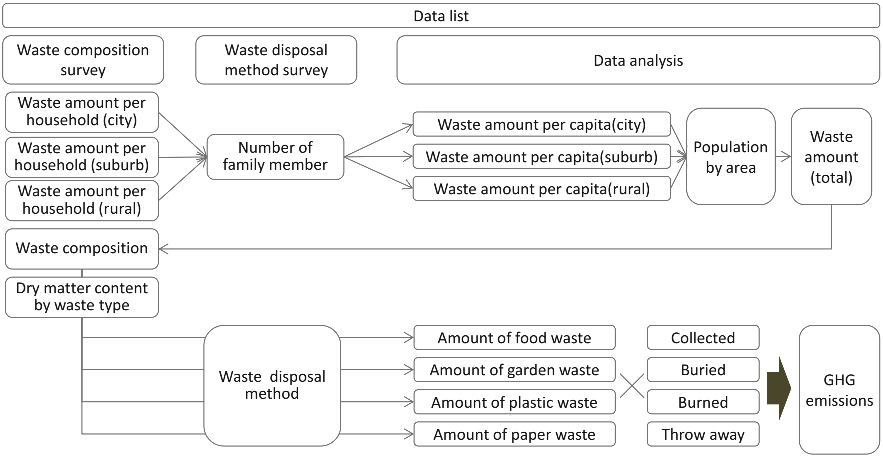


Fig. 3.9 Data analysis of household waste (JICA 2015a)

garden waste, paper and carton waste, plastic waste from the waste composition data, and dry matter content data by waste type. Then, on the basis of the percentage for each waste disposal method, the amount of waste by type and disposal method (collected, buried, burned, and thrown away) is calculated.

3.4.2.2 Methodology for Determining Market Waste

The methodology for determining market waste is basically the same as that for household waste. It consists of two surveys—a waste composition survey and a waste disposal method survey. In the waste composition survey, plastic disposal bags are provided to the surveyed stores when they open and collected when they close for the day. After collection, the amount of waste from each store is scaled, and then the bags are opened and the contents classified into 12 waste types by business type. For the waste disposal method survey, short interviews are conducted with store owners regarding their daily waste disposal methods. Unlike household waste, the main disposal method by markets is expected to be the use of waste collection services, as they are usually located in downtown areas. However, some portion of food waste and other items of some value, such as metals, might be collected by other businesses. These percentages are determined in the interviews. When selecting samples, the type of business must be considered. Businesses can be divided into eight types: meat; chicken; fish; fruit; vegetable; other food related; clothes, books, daily commodity, and others; and food and drink. Five to ten samples from each business type are required for the survey. The data analysis method, as shown in Fig. 3.10, requires the total amount of market-related waste (food, garden, plastic, and paper wastes) to calculate the GHG emissions. After calculating the waste amounts by waste and business types, on the basis of short

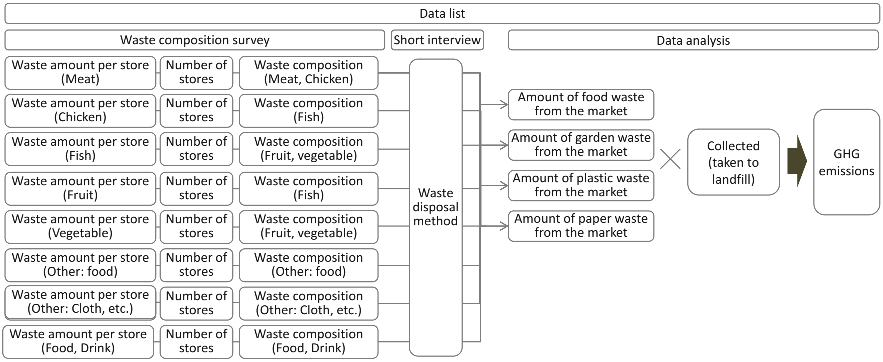


Fig. 3.10 Data analysis of market waste (JICA 2015a)

interviews, the amounts taken to landfill, buried, and burned are calculated. These amounts should be estimated by business type because waste amounts and compositions differ depending on the type of business. For example, the waste component from meat and chicken, fish, fruit, and vegetable stores is predominantly food waste; whereas, wastes from the other kinds of stores contain little or no food waste.

3.4.2.3 Example of Household Waste Survey: Prabumulih in South Sumatra

A survey in Prabumulih city in South Sumatra was conducted in August 2014. Prabumulih is a city located near the provincial capital of Palembang (Fig. 3.11) and has about 240,000 residents. The main industry is oil and pineapple production. To select samples, the Prabumulih region is divided into three areas—city, suburban, or rural—and then selected three districts from each area (Figs. 3.12 and 3.13).

Table 3.4 shows the population for each area, with almost half living in the city area. Figure 3.14 is the household waste questionnaire used in the survey in Prabumulih. The upper part is concerned about basic intelligence such as name, address, and conditions of waste collection availability. In the middle part, a list of waste disposal methods and waste types is indicated. The bottom part shows the information about surveyor. Household codes are indicated here as well.

Based on the waste composition survey results, it is known that the waste amount per capita in Prabumulih is 343 g in city areas, 490 g in suburban areas, and 743 g in rural areas, as indicated in Table 3.5. Using the population data by area, the total waste amount per year is calculated to be 39,805 tons (JICA 2015a).

Waste composition in Prabumulih is shown in Table 3.6. Based on these results, the waste composition weight was determined, as shown in Fig. 3.15. The main waste component was food waste (54.2 %), followed by yard and garden waste (17.5 %). Plastic waste (12.8 %) and paper and carton waste (5.1 %) were two other main components (JICA 2015a).

Fig. 3.11 Location of Prabumulih (JICA 2015a)

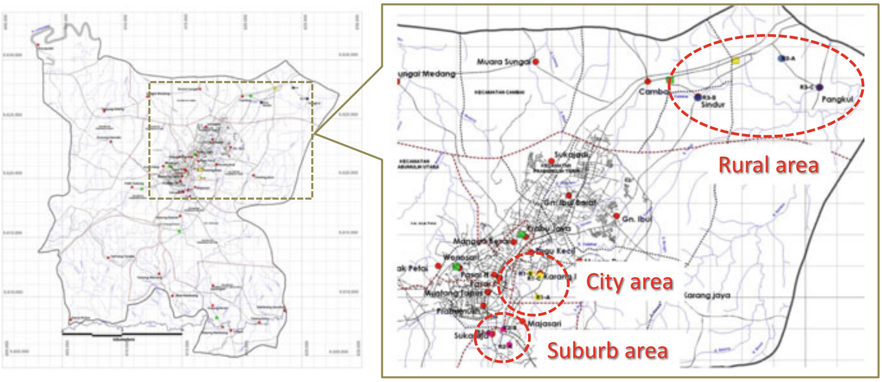
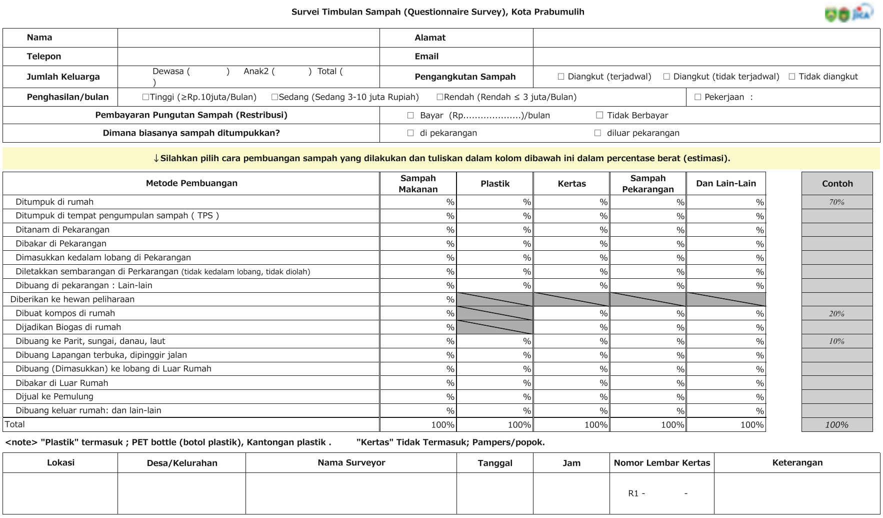


Fig. 3.12 Survey locations in Prabumulih (JICA 2015a)

Fig. 3.13 Environments of the selected areas (city (*left*), suburban (*middle*), and rural (*right*)) (JICA 2015a)

Table 3.4 Prabumulih population by survey locations of household waste (JICA 2015a)

Area	Population
City	146,311
Suburb	40,983
Rural	52,189
Total	239,483



Survei Timbulan Sampah (Questionnaire Survey), Kota Prabumulih

Nama		**Alamat**	
Telepon		**Email**	
Jumlah Keluarga	Dewasa ( ) Anak2 ( ) Total ( )	**Pengangkutan Sampah**	☐ Diangkut (terjadwal) ☐ Diangkut (tidak terjadwal) ☐ Tidak diangkut
Penghasilan/bulan	☐Tinggi (≥Rp.10juta/Bulan) ☐Sedang (Sedang 3-10 juta Rupiah) ☐Rendah (Rendah ≤ 3 juta/Bulan)		☐ Pekerjaan :
Pembayaran Pungutan Sampah (Restribusi)		☐ Bayar (Rp...................)/bulan	☐ Tidak Berbayar
Dimana biasanya sampah ditumpukkan?		☐ di pekarangan	☐ diluar pekarangan

↓Silahkan pilih cara pembuangan sampah yang dilakukan dan tuliskan dalam kolom dibawah ini dalam percentase berat (estimasi).

Metode Pembuangan	Sampah Makanan	Plastik	Kertas	Sampah Pekarangan	Dan Lain-Lain	Contoh
Ditumpuk di rumah	%	%	%	%	%	70%
Ditumpuk di tempat pengumpulan sampah (TPS)	%	%	%	%	%	
Ditanam di Pekarangan	%	%	%	%	%	
Dibakar di Pekarangan	%	%	%	%	%	
Dimasukkan kedalam lobang di Pekarangan	%	%	%	%	%	
Diletakkan sembarangan di Perkarangan (tidak kedalam lobang, tidak diolah)	%	%	%	%	%	
Dibuang di pekarangan : Lain-lain	%	%	%	%	%	
Diberikan ke hewan peliharaan	%					
Dibuat kompos di rumah	%		%	%	%	20%
Dijadikan Biogas di rumah	%		%	%	%	
Dibuang ke Parit, sungai, danau, laut	%	%	%	%	%	10%
Dibuang Lapangan terbuka, dipinggir jalan	%	%	%	%	%	
Dibuang (Dimasukkan) ke lobang di Luar Rumah	%	%	%	%	%	
Dibakar di Luar Rumah	%	%	%	%	%	
Dijual ke Pemulung	%	%	%	%	%	
Dibuang keluar rumah: dan lain-lain	%	%	%	%	%	
Total	100%	100%	100%	100%	100%	100%

<note> "Plastik" termasuk ; PET bottle (botol plastik), Kantongan plastik . "Kertas" Tidak Termasuk; Pampers/popok.

Lokasi	Desa/Kelurahan	Nama Surveyor	Tanggal	Jam	Nomor Lembar Kertas	Keterangan
					R1 - -	

Fig. 3.14 Household waste questionnaire (JICA 2015a)

Table 3.5 Household waste amount in Prabumulih (JICA 2015a)

	Waste generation (g/capita)	Population	Waste amount (t/y)
City	343	146,311	18,319
Suburb	490	40,983	7333
Rural	743	52,189	14,153
Total	–	239,483	39,805

Table 3.6 Household waste composition in Prabumulih (JICA 2015a)

	City (%)	Suburb (%)	Rural (%)
Food waste	62.9	40.8	49.9
Yard and garden	9.6	26.5	23.1
Wood	0.0	0.6	0.1
Paper and carton	4.2	5.4	6.2
Textile	1.7	1.0	1.0
Nappies	2.4	4.8	2.2
Rubber and leather	0.6	0.8	0.4
Plastic	13.4	12.7	12.0
Metal	1.4	1.3	0.9
Glass (ceramic)	3.2	1.7	1.5
Others (organic)	0.0	0.4	0.1
Others (inorganic)	0.7	4.0	2.6
Total	100	100	100

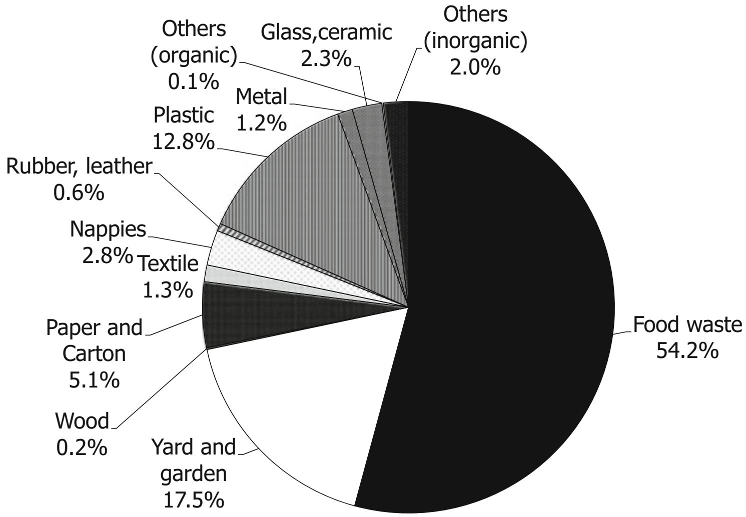


Fig. 3.15 Household waste composition averages in Prabumulih (JICA 2015a)

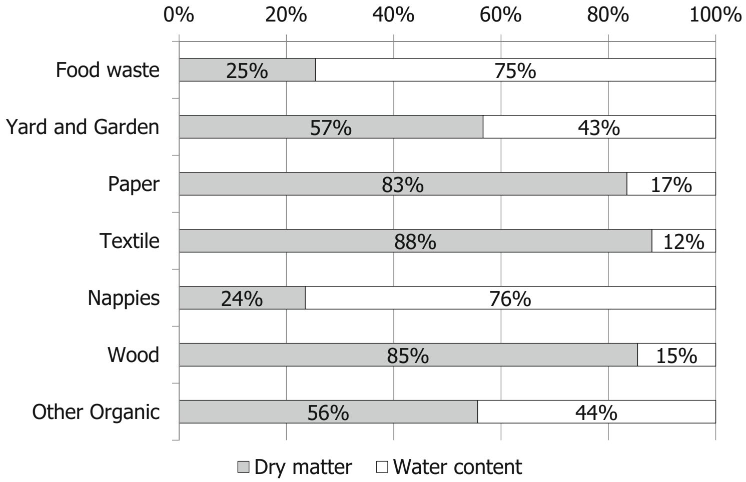


Fig. 3.16 Dry matter content by waste type in Prabumulih (JICA 2015a)

Figure 3.16 shows the dry matter content survey results for Prabumulih. Three samples for each waste type were examined and the average of these types was calculated. The water contents of food waste and disposable diapers were very high, whereas those of paper, textiles, and wood were very low (JICA 2015a).

Figure 3.17 shows waste disposal methods with respect to inappropriate disposals by area. On the left side of the Figure is the waste collection availability by area. In the city and suburban areas, where more than 90 % of the inhabitants have access to waste collection services, the main disposal method is "collected."

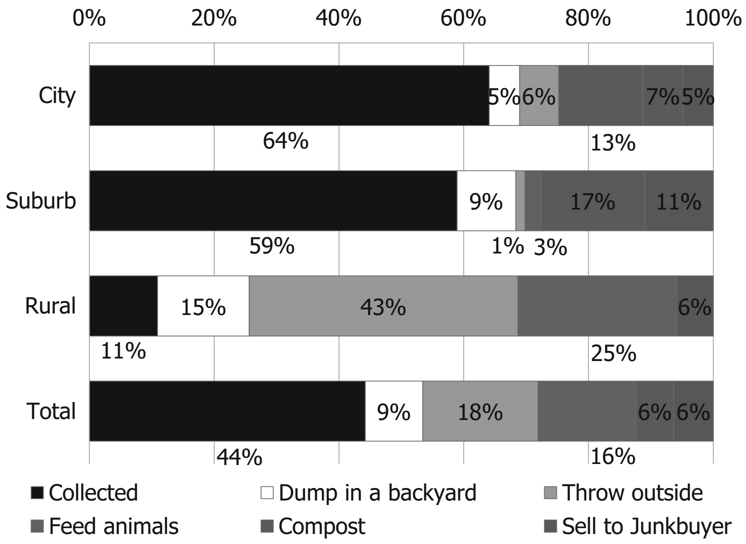


Fig. 3.17 Waste disposal method by area (JICA 2015a)

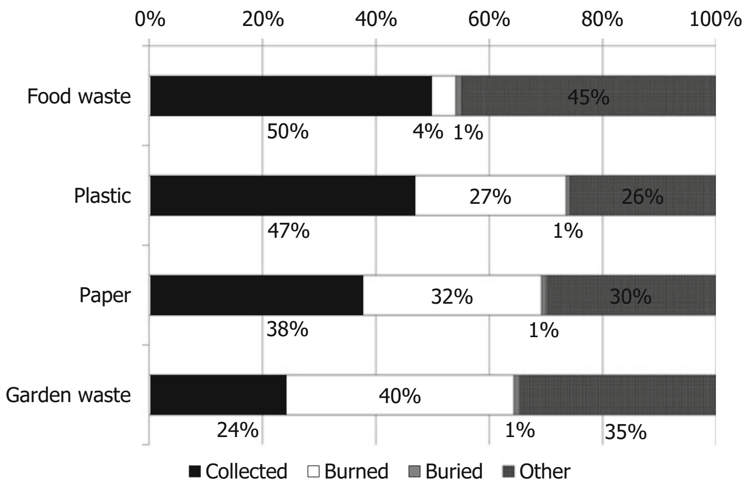


Fig. 3.18 Waste disposal method by waste type (JICA 2015a) (Note: Results are weighted values by population and waste amount per capita in Prabumulih.)

However, in rural areas, where only 27 % of the inhabitants have access to services, the main disposal method is "throw outside," and the relative percentage of "feed animals" is increased. Thus, waste collection service availability is closely related to the waste disposal methods used (JICA 2015a).

Figure 3.18 shows the waste disposal methods in terms of GHG emissions by waste type. For organic waste that is buried, 1 % of food waste is buried in a backyard or outside the house. Similarly, 1 % of paper waste and 1 % of garden waste are also buried. These values will be lost when GHG emissions are calculated from data obtained at the landfill. With regard to plastic waste, 27 % is burned. This value will also be lost from the GHG emissions based on the landfill data (JICA 2015a).

Based on the abovementioned results, Fig. 3.19 shows the GHG emissions from the disposal of household waste in Prabumulih. In the calculation, the amount of waste collected was regarded as waste landfilled. Collected waste accounted for 88 % of GHG emissions, and uncollected waste accounted for 12 %. The waste stream survey results enhanced the completeness of the GHG inventory in the waste sector. However, this calculation does not consider the amount of waste thrown into a river or the streets. In the near future, these waste methods will also be included. Figure 3.20 shows the predicted GHG emissions with those data included, revealing that GHG emissions will increase by 129 % from the current emission calculations.

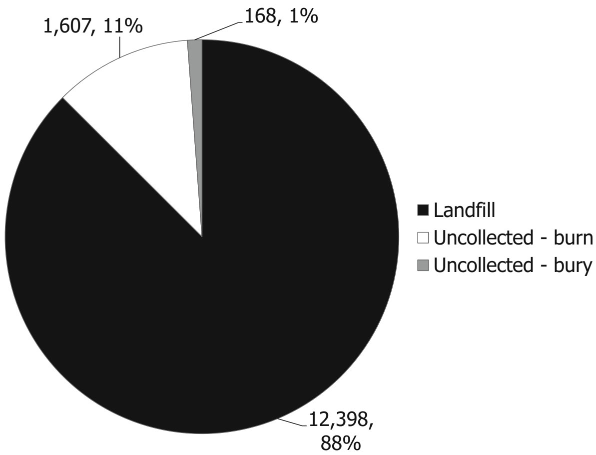


Fig. 3.19 GHG emissions in Prabumulih (household waste) (JICA 2015a)

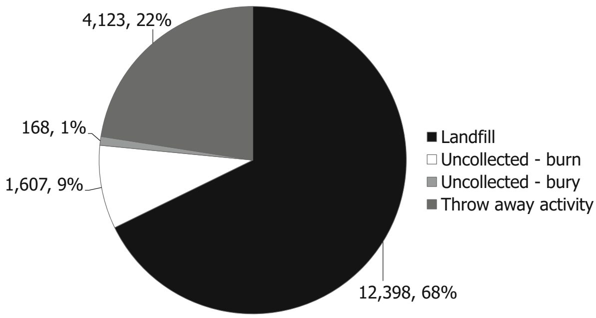


Fig. 3.20 Prediction of future GHG emissions (household waste) (JICA 2015a)

3.4.2.4 Example of Market Waste Survey: Prabumulih in South Sumatra

There is only one traditional market in Prabumulih, and 538 stores there sell foods such as chicken, meat, fish, and vegetables, as well as daily products such as dishes, books, and shoes (Fig. 3.21). Table 3.7 lists the number of stores by business type in the Prabumulih market. In total, 60 samples were taken, with consideration to the variety of products within each business type.

The waste composition survey results (Fig. 3.22) show that the waste amount per store varies depending on the type of business. The waste amount of the chicken store is the largest of the eight business types. Its main components are feathers and inedible body parts. The second biggest waste producer is the fruit store, and its main waste components are fruit peels and banana stems. The total amount of waste from the Prabumulih market is estimated to be 2344 tons per year (JICA 2015a). This result also provides useful data on waste amounts per store by business type, so that local governments can also estimate waste amounts based on the number of stores by business type.

Survey results show that the main component of market waste is food waste, except for the "other (non-food)" business type, although its percentage differs depending on the type of business. In addition to food waste, plastic waste and paper and carton wastes are also major waste components. The samples categorized as "other (non-food)" included several tailor stores. Therefore, the portion of

Fig. 3.21 Traditional market in Prabumulih (JICA 2015a)

Table 3.7 Total and sample number of stores in Prabumulih's traditional market (JICA 2015a)

Business type	Total number of stores	Sample
Meat	28	5
Chicken	69	5
Fish	37	10
Fruit	25	5
Vegetable	49	5
Other (food related)	65	10
Other (clothes, etc.)	232	10
Food/drink	33	10

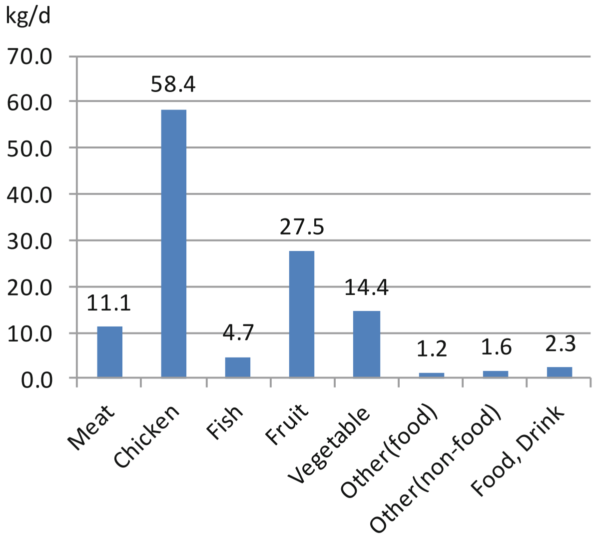


Fig. 3.22 Waste amount per store by type of business (JICA 2015a)

textiles is relatively high compared with the other business types (37.8 %), as depicted in Fig. 3.23.

As a result of short interviews with store owners, certain numbers of stores—all chicken stores and many fish and vegetable stores—dispose of their waste by giving or selling it to someone as animal feed or for another use, as shown in Fig. 3.24. Regarding chicken stores, approximately 50 % of their waste is given away or sold.

From the results of the waste composition survey and short interviews, Table 3.8 shows the amount of market waste estimated to be landfilled. Of these totals, 1129 tons of organic waste (the sum of food waste, paper and carton waste, and others) contribute to the GHG emissions from landfills. The emissions are estimated to be 872 tCO_2.

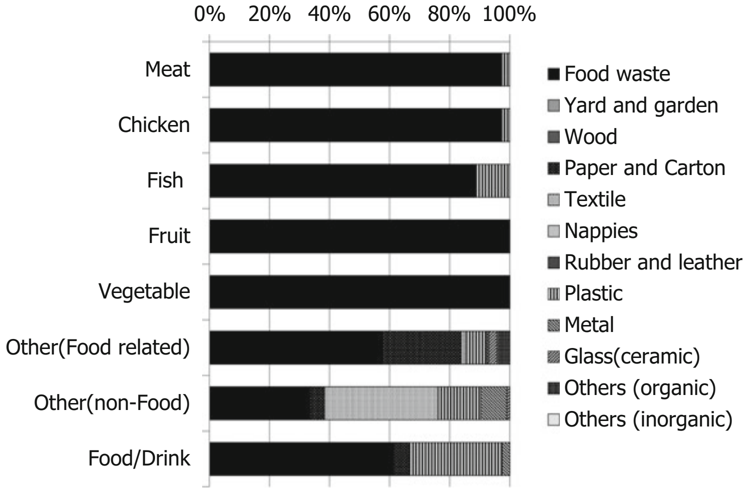


Fig. 3.23 Waste composition by type of business (JICA 2015a)

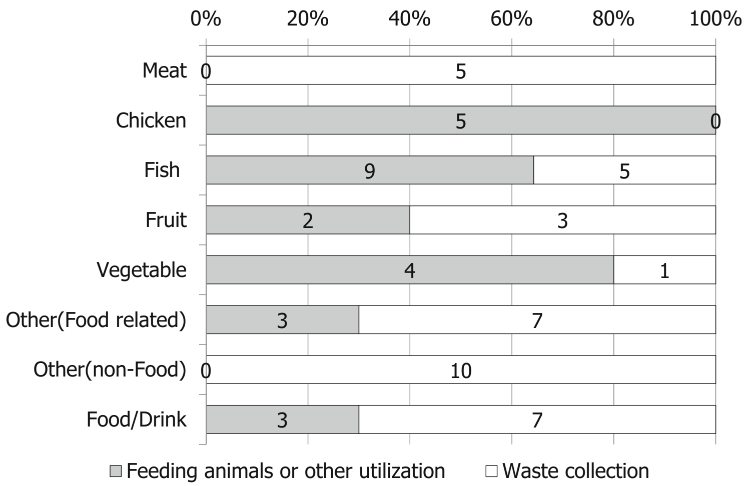


Fig. 3.24 Waste disposal methods by business type (JICA 2015a)

Table 3.8 Amounts of market waste estimated to be landfilled in Prabumulih (JICA 2015a)

	Waste generation	Waste landfilled (t/y)
Food waste	2182	1115
Yard and garden	–	–
Wood	–	–
Paper and carton	17	13
Textile	51	50
Nappies	0	0
Rubber and leather	–	–
Plastic	78	51
Metal	12	12
Glass (ceramic)	2	2
Others (organic)	1	1
Others (inorganic)	–	–
Total	2344	1245

3.5 Result and Discussion

By applying the higher-tier methodology of tier 2 (and partly tier 3), as indicated in Table 3.9, the GHG emissions from SWDSs decreased by 37.0 % in North Sumatra province and 28.9 % in South Sumatra province, as depicted in Fig. 3.25.

If the results of the pilot project were applied to other provinces, CH_4 emissions from SWDSs in other provinces would also be expected to decrease by approximately 30 %. This is because the tier 1 GHG estimation methodologies for the waste sector are used in other provinces, as had been the case for North Sumatra and South Sumatra before the pilot project started. This suggests that the national CH_4 emissions from SWDSs may be expected to decrease by approximately 30 % by the application of higher-tier methodologies.

Furthermore, by applying the result of waste stream survey in Prabumulih in 2014, GHG emissions from open burned MSW amounts 11 % of total GHG emissions from Prabumulih. However, before conducting waste stream survey, GHG emissions from open burned MSW were unknown. This suggests that the national CO_2 emissions from open burning of MSW may be expected to increase by the application of waste steam survey for improving accuracy of activity data.

GHG emissions from SWDSs in 2005 in Indonesia were estimated to be 24,409 $ktCO_2$ or 3.7 % of the national total GHG emissions without considering land use, land-use change, and forestry (LULUCF) (665,544 $ktCO_2$) (Ministry of Environment 2012). If the national CH_4 emissions from solid waste disposal sites were to decrease by approximately 30 %, as indicated by the result of the pilot project, this would represent an actual GHG emission reduction amounting to 7323 $ktCO_2$ or 1.1 % of the national GHG emissions. Considering the national GHG reduction target of 26 % by 2020, as compared to business-as-usual (BAU) emissions, the impact of a 1.1 % reduction in the national GHG emission would not be insignificant. This also suggests that even without the implementation of

Table 3.9 GHG inventory improvement by pilot project (JICA 2015b)

Improvement	Before pilot project	After pilot project
Methodology for CH_4 emissions from solid waste disposal site	Tier 1	Tiers 2 and 3 (partly)
Amount of landfilled waste	Estimated data from population	Monitored data and partly estimated data from population
Waste composition data	Introduced from previous research paper	Surveyed data in North Sumatra and South Sumatra province in 2011 and 2012
Dry matter content data	Not used	Surveyed data in North and South Sumatra province in 2011 and 2012

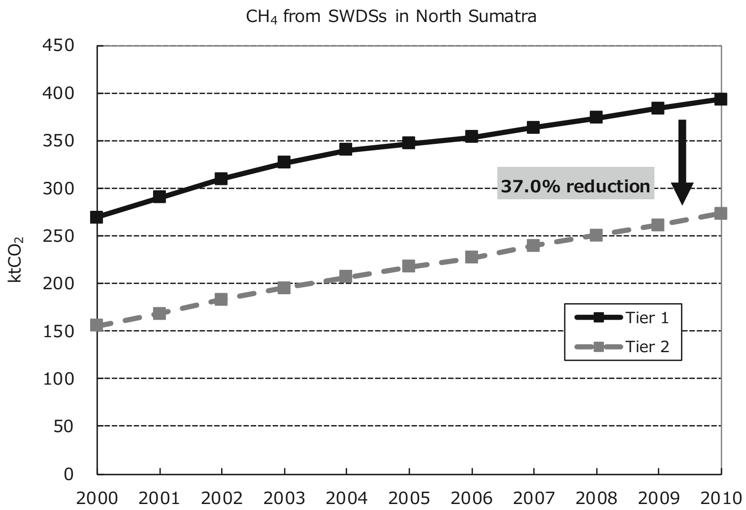


Fig. 3.25 Results from the application of a higher-tier methodology in North Sumatra and South Sumatra provinces in 2012 (JICA 2015a)

mitigation actions, 1.1 % of the national GHG emissions would be reduced by updating the GHG inventory from the application of higher-tier methodologies. However, this kind of GHG reduction should not be understood to be a true GHG reduction or target achievement, because the GHG reduction in the GHG inventory would not be based on implementation of actual mitigation actions but simply on changes in the methods of estimating the GHG inventory.

Figure 3.26 shows the influence of GHG inventory improvements to the national GHG reduction target. If BAU emissions and the GHG reduction target are not adjusted and GHG emissions decrease by GHG inventory improvements, it becomes easier for Indonesia to meet the national GHG reduction target. Therefore, updates to the national action plan for GHG emissions reduction must be considered if the GHG inventory is updated. Further, GHG reduction estimation methods for each mitigation action must be updated in conjunction with the GHG inventory update. This situation is relevant for all countries. Namely, if GHG emissions in

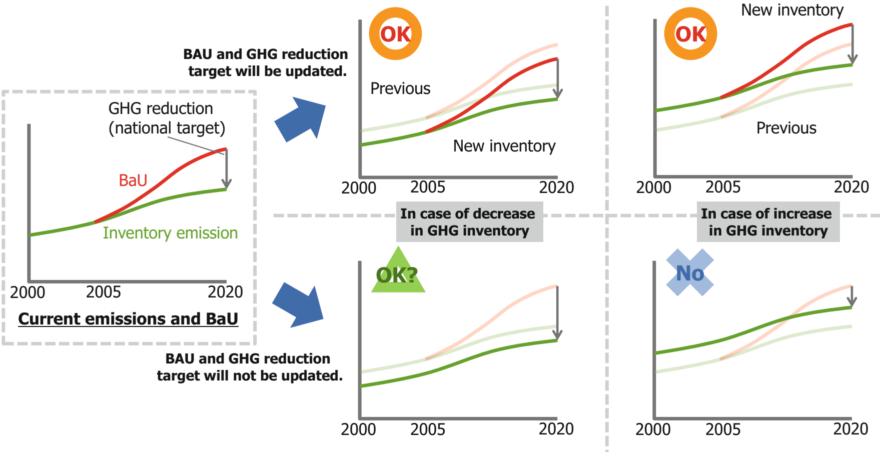


Fig. 3.26 Influence of GHG inventory improvement to the national GHG reduction target (by the authors)

each GHG inventory are updated, the resulting effect on the national GHG reduction targets must be considered.

3.6 Conclusion

This chapter discussed the importance of accurate estimation of GHG emissions for effective promotion of mitigation policies at the national and regional levels, using the result of pilot activity in North Sumatra and South Sumatra, which was conducted by KLH and JICA from 2011 to 2014 to enhance the quality of the GHG inventory in the waste sector. The application of higher-tier methodologies resulted in a decrease of GHG emissions from SWDSs by approximately 30 %. CH_4 emissions from SWDSs in other provinces are also expected to decrease by approximately 30 % because their GHG estimation methods are similar to what had been the case in North Sumatra and South Sumatra before the pilot project started. Updating the national action plan for GHG emission reduction must be considered along with the improvement of the GHG inventory.

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Chapter 4
Evaluation of National Adaptation Planning: A Case Study in Indonesia

Masato Kawanishi, Benjamin L. Preston, and Nadia Amelia Ridwan

Abstract The present study aims to evaluate national adaptation planning, using the National Action Plan for Climate Change Adaptation (RAN-API) in Indonesia as a case. In doing so, the current study applies the methodology used in Preston et al. (2011), where a set of 57 adaptation plans from three developed countries was evaluated against 19 planning processes. The same criteria and scoring system were applied to the current study to evaluate RAN-API, both as identified in its document and as viewed by the stakeholders. A desktop review and questionnaires were undertaken to this end. It was found that discrepancies exist between the status of RAN-API as documented and the stakeholders' views of some criteria, suggesting that information or knowledge gaps may still exist despite the efforts made for stakeholder engagement. In some of the other criteria, the stakeholders' views match the status as identified in the document. Most notably, they both agree that the weakness of RAN-API is related to limited consideration for non-climatic factors. While the development of RAN-API is a critical step taken in the country, the current study finds that there remains room for further improvement. The criteria or indicators to be used to assess the progress of RAN-API as a whole may need to be further elaborated.

Keywords Climate change • National adaptation planning • Monitoring and evaluation • Criteria and indicators • Mainstreaming • Indonesia

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4.1 Introduction

There is a substantial and growing interest among the policy and research community in monitoring and evaluation (M&E) of climate change adaptation. As indicated by Ford et al. (2013), this reflects a number of factors, including the need to evaluate adaptation funding, identify future priorities, and ensure the effective allocation of scarce resources. M&E plays an important role in any instance where practitioners seek to document results and improve performance. As indicated by Spearman and McGray (2011), however, given the uncertainty and dynamism associated with climate change, M&E is especially important for adaptation. Their study specifies two critical roles of M&E in promoting successful adaptation. It supports the long-term process of learning "what works" in adaptation. It also provides a tool for practitioners to manage their work in the context of the uncertainty surrounding climate change impacts. Similarly, Preston et al. (2011) identify three key reasons why the evaluation of adaptation processes and outcomes becomes increasingly important: (1) ensuring reduction in societal and ecological vulnerability, (2) learning and adaptive management, and (3) need for accountability in an evidence-based policy environment.

The present study aims to evaluate national adaptation planning, using the National Action Plan for Climate Change Adaptation (*Rencana Aksi Nasional untuk Adaptasi Perubahan Iklim*, RAN-API), which has been recently completed in Indonesia, as a case. In doing so, the current study applies the methodology that was used in Preston et al. (2011) to evaluate a set of 57 adaptation plans from three developed countries against 19 planning processes identified from existing guidance instruments, as will be described in detail later. The same criteria and scoring system were applied in the current study to evaluate RAN-API, based on the content of the document (BAPPENAS 2014) as well as the perspectives of key stakeholders. To this end, a desktop review and questionnaires were undertaken.

This paper will start with background information on (1) M&E of climate change adaptation, (2) climate variability, change and impacts in Indonesia, and (3) RAN-API. It will then describe the method and present the results, which will be followed by discussion and conclusion.

4.2 Background

4.2.1 M&E of Climate Change Adaptation

Consideration of the monitoring and evaluation of climate change adaptation has expanded significantly in recent years among both researchers and practitioners (Hedger et al. 2008; GIZ 2011; Sanahuja 2011; Spearman and McGray 2011; Lamhauge et al. 2012; Bours et al. 2013). The latest assessment report of the Intergovernmental Panel on Climate Change (IPCC) (Noble et al. 2014, p. 23) identifies three types of adaptation evaluation. The first type is to help determine the need or determinates of that need for adaptation. This type usually focuses on measuring vulnerability. The second type relates to measuring and tracking the process of implementing adaptive actions, such as spending on coastal protection and the number of early warning plans implemented. In this case, the selection of appropriate criteria and indicators is relatively easy. It is contentious, however, how much they measure the progress of adaptation rather than normal development. The third type relates to measuring the effectiveness of adaptation. While this is helpful in capturing the progress of adaptation, it is difficult to identify the effectiveness achieved due to adaptation as distinct from other potential factors. Noble et al. (2014, p. 26) state that “one of the central unresolved tensions in ongoing evaluation is the relative merit of easily targeting the completion of processes and outputs needed to implement an adaptation program versus the outcomes, such as changes in livelihoods or reduction in risks.”

Harley et al. (2008) suggest that a framework for the development of adaptation indicators will be necessary to make linkages between (1) building adaptive capacity, where indicators are needed to monitor the progress in implementing adaptation measures (so-called process-based indicators), and (2) delivering adaptation actions, where indicators are needed to measure the effectiveness of adaptation policies and activities in general (so-called outcome-based indicators). The above study also indicates that a complication in developing indicators relates to the difficulty in separating progress in adaptation, from progress achieved by broader sectoral policies. Good adaptation is primarily delivered through mainstreaming and usually involves a range of incremental activities in related sectors. Adaptation progress within a given sector may be difficult to attribute to adaptation policies or programs as distinct from any wider sectoral advances.

Preston et al. (2011), on the other hand, argues that the discussions on M&E of adaptation “have largely centered on evaluating substantive outcomes of capacity building activities and adaptation actions and do not necessarily examine or critique the upstream planning processes that lead to those actions.” This emphasis on outcomes is potentially problematic given significant time may transpire before the costs and benefits of adaptation can be evaluated. Therefore, a focus on the procedural rationality of adaptation planning may be a more useful evaluative criterion than the substantive outcomes of specific policies and measures. In this context, a set of 57 adaptation plans from three developed countries (Australia, the UK, and the USA) was evaluated against 19 planning processes identified from existing guidance instruments for adaptation planning.

At the first step, Preston et al. (2011) applied logical framework analysis to define four main stages of adaptation planning: “goal setting,” “stocktaking,” “decision-making,” and “implementation and evaluation.” Twenty guidance instruments for adaptation planning, which were all publicly available, were reviewed to identify key processes associated with adaptation planning. This led to the development of 19 process-based evaluation criteria, two pertaining to “goal setting,” five to “stocktaking,” eight to “decision-making,” and four to “implementation and evaluation,” as defined in Table 4.1. The above-identified criteria were

Table 4.1 Descriptions of adaptation planning stages and process used as evaluation criteria in Preston et al. (2011) and applied in the current study. Planning is categorized into four key stages, each of which is comprised of multiple adaptation processes

Adaptation stage	Adaptation processes (used as evaluation criteria)	Criteria description
Goal setting	Articulation of objectives, goals, and priorities	Establishing the objectives, goals, and priorities for adaptation
	Identification of success criteria	Consideration of what successful adaptation will look like and how it will be measured
Stocktaking	Assessment of human capital	Consideration of the existing skills, knowledge, and experience of individuals responsible for adaptation planning and implementation
	Assessment of social capital	Consideration of the existing governance, institutional, and policy contexts for adaptation, including the capacity and entitlements of those institutions, organizations, and businesses responsible for designing, delivering, and implementing adaptation measures
	Assessment of natural capital	Consideration of natural resource stocks and environmental services which are sensitive to climate and/or integral in the management of climate risks
	Assessment of physical capital	Consideration of material culture, assets, and infrastructure that are sensitive to climate and/or integral in the management of climate risks
	Assessment of financial capital	Consideration of stocks and flows of financial resources and obligations within and among individuals and institutions including cash revenues, credit and debt, and mechanisms for financial risk management
Decision-making	Stakeholder engagement	Engagement of relevant stakeholders and communities throughout the adaptation process
	Assessment of climate drivers	Consideration of historical climate trends, current climate variability, and future climate projections
	Assessment of non-climate drivers	Consideration of variability and trends in their environmental and socioeconomic factors relevant to the system of interest
	Assessment of impacts, vulnerability, and/or risk	Assessment of the impacts of changes in climate, vulnerability, or resilience to those changes and the relative importance of climate and non-climate risks
	Acknowledgement of assumptions and uncertainties	Transparency about the assumptions made to establish those impacts and risks and the uncertainties involved in their estimation
	Options appraisal	Identification and comparison of different adaptation options and a means for selecting between them

(continued)

Table 4.1 (continued)

Adaptation stage	Adaptation processes (used as evaluation criteria)	Criteria description
	Exploitation of synergies	Identification of where opportunities exist to implement adaptation in a manner that promotes synergies with existing policies or plans, including mitigation
	Mainstreaming	Identification of ways in which climate change adaptation can be institutionalized or embedded into existing or new polices and plans
Implementation and evaluation	Communication and outreach	Communication and dissemination of adaptation plans and any downstream outcomes to the appropriate stakeholders and communities
	Definition of roles and responsibilities	Establishing who is responsible for different aspects of adaptation strategy
	Implementation	Establishing the mechanisms that will allow implementation of adaptation measures
	Monitoring, evaluation, and review	Establishing a system of monitoring and evaluation that allows the performance of adaptation to be assessed against success criteria and for review of inputs and procedures

Adopted from Preston et al. (2011)

subsequently used to interrogate the selected adaptation plans. The evaluation was then performed by scoring each adaptation plan against the criteria on a three-point scale (0, 1, or 2), according to the requirements associated with each possible score, as described in Table 4.2. The results of this methodology suggested that adaptation plans within developed nations are largely underdeveloped yet also identified specific aspects of planning that could be improved.

4.2.2 *Climate Variability, Change, and Impacts in Indonesia*

4.2.2.1 Climate and Its Variations

Indonesia consists of more than 17,000 islands and lies on both sides of the equator. It is located between the Pacific and Indian Oceans and between the Asian and Australian continents. The climate diversity in Indonesia, especially rainfall, is influenced by climate factors with different spatial and temporal scales. Rainfall is deemed to be the most important climate element in Indonesia. As this is an equatorial tropical region, the annual variation of surface temperature is not so significant, while the rainfall is varied in spatial and temporal terms.

In terms of intra-annual rainfall patterns, Indonesia is divided into three climate regions with their distinct characteristics, as illustrated in Fig. 4.1 (Aldrian and Susanto 2003). Region A is located in the southern part of Indonesia, including Java

Table 4.2 Summary of scoring system used in Preston et al. (2011) and applied in the current study. The RAN-API was scored by respondents against 19 evaluation criteria as defined in Table 4.1. General conditions that merit the assignment of different scores are described below

Score	Necessary conditions
0	No evidence of consideration for a particular criterion was apparent within the published plan. This suggests a particular concept or planning process was neglected
1	Evidence exists of consideration of a particular criterion during the development of the adaptation plan. This suggests the concept or process in question was recognized or acknowledged as being of some importance. However, the concept or process remained underdeveloped, suggesting additional consideration may be required for robust planning
2	Evidence exists of consideration of a particular criterion during the development of the adaptation plan and significant effort was invested as part of the planning process (or prior to the planning process) to establish a particular criterion or complete a particular process

Adopted from Preston et al. (2011)

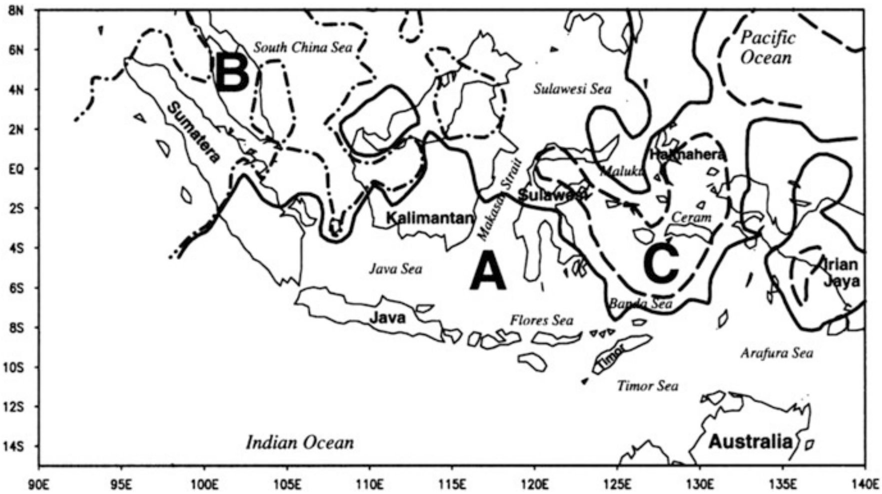

Fig. 4.1 Three climate regions in Indonesia: Region A in *solid line*, Region B in *short-dashed line*, and Region C in *long-dashed line* (Cited from Adrian and Susanto 2003)

and Bali. Region B is located in northwest Indonesia from northern Sumatra to northwestern Kalimantan. Region C encompasses Maluku and northern Sulawesi. As Aldrian and Susanto (2003) describe, Region B has two peaks of seasonal rainfall, one from October to November and the other from March to May. Those two peaks are associated with the southward and northward movement of the intertropical convergence zone (ITCZ), a zone of low-pressure near the equator. This is in contrast with Region A, which has one peak from November to March and one from May to September, with a strong influence of monsoons. Region C has one peak from June to July and one through from November to February.

There are phenomena relating to meteorological disturbances that affect the nature of seasonal rainfall, known as the intra-seasonal variation, which leads to seasonal irregularities. This is also considered as a trigger for the occurrence of extreme weather events. Wheeler (2003) stated that the anomaly of rainfall in January 2002, triggering floods in various locations, was caused by the Madden–Julian oscillation (MJO), which is an eastward movement of convection from the Indian Ocean to the Pacific Ocean (Hendon and Salby 1993; Zhang 2005; Tangang et al. 2008; Duncan and Han 2009; Salahuddin and Curtis 2009; Webber et al. 2010). On the other hand, Wu et al. (2007) and Trilaksono et al. (2011) attributed the large flood in Jakarta in 2007 to the cold surge, which is a flow of cold air mass from the Eurasian lands accompanied by a decline in temperature in most of the Southeast Asian region. Conversely, the southerly surge strengthens the wind going northward and shifts the position of ITCZ to the north, causing a decline of rainfall over Java and Nusa Tenggara (Davidson 1984). The interaction among the phenomena relating to the intra-seasonal variation, such as those described above, makes the climate pattern in the Indonesia–Australia region complex.

As for interannual climate variations, the El Nino-Southern Oscillation (ENSO) and the Indian Ocean dipole (IOD) are two dominant modes in the tropical Pacific and Indian Oceans, respectively, with a strong influence on the climate of Indonesia. There are two modes of ENSO, El Niño and La Niña. When El Niño is in effect, drier conditions prevail over Indonesia (Sahu et al. 2010). El Niño, which lasts from June to November, reduces an already low rainfall in Region A and thus causes drought. While Regions A and C have a strong ENSO influence, Region B has little relevance to the ENSO impact (Aldrian and Susanto 2003). IOD is a coupled ocean-atmospheric phenomenon in the tropical Indian Ocean. Recent studies (Saji et al. 1999; Behera and Yamagata 2003) found that IOD also has a strong influence on the climate of Indonesia. Like ENSO, there are two modes of IOD events, a positive and a negative IOD. A positive IOD causes drier conditions in Indonesia, particularly in the western part of the country. An IOD event usually starts around May or June, peaks between August and October, and then rapidly decays (Sahu et al. 2010).

The maritime climate in Indonesia is also affected by the Asia–Australia monsoon circulation through the subsequent change in sea flow and vertical movements of sea waters (BAPPENAS 2014). Generally, the sea surface temperature (SST) is above 28 °C in January and below 27 °C in August. The decline in SST is mainly due to upwelling of waters in the Indian Ocean as a result of the easterly wind in the Australian cold monsoon season, which causes migration of colder sea water mass from the Indian Ocean to the Java Sea. Conversely, the westerly wind brings in warmer sea waters from the Pacific Ocean around January. The sea flows associated with the monsoon circulation also affect sea level. Generally, it rises in January and falls in August. The interannual climate variations, such as ENSO and IOD, also influence it. Sofian (2007), for example, states that the increase in sea level is caused by La Nina, which strengthens trade winds in the Pacific Ocean, thereby bringing a water mass from the East Pacific around Peru to Indonesia.

4.2.2.2 Observed and Projected Climate Change

According to the Second National Communication of Indonesia (Ministry of Environment 2010), a significant increase in maximum and minimum temperatures was observed from 1980 to 2002 in most of the stations in the country. On average, the rate of changes in minimum and maximum temperatures across 33 stations was 0.047 °C and 0.017 °C per year, respectively. In ocean waters surrounding Indonesia, in the period 1993–2008, the average rate of SST increase ranged from 0.020 to 0.023 °C/year. The increase in global temperature caused an increase in sea level rise. Based on an analysis of altimeter data from January 1993 to December 2008, it was found that the rate of sea level rise ranged from 0.2 to 1 cm/year, with an average of approximately 0.6 cm/year. The trend analysis of historical rainfall data from 384 stations over time scales between 20 and 50 years indicates a significant decrease in December–January rainfall over a large portion of Kalimantan, whereas a substantial increasing trend has been observed in most of Java and eastern Indonesia, including Bali and Nusa Tenggara. For June–August rainfall, a significantly decreasing trend was observed in most of the Indonesian region with some exceptions. The monsoon onset also changed in many parts of Indonesia. Based on analysis of data from 92 stations, the monsoon onset has been increasingly delayed in some parts of Indonesia, particularly in Java. Similarly, the length of wet seasons has tended to shorten, particularly in Java and Kalimantan.

The simulations of 14 general circulation models (GCMs) under different emission scenarios were also assessed in the National Communication. Most of the models agree that the seasonal rainfall from December to February will increase in Java by 2025, while the rainfall from June to August in most parts of Java is likely to decrease. The impact of global warming on the monsoon onset in Java and Bali was studied by Naylor et al. (2007), using more GCMs and empirical downscaling models. It was found that the onset of rainy season in Java and Bali is projected to delay under a changing climate. Emanuel (2005) also suggested that increasing SST will strengthen tropical cyclones, causing strong winds and heavy rainfalls.

4.2.2.3 Climate Impacts: Rice Production as an Example

This section will describe climate impacts in Indonesia, using rice production as an example given its relevance to Chaps. 13 and 14 of this book. According to the World Bank (2013), Indonesia is the world's fifth largest agricultural producer after China, India, the USA, and Brazil. It is also the third largest rice producer and consumer after China and India. Rice is Indonesia's single most important commodity, and for most of her population, it is the staple food. Rice production in Indonesia, however, is faced with a number of socioeconomic problems (OECD 2012). The sectoral share of the GDP has been sharply decreasing despite its continued importance in rural development and employment. Estate plantation area, particularly for oil palm, has expanded substantially, while the area of paddy field increased only slightly nationwide, and it consistently decreased in Java. The yield growth has also declined, which is attributed by Fuglie (2010) and Simatupang and Timmer (2008) to the reductions of public investments in irrigation, subsidies for fertilizers, and funding for research and development on high-yield varieties since the 1990s.

These socioeconomic problems concerning rice production are exacerbated by climate impacts, as illustrated in Fig. 4.2, which indicates the importance of understanding how climate and non-climate factors interact with each other in designing adaptation measures. A number of studies have been performed to evaluate the impact of climate variability and change. Amien et al. (1996, 1999) and Matthew et al. (2007) used climate scenarios as inputs to rice crop models to project the effect of changes in temperature, rainfall, and CO_2 concentration on rice yield in Java. They found the models to predict a future yield reduction under climate change. Naylor et al. (2007) revealed a marked increase in the probability of a 30-day delay in monsoon onset in 2050, underscoring a need for adaptation strategies in rice production, including investments in water storage, crop diversification, and early warning systems.

4.2.3 RAN-API

RAN-API was officially announced in February 2014, after a series of consultations for about 2 years among the related ministries and agencies at different levels, with

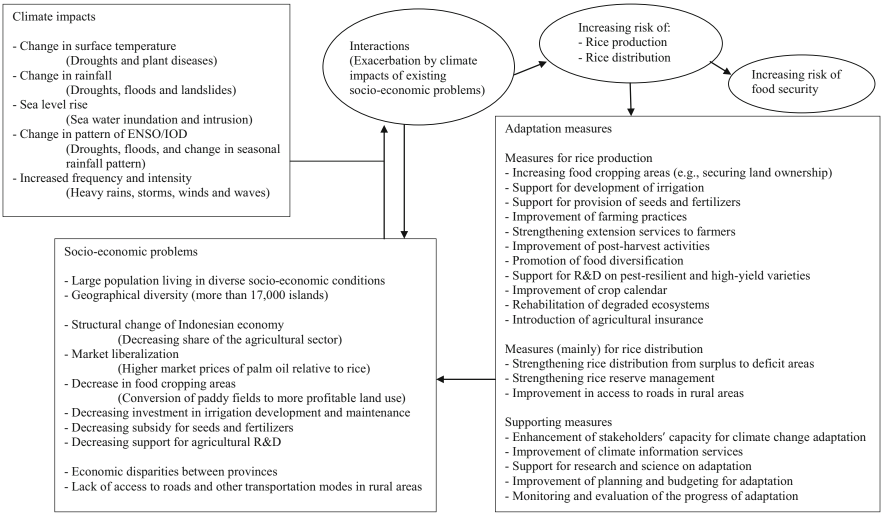

Fig. 4.2 Exacerbation by climate impacts of socioeconomic problems on rice production and distribution and adaption measures in Indonesia (Cited from Kawanishi 2014)

facilitation by the National Development Planning Agency (*Badan Perencanaan Pembangunan Nasional*, BAPPENAS), the Ministry of Environment (*Kementerian Lingkungan Hidup*, KLH), the Agency for Meteorology, Climatology and Geophysics (*Badan Meteorologi*, *Klimatologi*, *dan Geofisika*, BMKG), and the National Council on Climate Change (*Dewan Nasional Perubahan Iklim*, DNPI). Other stakeholders, such as nongovernmental organizations, universities, research institutes, and donors, were also invited to the drafting process.

RAN-API is aimed at providing directions for mainstreaming climate change adaptation into national, local, and sectoral development planning. It consists of actions directed toward strengthening the resilience of (1) the economic system, (2) livelihood, (3) environmental services, and (4) specific locations, such as coastal areas and small islands. It also includes strengthening a common capacity to support enhancing the above resilience. RAN-API has five major clusters, each of

Table 4.3 Structure of RAN-API (BAPPENAS 2014)

Chapter 1. Introduction
Chapter 2. Climate change and its impact in Indonesia
Chapter 3. Policy and objectives of RAN-API
Chapter 4. Adaptation strategy and action plan
4.1. Economic resilience
Food security
Energy
4.2. Livelihood resilience
Health
Settlements
Infrastructure
4.3. Resilience of environmental services
4.4. Resilience in specific areas
Urban area
Coastal area and small islands
4.5. Support system
Enhancement of capacity of stakeholders for adaptation to climate change
Improvement of climate information system
Research and science for climate change adaptation
Improvement of planning and budgeting
Monitoring and evaluation of the progress of adaptation
Chapter 5. Implementation mechanism
5.1. Coordination
5.2. Funding
5.3. Monitoring, evaluation, reporting, and review
Chapter 6. Pilot activities under RAN-API
Appendix 1. List of actions under RAN-API
Appendix 2. Summary of climate change impacts
Appendix 3. Consideration of gender in RAN-API

which has subclusters, such as food security under the economic resilience. Each subcluster contains more detailed adaptation options, along with information on the scope of actions, priority locations, and institutions involved for each. The structure of RAN-API is summarized in Table 4.3.

Coordination is one of the main challenges, as ministries and agencies at different levels are involved in the planning and implementation of RAN-API. In this regard, the Government of Indonesia has established the Climate Change Coordination Team under the Ministerial Decree of BAPPENAS. The Team consists of the steering committee and six working groups: (1) agriculture; (2) forestry and peat land; (3) energy, transportation, and industry; (4) waste; (5) cross sector; and (6) adaptation. The working group on adaptation has tasks, among others, (1) to coordinate the implementation of programs and activities in adaptation, (2) to synchronize the work plans of relevant line ministries, and (3) to formulate biannual and annual progress reports (BAPPENAS 2014).

4.3 Method

The present study builds upon Preston et al. (2011), which presented objective criteria and indicators to help replicating the methodology. However, the current study extends the earlier methodology by combining a desktop review of the RAN-API document with the use of stakeholder questionnaires to incorporate their perspectives. For the desktop review, the document of RAN-API (BAPPENAS 2014) was reviewed by the authors against 19 evaluation criteria as defined in Table 4.1, and scored on a scale of 0, 1, or 2, according to the general conditions that merit the assignment of different scores as described in Table 4.2. A complete description of process-specific scoring criteria, as developed by Preston et al. (2011), was also utilized. To minimize bias, the status of RAN-API as documented was evaluated and scored by one author, which was then reviewed by another to detect any inconsistencies.

Questionnaires were also used under the current study. After RAN-API was officially launched in February 2014, the first follow-up meeting, organized by BAPPENAS, took place in June 2014 in Jakarta. Invitations were extended to the relevant ministries and agencies, such as the Ministries of Public Works and Agriculture among others, at the national government, as well as related agencies, such as the Provincial Development Planning Agency (*Badan Perencanaan Pembangunan Daerah*, BAPPEDA) and the Provincial Environmental Agency (*Badan Lingkungan Hidup*, BLH) in the provincial governments. The meeting was attended by a hundred officials. Some of them were heavily involved in the consultation process toward the completion of the RAN-API document, while others were only recently appointed. Irrespective of the level of prior knowledge or experience, those participants are considered to be the immediate stakeholders for RAN-API, who are tasked with mainstreaming adaptation into their particular sectoral or local development plans.

Questionnaires aimed to understand the views of those immediate stakeholders on RAN-API. The participants at the above meeting were therefore sampled in a purposive manner (Miles and Huberman 1994, p. 27; McGuirk and O'Neill 2010, p. 205). With a prior consent by BAPPENAS, questionnaires were distributed by one of the authors to the participants at the beginning of the half-day session and collected at the end. In total, 71 responses were compiled, with 17 from the national and 53 from the provincial governments (JICA 2014).

The questionnaire was developed in a multiple-choice format in the Indonesian language. Respondents were requested to write the name of the organizations they belong to at the top of the sheet. Then, they scored RAN-API against the evaluation criteria as defined in Table 4.1, on a scale of 0, 1, or 2, according to the requirements associated with each possible score as described in Table 4.2. In doing so, they were requested to select one from four choices: 0, 1, 2, or "I don't know."

The responses were assessed in terms of scores both by respondents and by criteria. Firstly, scores were totaled for the respondents who gave answers either of 0, 1, or 2 to all of the questions without giving any answer "I don't know." Total scores were also calculated for all of the respondents, where the answer "I don't know" was counted as zero. The mean and range of the total scores were also assessed in reference to the results of the evaluation under Preston et al. (2011) as well as the desktop review of the RAN-API document under the current study. In addition, an independent-sample *t*-test was performed to see whether significant difference exists between the scores by respondents from the national government ($n_1 = 17$) and those from provincial governments ($n_2 = 54$). A null hypothesis was tested at an alpha value of 0.05. The *t*-test was performed after testing the equality of the variances between the two groups at an alpha level of 0.05.

Secondly, the criteria with the highest and lowest scores were identified and examined. The frequency of the answer "I don't know" was also counted for the respective criteria to identify the areas where information or knowledge gaps exist. In addition, the correlations between the scores given by the respondents for one criterion and those for another were investigated for 171 pairs (19*18/2) of the criteria. The *p* values were also calculated to understand the statistical significance of these correlations.

4.4 Results

4.4.1 Result of Desktop Review

Table 4.4 is a summary of desktop review of the RAN-API document. The overall score for the document was 21 points, 55.3 % out of the maximum possible score (2 points * 19 questions = 38 points), with 2 points each for "stakeholder engagement" and "assessment of climate drivers," while 1 point each for the remaining

Table 4.4 Result of desktop review of the RAN-API document with respect to the 19 criteria defined in Table 4.1

Criteria	Score	Status as found in the RAN-API document
Articulation of objectives, goals, and priorities	1	The broad purpose of the adaptation strategy is stated: RAN-API "is aimed at . . . securing the achievement of the main objectives of development" (p. 2). "The main purpose . . . is the implementation of development . . . that is sustainable and highly resilient to climate change impacts" (p. 3)
Identification of success criteria	1	The criteria and indicators of success are identified for the respective adaptation options, which are listed in Appendix 1 (p. 64–139). No clear indication is found concerning program-wide success criteria
Assessment of human capital	1	No substantial assessment of human capital is provided in the document, with some exceptions including the assessments of local government: "The resources and the capacity of local government are still limited," despite the importance of their role in the implementation of RAN-API (p. 56)
Assessment of social capital	1	The implementation of RAN-API and its monitoring and evaluation will build upon the existing governance and procedure for national, local, and sectoral development planning in Indonesia. It is stated that "RAN-API will be a part of the existing national development planning framework. . . . RAN-API is not a separate document which has formal legal powers of its own, but it is . . . an integral part of national . . . and (sectoral) planning documents. RAN-API is also a reference . . .in preparing local development planning documents" (p. 4). It is also stated that M&E of the progress of adaptation "should be done in line with the monitoring and evaluation that has been carried out for the implementation of development activities" (p. 53)
Assessment of natural capital	1	Assessment of natural capital in relation to impacts and resilience for environmental services as well as coastal areas and small islands is provided (p. 20–25; 28–30)
Assessment of physical capital	1	Assessment of physical capital in relation to impacts and resilience for settlements, infrastructure, and urban areas is provided (p. 20–25; 28–30)
Assessment of financial capital	1	Adaptation funding is presented in the document. It is stated that "the main funding source . . . is the state budget" (p. 6). Other potential domestic and international funding sources are also presented (p. 50–53)
Stakeholder engagement	2	"To ensure involvement and ownership . . ., the preparation of RAN-API has been carried out through a participatory approach involving various ministries and agencies. . . . In addition, there is the involvement of community service organizations and development partners in the drafting process" (p. 4–5)
Assessment of climate drivers	2	Historical trends and future projections for surface temperature, rainfall, sea surface temperature, sea

(continued)

Table 4.4 (continued)

Criteria	Score	Status as found in the RAN-API document
		level, and extreme climate events are presented (p. 8–20). Appendix 2, "Summary of climate change impacts," is also provided (p. 140–147)
Assessment of non-climate drivers	1	Some of the factors of relevance to "economic resilience," "livelihood resilience," "resilience of environmental services," and "resilience in specific areas" are addressed in RAN-API (p. 33–46). Limited consideration is taken, however, of how socioeconomic factors will interact with climate factors and how existing socioeconomic problems will be exacerbated by climate impacts
Assessment of impacts, vulnerability and/or risk	1	Impact of climate change on food security, energy, health, settlements, infrastructure, environmental services, urban/coastal areas, and small islands is presented, with identification of the most vulnerable areas in Indonesia (p. 20–26). Appendix 2, "Summary of climate change impacts," is also provided (p. 140–147)
Acknowledgement of assumptions and uncertainties	1	Acknowledgments of assumptions and uncertainties are given as follows: "The results of climate projections are dependent upon the scenario . . . based on the assumption of global socio-economic development as well as key technology" (p. 17). "A comprehensive study related to extreme events in Indonesia is still very limited" (p. 20). "The scope (of many studies on climate change impacts in Indonesia) is . . . still (only) on a national scale" (p. 21)
Options appraisal	1	Adaptation options are identified and listed in Appendix 1 (p. 64–139), with information on their respective objectives, periods, locations, budgets, and responsible organizations. No clear indication is given concerning a means of selection between the options
Exploitation of synergies	1	Adaptation options are considered in five clusters: (1) economic resilience, (2) livelihood resilience, (3) resilience of environmental services, (4) resilience in specific areas, and (5) support system, in order to ensure synergies across different sectors, recognizing that "each sector's development targets may not be achievable . . . without support of other sectors" (p. 34)
Mainstreaming	1	It is stated that "mainstreaming . . . is a necessity, (and) the issue of adaptation to climate change should be an integral and inseparable part in the preparation of national and sectoral development plans" (p. 2). A clear identification of the ways in which adaptation will be mainstreamed into development planning will be given later. Pilot activities in the selected locations are expected to provide useful inputs (p. 56)
Communication and outreach	1	The actions stipulated in RAN-API include the "efforts to implement education, counseling and training on

(continued)

Table 4.4 (continued)

Criteria	Score	Status as found in the RAN-API document
		climate change adaptation; and establishment of a forum/networking/alliance/working group for adaptation" (p. 44)
Definition of roles and responsibilities	1	"The preparation and implementation of RAN-API is the duty of the Adaptation Working Group" (pp. 49), which was established by the Ministerial Decree of BAPPENAS No. 38/M.PPN/HK/03/2012. The roles and responsibilities of other ministries, agencies, and provincial governments are also identified (p. 49)
Implementation	1	The mechanism for coordinating the implementation of adaptation measures is stated (p. 48–50). A list of adaptation options is also presented in Appendix 1, with information on their respective objectives, periods, locations, budgets, and responsible organizations (p. 64–139)
Monitoring, evaluation, and review	1	Monitoring of the implementation of RAN-API is performed by relevant ministries and agencies and periodically reported to BAPPENAS. The details of the monitoring and evaluation mechanism will be established later. Besides, RAN-API will be reviewed according to newly available scientific findings and other changes in national and global circumstances (p. 53)
Total score	21	

criteria. The brief descriptions of the status of RAN-API as found in the document (BAPPENAS 2014) are as follows.

The broad purpose of RAN-API, as well as the objectives of the respective adaptation options, is stated. While the criteria or indicators for the individual options are indicated, those to be used to assess the progress or success of RAN-API as a whole may need to be further elaborated. The entitled capitals have been assessed, albeit to varying degrees. The social capital, in particular the existing governance and procedures of development planning, implementation, monitoring, and evaluation, is presented to support mainstreaming.

Stakeholder engagement has been essential in the development of RAN-API. Mainstreaming is strongly emphasized, and it is stated that the implementation of RAN-API, and its monitoring and evaluation, will build upon the existing governance and procedure for national, local, and sectoral development planning. One of the chapters of the document is devoted to the assessments of climate drivers, impacts, and vulnerability. Historical trends and future projections for surface temperature, rainfall, sea surface temperature, sea level, and extreme climate events are presented. The impacts of climate change are indicated, with identification of the most vulnerable areas in the country. A summary table of these assessments is also provided in the Appendix of the RAN-API document. Assumptions made during these assessments are acknowledged. Some of the non-climate factors of relevance to "economic resilience," "livelihood resilience," "resilience of environmental services," and "resilience in specific areas" are addressed in the document. Limited consideration is taken, however, of how socioeconomic factors will interact with climate factors. Adaptation options are identified and listed, with information on their respective objectives, periods, locations, budgets, and responsible organizations. The importance of seeking synergies is also presented.

Communication and outreach are contained in the measures to be taken. The mechanism for coordinating the implementation of adaptation measures is stated. Roles and responsibilities are indicated for the coordination as well as for the implementation of respective adaptation options. Monitoring of the implementation of RAN-API is performed by relevant ministries and agencies and periodically reported to BAPPENAS. The details of the monitoring and evaluation mechanism will be established later. It is also stated that RAN-API will be reviewed according to newly available scientific findings and other changes in the national and global circumstances.

4.4.2 Result of Questionnaires

Out of 71 respondents, 25 gave answers either of 0, 1, or 2 to all of the questions without giving any answer "I don't know." The mean of these total scores is 21.1 points, 55.6 % out of the maximum possible score, the same as the scoring result of the desktop review, as presented in the previous section. The range is from 13 to 29 points, equivalent to 34.2–76.3 % of the highest possible.

In case the answer "I don't know" was counted as zero, the mean of the total scores of all the respondents was 17.8 points, 46.9 % out of the highest possible, lower than the scoring result of the desktop review. The range was from zero to 31 points, equivalent to 0–81.6 %. Less than a half of the respondents (33 out of 71) gave scores of more than 19 points, 50 % of the maximum possible. There were ten respondents whose scores are equal to or less than ten points, equivalent to the mean minus one standard deviation. As shown in Fig. 4.3, the above was compared to Preston et al. (2011), where 57 adaptation plans in three developed countries were evaluated against 19 criteria, with the result that the mean score was 14 points (37 %), ranging from six to 22 points (16–61 %). The comparison was made with the recognition that RAN-API is scored by multiple respondents through questionnaires under the current study, while multiple adaptation plans were scored through desktop review by two investigators under Preston et al. (2011). It was found that the mean of the respondents' scores on RAN-API was slightly better, but their views deviated more from the mean.

An independent-sample *t*-test was performed between the scores by the respondents from the national government ($n_1 = 17$) and those from provincial governments ($n_2 = 54$). In testing the hypothesis with equal variances assumed, the computed two-tailed p value was larger than the alpha value of 0.05. The computed t value was also less than the critical value of t at the alpha value. These findings fail

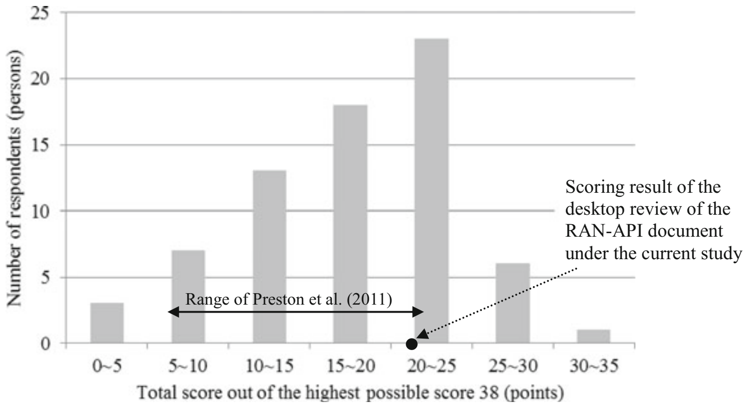

Fig. 4.3 Frequency distribution of total scores in the stakeholder questionnaires in comparison to the result of Preston et al. (2011) and the desktop review of the RAN-API document

to reject the null hypothesis, indicating that there is no significant difference between the scores given by the participants from the national government and those from provincial governments.

In case the scores are added by criteria, with the answer "I don't know" being counted as zero, the highest possible total score by criteria was 142 points (two points * 71 respondents). It was found that the mean score is 66.6 points, 46.9 % of the maximum possible. The range was from 40 to 100 points, equivalent to 28.2–70.4 %. As shown in Table 4.5, the criteria with the highest scores were "stakeholder engagement" (70.4 % of the highest possible score), "communication and outreach" (64.8 %), and "articulation of objective, goals, and priorities" (64.8 %). The criteria with the lowest scores, on the other hand, were "assessment of non-climate drivers" (28.2 %), "assessment of financial capital" (34.5 %), and "assessment of climate drivers" (35.9 %). The frequency of the answer "I don't know" was also counted by criteria. The mean of the number of answers "I don't know" was 13.3, which was 18.8 % out of the total number of responses per criterion (71). The range was from four to 21, equivalent to 5.6–29.6 % of the total. The criteria, where the replies "I don't know" were least frequent, were "articulation of objectives, goals, and priorities" (5.6 %), "stakeholder engagement" (7.0 %), and "mainstreaming" (12.7 %). The criteria where the replies "I don't know" were most frequent, on the other hand, were "assessment of non-climate drivers" (29.6 %), "assessment of climate drivers" (28.2 %), and "assessment of social capital" (26.8 %).

The correlations between the scores given by the respondents for one criterion and those for another were also investigated for 171 pairs of the criteria. It was found that more than 90 % of the pairs have correlation coefficients between −0.1 and 0.5, indicating that a strong relationship does not exist in scores between the criteria. There were 12 pairs whose correlation coefficients were larger than 0.5, indicating their positive correlations are sufficiently strong. It was also found that

Table 4.5 Result of questionnaires by evaluation criteria

Criteria with the highest scores (%[a])		Criteria where the answer "I don't know" was least frequent (%[b])	
Stakeholder engagement	(70.4)	Articulation of objectives, goals, and priorities	(5.6)
Articulation of objectives, goals, and priorities	(64.8)	Stakeholder engagement	(7.0)
Communication and outreach	(64.8)	Mainstreaming	(12.7)
Criteria with the lowest scores (%[a])		Criteria where the answer "I don't know" was most frequent (%[b])	
Assessment of non-climate drivers	(28.2)	Assessment of non-climate drivers	(29.6)
Assessment of financial capital	(34.5)	Assessment of climate drivers	(28.2)
Assessment of climate drivers	(35.9)	Assessment of social capital	(26.8)

[a]A percentage out of 142 points, the highest possible total score (two points * 71 respondents)
[b]A percentage out of 71, the number of respondents

ten out of these 12 were pairs between the criteria for a stage of "stocktaking," namely, "assessment of human capital," "assessment of social capital," "assessment of natural capital," "assessment of physical capital," and "assessment of financial capital." The computed p value was less than the alpha value of 0.05 for these ten pairs, indicating that the correlation is statistically significant.

4.5 Discussion

The development of RAN-API is an important step taken by the Government of Indonesia. It is an important basis for line ministries and local governments to mainstream climate change adaptation into their respective sectoral and local development plans. Given the mean of the total scores in the questionnaires, RAN-API is not viewed any worse than the adaptation plans in developed countries as studied in Preston et al. (2011). The stakeholders' views on RAN-API are varied, however, suggesting that there remains room for further improvement. In this section, the status of RAN-API as documented in BAPPENAS (2014) and the evaluation by stakeholders as found in the questionnaires are compared and discussed.

There are discrepancies between the status of RAN-API as documented and the stakeholders' views in some criteria, most notably the "assessment of climate drivers" and assessments of the entitled capitals. RAN-API is viewed as weak by the respondents in these criteria. It was also found that the assessments by the stakeholders for the entitled capitals tended to be correlated with each other. According to BAPPENAS (2014), however, one entire chapter is actually devoted to the presentation of historical trends and future projections for surface temperature, rainfall, sea surface temperature, sea level, and extreme climate events. Assessments of entitled capitals are also found in the document, albeit to varying degrees. Social capital, in particular the existing governance and procedures of development planning, implementation, and monitoring and evaluation, is presented to support mainstreaming. These discrepancies may suggest that information or knowledge gaps still exist among stakeholders, despite the efforts made for their engagement. The role of "communication and outreach" will be therefore important in the implementation stage. In this respect, RAN-API includes "capacity building for stakeholders in climate change adaptation" as one of the measures under the cluster of "support system," and it needs to be well designed. However, different explanations may exist for the above discrepancies: Stakeholders may not be familiar with RAN-API and its contents or interpret the criteria in the questionnaire differently from researchers.

For some of the other criteria, on the other hand, the stakeholders' views match the status as documented. RAN-API is viewed as strong in the criteria "articulation of objectives, goals, and priorities" and "stakeholder engagement," while viewed as weak in the "assessment of non-climate drivers." These views are generally endorsed by the desktop review of the document. The broad purpose of RAN-API is stated, while stakeholder engagement is emphasized. As for the assessment of non-climate drivers, it is found that limited consideration has yet been taken concerning how socioeconomic factors will interact with climate factors. Preston et al. (2011) indicate that "critical weaknesses in adaptation planning (in three developed countries) are related to limited consideration for non-climatic factors." The current study suggests that this is also the case for RAN-API.

The desktop review under the current study finds that the criteria or indicators to be used to assess the progress or success of RAN-API as a whole may need to be further elaborated. It also needs to be acknowledged that the criteria used for the evaluation under the current study were based on the prior research, thus not selected by the stakeholders themselves. Stakeholders might have selected different criteria which they considered more important, which would ultimately affect how the RAN-API is scored. The literature (Adger et al. 2005; Adger and Vincent 2005; Vincent et al. 2013) cautions that whether or not adaptation is successful, it is often dependent on scale. As indicated by Kawanishi and Mimura (2013), government countermeasures may face trade-offs between various adaptation actions and between adaptation and other development priorities over different spatial and temporal dimensions. For example, the expansion of agricultural area is identified in RAN-API as one of the measures to enhance food security against climate impacts, which is a part of the cluster "economic resilience." This may have a potential conflict, however, with the measures to increase the "ecosystem resilience," such as conservation and restoration of forest areas. It is important to evaluate particular adaptation actions from different dimensions to identify potential trade-offs and understand the sustainability of the proposed actions. It also underscores the necessity for further consideration of the mechanisms and procedures for resolving the above trade-offs. In this context, criteria and indicators for assessing and prioritizing the trade-offs may need to be developed.

4.6 Conclusion

The present study aims to evaluate national adaptation planning, using RAN-API in Indonesia as a case. In doing so, the current study applies the methodology used in Preston et al. (2011), where a set of 57 adaptation plans from three developed countries was evaluated against 19 planning processes identified from existing guidance instruments. The same criteria and scoring system are applied to the current study to evaluate RAN-API, both as identified in its document and as viewed by the stakeholders. A desktop review and questionnaires were undertaken to this end.

The development of RAN-API is an important step taken by the Government of Indonesia. This is an important basis for line ministries and local governments to mainstream climate change adaptation into their respective sectoral and local development plans. The current study finds that there remains room for further improvement. The present study also finds that discrepancies exist between the status of RAN-API as documented and the stakeholders' views in some criteria, such as the "assessment of climate drivers" and assessments of entitled capitals. This indicates that information or knowledge gaps remain among stakeholders, suggesting the importance of "communication and outreach" in the implementation stage. For some of the other criteria, on the other hand, the stakeholders' views match the status as documented. They both agree that the weakness in RAN-API is related to limited consideration of non-climatic factors.

The current study finds that the criteria or indicators to be used to assess the progress or success of RAN-API as a whole may need to be further elaborated. It also needs to be acknowledged that the criteria used for the evaluation under the current study were based on the prior research, thus not selected by the stakeholders themselves. They might have selected different criteria which they considered more important. Whether or not adaptation is successful, is often dependent on scale, and trade-offs may exist between various adaptation actions and between adaptation and other development priorities over different spatial and temporal dimensions. Further consideration may be necessary of the mechanisms and procedures for resolving trade-offs. In this context, criteria and indicators for assessing and prioritizing the trade-offs may need to be developed.

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Part II
Climate Change Sectoral Challenges

Chapter 5
Forest Concessions and Deforestation

Jarot Indarto

Abstract Deforestation is the most critical issue of climate change in Indonesia, as well as in other tropical countries. Reducing deforestation when major forests are managed under concession or permit system is increasingly challenging. The main focus of this chapter is to quantitatively investigate the association between forest permits and deforestation at national level in Indonesia. Hence, this chapter discusses the state of forest management and the forest permit system in Indonesia. Theoretical and empirical literature on the relationship have been extensively reviewed and summarized in the context of Indonesia. Furthermore, the empirical analysis with provincial data for the relation between two major forest permits, the logging permit and the plantation conversion permit, and forest cover loss are implemented. The results are different from the expectation posing a question on the effectiveness of the current forest moratorium policy as well as the forest tariff policy to the attempts in mitigating deforestation. Based on the empirical findings, some possible alternative forest policies in short- and long-term perspectives are discussed.

Keywords Deforestation • Forest cover loss • Forest concession or permit • The moratorium policy • The forest tariff policy • Indonesia

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5.1 Background

Deforestation is the most critical issue of the greenhouse gas (GHG) emission reduction in Indonesia. Approximately 62 % of total GHG emissions and around 80 % of total GHG emissions reductions are attributed to the forestry sector (MoE 2010), as established in the Presidential Decree Number 61 Year 2011 on the National Action Plan for GHG Emission Reductions. Indonesia's GHG emission reduction depends heavily on the mitigation of deforestation (Hunt 2010).

Along with enhancing carbon sink, reducing GHG emissions from forestry sector becomes the most crucial policy in Indonesia's climate change mitigation. In this context, the main policy directions at the moment in reducing deforestation are expected to be achieved by discouraging the logging permit while promoting plantation conversion permit. Since 2011, under the forest moratorium policy entitled Suspension of New License Issuance and Improvement Governance in Primary Forests and Peatlands, first established in the Presidential Instruction Number 10 Year 2011 and extended by Number 6 Year 2013, new logging permits in primary forests and peatland are suspended. Furthermore, recently, the government has further restricted issuing new logging permit in primary forests by increasing its forest fees. On the other hand, in addition to some subsidies for plantation conversion permit (Bull et al. 2006), the government reduces the forest tariffs through the establishment of Government Regulation Number 12 Year 2014 (GoI 2014).

The majority of tropical forests, globally as well as in Indonesia, are state forest managed under concession or permit system (Karsenty et al. 2008). Forest permit system has become the primary form of forest tenure and forest management around the world (Walker and Smith 1993; Gray 2002; Burgess et al. 2012). In recent decades, however, forest permit system has been criticized because of their damaging environmental impacts (Walker and Smith 1993; Barber and Schweithelm 2000; Gautam et al. 2000; Dennis et al. 2008; Amacher et al. 2012), namely, biodiversity loss, forest degradation, and deforestation (FAO 2001). Reducing deforestation when the majority of forest is managed under permit system (Gray 2002) has become increasingly challenging, both politically and economically (FAO 2001). There is no agreement on empirical evidence regarding the causality between forest permits and deforestation.

In the case of Indonesia, certain scholars indicate that forest permits are the major cause of deforestation (Dauvergne 1993; Nawir et al. 2008; Molnar et al. 2011). Nonetheless, in several observational studies, those relationships are mixed. A study by Brockhaus et al. (2012) shows that the logging permit in Sumatera and Kalimantan have had destructive impacts on forest cover, whereas studies by Gaveau et al. (2012) in Sumatera and by Gaveau et al. (2013) in Kalimantan show that it has been a relatively effective mean of maintaining forest cover. A few scholars suggest that the plantation conversion permit has enhanced forest cover (Meijaard and Sheil 2007), whereas some assert it has damaging effects on forest cover (Kartodihardjo and Supriono 2000; Curran et al. 2004; Nawir et al. 2008; Obidzinski and Chaudhury 2009; Barr and Sayer 2012).

In summary, the association between forest permits and forest cover loss or deforestation could be inconclusive. Results of some observational studies would be individually valid for their specific cases and levels. While national forest policies need to be supported by certain general pictures at national level, a general association between forest permits and deforestation cannot be simply generalized from those micro-/site-specific studies. The main objective of the analysis in this chapter is to fulfill this gap by investigating the general relationships between forest permits and forest cover loss at national level in Indonesia.

The rest of this chapter is outlined as follows. Basic understanding of how forests are managed and what types of forest permits are implemented is discussed in the second section. It elaborates the categorizations of forests and the types of forest permit system in Indonesia. The temporal and spatial dynamics of forest management and forest permits is also discussed in this section. The third section is to answer the main question of this chapter, the association between forest permits and deforestation at national level. This section reviews literature on how that association might take in place and provides main results of this chapters' quantitative analysis. The detail of econometric modeling and data for the empirical analysis are given in Appendix. The last section presents and discusses policy implications derived from the empirical results.

5.2 The Dynamics of Forest Management and Forest Permit System in Indonesia

5.2.1 Forest Management

In general, land use in Indonesia is mostly characterized by forest-dominant land uses. The Global Forest Assessment 2005 (FAO 2010) reports that around 49.6 % and 11.0 % of the total land uses in Indonesia are forest covered and wooded areas, respectively. The rests are inland water area (4.9 %) and other land uses (34.5 %).

Forests in Indonesia are broadly categorized into the private forest and the state forest. The state forest is the forest land use area where the government has established that there are no private rights over that area. The private forest is forest area where there are private rights attached (Contreras-Hermosilla et al. 2005). FAO (2010) estimates that approximately 91 % of the total forests in Indonesia is the state forest, while a higher estimation is reported by Rights and Resources Initiative (RRI 2012) calculating that state forest in Indonesia is around 97.1 % of total forests. Again, the state forest has dominated the total forest cover area in Indonesia.

The management of the state forest is based on their main functions, which are categorized into three categories of the state forests: the conservation, the protected, and the production forest (MoF 2008). The conservation forest is primarily to preserve biodiversity and ecosystem, consisting of the strict nature reserve and the wildlife sanctuary. The state forest that has the natural functions as the life-support system, including managing hydrological functions, preventing flooding and erosion, preventing seawater intrusion and maintaining soil fertility, is protected as the protected forest. Over this forest, only limited noncommercial human activities are allowed. The main function of the production forest is to produce forest products (timber, non-timber, forest services, and forest area).

The production forest is further classified into the permanent production forest, the limited production forest, the industrial plantation forest, and the convertible production forest. The classification for the first two classes is based on several factors (slope, soil, and precipitation) in which a relatively intensive extraction can be permitted within the permanent production forest. The permanent production forest is subject to relatively higher intensity of permitted logging (selective or clear-cut), whereas timber utilization in the limited production forest must be done selectively (MoF 2008). The first three classes are intended to be kept as forest uses, while the convertible production forest is allocated to be utilized for the development of non-forest uses or subject to a planned deforestation. Table 5.1 provides a general description of the state forest.

Table 5.1 General classification of the state forest in Indonesia

Main function	Designated under the state forest		General notes
To preserve biodiversity and ecosystem.	The conservation forest	The natural conservation forest: the national park, the grand forest park, the recreational park, and the provincial park.	To be kept as forest uses.
			Except for the provincial park, they are under authority of the central government, but daily management is managed by the province.
		The hunting park (*Taman buru*).	
To protect the life-support system (hydrology, flooding and erosion prevention, seawater intrusion protection, and soil fertility maintenance).	The protected forest	The protected forest.	To be kept as forest uses.
			Under authority of the local government.
To provide forest products.	The production forest	The permanent production forest, the limited production forest, and the industrial plantation forest.	To be kept as forest uses.
			Under authority of the central government.
		The convertible production forest.	Intended to be converted to non-forest uses.

Forest classification and zoning have institutional and legal consequences. Up to now, the current forest boundary has not been fully legitimized by all stakeholders. Land tenure conflict over forest area has occurred among government regulations and agencies, as well as between government, private, and community (Contreras-Hermosilla et al. 2005). With regard to this issue, the government had examined some efforts. In 1994, the Forest Boundary Setting by Consensus (*Tata Guna Hutan Kesepakatan* of TGHK), especially between the central and the local governments, had been proposed. Continuing this process, 5 years after, in 1999, TGHK had been harmonized with the provincial spatial development plans, resulting in the harmonization map (*Paduserasi*). Another effort is such collaborative forest management as has been introduced since 2004. Forestland tenure has still been a crucial issue of forest management in Indonesia.

In total area and in proportion, the state forest has been changing over time. The recent statistics reports (MoF 2014) that its total area is approximately 129.42 million ha, consisting of the conservation forest around 21.17 %, the protected forest 23.12 %, and the production forest 55.71 % (Fig. 5.1). The production forest

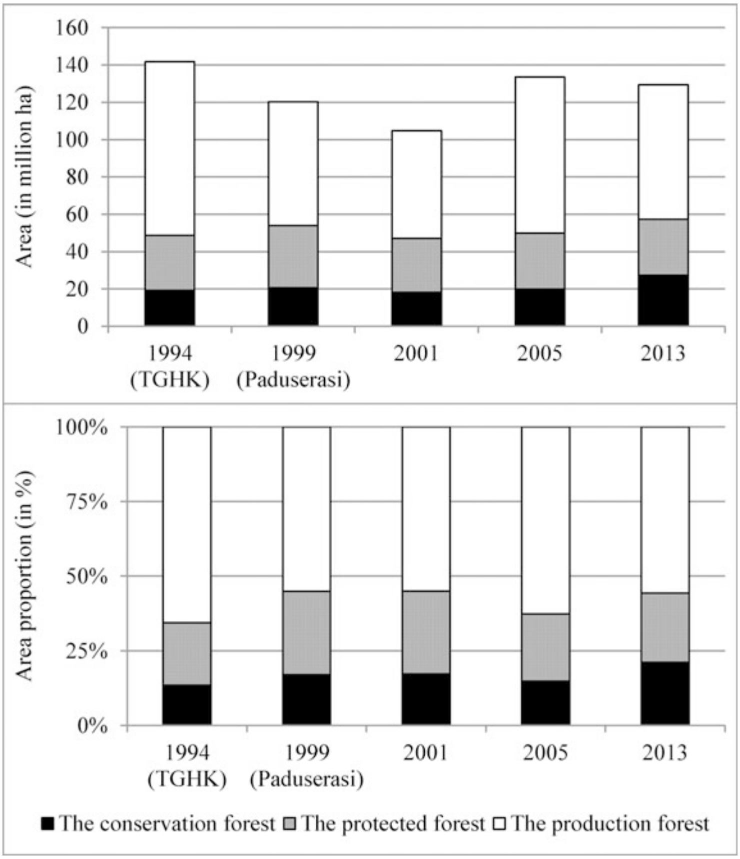

Fig. 5.1 The state forest over time (Source: MoF 1999, 2014)

area was around 66.33 % in 1994, and now is approximately 55.71 % of the total state forest or nearly 72.11 million ha. Over time, the major area and proportion of the state forest has been the production forest, on which this analysis is focused.

5.2.2 Forest Concessions or Permits

The forest permit or concession system has become the primary form of forest tenure and forest management (Walker and Smith 1993; Gray 2002; Burgess et al. 2012). FAO land tenure thesaurus (in Karsenty et al. 2008) defines a permit or concession as "a bilateral or unilateral legal act by which an authority grants a private or public entity a use of right or a privilege." Forest permit, then, is referred to a contract between a forest owner and another entity permitting the utilizing and/or managing of forest resources in a specified area at a definite time (Gray 2002). Forest permits consists of forest utilization contract in which concessionaire is given a rights to harvest forest products and services (timber, non-timber, or forest services) and forest management contract which is related to procurement contract for forest management (environmental protection, biodiversity conservation, etc.). In many countries, both contracts coexist in the permit as rights and obligation of the holder.

Within the state forest, multifarious types of forest permits are issued (Table 5.2). The utilization of forest products, such as timber, non-timber (honey, fruits, rattan, etc.), forest area (for cultivating mushroom, medicinal plants, flower, or wildlife breeding), and forest services (for tourism or natural water utilization) is subject to forest permits of concessions. In the production forest and the protected forest, permits are issued for commercial and noncommercial uses, whereas research and development, educational and training, or religious and cultural activity permits are issued in the conservation forest.

Commercial timber extraction in production forest may involve two major permits. One is for productive (high tree cover) production forest, where permitted business entities harvest timber selectively; the other is for unproductive production forest, where permitted business entities must first do planting and then harvest the timber when the planted trees are mature. The productive forest has so relatively rich forest cover and high timber potential that timber can be feasibly extracted by the logging permit (hereafter, called LP throughout this chapter). No or less forest cover or low timber potential falls into the unproductive forest, where the plantation conversion permit (hereafter, called PCP throughout this chapter) has to do planting first before harvesting the tree. Table 5.3 provides criteria of the productive and unproductive forests, whereas key attributes of those two forest permits is given in Table 5.4.

The government data, as of November 2012, presents that approximately 45.5 % of production forest has been licensed for commercial timber extraction permits, leaving the rest to be unmanaged or open-access areas. Among those permitted areas within production forest, LP and PCP have been the major permits, accounting

Table 5.2 Types of forest permits within the state forest

Types of permits and activities	Production forests			Protected forest	Conservation forest
	Permanent production forest		Convertible forest		
	Productive forest	Unproductive degraded forest			
Forest uses					
Commercial utilizations					
Timber extraction	Yes	Yes	–	–	–
Non-timber extraction	Yes	Yes	–	–	–
Area	Yes	Yes	–	Yes	–
Forest services	Yes	Yes	–	Yes	–
Noncommercial utilizations					
Timber extraction	Yes	–	–	–	–
Non-timber extraction	Yes	Yes	–	Yes	–
Others					
Research and development	–	–	–	–	Yes
Education and training	–	–	–	–	Yes
Religion and culture	–	–	–	–	Yes
Non-forest uses					
Agricultural plantation	–	–	Yes[a]	–	–

Source: Interpreted from Government Regulation No. 6/2007, Government Regulation No. 3/2008.
[a]The central government approval is required to convert forest land uses into other non-forest uses.

for around 68.5 % and 28.1 % of total commercial timber extraction permits, respectively. Therefore, analysis of this chapter focuses primarily on commercial timber extraction permits, particularly LP and PCP. The other types of permits in Table 5.2 are assumed to have limited association to forest cover loss and thus are not included in this analysis.

Indonesia has adopted forest permit system since 1957 through the establishment of the Government Decree Number 64 Year 1957. In the beginning, LP aimed to limitedly extract timber in the Outer Islands where its socioeconomic and environmental impacts were minor. The stipulation of this act followed by the Government Decree Number 21 Year 1970 was acknowledged as the critical initial point when the government has started to promote permit system for large-scale commercial

Table 5.3 Criteria of forest lands allocated for forest permits within production forest

Criteria	Commercial timber extraction permits	
	Productive production forest for LP	Unproductive production forest for PCP
Macro		
Vegetation cover	Productive forest with forest cover >60 %	Unproductive forest with forest cover <50 % or non-forested
Slope[a]	A-B-C-D-E	A-B-C
Accessibility	Low-mid	Mid-high
Micro		
Timber potential (standing tree/ha)		No/small/not feasible
10–19 cm	>108	
20–49 cm	>39	
>50 cm	>15	
Socioeconomic development level	Low-mid	High-mid
Land conflict	Low	Low
People dependency on forest	No	No

Source: Summarized from Appendix III of the Ministry of Forestry Decree No. 3803/Menhut-VI/BRPUK/2012.
[a]Slope classification: A 0–8 %, B 8–15 %, C 15–25 %, D 25–45 %, E >45 %.

Table 5.4 Key attributes of LP and PCP

Attribute	LP	PCP
Original condition of forests[a]	Productive production forests.	Unproductive or degraded production forests.
Main purpose	Utilization of timber resources.	Rehabilitation of nonproductive forests while utilizing timber products.
Major processes	Harvesting-selling-enriching-planting-growing.	Land preparation-nursery-planting-growing-harvesting-selling.
Application to	Central government.	Central government.
Maximum valid term	55 years and non-extendable.	60 years and extendable once for next 35 years.
Maximum area	50,000 ha (in Papua, 100,000 ha) and expandable.	50,000 ha (in Papua, 100,000 ha) and expandable only in some regions.
Limit per holder	Maximum 2 permits per company or 1 permit per holding company.	Maximum 2 permits per company or 1 permit per holding company.
Eligible entities	Individual, cooperative, private, central/local state-owned company.	Individual, cooperative, private, central/local state-owned company.

Source: Government Regulation No. 6/2007, Government Regulation No. 3/2008, the Ministry of Forestry Decree No. P.8/Menhut-II/2014.
[a]Criteria of forest lands allocated for LP and PCP is given in Table 5.2.

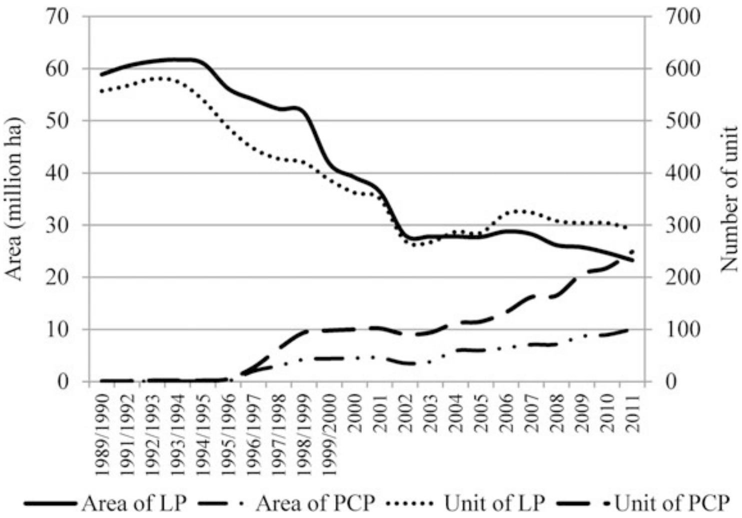

Fig. 5.2 Area and unit number of LP and PCP (Source: MoF 2014)

logging as a substantial instrument to accelerate national and local economic development. Another significant regulation is the Government Decree Number 6 Year 1999 by which LP had been integrated with the forest-based industry policy. Since then the increasing capacity of forest-based industry has increased the domestic demand of log.

Growing demand for forest-based industry initiated the government to establish PCP in 1986, with its initial purpose to enhance log supply for pulp- and wood-based industries. Moreover, the development of PCP is additionally initialized by the extent of forest land degradation. Since 1990 the government has also assigned PCP as the main strategy to reforest logged-over forests and to rehabilitate degraded land (FWI/WRI/GFW 2002; Resosudarmo et al. 2012).

The data of area and unit of the logging and the timber permits since 1989/1990 shows that LP had grown up until 1995 when PCP has started to be developed (Fig. 5.2). Since 1996, LP tends to decrease over time. Several circumstances explain the fall of LP. Singer (2008) argues that it is due to some reasons, including the depletion of timber, social conflicts, forest fires, and emerging environmental campaigns. Those variables affect the decreasing of LP. Currently, the falling of LP and the growing of PCP have been continuously occurring. The government policy seems to be in line with this trend. The government has stipulated some policies in order to discourage LP while promoting PCP. For the first objective, for example, the government establishes the forest moratorium policy (GoI 2011a, 2013) and the forest tariff policy (GoI 2014). The second policy has also been intended to promote PCP by lowering its fee tariff (GoI 2014).

At province level, large areas of LP have been taking place in Kalimantan Timur, Kalimantan Tengah, Papua, and Papua Barat during the period 2005–2012 (Fig. 5.3). From this spatial distribution, LP has been concentrated in Kalimantan

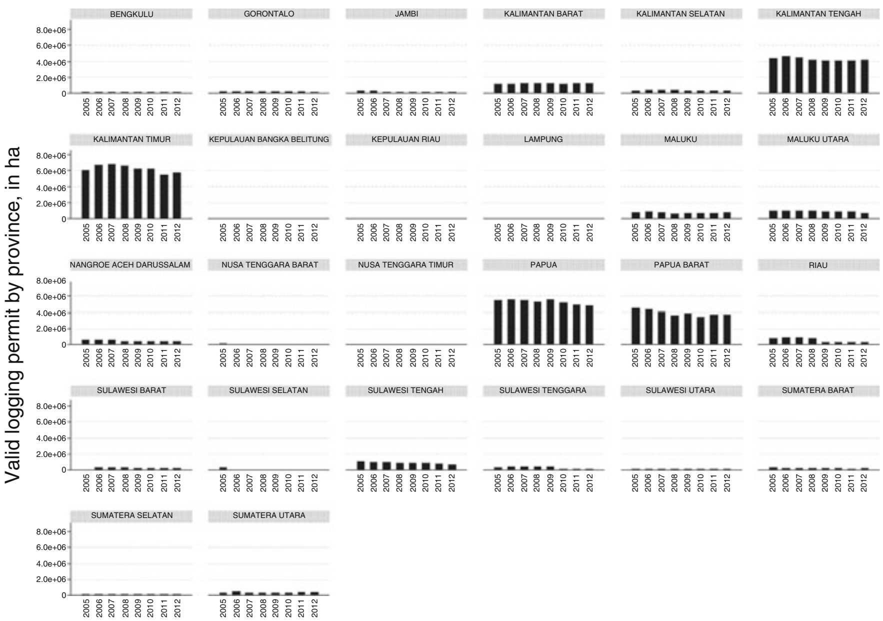

Fig. 5.3 Area of existing valid LP by province, in ha, 2005–2012 (Source: Analyzed from MoF 2014)

and Papua islands where rich primary forest cover (productive forest) has existed. The spatial distribution of LP has been in line with that of primary forest extent. According to Margono et al. (2014), around 38.10 % and 29.87 % of total 92.4 million ha primary forest of Indonesia has been found in Papua and Kalimantan in 2012, respectively. This fact also supports the statement arguing that Sumatera had experienced more intensive extraction of primary forest, while Kalimantan has still been in this process and Papua is at its more nascent stage (Margono et al. 2014).

On the other side, most of PCP has been taken place in Kalimantan Barat, Kalimantan Timur, Riau, and Sumatera Selatan (Fig. 5.4). On the contrary to LP spatial distribution, PCP has been concentrated in Sumatera and Kalimantan, the location of unproductive or non-forest cover area.

The authority of forest permits has dynamically evolved as well. The *Reformasi* era (1997/1998) that is characterized by the decentralization policy results in the establishment of the community-managed forest, as one of the strong demands from people and the local government. Types of forest permits have more diversified during this period. The decentralization policy had also granted the local government to have the authority to manage the community-managed, small-scale forest permits. However, because releasing this permit was uncontrollable, the government has withdrawn this authority to be centralized since 2002.

The decentralization period also passes another purpose of forest permits, which are for education, research, and development. These types of permit are granted for

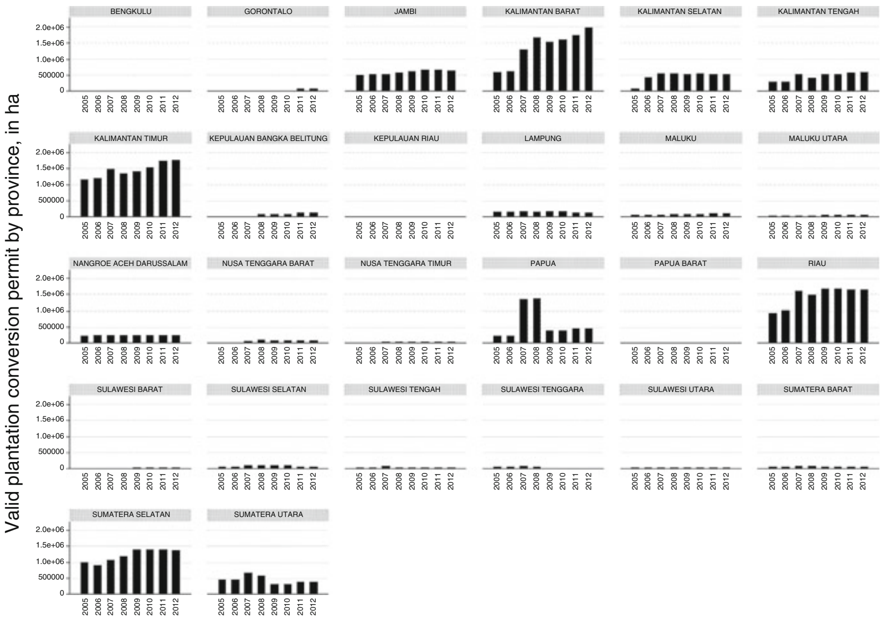

Fig. 5.4 Area of existing valid PCP by province, in ha, 2005–2012 (Source: Analyzed from MoF 2014)

higher education and research institutions. Recently, as climate change issues in forestry sector gain strong attention, there is the needs to incorporate ecosystem and carbon issues in forest permit system. It turns the government to establish the ecosystem restoration permit in 2007. Nowadays, carbon permit is started to be examined in forest permit.

How forest permits are granted is by application. Every year, the government designates which area is designated for forest permits. In the case of LP and PCP, for example, based on this designation, business entities (company, state-owned company, cooperative, community, and individual) send the proposal application to the central government. The central government, then, do some processes and assessments whether or not the applicant is eligible. However, it is worth mentioning also that, alongside this application approach, in 1998/1999 the International Monetary Fund (IMF) was trying to introduce a market approach for forest permit in Indonesia. The government was trying to initially introduce this market approach by establishing the Ministry of Forestry Decree No. P.15/Menhut-II/2004. However, in 2007 the government ends this policy introduction by establishing the Ministry of Forestry Decree Number P.61 Year 2007 and Number P.12 Year 2008. The dynamics of these mechanisms is presented in Fig. 5.5.

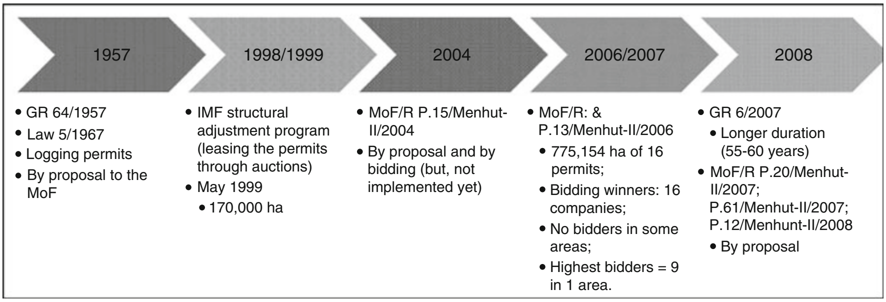

Fig. 5.5 The dynamics of the mechanism to allocate forest permits in Indonesia

5.3 Do Forest Permits Cause Deforestation in Indonesia?

The previous section discusses the dynamics of forest management and forest permit system in Indonesia. LP and PCP have been the two major forest permits within the production forest, the major portion of the state forest. Their general picture is a diminishing area and unit of LP and an increasing trend of PCP. The discussion of this section briefly starts with the dynamics of forest cover loss and is followed by the literature review and empirical analysis of the relationship between forest permits and deforestation.

During the period of 2000–2005, FAO reports that forest cover loss in Indonesia was around 1.9 million ha per year (FAO 2006), whereas, in the IFCA report (MoF 2008), this value was around 1.04 million ha with an increasing trend. Meanwhile, based on OSIRIS database (Busch et al. 2012), its average value was reported around 0.7 million ha/year. In the period of 2005–2010, FAO (FAO 2010) estimates deforestation decreased to be nearly 0.7 million ha/year. IFCA also estimates that most of forest cover loss has occurred within the production forest (MoF 2008).

The Annual Forestry Statistics by the Ministry of Forestry also reports the estimation of deforestation. It was approximately 1.2 million ha/year for the period 2003–2006, around 0.8 million ha/year for 2006–2009, and nearly 0.5 million in 2009–2011 and for 2005–2010. The Global Forest Change or Hansen dataset, which the analysis of this chapter is based on, brings a recent and more detail estimation of deforestation. Based on this, Indonesia has experienced an increasing trend of forest cover loss during 2001–2012. Forest cover has been reduced from around 0.75 million ha in 2001 and nearly 1.18 million ha in 2005 to 2.03 million ha in 2012 (Fig. 5.6) or on average nearly 1.30 million ha/year during this period.

In fact, after the implementation of the forest moratorium policy since 2011, forest cover loss has drastically moved upward in the rate nearly 34.1 % from 2011 to 2012. This fact raises an important question about the actual effect of this policy to reduce deforestation as raised by some scholars (Murdiyarso et al. 2011; Laurance et al. 2012; Margono et al. 2014). By province, Riau, Kalimantan Barat, Kalimantan Tengah, Kalimantan Timur, and Sumatera Selatan have experienced relatively high forest cover loss during 2005–2012 (Fig. 5.7). Their forest

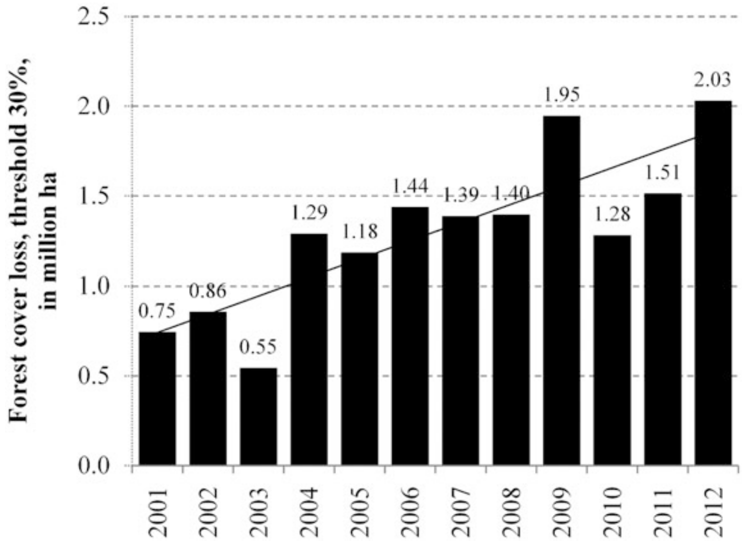

Fig. 5.6 Annual forest cover loss (threshold 30 % of canopy cover), in million ha, 2001–2012 (Source: Analyzed from Hansen et al. 2013b; Note: the *straight line* is the estimated trendline of forest cover loss)

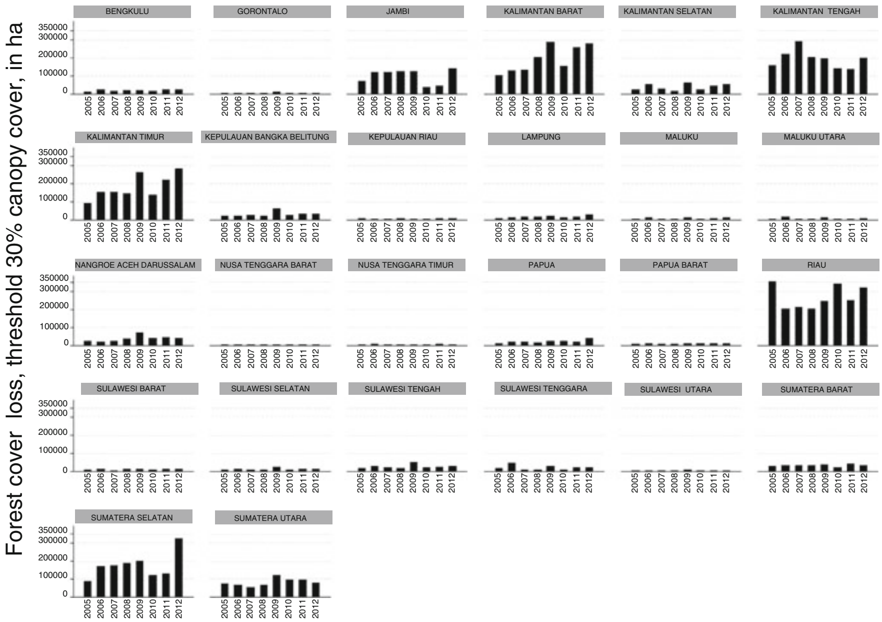

Fig. 5.7 Forest cover loss by province, threshold 30 % canopy cover, in ha, 2005–2012 (Source: Analyzed from Hansen et al. 2013b)

cover losses count approximately 66.31 % of the total forest cover loss. Increasing trend of forest cover loss has been found in Kalimantan Barat, Kalimantan Timur, Riau, Papua, and Sumatera Selatan.

5.3.1 Literature Review

For decades, forest permits have been criticized by their negative environmental impacts, including forest degradation and deforestation. Furthermore, the forest land allocation framework continues to prioritize large-scale interests (Brockhaus et al. 2012). It is generally confirmed that selective logging under forest permits will directly diminish primary forest, transforming them into secondary degraded or logged-over forest. Utilization of timber within LP areas removes selected trees in primary forest (Fearnside 2005; Margono et al. 2012). Selective timber harvesting in primary forest can also unintentionally damage standing and small trees (Repetto and Gillis 1988; Verissimo et al. 1992; Iskandar et al. 2006). Intensifying or high-grading activities done by concessionaire have been found, leading to forest degradation (Jepson et al. 2001; Curran et al. 2004; Burgess et al. 2012). Development of logging roads to support concession activities facilitates forest fragmentation directly and indirectly (Skole and Tucker 1993; Achard et al. 2002; Fearnside 2005; Abdullah and Nakagoshi 2007; Fitzherbert et al. 2008; Arbainsyah et al. 2014; Margono et al. 2014). Some scholars find that logging roads have also widened canopy gaps (Sist et al. 2003; Fearnside 2005; Carlson et al. 2012; Margono et al. 2012), leading to degrade forest.

On the other side, the association between forest permits and deforestation may not be simple, however. Conceptually, the direct impact of LP on deforestation will largely be determined by whether or not sustainable forest management is implemented properly (Walker and Smith 1993; Damette and Delacote 2011). Unsustainable forest management (Walker and Smith 1993) and violation of such sustainable measurements (FWI/WRI/GFW 2002; Amacher et al. 2012) enable forest canopy to decline drastically below the threshold of being considered as forests. Those mechanisms will turn into deforestation directly in permitted areas. Palmer (2000) reports that unsustainable timber extraction has not only been witnessed in the first round but also during second rotation. Some concessionaires have been found not to be undertaking replantation as regulated by the government (Nawir et al. 2008), from which natural regeneration process will unlikely take place. In general, due to little incentive (Palmer 2000; Merry et al. 2003) or lack of the government capability (MoF 2008; Burgess et al. 2012), the implementation of such sustainable forest management is still poor or even violated. Only if such a sustainable practice is well performed and not violated, forest permit system may not prompt unplanned deforestation.

Illegal logging is another critical mechanism of unplanned deforestation under forest permit system (CIFOR 2004; Tacconi et al. 2004; MoF 2008; Burgess et al. 2012). Illegal logging may take place inside (Barr et al. 2006) and outside permitted areas (Barr et al. 2006; Smith et al. 2003; Curran et al. 2004; Fuller et al. 2004). Both concessionaire and/or outsider (local inhabitant/farmer) may be potential players of this activity. Overwhelming supply-demand gap of logs has driven concessionaires to involve in illegal logging (Holmes 2002); they may unsustainably extract timber in their areas by cutting more trees than are allowed (Amacher et al. 2012). Jepson et al. (2001) reports that, to compete with outsider illegal loggers, concessionaires have been found to illegally accelerate and intensify logging to harvest their timbers before they are felled by illegal loggers. They have faced little incentives to safeguard their areas (Palmer 2000) from illegal loggers (Abood et al. 2014).

Scholar also indicates that forest permit activities have been found to take place outside of permitted areas (Gaveau and Salim 2013). Therefore, protected forest is prone to illegal logging by concessionaires (Curran et al. 2004) and farmers (Jepson et al. 2001). A recent study asserts that illegal logging by concessionaire can be induced by the dynamics of administrative jurisdictions or establishment of new local governments (Burgess et al. 2012). Moreover, regenerating areas has been indicated also being vulnerable to illegal re-logging in permitted areas (Palmer 2000; Barr 2001), which has further diminished timber availability during second rotation (Hoffman et al. 1999; Holmes 2002). Better infrastructure developed for the purposes of forest permits (Thiele 1994) has facilitated illegal access (Poffenbergen 1997; Barbier et al. 2010; Obidzinski et al. 2013) and illegal encroachment to remote primary forest by which land clearing has been commonly done (Fearnside 2005). In most tropical forest countries where regulations are poorly implemented and not well enforced, illegal logging has remarkably contributed to deforestation (Burgess et al. 2012). In Indonesia case, this problem has been exaggerated by corruption (Palmer 2000; Amacher et al. 2012) as well as by weak and fragmented forest authorities (Smith et al. 2003).

Moreover, an open-access area is a serious issue, due to lack of government capability to manage forests. These open-access areas are very vulnerable to illegal logging and illegal encroachment. Two important mechanisms are proposed to explain how open access may relate to deforestation (Barbier et al. 2010). The first is that rent-seeking behavior, through which valuable forest resources (timber) are unsustainably extracted, will take place in open-access areas. Secondly, very low or no opportunity costs of keeping those areas to be forests stimulate local inhabitants or farmers to convert them into higher market value non-forest uses. Open access forest is very prone to deforestation (von Amsberg 1994; Kaimowitz and Angelsen 1998; MoE 2010).

In Indonesia case, the government has so limited resources that only protected and conservation forests can be directly managed and supervised. Noncompliance cases have encouraged the government to revoke some forest permits (Barber and Schweithelm 2000; Casson 2000; Kartodihardjo and Supriono 2000; Barr 2001, 2002). These revoked forest permit areas have become huge open-access areas (Resosudarmo et al. 2012). In addition to withdrawn forest permit areas, around 54.5 % of production forest have not been entitled any permits (MoF 2012).

Conceptually, potential negative impact of PCP on deforestation is expected to result in a comparatively longer term, which is during harvesting planted tree period. However, since the government regulates that this permit should be legally established in unproductive production or degraded forest with low tree cover, its development is expected to significantly contribute to reforestation and forest rehabilitation programs (FWI/WRI/GFW 2002; Nawir et al. 2008; Resosudarmo et al. 2012). In fact, their immediate negative impacts on forest cover have been witnessed (Nawir et al. 2008), especially due to the fact that most PCP has been issued in relatively rich natural or high tree-covered forest (Barr 2002; Cossalter and Pye-Smith 2003; Obidzinski and Chaudhury 2009). Data and information about forest categories are lacking of clarity and accuracy (Brockhaus et al. 2012). Standing trees in degraded or logged-over forest with relatively high tree cover are removed during the initial stage; land clearing is allowed during land preparation. In addition to little incentive for them to leave commercially valuable stems standing (Barr 2002), gaining double economic benefits from extracting timber cut during the forest clearing stage is their basic motivation in this business (Obidzinski et al. 2013); even abandoning the land without doing replantation has been found in the field (Kartodihardjo and Supriono 2000). Illegal activities have been observed in PCP (FWI/WRI/GFW 2002).

Another crucial concern that forest permits might lead to deforestation immediately is through planned deforestation, conversion into non-forest uses. Tropical forests are very prone to agricultural expansion (Rudel and Roper 1997; Lopez 1998; Casson 2000). In Sumatera, for example, intensive forest clearing has resulted in the conversion of around 70 % forested area through 2010 (Margono et al. 2012). Recent studies present that most remaining intact forest in Kalimantan (Gaveau et al. 2014) and in Papua (Brockhaus et al. 2012) will likely be converted under current designation. The government also tends to reclassify degraded or logged-over forest into convertible production forest after PCP period (Cossalter and Pye-Smith 2003). This phase obviously lead to deforestation (Gaveau et al. 2012, 2013). Additionally, other indirect impacts include the induced effects of logging activities through forest fires (Thiele 1994). However, infrastructure provisions may either facilitate further pressure on forest land (Rudel and Roper 1997), as spatially explicitly occur in Papua (Margono et al. 2014), or improve forest management and monitoring (Mahapatra and Kant 2005). In production forest where LP and PCP are issued, forest degradation and deforestation may take place (Margono et al. 2012).

Lastly, it is about to briefly overview those intertwined processes between forest permits, forest degradation, and deforestation. Selective logging activities by LP directly degrade forest. There are also possible circumstances through which LP may limitedly induce deforestation, namely, planned conversion and unsustainable logging. Planned conversion from production forest into large-scale non-forest economic activities will directly result in deforestation (Abood et al. 2014). As proven by Margono et al. (2014) that most forest loss occurred in degraded forest (PCP areas), there are small portion where forest cover loss took place in primary forest (LP areas). In a certain area of LP, after concession period is over and this area falls under unproductive production forest, PCP takes place. In this phase, deforestation may be potentially caused by clearing the standing trees and, again, the intended conversion occurs. In general, logging precedes clearing (Margono et al. 2014); and planned deforestation has a direct and obvious impact. Alongside those circumstances, illegal logging practices and negative effects of better infrastructure may play important roles during all phases.

Some policies and actions have been undertaken by the government to reduce GHG emissions from forestry sector. In the Presidential Instruction Number 61 Year 2011 (GoI 2011b), the government accentuates several national strategies, including forest and peatland fire prevention, illegal logging prevention, and sustainable forest management enhancement. Furthermore, strengthening forest land use boundary and customary has been strengthened to prevent forest conversion. The One Map Initiative has been developed to clarify land ownership and concession boundary (Anderson 2013). With regard to prevent conversion, Indonesia has strongly committed to develop and support REDD (reducing emissions from deforestation and forest degradation) initiative, an incentive mechanism to maintain forest. To protect forests, protected and conservation forests have also been extended, in which both forests have increased from approximately 52.3 million ha in 2001 to nearly 57.6 million ha in 2012.

Some environmental countermeasures are obligatory under forest permits. Improving the sustainable forest management (selective logging, RIL, forest certification, and silviculture technique) has been promoted and applied to reduce GHG emissions during logging activities (Gullison 2003; Dennis et al. 2008; MoF 2011). Initially introduced in 1972, the government has legalized the Indonesian Selective Logging and Replanting System (*Sistem Tebang Pilih Tanam Indonesia*) in which timber harvesting is supposed to be selective. Minimum planted area is also imposed. Since 2001, the Reduced-Impact Logging (RIL) Guideline for Indonesia has also been disseminated (Elias et al. 2001). To a greater extent, since 2009, in collaboration with Voluntary Partnership Agreement (VPA), the government develops and establishes the Indonesian Timber Legality Assurance System (*Sistem Verifikasi Legalitas Kayu*) under which the holders are legally obliged either to maintain permanent natural forest cover or to keep other standing trees for long-term generation in their concession areas (Gaveau et al. 2013). Converting forest permit area to other land uses is generally prohibited.

Furthermore, loggers are compulsory to undertake such common environmental mitigations: strategic environmental and environmental impact assessments, high conservation value (HCV) and high carbon stock (HCS) forests conservation, and environmental taxation. Those environmental countermeasures have been enforced to mitigate destructive environmental impacts of logging practices. Some scholars believe that when such sustainable harvesting management and practices are enforced properly in logging activities, sustainability of forest under permit system is attainable (Merry et al. 2009; Giudice et al. 2012). RIL adoption, for example, offers the opportunity to reduce CO_2 emissions by 30–50 % across tropical forests (Griscom et al. 2014).

In addition to those GHG emission reduction-related policies, since 2011, the government has enacted a more stringent policy, the forest moratorium policy stipulated in the Presidential Instruction Number 10 Year 2011, and extended by Presidential Instruction Number 6 Year 2013. Under this policy, the government has suspended new LP in primary forest to prevent forest degradation and in peatland to avoid deforestation. It is regarded as a key element of Indonesia's climate change strategy (Anderson 2013) and the most significant REDD initiative (Margono et al. 2012). Recently, through the establishment of Government Regulation Number 12 Year 2014 on the types and the level of fee tariff for forestry sector or the forest tariff policy (GoI 2014), the government has established new fee structure that had not been changed since 1998/1999. Under this new policy, the government has put more restrictions for business entities to access productive production forest by increasing the license fee and the provision fee for LP. Meanwhile, in the same policy, in addition to current incentives (Bull et al. 2006; Obidzinski and Chaudhury 2009), the government reduces those fees for PCP in order to further promote their development.

5.3.2 *Empirical Analysis*

Although permit system has been widely implemented as a dominant policy in managing the vast majority of global forests, to the best of our knowledge, forest permits have rarely been integrated into such quantitative studies. On a global level, however, Damette and Delacote (2011) use timber harvesting (volume and value) in explaining deforestation rates. This cross-national panel data from 1972 to 1994 indicates that timber harvesting is positively associated with deforestation.

At national level in Indonesia case, few quantitative studies have focused on the association between forest permits and deforestation, with the exception of studies by Busch et al. (2012) and Wheeler et al. (2013). Both studies, however, do not focus on estimating and discussing impacts of forest permits on deforestation. The main interest of the former study is to analyze the relationship between carbon payments and deforestation, while the primary purpose of the latter work is how relative prices of agriculture and forest affect the probability of forest clearing at micro-/site level. Nevertheless, it is worth mentioning that they controlled LP and PCP in their econometric models, resulting in a negative sign for LP and a positive sign for PCP. None of them discusses why those signs arrived.

At regional (island) level, two other notable quantitative studies are done by Gaveau et al. (2012) for Sumatera case and Gaveau et al. (2013) for Kalimantan case. Their propensity score matching and linear regression models show an insignificant difference of the deforestation occurring in LP and protected forest areas. They, in conclusion, highlight similar ability of LP (referring to primary forest timber concession on their papers) as protected forest to maintain forest cover in Sumatera and Kalimantan cases, subject to prevention from reclassification and conversion. Unlike those aforementioned quantitative studies, this current analysis is able to quantify general impacts of forest permits on forest cover loss in Indonesia. Table 5.5 presents the position of our analysis among other quantitative studies. Material and methods of analysis of this chapter is provided in Appendix.

Table 5.5 Position of this chapter's analysis

Aspect	Busch et al. (2012)	Wheeler et al. (2013)	Gaveau et al. (2012, 2013)	Analysis of this chapter
Measurement of deforestation	Deforestation rate[a] for 5 years.	Forest clearing index.[b]	Deforestation rate as of 1990 and tree cover loss.	Forest cover loss.
Type of permits	Logging and plantation conversion permits (% of land area).	Designated zone for logging and plantation conversion permits as of 2005 (% of land area).	Logging permits, oil palm permits, and protected forests (area).	Logging and plantation conversion permits (area).
Unit of analysis	Grid cells, average trend.	Grid cells converged into district level, monthly.	Grid cells, average.	Grid cells converged into provincial level, annual.
Coverage (spatial and temporal)	All provinces and districts; 2000–2005.	All provinces and districts excluding provinces in Java, Bali, and Nusa Tenggara, 2006–2010.	Sumatera, 1990–2000, and Kalimantan, 2000–2010.	All provinces excluding provinces in Java and Bali; 2000–2012.
Empirical method	Cross-section negative binomial regression with Poisson quasi-maximum likelihood and robust standard errors.	Random effects and spatial autocorrelation.	Propensity score matching and linear regression.	Fixed effects with year effect and robust standard errors.
Economics-demographic factors	–	Population density and poverty rate in 2000.	–	GDRP/capita, population, population density, population growth, oil palm productivity, and timber production.
Environmental factor	–	–	–	Forest certification.
Source of data	OSIRIS v1.5 database (satellite data)	FORMA database (satellite data)		Forest Cover Change or Hansen dataset (satellite data)

[a]Data is stratified into five classes of forest cover: no forest cover, low forest cover, low-medium forest cover, medium-high forest cover, and high forest cover.
[b]Monthly change of forest cover in the number of 1 km^2 that have experienced clearing with probability more than 50%.

Table 5.6 Estimation results: impacts of LP and PCP on forest cover loss with 30 % threshold of canopy cover

Variables	Basic model	Reduced-form model	Full model
GDRP/capita	19.9953	11.5636	21.9947
	(5.2480)***	(5.2700)**	(7.4160)***
Square of GDRP/capita	–0.000862	–0.000517	–0.000967
	(0.0002)***	(0.000195)**	(0.0003)***
Number of population	0.0307	0.0560	0.0337
	(0.0272)	(0.0180)***	(0.0271)
Area of LP	0.00553	0.00759	0.00567
	(0.0717)	(0.00315)**	(0.0034)
Area of PCP	0.0717	0.0695	0.0733
	(0.0271)**	(0.0231)***	(0.0272)**
Timber production	0.00481	–	0.00482
	(0.0021)**	–	(0.00217)**
LP SFM-certified area	–	0.0169	0.0481
	–	(0.0873)	(0.109)
PCP SFM-certified area	–	−0.0377	−0.0347
	–	(0.0506)	(0.0469)
Year effect	Yes	Yes	Yes
Constant	−168,611	−212,114	−183,936
	(102.5090)	(68.8800)***	(108.9610)

Note: robust standard errors are in parentheses; significance at 1 %, 5 %, and 10 % are denoted by ***, **, and *, respectively.

Table 5.6 presents estimation results of this analysis. When timber production is not controlled in the model (reduced-form model), LP has a positive and significant correlation to forest cover loss. However, its impact becomes insignificant when timber production is considered in the model (full model). On the other side, results on PCP bring a consistent sign in which this type of permit is positively associated with forest cover loss. This analysis estimates an increasing 1 ha PCP is likely to increase loss of forest cover by nearly 0.073 ha.

In addition to LP and PCP, the volume of timber production has played a significant role to forest cover loss, in which an increasing 1 m^3 of timber production is estimated to reduce around 0.005 ha forest cover (full model). We further checked whether forest permits contribute to timber production, resulting in insignificant signs for both permits (Table 5.7). Another interesting finding is that magnitude of sustainable forest management implementation (represented by certified area) has been insignificantly associated to forest cover loss.

The signs of control variables are consistent with expectations. Different from other studies that find a U-shaped EKC for deforestation for Asia case (Koop and Tole 1999; Bhattarai and Hammig 2001), interestingly, a positive significant sign of GDRP/capita and a negative significant sign of its square, the EKC for deforestation, are found for Indonesia case. With regard to demographic factors, the parameter of the number of population results in a positive significant sign when timber

Table 5.7 Estimation results: LP and PCP on timber production

Variables	Timber production
Area of LP	0.247
	(0.210)
Area of PCP	0.215
	(0.700)
LP SFM-certified area	1.402
	(1.836)
PCP SFM-certified area	1.181
	(6.478)
Number of population	3.891
	(2.584)
Year effect	Yes
Constant	−1.363e+07
	(9.580e+07)

Note: robust standard errors are in parentheses; significance at 1 %, 5 %, and 10 % are denoted by ***, **, and *, respectively.

production is not controlled. At the last, however, this variable ends up with an insignificant effect on forest cover loss (full model). This result supports some regional studies for Asian country case (Cropper and Griffiths 1994; Koop and Tole 1999; Culas 2012; Wheeler et al. 2013).

Results of LP in this analysis, finding an insignificant association between LP and forest cover loss, are different from the results of Busch et al. (2012) and Wheeler et al. (2013). Different unit of analysis may lead to different results and interpretation. The unit of forest permits in both earlier studies is the percentage of forest permit areas in total land area, while this current analysis takes the absolute size of forest permit areas as the measurement. It may also due to the differences in the dependent variables and econometric models. The former study pays less attention to macroeconomic-demographic variables in the association with deforestation rate, while the latter incorporates fewer control variables to be correlated to the forest clearing index. Finding an insignificant correlation between LP and forest cover loss, our results are more or less concurrent with those of two studies in Sumatera and Kalimantan cases (Gaveau et al. 2012, 2013). They have a different focus, as well as a particular merit, in which they estimate association of forest permits in comparison to that in other forest uses (unprotected, protected, and managed protected forest and oil palm plantation). Their results, indeed, apply only for Sumatera and Kalimantan cases. Our analysis does not utilize other forest uses as the benchmark for comparison. Unlike aforementioned studies, this current analysis took into account environmental management factor (FSC-certified area) as suggested by Damette and Delacote (2011). This current analysis is able to confirm a general association between LP and forest cover loss at national level in Indonesia, showing that they are not significantly associated each other. A positive significant correlation between LP and deforestation reported by some micro-/site studies is valid for their specific cases and cannot be generalized into national level in Indonesia.

Conversely, the effect of PCP to mitigate deforestation has moved toward an unexpected direction, leading to forest cover loss. The growing demand of log for forest-based products has prompted the government to establish PCP since 1986 (Obidzinski and Chaudhury 2009; Brockhaus et al. 2012). Since 1990 when forest land has started to be seriously degraded, the government has further promoted PCP, expecting that the development of this monoculture fast-growing forest can considerably contribute to reforestation and rehabilitation programs (FWI/WRI/GFW 2002; Nawir et al. 2008; Resosudarmo et al. 2012). This analysis, unexpectedly, results in a positive significant effect of PCP on forest cover loss.

The inability of PCP to contribute to reforestation program is supported by the fact that areas of reforestation program have been continuously much less than the scale of deforestation over period which supports the results (Fig. 5.8). Another argumentation is the figure presented in Fig. 5.2, affirming that areas covered by PCP have continuously been smaller than those covered by LP. PCP is not able to cover whole degraded/logged-over forests; PCP cannot offset deforestation (Nawir et al. 2008). Instead, increasing its area will facilitate more forest cover loss. These findings support results of some observational studies and reports (Kartodihardjo and Supriono 2000; Cossalter and Pye-Smith 2003; Nawir et al. 2008; Obidzinski and Chaudhury 2009; Brockhaus et al. 2012).

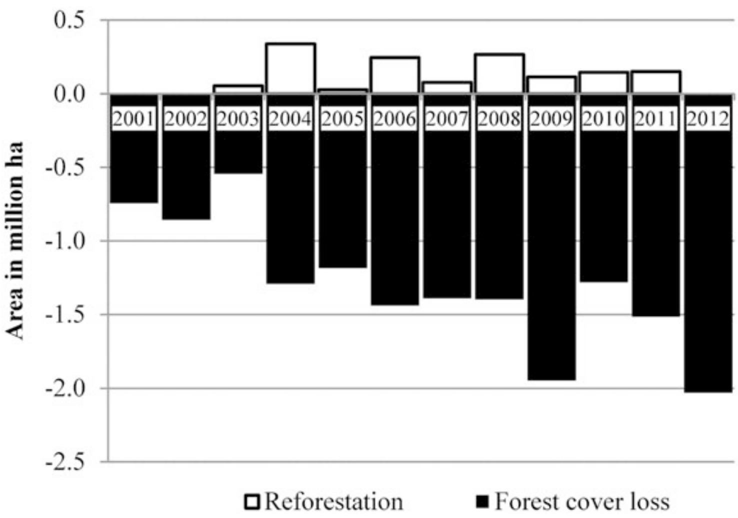

Fig. 5.8 Area of reforestation program and forest cover loss (threshold 30 % of canopy cover) in million ha, 2001–2012 (Source: Analyzed from MoF 2014; Hansen et al. 2013b; Note: data of reforestation programs in 2001, 2002, and 2012 is not available)

5.4 Concluding Remarks

Analysis of this chapter quantitatively estimates impacts of forest permits (areas of valid LP and PCP) on forest cover loss in Indonesia. Based on the results, it argues that insignificant correlation between LP and forest cover loss and significant positive impact of PCP on forest cover loss is the general association between forest permits and forest cover loss at national level in Indonesia. These main findings partly support the result of a spatially explicit study finding that logging precedes clearing (Margono et al. 2014). The development of PCP significantly diminishes forest cover at the expense of the primary forest (Kartodihardjo and Supriono 2000). An appropriate entitlement of the unproductive production forest is one of the explanations of positive relations between PCP and forest cover loss. The unproductive production forest may have a higher tree canopy cover (up to 50 %) than the maximum threshold of that of deforestation. Secondly, plantation that is supposed to be the main activity of PCP to reforest the unproductive production forest has not been properly done in the field.

In addition to these findings, increasing area of forest (FSC) certification cannot significantly mitigate forest cover loss, while timber production has a considerable role in diminishing forest cover. It calls further researches to investigate current performance of such forest management certification and invisible role of illegal logging, including legalizing illegal logging activities. This analysis, additionally, clarifies that a U-shaped EKC for deforestation in Indonesia does not exist, but an inverted U-shaped.

Reflecting these main results to the forest moratorium policy and the forest tariff policy, results suggest that discouraging and/or limiting LP in general may not effectively contribute to the attempts in reducing deforestation. Rather, considering the fact that open-access areas are enormously large, potential ability of LP to maintain forest cover (Meijaard and Sheil 2007; Fisher et al. 2011; Gaveau et al. 2012, 2013) could be further examined as a possible policy to reduce deforestation. On the other hand, promoting PCP has contradicted to the efforts in reducing deforestation. Based on these results, assuming other factors are held constant, discouraging and/or suspending new PCP is another alternative policy that could be further examined in reducing deforestation for short run. To further limit PCP area through, for example, directing PCP toward degraded forest with relatively low tree cover, the government should immediately revise the criteria of unproductive production forest to have tree cover up to 30 % in order to be in line with how forest is defined by the government (see Table 5.2). Consequently, the government needs to pay attention to essentially revitalize PCP in order to redirect its current path toward reforestation and forest rehabilitation programs; such a comprehensive evaluation of PCP is an important initial step.

In longer term, instead of revoking either noncompliance permits or PCP that is found by this analysis to have a positive contribution to forest cover loss, the government should urgently emphasize real actions to improve the existing on-the-ground environmental performance of forest permits (Gray 2002;

McAllister et al. 2007). Improving clarity and accuracy of forest categories allocated for forest permits (Brockhaus et al. 2012), preventing conversion of forest permit areas into non-forest uses, and alleviating illegal logging are among the alternative actions for consideration in forest permit-related policies. Finally, proposed policies have to be promptly enforced into real actions and be framed in the context of evidence-based forest management and forest governance (Jepson et al. 2001; Blair et al. 2007).

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Appendix

Material and Methods

Framing the Model

This analysis has been framed in the proximate underlying approach of deforestation (Geist and Lambin 2002). Proximate causes could relate to agricultural expansion, wood extraction, and infrastructure extension. These factors are even sometimes used as proxies of deforestation (Choumert et al. 2013). Underlying causes are typically classified into several factors: economic, demographic, technological, policy/institutional, and cultural factors. In this analysis, forest permits are considered as one of the policy factors undertaken by the government in managing state forests. The government has a strong authority to issue or not, to revoke, to designate location, and to decide how much area will be permitted within production forest. Furthermore, economic, demographic, and technological factors represented by gross domestic regional product per capita (GDRP/capita), population, and oil palm productivity, respectively, are other important factors affecting deforestation. It should be noted that cultural factors and other underlying variables are not incorporated in this analysis.

For economic factors, the immiserization theory postulates that rising economic levels (GDRP/capita) generate off-farm job opportunities that can prompt a shift away from reliance on forests (Rudel and Roper 1997). Conversely, the forest frontier theory suggests that better capital availability generated by economic development in forest regions enables loggers to expand and intensify their logging activities, which may or may not lead to greater deforestation (Rudel and Roper 1997). Generally, increasing per capita income may increase deforestation, but at a certain level, and then the trend is reverted. The existence of the Environmental Kuznets Curve (EKC) for deforestation is confirmed by some studies for cross-country case (Koop and Tole 1999; Barbier and Burgess 2001), Latin America (Cropper and Griffiths 1994; Barbier and Burgess 2001; Bhattarai and Hammig

2001; Culas 2007), and Africa (Bhattarai and Hammig 2001). A different pattern, a U-shaped EKC for deforestation, is found for Asia (Koop and Tole 1999; Bhattarai and Hammig 2001), arguing that it is due to the successful story of reforestation programs in certain tropical countries. Considering reforestation programs promoted through the development of PCP, analysis of this chapter also expects that a U-shaped EKC for deforestation exists in Indonesia.

Demographic factors also have dual effects on deforestation. The Malthusian theory suggests that an increase in population increases pressure on natural resources (Palo 1994). However, the Boserup effect indicates that more population may reduce deforestation through better innovation, technology, and institutions (Bilsborrow and Geores 1994). In the context of Asian countries, certain studies suggest that the population's effect on deforestation is insignificant (Cropper and Griffiths 1994, Koop and Tole 1999, Culas 2012). This analysis follows the Malthusian theory, expecting that an increase in population increases deforestation. Population of Indonesia increased approximately 1.49 % from 2000 to 2010 and is projected to grow 1.39 % from 2010 to 2015 (BPS 2010).

Technology factors specifically refer to technology in the agriculture sector regarded as one of the main pressures on the forest frontier, whereas technology factors in forest sector is represented by income as stated above. In Indonesia, oil palm development brings a significant pressure on forests. This analysis expects that better agricultural technology, represented by oil palm productivity, is negatively correlated to deforestation. Improving productivity enables oil palm plantations to produce more in the same amount of land (Mahapatra and Kant 2005), resulting in less demand of forest land to be converted and less pressure on forests. On the other side, higher oil palm productivity becomes a strong economic incentive of oil palm expansion. A more available capital generated by an increasing economic, likewise, will induce the development of oil palm plantation, bringing about more pressures on forests.

Since most forests are owned by the government, issuing and/or terminating forest permits is one of the important policies. LP is issued in productive production forest. The holders are allowed to extract timber immediately, but selectively. On the other side, PCP that has been designed as one of the main programs of forest rehabilitation and reforestation should be established in unproductive production or degraded or logged-over forests. In this type of permit, conceptually, the holders can utilize those areas by planting trees first before harvesting timber. In practice, however, immediate clear cutting has been taking place during land preparation stage. Lastly, utilization of production forest is subject to sustainable forest management, expecting that forest permits will not induce deforestation. Therefore, LP is expected to positively and/or insignificantly associated with forest cover loss, while its negative correlation is expected for PCP.

Empirical Model

To estimate the impacts of LP and PCP on forest cover loss, a panel data is developed by using the Forest Cover Change known as Hansen dataset (Hansen et al. 2013a). The main interest of this analysis is the marginal effect of area of valid LP and PCP on forest cover loss. The econometric model is specified as follows:

$$\mathrm{DEF}_{it} = \alpha + \beta_1 \mathrm{X}_{it} + \beta_2 \mathrm{LP}_{it} + \beta_3 \mathrm{PCP}_{it} + ut + \varepsilon_{it}$$

where DEF, LP, PCP, X, u, ε, i, and t denote deforestation in ha, LP in ha, PCP in ha, other potential explanatory variables, time or year effect, within-entity errors, province, and year, respectively.

Forest cover loss is used as the proxy of deforestation (DEF). Explanatory variables, including GDRP/capita in thousand Rupiah at 2000 constant price, square of GDRP/capita, population, population density per square kilometer, population growth in annual percentage, oil palm productivity in ton per ha, and timber production in cubic meter, are controlled in this model. Year dummy is expected to capture time effects, for each year, whereas province dummy captures region-specific character in each province. Furthermore, it takes into account roles of sustainable forest management, which is measured by Forest Stewardship Council (FSC) certified area in ha for both permits.

Since deforestation is a complex process, correlation between unobserved components and some explanatory variables is assumed to exist. To this end, the fixed-effect estimator is applied in this analysis (Damette and Delacote 2011). Heterogeneity issue is solved by running robust standard errors.

During analysis processes, those three demographic factors (population density, population growth, and number of population) were separately examined. At the end, since a number of population brought a significant sign, it was chosen to be incorporated in the model. Consequently, results and discussion on demographic factor in this chapter refer to the number of population. It was also decided to exclude oil palm productivity from the analysis for two reasons: its sign was consistently insignificant during the analysis process and excluding this insignificant factor improved the model specification because of the degree of freedom. Explanation of variables included in the discussion is presented in Table 5.8.

Data

The data of this analysis are provincial data covering all provinces in Indonesia. The data of deforestation (forest cover loss), the dependent variable, are based on Global Forest Change or Hansen dataset (Hansen et al. 2013a) and accessed from Global Forest Watch website (Hansen et al. 2013b). In this dataset, forests refer to tree cover, where trees are defined as all vegetation taller than 5 m in height and canopy cover at least 30 % at the Landsat 30 × 30 m pixel scale. By this definition, commercial forestry plantations, as well as primary and secondary forests, are

Table 5.8 Variables, data sources, and expected signs

Variable	Explanation	Unit of measurement	Source of data	Expected sign
Dependent variable				
DEF	Area of forest cover loss at 30 % threshold of canopy cover.	ha	(Hansen et al. 2013b)	–
Independent variables				
LP	Area of logging permits.	ha	Ministry of Forestry	Insignificant/ positive
PCP	Area of plantation conversion permits.	ha	Ministry of Forestry	Negative
GDRPcap	Provincial gross domestic regional product per capita.	Rp 000/capita (in 2000 constant)	BPS-Statistics Indonesia	Negative
sqGDRPcap	Square of GDRPcap.	–	–	Positive
POP	Number of population.	Number	BPS-Statistics Indonesia	Positive
SFM_LP	Area of FSC-certified area for LP.	ha	Ministry of Forestry	Negative
SFM_PCP	Area of FSC-certified area for PCP.	ha	Ministry of Forestry	Negative
POL	Volume of timber production.	m^3	Ministry of Forestry	Positive

accounted as forests. To be in line with how the government defines forests (MoF 2008), the threshold of 30 % canopy cover was chosen. Threshold of 10 % canopy cover was utilized to check the robustness of estimation results (see Table 5.9). Deforestation is defined as forest cover loss, the disturbance or complete removal of tree cover canopy. It is calculated by subtracting forest extent in the previous year with that in the current year for each province. Positive value of forest cover loss represents the magnitude of deforestation area.

Since the government has not designated any LP and PCP in the provinces within Java and Bali islands, this analysis employs 26 out of 33 provinces, excluding the provinces in Java and Bali. This analysis takes into account the dynamics of decentralization in which new provinces were established (Banten from West Java in 2000, Kepulauan Bangka Belitung from Sumatera Selatan in 2000, Gorontalo from Sulawesi Utara in 2000, Papua Barat from Papua in 2001, Kepulauan Riau from Riau in 2002, and Sulawesi Barat from Sulawesi Selatan in 2004). In those cases, the data of the explanatory variables are available 1 year after their establishment years. Therefore, the balanced panel data for this analysis is in the period of 2005–2012. The descriptive summary of the data is given in Tables 5.10 and 5.11 for a more detailed summary.

Table 5.9 Estimation results: impacts of LP and PCP on forest cover loss with 10% threshold of canopy cover

Variables	Basic model	Reduced-form model	Full model
GDRP/capita	20.0165	11.5782	22.0316
	(5.2610)***	(5.2820)**	(7.4360)***
Square of GDRP/capita	−0.000863	−0.000518	−0.000969
	(0.0002)***	(0.0002)**	(0.0003)***
Number of population	0.0307	0.0560	0.0337
	(0.0273)	(0.0180)***	(0.0271)
Area of LP	0.00555	0.00762	0.00569
	(0.0033)	(0.0032)**	(0.0034)
Area of PCP	0.0719	0.0697	0.0734
	(0.0271)**	(0.0232)***	(0.0273)**
Timber production	0.00484	–	0.00484
	(0.0021)**	–	(0.0022)**
LP SFM-certified area	–	0.0173	0.0484
	–	(0.0878)	(0.1090)
PCP SFM-certified area	–	−0.0379	−0.0350
	–	(0.0508)	(0.0472)
Year effect	Yes	Yes	Yes
Constant	−168,601	−212,252	−184,047
	(102.6970)	(69.0250)***	(109.2010)

Note: robust standard errors are in parentheses; significances at 1 %, 5 %, and 10 % are denoted by ***, **, and *, respectively.

Table 5.10 Descriptive statistics of main variables, 2005–2012

Variable	Observation	Mean	Standard deviation	Minimum	Maximum
DEF	208	58,050.97	80,577.85	1146	353,590
LP	208	1,003,365.00	1,742,085.00	0	6,773,357
PCP	208	339,940.40	507,413.80	0	1,966,186
GDRPcap	208	8,256.38	6,651.05	2166	32,689
POP	208	36,39707.00	2,737,832.00	643,012	1.33e+07
SFM_LP	208	14,517.23	62,570.30	0	462,710
SFM_PCP	208	10,106.99	46,423.42	0	260,829
POL	138	1,066,188.00	2,282,799.00	0	1.80e+07

Table 5.11 Descriptive statistics of panel data, 2005–2012

Variable		Mean	Standard deviation	Minimum	Maximum	Observations
DEF	Overall	58,050.97	80,577.85	1,146.00	353,590.00	$N = 208$
	Between		76,469.22	2,174.50	266,661.80	$n = 26$
	Within		29,034.32	−31,539.00	210,054.00	$T = 8$
LP	Overall	1,003,365.00	1,742,085.00	0.00	6,773,357.00	$N = 208$
	Between		1,765,816.00	0.00	6,221,368.00	$n = 26$
	Within		148,981.40	269,446.60	1,612,888.00	$T = 8$
PCP	Overall	339,940.40	507,413.80	0.00	1,966,186.00	$N = 208$
	Between		490,010.30	0.00	1,457,750.00	$n = 26$
	Within		159,619.20	−457,671.0	1,108,101.0	$T = 8$
GDRPcap	Overall	8,256.38	6,651.05	2,166.00	32,689.0	$N = 208$
	Between		6,701.10	2,573.18	31,689.11	$n = 26$
	Within		922.10	5,077.66	14,248.56	$T = 8$
POP	Overall	3,639,707.00	2,737,832.00	643,012.00	1.33E+07	$N = 208$
	Between		2,779,276.00	725,706.90	1.28E+07	$n = 26$
	Within		180,435.10	3,103,806.00	4,230,581.00	$T = 8$
SFM_LP	Overall	14,517.23	62,570.30	0.00	462,710.00	$N = 208$
	Between		52,327.58	0.00	241,339.80	$n = 26$
	Within		35,629.51	−110,222.00	352,488.50	$T = 8$
SFM_PCP	Overall	10,106.99	46,423.42	0.00	260,829.00	$N = 208$
	Between		36,800.32	0.00	163,018.10	$n = 26$
	Within		29,097.54	−152,911.00	107,917.90	$T = 8$
POL	Overall	1,066,188.00	2,282,799.00	0.00	1.80E+07	$N = 138$
	Between		1,844,244.00	4,214.93	8,548,080.00	$n = 26$
	Within		1,248,778.00	−7,445,841.00	1.06E+07	T-bar = 5.30

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Chapter 6
Mitigating Climate Change by Preventing Peatland Fire: Conditions for Successful REDD+ in Indonesia

Yuki Yamamoto and Kenji Takeuchi

Abstract This chapter investigates key issues related to the implementation of REDD+ in Central Kalimantan Province of Indonesia, where peatland fires contribute significantly to the release of large amounts of carbon. We focus on the investigation of factors that promote peatland fire prevention and on the estimation of the Kalimantan Forest Carbon Partnership (KFCP), one of the earliest REDD+ plot projects. In our analysis, no effect of the KFCP is found, whereas economic factors, such as the value of labor allocation for rubber production and additional off-farm income, and noneconomic factors, such as traditional mutual assistance called *Gotong-royong*, can promote fire prevention. This finding is attributed to the fact that the KFCP failed to develop an appropriate incentive scheme. These results suggest that a better design for intervention would incorporate a combination of economic and noneconomic incentives to achieve an effective REDD+ policy.

Keywords REDD+ • KFCP • Peatland fire • Climate change • Indonesia • Central Kalimantan

6.1 Introduction

The mitigation of climate change has focused on the industrial sector but has recently expanded to include attempts to reduce emissions from the forest sector. One such attempt is REDD+ (reducing emissions from deforestation and forest degradation, plus). It is expected to play a role in reducing deforestation in rapidly developing countries, such as Indonesia. Previous studies have found that Indonesia has significant potential as a target area for REDD+. Deveny et al. (2009) assess the

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capacity for implementing REDD+ in each country using the Forest Carbon Index (FCI) and conclude that Indonesia like Brazil, Russia, Peru, Bolivia, and Colombia has high potential.

The forest area in Indonesia decreased from 121 million hectares in 1990 to 100 million hectares in 2005, and Kalimantan Island and Sumatra Island accounted for approximately 76 % of its deforestation (Hansen et al. 2009). The average rate of deforestation in Indonesia from 2000 to 2005 was 0.71 million hectares per year. This figure is rather modest compared to the 1.78 million hectares per year from 1990 to 2000, although still high. The vast amount of carbon release from deforestation made Indonesia the third largest greenhouse gas (GHG) emitter in the world (Myers Madeira 2008).

One of the key issues for implementing REDD+ in Indonesia is the high risk of peatland fires. Forestland in Central Kalimantan Province of Indonesia is composed of thick peat swamp and 2,000–6,000 metric tons of carbon per hectare (t C/ha), which is larger amount compared to the average 225 t C/ha in moist tropical forests in Southeast Asia (Page et al. 1999; IPCC 2006). Once peat has been ignited, the burning of its organic-rich materials is hard to extinguish, and it releases its carbon into the atmosphere. For example, during a large-scale peatland fire in 1997, the total carbon dioxide emission from Indonesia was estimated to be between 0.81 and 2.57 Gt, which is equal to 13–40 % of the mean annual global carbon emissions from fossil fuels (Page et al. 2002).

This chapter investigates the conditions for successful REDD+ in Indonesia by focusing on the prevention of peatland fires. Although fire prevention is an important aspect of forest and climate policy, it has not been seriously addressed in the economics literature. We evaluate the effect of the Kalimantan Forest Carbon Partnership (KFCP) on farmers' decision making for preventing fire as one of the earliest REDD+ pilot projects to assess the feasibility of REDD+. With the growth of REDD+ pilot projects in recent years, there is a need to evaluate their performance. Our main finding is that designing appropriate economic incentives and securing the adequate monitoring of farmer's behavior are important for implementing effective REDD+.

6.2 REDD+ Under the Climate Change Policy

6.2.1 The Historical Background of REDD+

REDD+ can be classified as one of the LULUCF (land use, land use change, and forestry) activities in developing countries. Articles 3.3 and 3.4 of the Kyoto Protocol allow developed countries to account for afforestation activities in LULUCF since 1990 for compliance with the target in the protocol. After the COP7 (Conference of the Parties of United Nations Conventions), afforestation and reforestation in developing countries were validated as a Clean Development Mechanism (CDM) project under the protocol. REDD+ differs from these activities in its focus on the prevention of forest degradation and deforestation in developing countries.

At COP9 held in Milan in 2003, a fundamental concept of REDD+ was proposed by Brazilian institutions. The carbon credit could be issued based on the difference between the baseline, which would be defined as the amount of forest estimated from the past deforestation trend, and the actual amount of forest. At COP11 held in Montreal in 2005, Papua New Guinea and Costa Rica, on behalf of the Coalition for Rainforest Nations (CfRN), proposed a mechanism to issue carbon credits for avoiding deforestation in developing countries. In response to this proposal, REDD+ has been addressed in the SBSTA (Subsidiary Body for Scientific and Technological Advice) of the UNFCCC (UN Framework Convention on Climate Change).

In 2009, COP15 confirmed the effectiveness of forest conservation and the necessity of the REDD+ activity in climate change mitigation. The Copenhagen Accord includes the following statement: "We recognize the crucial role of reducing emission from deforestation and forest degradation and the need to enhance removal of GHG emission by forests and agree on the need to provide positive incentives to such actions through the immediate establishment of a mechanism including REDD+, to enable the mobilization of financial resources from developed countries." The financial support from developed countries was also advanced at COP15. To promote mitigation and adaptation, technology transfer, and capacity building in developing countries, USD 30 billion in financial assistance from 2010 to 2013, with an additional USD 100 billion per year until 2020, was included in the Copenhagen Accord.

In 2010, at COP16 held in Cancun, the promotion and support of the safeguards in the REDD+ implementation was agreed upon. The safeguards include the property rights of indigenous people and communities and their dependence on forest resources. Three years later, at the COP19 held in Warsaw, it was agreed that the countries are required to report how safeguards are promoted and supported every 2 years. However, there is no mechanism to evaluate how governments make an effort toward complying with the safeguards. Thus, a warning of the increased risk of making light of safeguard agreements was issued at COP20 held in Lima in 2014.

6.2.2 The Basic Mechanism of REDD+

REDD+ has been a focus of international discussion as an efficient climate change policy because deforestation and forest degradation have great implications for carbon emission through the process of its organic decomposition. According to IPCC (2007), 1.6 G tons of carbon are emitted every year due to deforestation in the world. This amount is estimated to be 20 % of global GHG emissions and is beyond the percentage of emissions from the transportation sector. In terms of the amounts of GHG emissions, countries with the highest deforestation ratios, such as

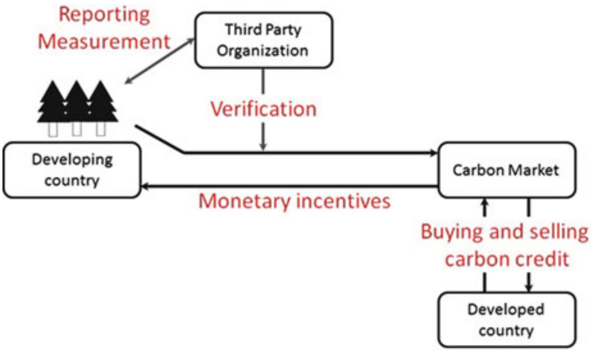

Fig. 6.1 The flow of credit and monetary incentives of REDD+ under the market-based mechanism

Indonesia, Brazil, and Malaysia, are comparable to Russia, Japan, and Germany (Myers Madeira 2008).

The basic function of REDD+ is to offer developing countries a response to avoid carbon emissions through forest conservation. Figure 6.1 shows the flows of carbon credit and monetary incentives on the market-based mechanism. To be valid, the volume of protected forestland in developing countries should be reported to and measured by a third-party organization. Developing countries are able to receive monetary incentives in response to forest protection by trading the carbon credit on the carbon market. In exchange, developed countries can acquire carbon credits, which can be used to achieve compliance with the target of carbon emission reduction. In this context, REDD+ might play a role in reducing the conflict between developed and developing countries in the climate change discussion.

The payment mechanisms currently under consideration can be broadly classified as either fund-based or market-based mechanisms (Parker et al. 2009; Isenberg and Potvin 2010). Under the fund-based scheme, money is distributed to participating governments on the basis of their performance in forest protection. Under the market-based system, credit is issued for emission reductions by REDD+ and developed countries trade them on the carbon market.

To design a workable REDD+ mechanism, the revenue from forest protection must be higher than the revenue from forest exploitation. There have been many attempts to estimate the cost of protecting forest in various countries. For Indonesia, Yamamoto and Takeuchi (2012) estimated the break-even price of carbon as a carbon price satisfying the minimum needed to compensate for a forgone chance of forest development, and they found that the current level of carbon price can provide the necessary compensation for forest protection in Central Kalimantan.

Through these international negotiations and investigations, REDD+ is becoming increasingly important in the global attempt to mitigate climate change. Several pilot projects of REDD+ are in progress across the world. With the growth of REDD+ initiatives and projects across the world in recent years, there is a need to objectively evaluate their performance against stated aims.

6.2.3 The Kalimantan Forest Carbon Partnership (KFCP)

The KFCP was one of the earliest of the 15 REDD+ pilot projects. It was launched in June 2008 by the governments of Indonesia and Australia (Carlson 2009). The main objective of the project was to mitigate GHG emission from the degradation of peatland and to reduce the risk of peatland fires by providing incentive payments. This aim was in line with the concept of REDD+, which is an attempt to offer developing countries an opportunity for financial support in response to avoiding carbon emissions through forest conservation. The KFCP involved 14 communities in Blocks A and E of the Kapuas Regency, which comprised 120,000 ha of peatland and forests that were heavily degraded by the Mega Rice Project (MRP) launched by the Indonesian government in 1995.

The KFCP aimed to enhance sustainable farming practices by providing rewards for farmers as incentives. There were three categories for such incentives described in the project design document of the KFCP: (1) input-based incentives, such as building dams, planting trees, growing nursery plants, and eliminating fire use on peat soils; (2) performance-based incentives, such as maintaining dams to keep water levels high, protecting forests from encroachment, and reducing the incidence and extent of fires; and (3) outcome-based incentives, such as payment for actual reduced GHG emissions (KFCP 2009, p. 24).

The provision of these incentives, however, was limited. Our interview, conducted from October to December of 2012, found that input-based incentives were offered much more than performance-based or outcome-based incentives in three communities, Katimpun, Kalumpang, and Tumbang Mangkup, in Blocks A and E. All respondents reported that the KFCP had offered them input-based incentives: seeding nurseries, clearing land, and planting trees in the project site. Figure 6.2 is an example of a project site for a nursery plant. Because the site was located outside of agricultural land owned by farmers, input-based incentives did not directly promote fire prevention on farmers' land. The average rewards for each activity per year amounted to 605,000 rupiahs for seeding nurseries, 118,000 rupiahs for clearing land, and 432,000 rupiahs for planting trees in 2012 (then thousand rupiahs were equal to approximately 1 US dollar as of June 2012).

The KFCP has provided not individual activities, such as fire prevention at individual plot, but organized activities, such as growing nurseries and planting trees at project site. This might be because it is costly to monitor individual household activities. The high cost of implementing monitoring is known as the issue of measurement, reporting, and verification (MRV) in the international discussion of REDD+. Another problem that might have prevented enough implementation of the plan was the reduction of the budget. Olbrei and Howes (2012) report that only 50,000 trees were planted, although the initial target was to plant 100 million trees, because the budget for implementing the KFCP was scaled down significantly.

Fig. 6.2 A growing nursery plant for the KFCP in Desa Katimpun

6.3 Data

6.3.1 Sample and Key Features

The data employed in this chapter are from a field survey conducted in Central Kalimantan Province of Indonesia from September to December 2012. The sample consisted of 288 households in 29 communities and included 6 communities involved in KFCP (Fig. 6.3). The communities were selected considering the balance of ethnicities and the degree of involvement in the KFCP project. The communities consisted of 11 transmigrant communities and 18 Dayak tribe communities. Of the 18 Dayak communities, 6 were involved with the KFCP project.

Two types of people have settled in Kapuas Regency: indigenous Dayak tribes who traditionally lived there and transmigrants who moved from other islands of Indonesia or other parts of Kalimantan (Fearnside 1997). Transmigration to this area was promoted by government policy, particularly during the MRP in the 1990s. Although the government abandoned the MRP, a number of transmigrants continued to live in the area as rice farmers. Both communities rely on agricultural product as their main source of income (De Jong et al. 2001).

The respondents of the interview were asked about their economic status, type of agriculture, demographic characteristics, experience of fire damage, and fire prevention activities. Although we collected information from a total of 288 randomly selected households, to focus on the decisions of household heads, we excluded

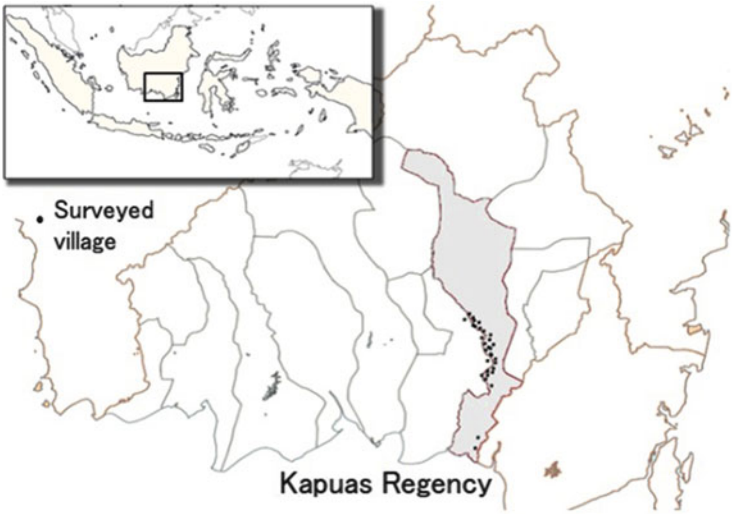

Fig. 6.3 Geographical representation of Kapuas Regency

73 responses from non-household heads and 35 responses with incomplete data.[1] Thus, the final number of observations for the analysis was 182. Table 6.1 summarizes the descriptive statistics of the sample.

6.3.2 Empirical Variables

The empirical variables used in our analysis are summarized in Table 6.1. We find that households in the area face a high risk of fire damage: 38 % of the households have experienced accidental fire damage on their agricultural plots. To adapt the risk of fire damage, 88 % of the households have been engaging in fire prevention activities. We define a household as a fire prevention participator if it has engaged in patrolling or clearing grass at individual plots for fire prevention in the 12 months preceding the interview.[2]

The main source of income in the area is agriculture (91 %), and many farmers cultivate rice (79 %) and rubber (58 %) in the area. We define shadow wage as an opportunity cost of the time of adult labor for each production.[3] The estimated mean

[1] For example, we left out respondents who did not engage in agriculture or who did not own any agricultural plots.

[2] The exact wording of the questionnaire is "Do you clear grass on your land to prevent fires?" and "Do you look around your land carefully to prevent fires?"

[3] We do not estimate the shadow wage of rice production because rice products are primary captive consumption in the area.

Table 6.1 Descriptive statistics for sample households

Explanation	Mean	S.D.
Economic parameters		
Shadow wage of rubber production (IDR/day/person)	16,483.94	11,978.18
Shadow wage of off-farm work (IDR/day/person)	11,353.17	24,666.6
Total size of agricultural plot (hectare)	3.45	4.81
Agriculture as primary source of income	0.91	0.29
Households with plots for rice production (0,1)	0.79	0.41
Cultivated rice product last year (kg)	928.11	1328.7
Household with plots for rubber production (0,1)	0.58	0.5
Cultivated rubber product last year (kg)	2291.71	5387.24
Fire-related variables		
Experienced fire damage in the last 5 years (0,1)	0.38	0.49
Number of hot spots observed in 2012	2.89	6.91
Number of hot spots observed from 2001 to 2007	30.32	38.91
Household characteristics		
Involved with a KFCP site (0,1)	0.22	0.41
Participated in Gotong-royong activities in the last year (0,1)	0.64	0.48
Number of household members	4.38	1.69
Number of children age <6	0.35	0.58
Access time to market (minutes)	59.46	70.75
Age of household head	46.76	10.95
Transmigrant (0,1)	0.46	0.5
Number of years on lot (year)	31.97	17.82
Engaged in fire prevention in the last year (0,1)	0.88	0.33
Days spent on fire prevention	129.42	153.18
Size of burned plot for agriculture in the last year (hectare)	0.77	3.78
Allocated labor for off-farm work in the last year (0,1)	0.65	0.48

shadow wage of rubber cultivation and off-farm work are 16,483.94 rupiahs and 11,353.17 rupiahs.[4]

We focused on the mutual assistance custom called *Gotong-royong* as an important factor in the decision making regarding the allocation of household labor for fire prevention. *Gotong-royong* includes a wide range of group activities in the community, such as providing labor to clear agricultural plots, the construct and repair of public infrastructure, guarding the communities, and financial support.

[4] To define the opportunity cost of rubber production time, we estimated the production function. The F-statistic of the estimation is 38.17 with 127 degrees of freedom. The annual amount of rubber produced by households was used as the dependent variable. The independent variables that were statistically significant at 1 % were household labor time (+), capital input (+), hired labor (+), chemical fertilizer input (+), years since the rubber was planted (+), and the square of years since the rubber was planted (–). The chemical input and the experience of fire damage were statistically insignificant. The estimated coefficient for the household labor time variable was used as the opportunity cost of the rubber production time in the analysis of this section.

This behavior provides the community with social norms and serves as a determinant of social capital based on the norms that are generally observable in urban and rural Indonesia (Bowen 1986).

6.4 Estimation Result

We investigate the effect of the KFCP and factors that promote farmers' fire prevention by estimating an econometric model. We regress the number of days allocated for fire prevention activities within the previous 12 months (L_p) on various factors. In this study, fire prevention activities are limited to patrolling or clearing grass on individual plots. Because our data contain zero prevention from farmers who did not engage in fire prevention, we use a Tobit model for estimation:

$$L_p^* = \beta_0 + \beta_k X_k + \beta_e X_e + \beta_s X_s + \beta_f X_f + \varepsilon$$
$$y^* = L_p \cdot \text{if} \cdot L_p > 0$$
$$y^* = 0 \cdot \text{if} \cdot L_p = 0$$

where X_k is the dummy variable of the KFCP project; X_e is a vector of explanatory variables of economic factors; X_s is a vector of the explanatory variables of noneconomic factors, such as household characteristics; and X_f is a vector of the explanatory variables of the risk of fire damage, such as the experience of fire damage and the number of hot spots in 2012.[5]

To evaluate the effect of the KFCP, policy endogeneity should be considered. There is a possibility that households on the KFCP site were more likely to engage in fire prevention not because of the project but because of the higher risk of fire damage. To take this bias into account, we used the instrumental variable method that follows:

$$X_k = \gamma_e X_e + \gamma_s X_s + \gamma_f X_f + \gamma_p X_p + v,$$

where X_p is the instrument variable of the total number of hot spots observed at pre-period of the KFCP project from 2001 to 2007. Because the project started in 2008, the pre-period hot spots from 2001 to 2007 can be considered to have an effect on the KFCP site selection but not on the household fire prevention decision in 2012. Thus, we can control the endogeneity caused by KFCP site selection. Table 6.2 shows the results of the first-stage regression for the IV-Tobit for

[5] Hot spot data in our analysis cover the entire Kapuas Regency, from 114.000 to 114.450° east longitude and from 2.05 to 3.40° south latitude from 2001 to 2012. We counted the number of hot spots on the basis of 532 meshes that divided the Kapuas Regency with 0.05° of longitude and 0.025 of latitude.

Table 6.2 KFCP site selection, first-stage regression

	Probit	IV
Independent variable	Coefficient (robust S.E.)	Coefficient (robust S.E.)
Number of hot spots observed from 2001 to 2007	2.426*** (0.354)	0.139*** (0.038)
Participated in Gotong-royong	−0.398 (0.813)	–0.040 (0.065)
Shadow wage of rubber products	0.287*** (0.069)	0.008* (0.004)
Shadow wage of off-farm work	0.071* (0.041)	0.004 (0.003)
Amount of rice product cultivated last year	−0.047 (0.078)	–0.013 (0.008)
Number of hot spots observed in 2012	–1.007** (0.469)	–0.110** (0.048)
Experienced fire damage in the last 5 years	2.504*** (0.443)	0.160*** (0.051)
Number of household members	1.221** (0.488)	–0.016 (0.051)
Number of children age <6	–1.678*** (0.346)	–0.052 (0.044)
Access time to market	2.479*** (0.372)	0.189*** (0.042)
Age of household head	–0.220*** (0.079)	–0.009 (0.010)
Squared age of household head	0.002***(0.001)	0.000 (0.000)
Transmigrant	–4.502*** (0.612)	–0.429** (0.167)
Number of years on lot	–1.139** (0.473)	–0.019 (0.142)
Agriculture as primary source of income	–0.692 (0.734)	–0.099* (0.060)
Total size of agricultural plot	–0.406 (0.361)	0.017 (0.042)
Size of burned plot for agriculture	1.880*** (0.646)	0.104* (0.057)
Constant	–12.566*** (3.603)	–0.306 (0.518)
Number of observations	182	182
Pseudo R^2	0.853	

Clustered standard errors are given in parentheses
Variables except for dummies are in log form
***, **, and * = statistically significant at 1 %, 5 %, and 10 %, respectively

IV-Tobit model. The result of first-stage regression shows that the coefficient of the pre-period hot spots is positive and statistically significant at the 1 % level, indicating that KFCP selected a project site where the risk of fire is higher than in other sites in the Kapuas Regency.

The estimation result is summarized in Table 6.3. The first specification (Column 1) uses a Tobit model, and the second specification (Column 2) uses the instrumental variable model to take the endogeneity bias into account. We find that the coefficient of the KFCP is statistically insignificant in both models, indicating that the effect of KFCP was not enough to cause households to allocate additional time for fire prevention. As stated in Sect 6.2.3, this might be because the KFCP offered payments not for fire prevention on individual plots but for planting on project plots. Nevertheless, the initial purpose of the KFCP was to reduce the risk of fire by enhancing households' activities; such rewards, which constituted an increase in households' additional off-farm income, could create a negative incentive for households' fire prevention activity. By increasing households' additional

Table 6.3 Estimation models for either patrolling or clearing grass

	Tobit model	IV-Tobit model
Independent variable	Coefficient (robust S.E.)	Coefficient (robust S.E.)
Household involved with a KFCP site	0.061 (0.360)	0.104 (0.759)
Participated in Gotong-royong	0.660** (0.263)	0.661** (0.261)
Shadow wage of rubber products	0.052** (0.023)	0.052** (0.024)
Shadow wage of off-farm work	–0.034** (0.014)	–0.034** (0.014)
Amount of rice product cultivated last year	–0.032 (0.028)	–0.032 (0.029)
Number of hot spots observed in 2012	0.083 (0.135)	0.086 (0.159)
Experienced fire damage in the last 5 years	0.028 (0.217)	0.020 (0.260)
Number of household members	0.311 (0.332)	0.308 (0.323)
Number of children age <6	–0.426 (0.317)	–0.422 (0.335)
Access time to market	–0.017 (0.134)	–0.026 (0.148)
Age of household head	0.027 (0.052)	0.028 (0.052)
Squared age of household head	–0.000 (0.001)	–0.000 (0.001)
Transmigrant	–0.421 (0.437)	–0.402 (0.522)
Number of years on lot	–0.567 (0.372)	–0.563 (0.375)
Agriculture as primary source of income	0.593* (0.326)	0.595* (0.330)
Total size of agricultural plot	0.174 (0.159)	0.172 (0.159)
Size of burned plot for agriculture	0.174 (0.159)	0.172 (0.159)
Constant	1.657 (1.752)	1.656 (1.758)
Number of observations	182	182
Pseudo R^2	0.853	
Log-likelihood	−252.502	−242.568

Clustered standard errors are given in parentheses
Variables except for dummies are in log form
** and * = statistically significant at 5 % and 10 %, respectively

off-farm income, the KFCP could deprive households of incentives to allocate labor for fire prevention on their own plots; because the coefficient of the shadow wage of off-farm work is negative and statistically significant, this effect is plausible. Furthermore, the KFCP might have been insufficient in providing information and knowledge on its strategies. Resosudarmo et al. (2012) compared the knowledge of villagers between several REDD+ pilot projects and found that the KFCP was less acknowledged by local residents.

The estimation result suggests that economic factors have a significant effect on decision making for fire prevention. The coefficient of the shadow wage of rubber production is positive and statistically significant at least at the 5 % level, indicating that households with higher values of rubber work are more likely to allocate labor for fire prevention. A higher rubber product value creates an incentive for households to protect themselves from fire damage. This result is consistent with Bowman et al. (2008), who found that the shadow wage of agricultural work has a positive and statistically significant effect on household decision making regarding fire prevention in Brazil. The coefficient of the shadow wage of off-farm work is negative and statistically significant, indicating that an increasing off-farm wage increases the opportunity cost of time, and a high opportunity cost causes households not to allocate their time to fire prevention. The coefficient of *Gotong-royong* is positive and statistically significant in the estimation, indicating that the households that participate in *Gotong-royong* are more likely to engage in fire prevention. Because *Gotong-royong* reinforces a community's norms and ethics, it might promote cooperation between households. Another possibility is that *Gotong-royong* plays the role of a mutual surveillance system, which allows farmers to know what their neighbors are doing on their agricultural plots. This can function as peer pressure facilitating more frequent activities of fire prevention.

The coefficients of the experience of fire damage and the number of hot spots in 2012 are positive but statistically insignificant in the estimations. These results suggest that prevention activities by households might be based on subjective risk perception. Empirical findings show that households in developing countries are typically defined as risk averse (Rosenzweig and Binswanger 1993; Morduch 1995; Barrett 1999; Shively 2001).

6.5 Conclusion

This chapter investigates the effectiveness of REDD+ by evaluating the KFCP as one of the REDD+ pilot projects. The effect of the KFCP is found to be statistically insignificant on households' fire prevention activities in our estimation, whereas the effect of economic factors is statistically significant. This finding is attributed to the fact that the KFCP failed to develop an appropriate incentive scheme. For example, the KFCP paid households not for fire prevention in individual plots but for planting or preparing trees for reforestation in project plots. Increasing this type of payment might decrease the amount of labor allocation for fire prevention because increasing the attractiveness of off-farm work would deprive households of their willingness to allocate labor for fire prevention on their land.

We also conclude that noneconomic factors have important implications for effective policy implementation. Mutual assistance, *Gotong-royong*, might enhance the relationships and the responsibility of households in the community. Thus, households that participate in *Gotong-royong* activities tend to allocate more labor and time for fire prevention on individual plots. The combination of noneconomic factors and monetary incentive scheme could lead to a better design of REDD+ under the complex decision-making process of indigenous peoples. Together, these findings provide policy implications for the mitigation of forest fires and deforestation in Central Kalimantan and in other tropical regions. The high costs of implementing incentive schemes and monitoring individual actions which are known as the MRV problem are at the center of the international discussion on REDD+. Peer pressure between households is one possible way to reduce the cost of implementation. To secure implementation, policy design should include mutual pressure from each household and appropriately designed economic incentives.

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Chapter 7
Indonesian Fuel Subsidy Removal Impact on Environment: A Partial Equilibrium Analysis

Ahmad Luthfi and Shinji Kaneko

Abstract Due to its accelerating economy and growing population, Indonesia consumed more and more energy. It has become an oil-importing country since 2003. Furthermore, Indonesia's energy policy has changed drastically since the Asian crisis by giving more funds to fuel subsidy than development fund. These facts made scholars and international institutions urge the government of Indonesia to remove the subsidy. One of the benefits of removal of subsidy is lessening CO_2 emission due to lower fuel consumption. There are several studies conducted to estimate the impact of subsidy removal using descriptive analysis, computable general equilibrium and partial equilibrium analysis. This paper tries to estimate the CO_2 emission reduction using partial equilibrium analysis based on several price adjustment scenarios. The policy implication of this paper would be that the government should keep the ongoing removal of fuel subsidy because this action would be more environmental friendly by saving around 70 million tonnes CO_2 which is double compared to IEA estimation using 1998 data (IEA 2000).

Keyword Fuel subsidy • Subsidy removal effect • Partial equilibrium analysis

7.1 Introduction

Indonesia is one of the energy-exporting countries in the world. It consists of more than 17,000 islands (the largest archipelago in the world) and has enormous population, more than 240 million people (fourth in the world). Indonesia's economy grows fast, at least by 4.5 % annually after the 1998 Asian crisis, and recently successfully surpassed several industrial countries in terms of GDP (purchasing power parity based) and is the ninth largest economy in the world (International Monetary Fund 2013a).

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Table 7.1 Energy availability in Indonesia 2012

No	Energy type	Reserve	Production	Consumption
1.	Oil	3.7 billion barrels (0.2 % world)	918 thousand barrels per-day	1565 thousand barrels per-day
2.	Natural gas	103.3.89 TSCF (1.2 % world)	6.3 TCF	3.5 TCF
3.	Coal	5529 million tonnes (0.6 % world)	386 million tonnes	50.4 million tonnes
4.	Hydroelectricity			12.8 TWh
5.	Geothermal, bio-mass, and others			9.8 TWh

Source: Indonesia's Ministry of Energy and Mineral Resources (2012) and BP – British Petroleum (2013)

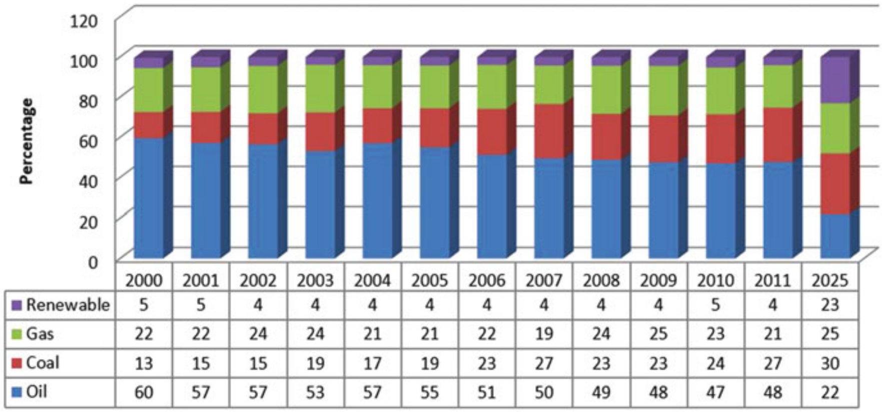
Indonesia also has enormous energy resources. Except for oil, other energy resources such as natural gas, coal, and geothermal are plentiful in Indonesia. Table 7.1 shows the energy resources in Indonesia.

As we can see in the table, all resources are quite rich, except for oil. For oil, Indonesia has become a net oil importer since 2003, resigning as an OPEC (Organization of the Petroleum Exporting Countries) member in 2008.

Figure 7.1 shows the compositions of primary energy from 2000 to 2011 as well as the composition indicated in the Indonesian National Energy Plan in 2025. The National Energy Plan presents the "ideal" proportions of primary energy in 2025, which are 23 %, 25 %, 30 %, and 22 % for renewable energy, gas, coal, and oil, respectively.

The government of Indonesia still needs extra work to achieve the composition targeted for 2025 except for coal and gas. The percentage of coal usage doubled in 11 years, thus obtaining 3 % more is not so difficult. Moreover, as the percentage of gas usage was relatively stable between 19–24 % in that time frame, the government may only need small steps; one such step is building more gas infrastructures. For reducing oil consumption and boosting renewable energy usage, the government needs extra effort. In 11 years, the average decreasing rate for oil is about 1 % per year, and if the decrease continues linearly, the composition rate will end up to 34 % in 2025. For renewable energy, the percentage remains between 4–5 %, compared to 23 % as targeted for 2025. Thus, reducing fuel subsidy and providing more incentives for developing renewable energy is required.

Figure 7.2 shows the energy usage by sectors. In 11 years, the energy consumption increased by almost 60 % from about 468 million BOE (barrel of oil equivalent) to 736 million BOE. While the transportation sector doubled its consumption, the industrial and commercial sectors increased by more than 60 %. However, the household sector slightly decreased. While the increase in the industrial and commercial sectors represents the effect of economic growth, the increase in the transportation sector is attributed to both economic and fuel subsidy policies.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2025
Renewable	5	5	4	4	4	4	4	4	4	4	5	4	23
Gas	22	22	24	24	21	21	22	19	24	25	23	21	25
Coal	13	15	15	19	17	19	23	27	23	23	24	27	30
Oil	60	57	57	53	57	55	51	50	49	48	47	48	22

Fig. 7.1 Indonesia primary energy 2000–2011 and National Energy Plan 2025 (Source: Indonesia's Ministry of Energy and Mineral Resources (2012))

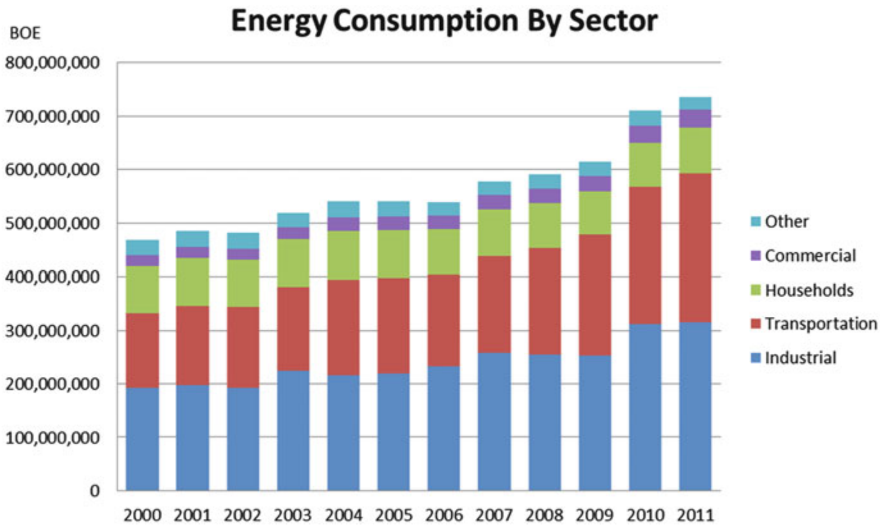


Fig. 7.2 Indonesia energy consumption by sector 2000–2011 (Source: Indonesia's Ministry of Energy and Mineral Resources (2012))

7.2 Oil Price, Oil Revenue, and Fuel Subsidy

This section will explore the Indonesian energy subsidy policies. Based on oil price and Indonesian policies related to domestic fuel price, three time frames: 1969–1985, 1986–1997, 1998–2012 are identified (Fig. 7.3).

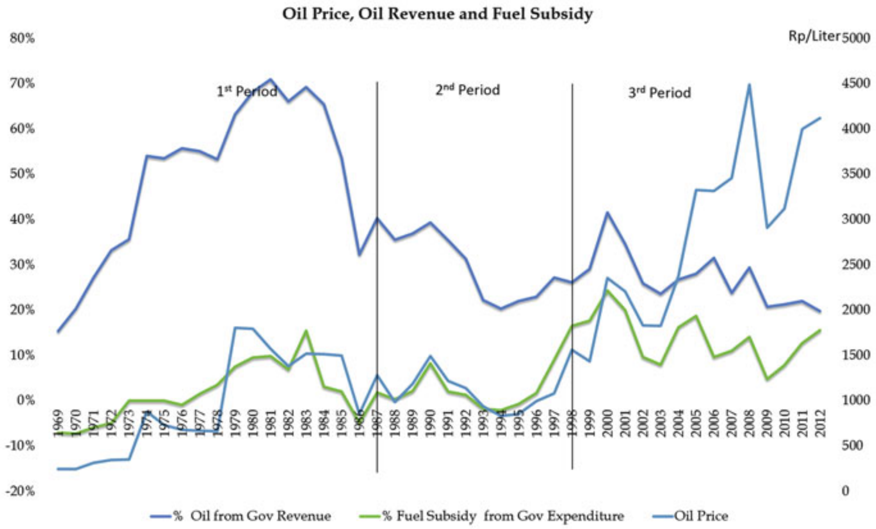


Fig. 7.3 Oil price, oil revenue and fuel subsidy in Indonesia 1969–2012 (Source: Indonesia's Ministry of Finance (2004) and Bank Indonesia (2013))

7.2.1 Windfall Profit Period (1969–1985)

In this period, Indonesia gained windfall profit from oil price hikes. The average net oil export is about 1.037 million barrels/day, and the average price is about Rp. 953/l (2005 constant price) (BP – British Petroleum 2013). There were some political events such as the Iranian revolution and the Arab oil embargo, which lifted the oil price. In this stage, about half of the government revenue was derived from oil and the average fuel subsidy was only 1.59 % of government expenditure (Indonesia's Ministry of Finance 2004). Indeed, instead of providing subsidy, the government made revenue from sales of fuels (negative subsidy) for some years. At the end of this period, the oil price suddenly declined. The government successfully managed this challenge by launching reform packages: exchange rate management, trade liberalization, and prudent fiscal policy (Hill 2007).

7.2.2 Role Model Period (1986–1997)

In this stage, due to those reform packages at the end of the previous period, Indonesia became less dependent on oil (oil contribution accounted for about 30.35 % of the national income) and effectively maintained the fuel subsidy at about 2.01 % of the government spending (Indonesia's Ministry of Finance 2004).

In this stage, Indonesia was considered by some scholars as a role model for an oil-exporting country as it effectively managed income from oil and escaped from resource curse (Rosser 2007). Resource curse is a common phenomenon in oil-exporting countries that even if they gained a huge income from oil, their economy did not perform better than resource-poor countries. The average oil price in this stage was Rp. 1,071/l, and the oil net export slightly declined to 0.813 million barrels/day (BP – British Petroleum 2013).

7.2.3 After Crisis Period (1998–2012)

In 1998 Indonesia experienced severe economic crisis. In that year, the economy declined by about 13.9 %, and many industries collapsed due to a very high interest rate and an extreme change in exchange rate (1 USD = Rp. 2,791 in Q_3 1997, 1 USD = Rp. 12,252 in Q_3 1998, International Monetary Fund 2013b). This economic event stimulated political reform and ultimately overthrew the 32-year presidency of Soeharto. In this stage, oil production declined, and at the same time the demand for fuel rose. As a result, the net oil export became −0.102 million barrels/day and oil price about Rp. 2,822/l (2005 constant price) (BP – British Petroleum 2013).

The subsequent governments could not maintain the prudent fiscal policy. The fuel subsidy sharply rose from 2.01 to 12.75 % of the national budget (Bank Indonesia 2013).

7.3 Impact of Oil Price

There are some prior studies about the impact of oil price on Indonesia's economy. Abeysinghe (2001) investigates the impact of oil price in several Asian countries including Indonesia. The author examined not only the immediate impact of oil price but also secondary impact from trading. The study found that for oil-exporting countries such as Malaysia and Indonesia, the first impact is positive but secondary impact from trading with partner countries is negative, with the net impact being negative. The second literature by Mehrara and Oskoui (2007) examines the impact of oil price in four notable oil-exporting countries, Saudi Arabia, Iran, Indonesia, and Qatar. The impact is different among the countries; for the countries which have invested their oil revenues in infrastructure development, like Qatar and Indonesia, the fluctuation in oil price does not have significant impacts on their GDP. The result is in contrast to the two other countries.

7.4 The Impact of Indonesian Energy Subsidy Removal on the Environment

Our study employing the vector autoregression model indicates that the fuel subsidy provided by the government of Indonesia was not so effective in avoiding the negative impact of oil price changes after the Asian crisis. The next question is that how much benefit can be gained if the government of Indonesia decides to remove the fuel subsidy.

Before we discuss the effect of energy subsidy elimination on the environment, we will describe some studies that have been done in the Indonesian case. In general, there are three methods that have been used: descriptive analysis, partial equilibrium analysis, and computable general equilibrium analysis.

7.4.1 Descriptive Analysis

One of the studies using descriptive analysis was conducted by Hope and Singh (1995). They compared some economic and social variables before and after the government increased the fuel price between 1982 and 1985. In those years, the government increased the fuel price by 10–50 % annually. Even if the fuel price looks very high, if the price in Indonesia is compared with some neighboring countries, the diesel and kerosene prices were mostly lower during the period. The authors examined the impacts of increasing diesel and kerosene prices respectively.

For diesel, the impact mostly hampered the industrial sector. For the high intensive fuel subsectors, the effects were worse. For instance, the impacts in yarn and thread, weaving mills, and plywood subsectors were greater than others since their energy cost accounted for a relatively high share of total cost. However, as a whole, the output was slightly growing in those periods despite the increase in fuel prices.

To investigate the impact in the household sector, the authors used kerosene. In welfare effect, the loss of consumer surplus due to the increase of kerosene price is about 0.65–2.23 % of monthly income. However, the effect of fuel price on CPI (Consumer Price Index) is very small since the government provided quite a large subsidy in fertilizer; thus the food price did not change. For the GDP, the impact is positive since the increase of fuel price generates revenue effect and provides more efficient input price.

7.4.2 Partial Equilibrium Analysis

The second method, partial equilibrium method, is employed by IEA (2000). Partial equilibrium analysis considers only direct impact of the proposed subsidy removal and identifies price and output change of the market. The relation is illustrated in the figure below. (Fig. 7.4):

On the graph above, point A denotes price (P_2) and quantity (Q_1) of subsidized fuel. The equilibrium should be in point E with higher price (P_0) and lower quantity (Q_0). If the government removes the subsidy, the quantity decline from Q_1 to Q_0 and dead weight loss area for producer and consumer are P_0 P_2 E A and P_0 P_1 E B. However, the government will gain P_1 P_2 E A B; thus, the net benefit from this policy is E A B.

The most important element in this type of analysis is demand and supply curves. The steepness of these curves determines the impact of subsidy removal. It represents the elasticity; how much quantity of fuel will change per unit of price increase.

The following are some of the steps to calculate the impact of subsidy removal. The first is to determine the amount of energy subsidy by finding a gap between reference price and consumer price. Then, by using price elasticity of demand, a change in energy consumption due to removal of the subsidy is calculated. Moreover, the impact on CO_2 emission can be identified by multiplying the relevant carbon dioxide emission factor with the delta consumption. The amount of decreasing (increasing) energy import (export) value can also be estimated. Furthermore, welfare loss is found by subtracting total transfer from the producer and consumer surplus. Finally, potential revenue from CO_2 emission trading is calculated. Thus, the impact of removal of subsidy on economy and environment can be revealed (Fig. 7.5).

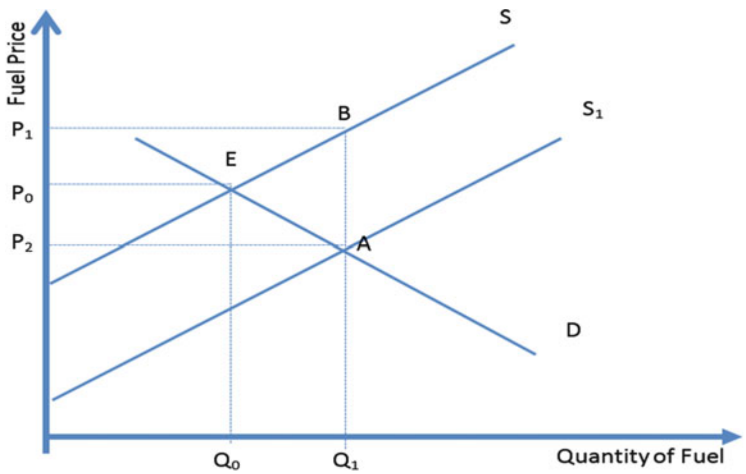


Fig. 7.4 Subsidy removal impact on fuel consumption

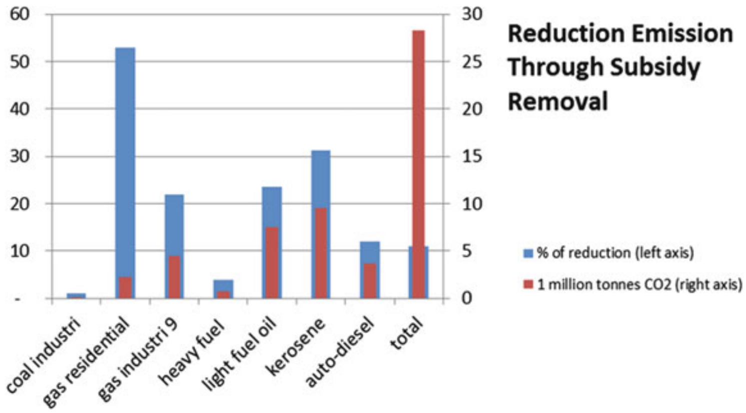


Fig. 7.5 The result of partial equilibrium analysis of removing energy subsidy in Indonesia (Source: IEA (2000))

The study indicates that the savings from subsidy removal differ among the energy commodities. The total savings are about 11 % which is about 28 million tonnes. The values range from about 100,000 tonnes of CO_2 for coal to more than 9 million tonnes of CO_2 savings for kerosene. In percentage term, the values range from <1 % in coal to more than 50 % savings in gas residential.

7.4.3 Computable General Equilibrium Analysis

There are at least two analyses about the impact of energy subsidy removal on the Indonesian economy and environment. One was conducted by Hartono and Resosudarmo (2008), the other by Burniaux et al. (2009). Hartono et al. employed single-country dynamic CGE and Burniaux et al. used multi-country static CGE. The difference between static and dynamic CGE is that in the dynamic CGE model, the model incorporates dynamic equation which represents time factor.

Study by Hartono uses Indonesian Energy Social Accounting Matrix (ESAM) year 2000 as framework. This model is constructed from seven blocks, namely, production block, household block, government block, investment and capital block, export-import block, market clearing block, and inter-temporal block.

This study attempts to elucidate what will happen if the government increases fuel price by 10 % each year, beginning 2010 for 10 years, and compares the subsidy removal policy with business as usual scenario. This study also considers a case where those sector react to the subsidy removal policy by being more efficient in using energy. The result is seen in the table below (Table 7.2).

Table 7.2 The impact of energy subsidy removal

	Without energy efficiency			Energy efficiency in industry sector			Energy efficiency in the industry and household sector		
	Without cash transfer	Proper cash transfer	Improper cash transfer	Without cash transfer	Proper cash transfer	Improper cash transfer	Without cash transfer	Proper cash transfer	Improper cash transfer
Increasing GDP	0.48–0.51 %			1.39–1.43 %			1.45–1.48 %		
Decreasing Gini coefficient	7.9 %			7.9 %			7.9 %		
Poor HH incomes	Lower than base scenario	Increase 0.06–1.33 %	Decrease −34.23–36.60 %	Higher than base scenario	Increase 0.87–2.10 %	Decrease −20.84–29.66 %	Higher than base scenarios	Increase 0.89–2.13 %	Decrease incomes −20.42–29.23 %

Source: Hartono and Resosudarmo (2008)

Table 7.3 The impact of energy subsidy removal

	2020			2050		
	CO_2 emission from combustion	GDP	Household equivalent real income	CO_2 emission from combustion	GDP	Household equivalent real income
Oil-producing countries	−13.7 (−0.3)[a]	−0.1 (−2,1)	−1.1 (−13.3)	−20.2 (−4.2)	0.5 (−4.5)	1.0 (−37.4)

[a]The value without bracket is removing the energy subsidy unilaterally, with bracket multilaterally. The value is in percentage compared with the BAU scenario Source: Burniaux et al. (2009)

We can see that the impact of energy subsidy removal is positive for GDP in all scenarios, ranging between 0.48 and 1.48 %, with the same value (7.9 %) for decreasing Gini coefficient. It will reduce the poor household income, if the policy without transfer program could not induce the efficiency reaction from industrial and household sector. If the cash transfer program is running well, it will increase the poor household income between 0.06 and 2.13 %, higher in more energy-efficient sector(s). However, if the cash transfer program does not achieve its target, the impact becomes very negative, between −20.42 and 36.6 %, the worst for the inefficient scenario. Unfortunately, this analysis only examines the impact on the economy, not the environment.

In the second literature, the author groups Indonesia as an oil-exporting country along with Algeria, Libya, Egypt, and Venezuela.[1] The result of the analysis is as follows (Table 7.3):

This study indicates that removing energy subsidy unilaterally has more benefit to oil-exporting. In long term, the effects on GDP and household turn to be even positive, which is negative in case energy subsidy is removed multilaterally.

7.4.4 The Impact of Energy Subsidy Removal on the Environment; A Partial Equilibrium Analysis

Following IEA (2000), we construct a partial equilibrium analysis using update data, 2012. There are some differences between the 1998 data and 2012 data. In 1998, Indonesia subsidized all fuel and electricity, but in 2012, only five energy commodities were subsidized by the government, namely, gasoline (octane 88), diesel, kerosene, LPG 3 kg, and electricity. For LPG 12 kg, the subsidy is provided by PT Pertamina (oil and gas state-owned company).

[1] In our opinion, grouping Indonesia as an oil-exporting country along with Algeria, Libya, Egypt, and Venezuela is not precise because Indonesia has become an energy-importing country since 2003.

In this calculation, we use some reference prices to determine the market price. For subsidized fuel (gasoline, diesel, kerosene, and LPG 3 kg), we use government reference price to be the market price. For others, we use data mainly from *Handbook of Energy and Economic Statistics of Indonesia 2013* for coal and natural gas. Furthermore, for LPG 12 kg, we also use the reference price of LPG 3 kg as the market price. Finally for electricity, we use the government of Indonesia's financial statement.

Mathematically, we can formulate the price gap approach as

$$\begin{aligned} \boldsymbol{\Delta q} &= \mathbf{Q_0 - Q_1} \\ \mathbf{LnQ_1} &= \boldsymbol{\varepsilon} \times (\mathbf{Ln\ P_1} - \mathbf{Ln\ P_0}) + \mathbf{Ln\ Q_0} \\ \boldsymbol{\Delta}\mathbf{CO_2} &= \boldsymbol{\Delta q} \times \mathbf{CO_2EF} \end{aligned}$$

Δq = decrease in consumption if the price gap is removed
Q_0, P_0 = quantity/price before removal of the price gap
Q_1, P_1 = quantity/price after removal of price gap
ε = the long-term demand elasticity
ΔCO_2 = the greenhouse gas emissions saved due to the abolition of subsidies
EF = carbon dioxide emissions factor

To see the impact, we simulate four policies, to increase the price by 30 %, 50 %, and 70 % and remove all energy subsidies. The result is as follows (Table 7.4). The detailed information on elasticity, reference price, and energy consumption is provided in Table 7.5.

Table 7.4 The impact of Indonesian energy subsidy removal to environment

Policy		Increase 30 %	Increase 50 %	Increase 70 %	Remove all
Gasoline		3,070,083.44	4,677,926.16	6,046,990.29	6,480,452.28
Kerosene		81,546.08	125,130.10	162,742.88	349,047.24
LPG	3 kg	301,683.57	462,924.70	602,074.95	1,133,689.27
	12 kg	61,820.40	94,861.62	123,376.01	162,343.92
Diesel		1,165,605.23	1,776,047.89	2,295,834.51	3,032,663.23
Natural gas	Electricity	4,403,188.87	6,463,717.23	7,486,740.84	7,486,740.84
	Others	5,691,110.61	8,354,338.35	9,676,593.81	9,676,593.81
Electricity	Social	408,869.66	610,279.58	775,007.41	976,215.60
	Household	6,602,859.86	9,855,440.37	12,515,639.60	18,010,404.12
	Commercial	2,536,223.55	2,997,557.24	2,997,557.24	2,997,557.24
	Industry	5,529,986.64	8,254,067.90	10,482,021.62	10,718,061.45
	Government	806,347.74	1,023,547.28	1,023,547.28	1,023,547.28
Coal	Electricity	7,034,458.21	7,034,458.21	7,034,458.21	7,034,458.21
	Others	553,603.60	553,603.60	553,603.60	553,603.60
Total CO_2 (tonnes)		38,247,387.47	52,283,900.25	61,776,188.26	69,635,378.10

Table 7.5 References to estimate CO_2 emission reduction

Energy type	Gasoline	Kerosene	LPG	Diesel	Natural gas	Electricity	Coal
Elasticity of demand (IEA 2000)	−0.2	−0.1	−0.1	−0.2	−0.1	−0.5	−0.1
Emission factor (British Colombia Ministry of Environment 2013)	2.175 ton/l	2.616 ton/l	1.507 ton/l	2.175 ton/l	1.916 ton/l	771 ton/GWh	1
Consumption year 2012 (Indonesia's Ministry of Energy and Mineral Resources 2012)	160,910 BOE	7015 BOE	4704 t	61,092 BOE	169,754 MMBTU	167,546 GWh	344,849 t
Reference price and source	Rp. 1,188,445.45/barrel (government reference price/harga patokan)[a]	Rp. 1,241,336.48/barrel (government reference price/harga patokan)[a]	Rp. 10,755.12/kg (government reference price/harga patokan)[a]	1,231,337.08/barrel (government reference price/harga patokan)[a]	USD 12.58/MMBTU (average price of LNG export)	Rp. 1361.88/KWh (production cost + margin of National Electricity Company)	79.88 USD/ton (average price of coal export)

[a]Government reference price/harga patokan is reference price based on MOPS (Mean of Platts Singapore) + distribution fee and margin, used by the government to pay the subsidy to state-owned oil company. For details see Ministry of Energy and Mineral Resources Decree no. 1713 K/12/MEM/2012

7.5 Conclusion and Policy Implication

From the calculation using a partial equlibrium analysis, the estimation of CO_2 saved from entire removal of energy subsidy in 2012 is around 70 million tonnes, which is double compared to year 1998 (IEA 2000). The policy implication of this result would be that the government should keep the ongoing removal fuel subsidy policy since the impact on the environment is significant.

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Chapter 8
Energy in the Power Sector and GHG Emissions: Modeling as an Input to the Formulation of the Next Midterm National Development Plan

Nataliawati Siahaan, Inez S.Y. Fitri, and Hakimul Batih

Abstract In 2014, Indonesia is reported as the world's tenth largest economy in the world. With stable economic growth rate above 5 % per annum in the last 10 years, national energy demand is projected to increase from 712 million barrel of oil equivalent (BOE) in 2010 to 1.3 billion BOE in 2019. Indonesia is highly dependent on fossil fuel. The country has become a net importer of oil with 800,000 barrel oil per day imported that year. In order to reduce the burden of national budget for oil import, the government has established the national energy policy that shifts the main energy source from oil to other sources. It has also set up regulation for developing approximately 20,000 MW of coal-fired power plants (Fast Track Program Phases 1 and 2) at the expense of higher greenhouse gas (GHG) emissions. In order to provide an insight for government in developing a strategy for mitigating GHG emission, alternative scenarios of electricity planning are analyzed using the Indonesia Integrated Energy, Economic, and Environmental Modeling (I2E3M) software. The alternative scenarios include higher utilization of renewable energy and demand-side management program. The results confirm that limiting the GHG emission will increase the share of renewable energy in the primary energy mix for electricity generation. By setting GHG emission at 10 % lower than business as usual (BAU) case, the share of renewable energy will be increased to around 15 % in 2020. Moreover, the demand-side management program is another option in reducing GHG emission from electricity generation activities.

Keywords Indonesia • Power sector • GHG emission • Energy modeling • I2E3M • Energy policy • Scenario analysis

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8.1 Introduction to Power System in Indonesia

Indonesia is an archipelago country consisting of 13,466 islands (Badan-Informasi-Geospasial 2014) with 2342 inhabited islands (Kementerian-Kelautan-dan-Perikanan 2013). The population census in 2010 showed the total population of 237,556,363 people (BPS 2010), placing Indonesia as the fifth largest in the world after China, India, the European Union, and the United States (CIA 2014). Indonesia's population has increased at 1.49 % per year during the period of 1990–2000 (BPS 2014b). The country has emerged as the world's tenth largest economy in the world as reported by the World Bank (Kemenkeu 2014).The growth of gross domestic product (GDP) of Indonesia is recorded at above 5 % since 2004 to date except in 2009 when it dropped to 4.6 % (BAPPENAS 2014). In 2013, GDP growth was recorded at 5.78 % (BPS 2014a).

Economic and population growths are the factors that drive the increase of national energy demand. According to the projection of the Ministry of Energy and Mineral Resources (MEMR), with population growth rate at 1.1 % and economic growth rate at 6.1 %, the national energy demand will increase from 712 million BOE in 2010 to 1.3 billion BOE in 2019 or at increasing rate of 7.1 % per year (Kementerian-ESDM 2014b).

Indonesia's economy still relies on fossil energy. As shown in Fig. 8.1, the national energy mix in 2011 is dominated by oil at 46.77 %. Adding to economic and population growths, the subsidy for fuels has driven the domestic oil demand higher than the domestic production. Consequently, the government imported oil to fulfill the domestic demand up to 800,000 barrel per day in 2014 (Kementerian-ESDM 2014c). Indonesia's oil supply and consumption is depicted in Fig. 8.2.

In order to reduce oil import and to become more resistant to oil price shock, the government has prepared the national energy policy known as KEN (*Kebijakan Energi Nasional* or National Energy Policy) aimed at ensuring national energy security for supporting sustainable development (DEN 2010). KEN focuses on improving energy efficiency and energy diversification with 23 % share of new and renewable energy use by 2025. KEN is then extended into more detailed legal framework by the government, namely, RUEN (*Rencana Umum Energi Nasional*, National Energy General Plan) and RUKN (*Rencana Umum Ketenagalistrikan Nasional*, National Electricity General Plan) (Kementerian-ESDM 2012).

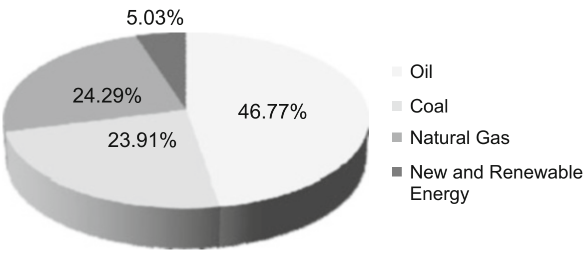

Fig. 8.1 Indonesia primary energy mix, 2011 (Kementerian-ESDM 2014b)

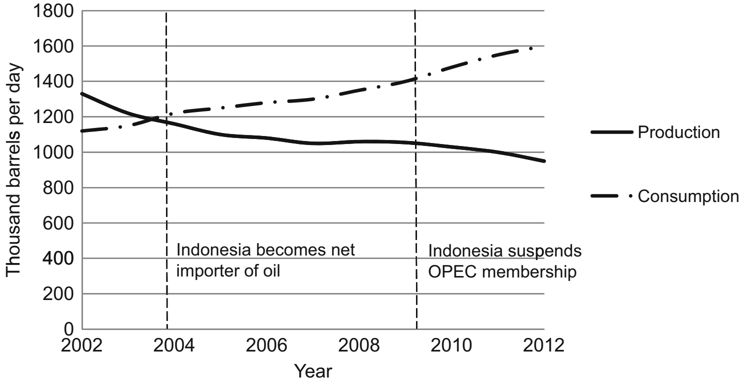

Fig. 8.2 Indonesia oil supply and consumption, 2002–2012 (EIA 2014)

The demand for electricity is growing along with the country's population (IPA 2012). The projection by the State Electricity Company (*Perusahaan Listrik Negara*, PLN) on the increase of electricity demand is at 8.4 % per year (PLN 2013c). According to MEMR, national electricity consumption reached 188 TWh (terawatt hour) in 2013. The household sector accounted for 41 % of the total electricity consumption of the country, followed by the industry, the commercial, and the public for about 34 %, 19 %, and 6 %, respectively (Kementerian-ESDM 2014a).

Electrification ratio, which is defined as the number of households that have access to electricity divided by the total number of households nationwide, increased from 62.3 % in 2008 to 75.9 % in 2012 (Kementerian-ESDM 2014a). The electrification ratio is different in all provinces. The lowest in 2012 was 34.62 % in Papua Province (see Fig. 8.3). Furthermore, the electricity consumption per capita shows an increasing trend (see Fig. 8.4). The growth of population, electrification ratio, and electricity consumption per capita will in turn lead to an increase of total electricity demand.

PLN is the main actor in power sector in Indonesia. PT PLN (Persero) is a state-owned enterprise which manages electrical power supply to approximately 53 million customers throughout Indonesia. PLN deals with the production and distribution of electrical power. The coverage area of PLN is divided into three areas: Sumatera, Eastern Indonesia, and Java-Bali areas. As of September 2013, the installed capacity of power plants and the independent power producers (IPPs) in Indonesia is 40,533 MW, consisting of 31,815 MW in Java-Bali and 8718 MW in Sumatra and Eastern Indonesia (PLN 2013c). By the end of 2013, the installed capacity for national level has increased to 46,104 MW with 74.2 % capacity generated from PLN-owned power plants (PLN 2013a). The company provides public services and receives financial assistance in the form of direct compensation or subsidy. The subsidy is channeled to PLN to cover the operational cost and to supply electricity at affordable prices for customers.

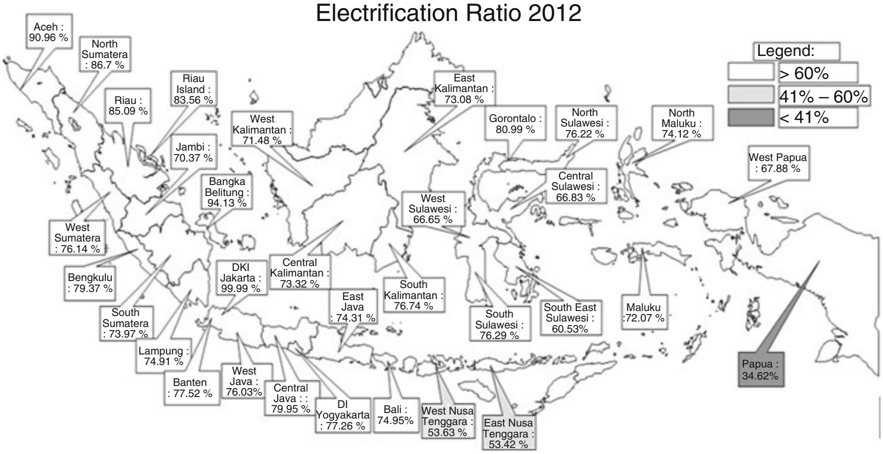

Fig. 8.3 Indonesia electrification ratio, 2012 (Kementerian-ESDM 2013)

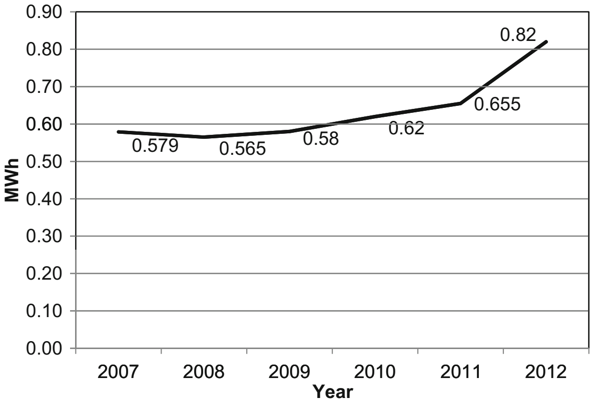

Fig. 8.4 Indonesia electricity consumption per capita, 2007–2012 (Kementerian-ESDM 2013)

In 2008, primary energy mix was dominated by coal and oil. During 2009–2012, the share of energy mix for power plants was dominated by coal. Oil was also dominant in the primary energy use by more than 20 %. The share of oil was decreased to 15 % and coal was increased up to 50.4 % in 2012. Figure 8.5 shows the primary energy mix for electricity generation in 2008–2012. PLN's unit generation cost is still high due to fuel oil cost. In order to lower unit generation cost, PLN is diversifying to non-oil-based fuel fired power plant through Fast Track Program (FTP) Phases 1 and 2. PLN decreases the use of fuel oil for electricity generation and shifts the main primary energy mix to coal. This strategy includes the utilization of compressed natural gas (CNG) to meet the demand during peak period, the utilization of renewable energy such as biodiesel and biogas and also solar and wind power especially in remote areas. The long-term targets of PLN

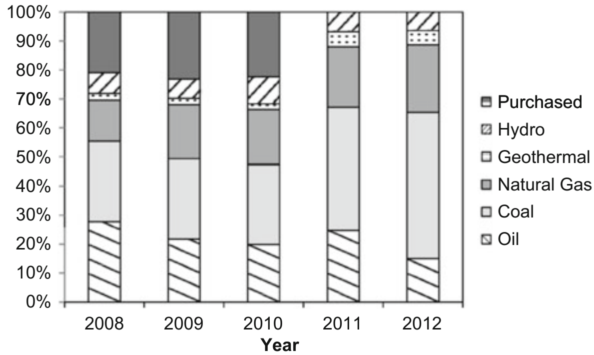

Fig. 8.5 Indonesia energy mix for electricity generation, 2008–2012 (PLN 2013b)

include increasing renewable energy share in energy mix to a minimum of 8 % and decreasing oil share to a maximum of 3 % by 2017 (PLN 2013b).

Even though fuel oil was only 20 % of the total primary energy mix, it accounted for 70 % of the operational costs (PLN 2012a). The unit generation cost is closely linked to the subsidy from the government in order to provide affordable price of electricity to the people. The heavy reliance of electricity generation on fuel oil that caused high unit cost has made the government shift to the abundant domestic coal resources. The main reason is to aim for the lowest cost of electricity generation.

PLN releases RUPTL (*Rencana Usaha Penyediaan Tenaga Listrik*, Electricity Supply Business Plan) as a guide to develop company's long- and short-term plans as well as budget for infrastructures in PLN's catchment areas. The latest 2013–2022 RUPTL has been developed according to the 2008–2027 RUKN and the 2012–2013 RUKN draft established by the government. In order to meet the electricity demand of 387 TWh by 2022, the 2013–2022 RUPTL includes the plan to build new power plants with total capacity of 60,000 MW (PLN 2013c). Major plan in the development of the power sector by increasing the use of coal and renewable energy for electricity generation is in line with the target of national energy mix by 2025 as set in the national energy policy or KEN.

The Presidential Regulation No. 71/2006 was issued in order to meet the electricity demand and to accelerate the energy diversification for electricity power plants that use non-petroleum fuels. The government has assigned PLN to develop around 10,000 MW of coal-fired power plants. The assignment which is also known as "Fast Track Program Phase 1 (FTP 1)" will build coal-based power plants at 40 locations, consisting of 10 plants in Java-Bali and 30 plants outside Java-Bali. The program is scheduled for completion in 2009. The program, however, could not be completed as originally scheduled due to a number of constraints, such as the delay in the fund disbursement, a prolonged process of land acquisition and acquiring a number of permits, and a lack of domestic and international contractors' capabilities (PLN 2012b). Therefore, the government revised the regulation by issuing the Presidential Regulation No. 59/2006 and the Presidential Regulation No. 47/2011. One of the articles under the new regulation stipulates that the FTP 1 will be completed by the end of December 2014. As of September 2013, a total of 12 steam-turbine power plants have operated (PLN 2013c). The current status of FTP 1 shows a progress and operates at a capacity of 4560 MW at nine locations. As of the end of 2013, 6377 MW total capacity of FTP 1 power plants has been operating, comprising 6130 MW for Java-Bali, 7 MW in Sumatera, and 240 MW in East Indonesia (PLN 2013a). The list of power plants in FTP 1 is presented in Table 8.1.

Following FTP 1, Fast Track Program Phase 2 (FTP 2) was established to speed up the construction of renewable energy-based power plants such as geothermal, hydro power, coal, and natural gas. FTP 2 with the total capacity of 9522 MW is currently ongoing and targeted to be completed in 2014. PLN-constructed power plants have the total capacity of 4216 MW, while the total capacity of 5306 MW is built by private parties. FTP 2 was stipulated in the Presidential Regulation No. 4/2010 and the MEMR Minister Instruction No. 15/2010, which was subsequently amended in the MEMR Regulations No. 1/2012 and No. 21/2013. The total capacity of FTP 2 was modified to 17,918 MW. Figure 8.6 shows the shares of the FTP 2 total capacity by fuel type (PLN 2013a).

Unlike FTP 1, the fuel type for FTP 2 is not 100 % coal. Under FTP 2, the role of renewable energy (geothermal and hydro) is expected to contribute around 38 % out of the total electricity-generating system. The additional power plant capacity over the next 10 years (2013–2022) for the entire Indonesia is projected to reach 59.5 GW or at 6 GW increase of average capacity per year. Coal power plants will dominate the newly developed power plant with the capacity of 38 GW or 63.8 % of the total capacity, while gas combined-cycle power plant and gas-fired power plant will have the capacity of 5 GW and 3.7 GW, respectively. The largest hydro power plant will have 6.5 GW capacity or 11 % of the total capacity, followed by geothermal with 6.0 GW capacity. The remaining renewable energy-based power plants will have the total capacity of 0.3 GW, comprising modular thermal power generation, solar power plants, wind power plants, etc. (PLN 2013c).

In accordance with its mission “to implement environmentally sound business activities” and the national commitment to reduce greenhouse gas (GHG) emissions, PLN will make efforts to reduce GHG emissions in all its activities. PLN policies to mitigate climate change are as follows:

1. Prioritizing the development of renewable energy
   PLN emphasizes the hydro and geothermal power plants to get into the power system whenever they are ready.
2. Adopting low-carbon technologies
   PLN’s electricity supply by 2022 will still be dominated by fossil fuel, especially coal. In this regard, PLN will only use ultra-supercritical boilers for coal power plant to be developed in Java.
3. Transfer of fuel (fuel switching)
   In order to reduce fuel consumption, PLN plans to divert the fuel consumption to gas for power plants (PLTG, PLTGU, and PLTMG), which will directly reduce GHG emissions due to lower gas emission factor.
4. Energy efficiency in power plant
   PLN is making efforts in maintaining the efficiency of the generator to increase the efficiency of production and simultaneously reduce GHG emissions.

Table 8.1 List of FTP 1 power plant status by September 2012 (PLN 2012c)

No	Name	Capacity (MW)	COD	No	Name	Capacity (MW)	COD
1	PLTU Labuhan	2 × 315	2009–2010	21	PLTU Tarahan Baru	2 × 100	2012
2	PLTU Indramayu	3 × 330	2011	22	PLTU Parit Baru	2 × 50	2014
3	PLTU Suralaya #8	1 × 625	2011	23	PLTU Kariangau	2 × 110	2014
4	PLTU Lontar/ Teluk Naga	3 × 315	2011–2012	24	PLTU Pulang Pisau	2 × 60	2014
5	PLTU Pelabuhan Ratu	3 × 350	2013	25	PLTU Asam-asam	2 × 65	2013
6	PLTU Rembang	2 × 315	2011	26	PLTU Amurang	2 × 25	2012
7	PLTU Adipala	1 × 660	2014	27	PLTU Gorontalo	2 × 25	2014
8	PLTU Pacitan	2 × 315	2012–2013	28	PLTU Tidore	2 × 7	2013
9	PLTU Paiton #9	1 × 660	2012	29	PLTU Jayapura	2 × 10	2013
10	PLTU Tanjung Awar-awar	2 × 350	2013	30	PLTU Timika	2 × 7	Canceled
11	PLTU Meulaboh	2 × 110	2013	31	PLTU Ambon	2 × 15	2013–2014
12	PLTU Pangkalan Susu	2 × 220	2014	32	PLTU Kendari	2 × 10	2012
13	PLTU Bengkalis	2 × 10	Canceled	33	PLTU Barru	2 × 50	2012–2013
14	PLTU Tenayan Raya	2 × 110	2014	34	PLTU Lombok	2 × 25	2013
15	PLTU Tanjung Balai	2 × 7	2012–2013	35	PLTU Ende	2 × 7	2013
16	PLTU Belitung	2 × 16.5	2013	36	PLTU Kupang	2 × 16.5	2013
17	PLTU Air Anyer	2 × 30	2013	37	PLTU Bima	2 × 10	2014
18	PLTU Selat Panjang	2 × 7	Canceled	38	PLTU Sulut	2 × 25	2014
19	PLTU Pantai Kura-kura	2 × 27.5	2014	39	PLTU Kalteng	2 × 7	Canceled
20	PLTU Teluk Sirih	2 × 12	2013				

PLTU pusat listrik tenaga uap (coal steam power plant), *COD* commercial operation date

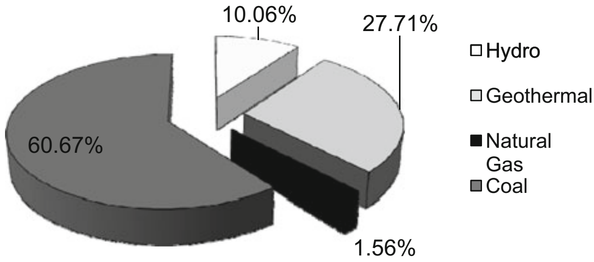

Fig. 8.6 Primary energy composition of FTP 2 (Adapted from: Draft of 2013–2022 RUKN)

Coal power plant is designed to carry the base load demand. Coal price is relatively lower compared to other fossil fuels. On the contrary, burning coal produces carbon dioxide (CO_2) emission that contributes to global warming. It also generates pollution particles and chemical waste that can cause negative impacts on the local environment. Thus, PLN is planning to use cleaner technology and ensuring more environmentally friendly exhaust gas resulted from coal-fired power plants. The use of ultra-supercritical technology in power plant development has been emphasized by PLN in planning for large-scale power plant in Java in order to achieve higher efficiency and lower CO_2 emission. Other clean coal technologies, such as IGCC (integrated gasification combined cycle) and CCS (carbon capture and storage), have not been planned in the 2013–2022 RUPTL, since they are not yet technically and commercially mature (PLN 2013c). Further, PLN will initiate the implementation of smart grid in the electricity system (PLN 2013a).

In order to address the high potential of greenhouse gas emission from utilizing coal as the main primary energy source for electricity generation, the Indonesian Institute for Energy Economics (IIEE) conducted a study in order to give insight to the government on GHG mitigation strategy that has not been accommodated in PLN’s plan. Although PLN has set up the mitigation plan for the negative impact of coal utilization, it is based on only one scenario. Moreover, PLN did not include energy conservation as part of demand-side management strategy in the long-term plan. The study proposes an alternative energy planning in order to know the implication of mitigation options particularly in the electricity sector. Analysis will be conducted using the Indonesia Integrated Energy, Economic, and Environment Modeling (I2E3M).

8.2 Indonesia Integrated Energy, Economic, and Environment Modeling (I2E3M)

I2E3M is a computer-modeling system that integrates demand, conversion, and supply within Indonesia's energy market based on economic variables. I2E3M incorporates the environmental impacts, especially greenhouse gas emissions from energy uses.

I2E3M, which was first developed by IIEE in 2003, has been used as supporting tool to provide input to the National Medium Term Development Plan (*Rencana Pembangunan Jangka Menengah Nasional*, RPJMN,) in terms of energy sector planning by the National Development Planning Agency (*Badan Perencanaan Pembangunan Nasional*, BAPPENAS). I2E3M adopts the National Energy Model System (NEMS) basic structure of the US Department of Energy. I2E3M structure uses a modular approach which consists of the following (Fig. 8.7 shows the model structure of I2E3M):

- Four energy supply modules (oil and gas, coal, transmission and distribution of oil and gas, new and renewable energy)
- Two conversion modules (electricity and refinery)
- Four demand modules (household, commercial, industry, and transportation)
- International energy activities module

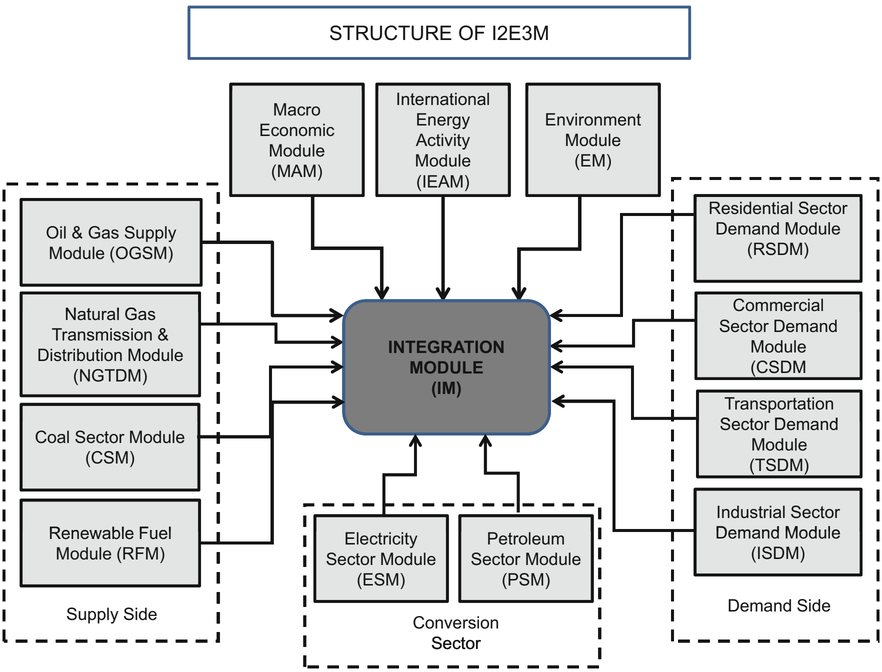

Fig. 8.7 Model structure of I2E3M

- Macroeconomic module
- Environmental module

The integration module (IM) plays an important role in distributing data from one module to the other modules and finding the equilibrium solution based on specific tolerance value. Another function of IM is to extract various generated data to create final reports of the modules. Each module has different output data to be used for further analyses. Furthermore, the interaction among modules is intended to find final solution under the optimization approach.

In this study, I2E3M modeling is applied by focusing only on power sector. Under I2E3M modeling for power sector case study, four demand modules are run, namely, residential sector module (RSM), commercial sector demand module (CSDM), industrial sector demand module (ISDM), and electricity sector module (ESM). The transportation sector demand module (TSDM) is not used, since the electricity demand from transportation sector is not significant.

8.2.1 Demand-Side Modules

Demand-side modules are composed of RSDM, CSDM, and ISDM. The function of those modules is to provide information about the amount of electricity demand of each sector. Demand sector modules provide the quantity of electricity demand to ESM and receive the price of the fuels from ESM in return. The relationship between electricity sector module and demand-side modules is depicted in Fig. 8.8. Meanwhile, core variables in each module that influence the electricity demand are shown in Table 8.2.

8.2.2 Electricity Sector Module (ESM)

The function of ESM module is to estimate the needs of a new power generation to fulfill power demand within an electrical system. ESM module uses the mixed integer linear programming (MILP) in its optimization process, where both objective function and constraint are in the linear form with decision variables that can be mixed between integer and real variable. MILP has a different algorithm from the linear programming (LP), in terms of its decision variables which are continuous variable. The structure of ESM model is shown in Fig. 8.9. This module works, based on optimization using the least cost principle under the constraints. Table 8.3 elaborates the costs and constraints that must be met in this module.

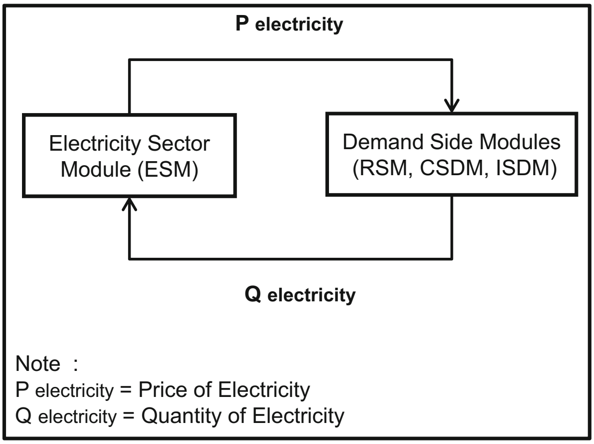

Fig. 8.8 Relationship of ESM and demand-side modules

Table 8.2 Core variables for ESM

Module	Core-driving variables
RSDM	Population, household size
	Energy intensity in residential sector
	Net price of each fuel/energy and its substitution product
CSDM	Gross regional domestic product of each commercial subsector in each demand region
	Energy intensity in commercial sector
	Net price of each fuel/energy and its substitution product
ISDM	Gross regional domestic product of each commercial subsector in each region demand
	Energy intensity in industrial sector
	Net price of each fuel/energy and its substitution product

8.3 Indonesia's Long-Term Alternative Electricity Planning

The objective of this study is to provide alternative electricity planning as an input to the formulation of the next midterm national development plan (2015–2019). The approach for this study is "scenario-based analysis." In order to develop a scenario for alternative planning, some requirements need to be set up beforehand. These requirements are included in the general assumptions for developing the model. The model development starts with demand forecasting. The next step is to develop scenarios as alternative planning to fulfill the forecasted demand. There are three scenarios that have been developed to reflect the possibilities of high utilization of coal and renewable energy in mitigating climate change, which are:

- Business as usual (BAU) scenario
- Renewable energy scenario
- Renewable energy and energy conservation scenario

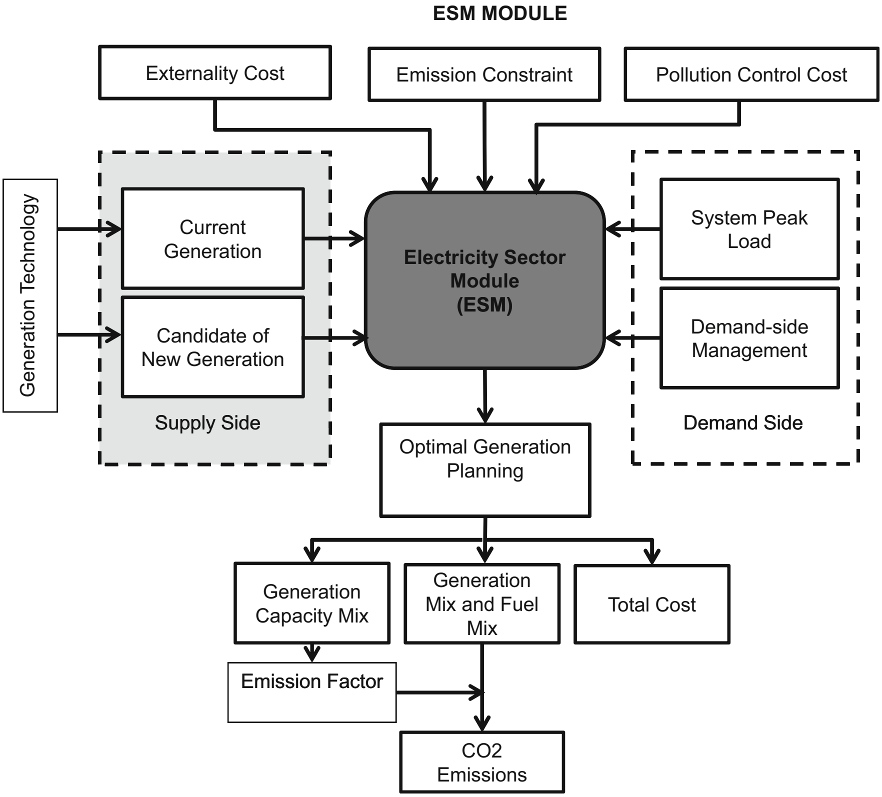

Fig. 8.9 Structure of ESM model

Table 8.3 Costs and constraints of ESM module

Costs	Constraints
Capital cost for new generation construction	Peak load demand
Operations and maintenance cost	Availability of electrical power
Fuel cost	System reliability
Other variable cost related to power generation activities	Availability of electrical power for whole system
Option cost of demand-side management	Availability of electrical power from hydro power plant
	The maximum potential capacity
	Availability of energy sources for generation
	Limitation of energy availability condition within hydro-thermal mix system
	Availability of electrical power from outside system
	Emission of generation system
	Demand-side management option

8.3.1 General Assumptions

This section discusses the general assumptions and technical parameters used in the model for all scenarios. The data input is based on the historical data of electricity demand of the interconnected system of JAMALI, which stands for the "Java-Madura-Bali" region. In order to simplify the model, available data of seven provinces (Banten, DKI Jakarta, West Java, Central Java, DI Yogyakarta, East Java, and Bali) in JAMALI region is aggregated into one single value. The model using data input of JAMALI region is considered as representative to national case since the installed capacity of JAMALI system is 31.815 MW which covers 78.49 % of the national capacity (PLN 2013c).

The demand side is divided into three sectors, which are residential, commercial, and industrial sectors. Transportation sector is also using electricity for the electrical train. However, since the electricity demand from transportation sector is not significant, the transportation sector is excluded from the model.

I2E3M models the electricity generation profile from 2010 to 2020. Demand forecasting is done based on the historical data of electricity demand, the number of customers in residential sector, PDRB (Produk Domestik Regional Bruto), and energy intensity for commercial and industrial sectors from 2010 to 2012. The general assumptions such as economic growth and population growth are similar to the assumptions used by PLN in the RUPTL.

The electricity demand growth is influenced by economic growth and population growth. Economic growth in simple terms is the process of increasing the output of goods and services. The process requires electricity as one of the inputs to support it, in addition to the inputs of raw materials and other services. Furthermore, the result of economic growth is an increase in people's income which drives the increase demand for electrical appliances such as televisions, air conditioners, refrigerators, etc. As a result, demand for electricity will increase.

Indonesia's economic growth over the last 12 years are expressed in GDP at constant 2000 prices, which increased at an average of 5.36 % per year, for the period 2015–2022; the RUPTL economic growth rate in the 2010–2029 RUKN draft, which is an average of 6.9 % per year, was adopted. The assumption of economic growth rate used in IIEE's model is shown in Table 8.4.

Based on the census in 2010, the population of Indonesia in 2010 was 240.6 million with 61.2 million households. PLN used the assumption of population growth rate based on the Population Projection Books BPS-BAPPENAS-UNFPA in December 2012 to estimate the total population by the year 2022. Table 8.5 shows the assumed population growth rate used in the IIEE's model.

The potential power plants in this model include the existing capacity of power plants and the ongoing project with the COD (commercial operation date) in 2014, which consists of six types of power plant as described below. The power plants are divided into several types according to the technology used to generate electricity. The list of types of power plant included in the model is shown in Table 8.6.

Table 8.4 Assumption of economic growth rate

Year	Assumption of economic growth rate (%)
2013	6.85
2014	6.11
2015	7.27
2016	7.28
2017	7.28
2018	7.28
2019	7.28
2020	7.28

Table 8.5 Assumption of population growth rate

Year	Assumption of population growth rate (%)
2013	1.08
2014	1.06
2015	0.96
2016	0.94
2017	0.93
2018	0.92
2019	0.90
2020	0.82

Table 8.6 Types of power plants

Type	Fuel	Efficiency (%)	Merit order
Coal steam power plant	Coal	30–35	Base loader
Oil steam power plant	MFO	30–37	Base loader
Gas steam power plant	Natural gas	35–40	Base loader
Geothermal power plant	Geothermal steam	30–41	Base loader
Gas turbine power plant	Natural gas	40–43	Peak loader
Gas combined power plant	Natural gas	43–51	Middle loader
Gas engine power plant	Natural gas	25–35	Peak loader
Diesel engine power plant	HSD	25–35	Peak loader
Large hydro power plant	Hydro	60–90	Peak loader
Mini/micro hydro power plant	Hydro	60–70	Peak loader

MFO marine fuel oil, *HSD* high speed diesel

- PLTU (*Pusat Listrik Tenaga Uap*, Steam Power Plant) is a power plant which utilizes kinetic energy of steam to generate electricity. The fuel types used for heating up boiler and producing steam include coal, marine fuel oil (MFO), and natural gas.
- PLTG (*Pusat Listrik Tenaga Gas*, Gas Turbine Power Plant) is a power plant which utilizes kinetic energy of combustion gas to generate electricity. The fuel types used for heating up boiler and producing steam include MFO and natural gas.

- PLTGU (*Pusat Listrik Tenaga Gas Uap*, Combined-Cycle Power Plant) combines the gas cycle and steam cycle and thus has higher efficiency than PLTG and PLTU which apply single cycle.
- PLTA (*Pusat Listrik Tenaga Air*, Hydro Power Plant) is a large scale hydro power plant. Moreover, PLTMH (*Pusat Listrik Tenaga Mini/Mikrohidro*, Mini/Micro Hydro Power Plant) is hydro power plant with the capacity of 10 MW or below.
- PLTP (*Pusat Listrik Tenaga Panas Bumi*, Geothermal Power Plant) is a power plant which utilizes kinetic energy of geothermal steam to generate electricity.
- PLTD (*Pusat Listrik Tenaga Diesel*, Diesel Power Plant) is a power plant which utilizes kinetic energy of exhaust gas from diesel combustion to generate electricity.

Reserve margin for electricity generation is assumed at 10 % of the forecasted demand. Reserve margin is the additional capacity of power plant calculated from the peak load in order to overcome transmission and distribution (T&D) losses and own use electricity which assumed to be 12.9 % in average. This study only focuses on CO_2 emission of power plants; other emissions are beyond the scope of this study. In terms of emission calculation, emission factors used in the model are taken from the Intergovernmental Panel on Climate Change (IPCC) tier II method, which is different from emission calculation method in RUPTL.

8.3.2 Demand Forecasting

The demand forecast of electricity in JAMALI region is the summation of the forecast of electricity demand for three sectors (residential, commercial, and industrial sectors) in the seven provinces mentioned above. For commercial and industrial sectors, electricity demand is the multiplication of PDRB and its energy intensity in the given year. Energy intensity is calculated from the historical data of PDRB and electricity consumption. For residential sector, electricity demand is obtained by multiplying the number of customer in residential sector with the amount of electricity consumption per household in the given year. The amount of electricity consumption per household is obtained from the historical data.

8.3.3 Expansion Planning

In order to fulfill the electricity demand as forecasted by using the above technique, electricity expansion planning for the generation system is based on scenario planning. A traditional economic dispatch strategy was applied in this study. This strategy ranks supply resources by marginal operating cost to determine the dispatch order (order of priority in which a unit of generation capacity is selected for operation). Low operating cost power plants such as coal-fired power plants run as continuously as possible to meet base load demand. The next block of demand above the base load demand is met by combined-cycle power plants. Finally, the demands close to the peak demand are met by diesel and gas turbine power plants, which are characterized by low capital cost and high flexibility; the high operating cost is only a minor penalty since they are operated at a low load factor (Swisher et al. 1997).

8.3.3.1 Scenario I (Business as Usual Scenario)

Scenario I is a business as usual (BAU) without any policy intervention. It describes a pattern of electricity demand which will affect electricity generation in the module, including the addition of generation capacity where each type of power plant competes in accordance with its marginal electricity generation cost.

This scenario shows the existing condition of power generation in Indonesia and the projection until 2020 without any effort of reducing emission or by keeping the composition in the energy mix for electricity generation. The primary energy used in this scenario is coal. The objective of this scenario is to obtain the configuration of generation plant development which gives the cheapest total NPV (net present value) cost for providing the electricity (least cost) within the period of 2010–2020. The cheapest configuration is obtained through a process of optimization with the objective function of minimizing the NPV of operational cost comprising of fuel cost, maintenance cost, overhead cost, investment cost of new power plants, and also the investment cost for energy conservation.

Since the least cost objective will lead to the high share of coal as primary fuel for power generation, it is necessary to introduce the alternative scenarios in order to mitigate the CO_2 emission which resulted from coal-fired power plants. Therefore, Scenarios II and III are created. Detail descriptions of these scenarios are presented in the following section.

8.3.3.2 Scenario II (Renewable Energy Scenario)

Scenario II (renewable energy scenario) involves increasing renewable energy share into the energy mix for electricity generation to some extent. Meanwhile, on the demand side, this scenario assumed the same amount of electricity demand as in BAU case. This effort is taken in order to reduce emission from electricity generation. In this case, limitation is applied for CO_2 emission at 10 % below the emission generated in the Scenario I by 2020. By limiting the CO_2 emission, it is expected that more renewable energy power plants will exist in the capacity mix for electricity generation.

8.3.3.3 Scenario III (Renewable Energy and Energy Conservation Scenario)

Scenario III (renewable energy and energy conservation scenario) follows Scenario II on the supply side that includes renewable energy as the primary energy for electricity generation. CO_2 emission reduction is carried out through incorporating demand-side management in order to reduce the electricity demand. The demand-side management program includes the following:

- The use of more efficient lighting appliances using compact fluorescent lamp (CFL) and light-emitting diode (LED) technologies.
- The introduction of star label for high energy-consuming appliances with relatively higher efficiency which has been done in many countries, not only for household appliances such as air conditioner and refrigerator but also for industrial equipment including industrial fans, blowers, pumps, and motors.
- Managing the utilization of energy-consuming appliances by setting the machines or appliances at optimum capacity during the use and putting them at lower speed when idle in order to reduce the energy consumption.
- In the industrial sector, electric motors consume high amount of energy. Therefore, the use of high efficiency motor is one of the important efforts which contribute significantly to greenhouse gas emission reduction. Induction motor with higher efficiency is used to replace the conventional motor. Placement of electrical equipment in a well-ventilated room can also contribute to lower energy consumption.
- Electricity consumption can be reduced using thermal energy storage technology. In a nutshell, the electricity is used at night to store heat in a thermal mass (e.g., chilled water or ice) and then use it as the cooling source for air conditioner of the building during daytime.

In this scenario, it is assumed that the reductions of energy intensities in residential, commercial, and industrial sectors in 2020 are 5 %, 15 %, and 15 %, respectively, compared to historical data in 2012. It is expected that by incorporating demand-side management program, the CO_2 emission in Scenario III can be reduced further as a result of less electricity demand.

8.4 Result and Discussion

This section discusses the result of IIEE's model for the three scenarios of power plant expansion planning for JAMALI region using I2E3M software. The analysis focuses on capacity mix, generation mix, and fuel mix of power plants. Furthermore, the latter part discusses the impact of power plants configuration in each scenario to CO_2 emission.

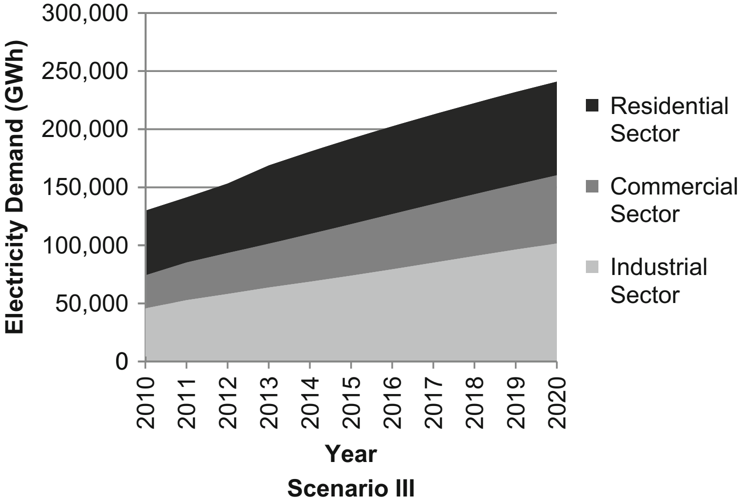

Fig. 8.10 Electricity demand in JAMALI region, 2010–2020

8.4.1 Electricity Demand and Production

8.4.1.1 Electricity Demand Forecast

The electricity demand forecasts resulting from I2E3M model for Scenarios I and II are similar to the electricity demand forecast by PLN. As shown in Fig. 8.10, the total electricity demand for JAMALI region is increased from 129,947 GWh in 2010 to 270,985 GWh in 2020 with 35 % from residential sector, 26 % from commercial sector, and 39 % from industrial sector. On the other hand, total electricity demand for Scenario III in 2020 is 241,034 GWh. The share of electricity demand in 2020 for Scenario III is 33 % from residential sector, 24 % from commercial sector, and 42 % from industrial sector.

8.4.1.2 Capacity Mix

Capacity mix can be elaborated as the configuration of power plants which consists of certain capacities of each type of power plants. There are assumptions that underpin the scope of analysis regarding capacity mix of power plants installed in JAMALI region in order to meet the objective of the least cost power plants configuration in this study. First, the result of this study shows the capacity mix of power plants in JAMALI region during the midyear when the electricity demand is in its highest level of the year. Second, the result also accounts for rainy season where the utilization of hydro power plants can be optimized. Based on these assumptions, the installed capacity for the base-case scenario is increased from 22,206 MW in 2010 to 40,904 MW in 2020. Figure 8.11 depicts the capacity of

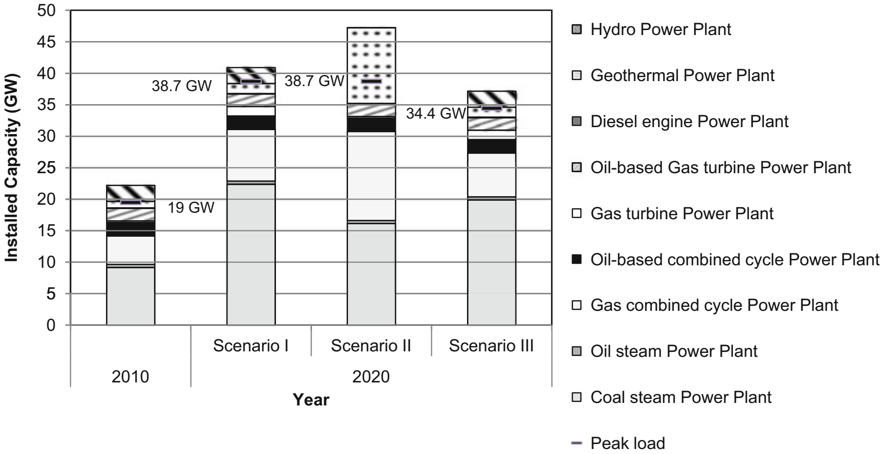

Fig. 8.11 Installed capacities of power plants in JAMALI region, 2010–2020

power plants in JAMALI region in 2020 resulting from IIEE's model. The total capacity of Scenarios II and III are 47,236 MW and 37,154 MW, respectively. The peak load during the scope of analysis is 19,486 MW in 2010. The peak loads of electricity for JAMALI region resulting from the model are 38,717 MW for Scenario I in 2020 which is similar to Scenario II. This is due to the similarity of electricity demand without demand-side management. In 2020, on the other hand, Scenario III shows lower peak load of 34,439 MW with demand-side management.

As shown in Fig. 8.12, the installed capacity of power plants in 2010 is dominated by coal steam power plants of 41 %, followed by 20 % of gas combined-cycle power plants, 11 % of hydro power plants, 9 % of oil-based combined-cycle power plants, etc. The configuration of power plants in 2020 under Scenario I consists of 55 % of coal steam power plants, 20 % of gas combined-cycle power plants, 6 % of hydro power plants, 5 % of oil-based combined-cycle power plants, etc. Due to CO_2 emission limitation, Scenario II shows the increasing capacity of geothermal power plants in 2020 up to 25 % compared to 4 % in Scenario I. However, it is still dominated by coal steam power plants and gas combined-cycle power plants by 34 % and 30 %, respectively. In Scenario III, the compositions of power plants' capacity in 2020 are dominated by 54 % of coal steam power plants, followed by 19 % of gas combined-cycle power plants, 6 % of oil-based combined-cycle power plants, 7 % of hydro power plants, etc.

Under Scenario I, the power generation capacity expansion is dominated by steam coal-based power plant in the period 2010–2020 since FTP 1 will be fully operated. This is due to the low cost of coal steam power plants. The addition of FTP 1 is projected to address the growing demand of electricity. There are only small additions of renewable energy power plants in Scenario I.

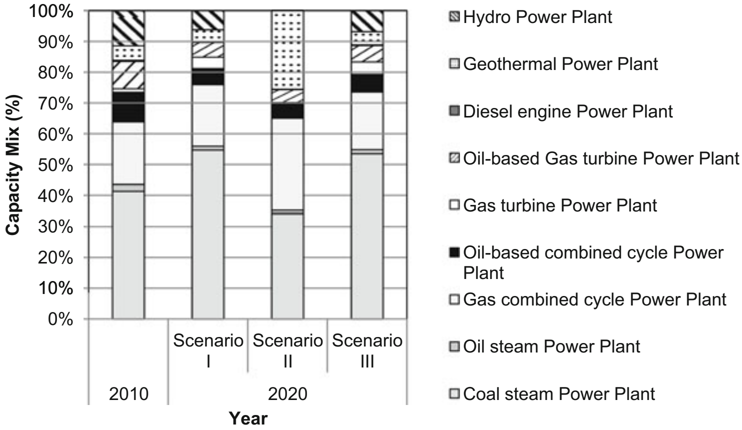

Fig. 8.12 Capacity mix of power plants in JAMALI region, 2010–2020

Scenario II is designed to mitigate the CO_2 emission by 10 % from the base-case scenario, resulting in the increase of renewable energy power plants in the JAMALI system especially from geothermal. However, the domination of coal steam power plants is related to the low cost of coal steam power plants.

The total capacity of power plants in Scenario II is higher than Scenario I in 2020 because of the low minimum capacity of geothermal power plants even though the peak loads for both scenarios are similar. Furthermore, the total capacity of power plants resulted from Scenario III in 2020 is lower than Scenario I following the trend of peak load in Scenario III. This demonstrates the importance of demand-side management which leads to lower electricity demand.

8.4.1.3 Generation Mix

The objective function applied in IIEE's model in this study is to obtain the least cost power plants configuration. Figure 8.13 shows the optimum strategy for electricity generation in JAMALI region in 2020 under three scenarios. The scope of electricity generation modeling includes the total electricity generation in JAMALI region throughout the year under each scenario. Due to the demand-side management, the electricity demand in Scenario III is the lowest in year 2020 among other scenarios. It is consistent with the peak load trend. Aligned with the trend of total installed capacity, results of total electricity generation for Scenarios I, II, and III in 2020 are 294,828 GWh; 298,610 GWh; and 284,137 GWh, respectively.

Figure 8.14 shows the generation mix of power plants in 2020 resulting from IIEE's model. In 2010, the electricity generation is dominated by coal steam power plants of 45 %, followed by 26 % of gas combined-cycle power plants, 12 % of oil-based combined-cycle power plants, 8 % of oil-based gas turbine power plant,

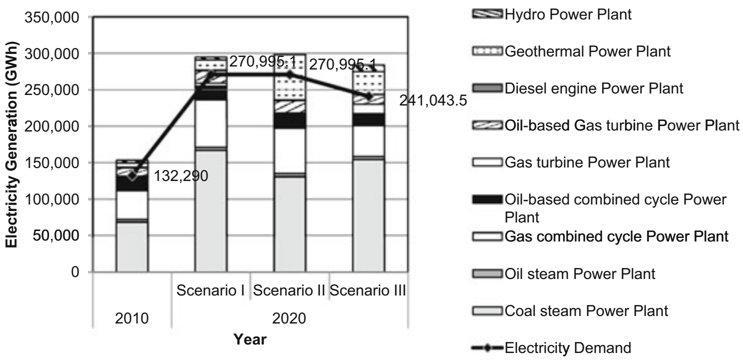

Fig. 8.13 Electricity generations of power plants in JAMALI region, 2010–2020

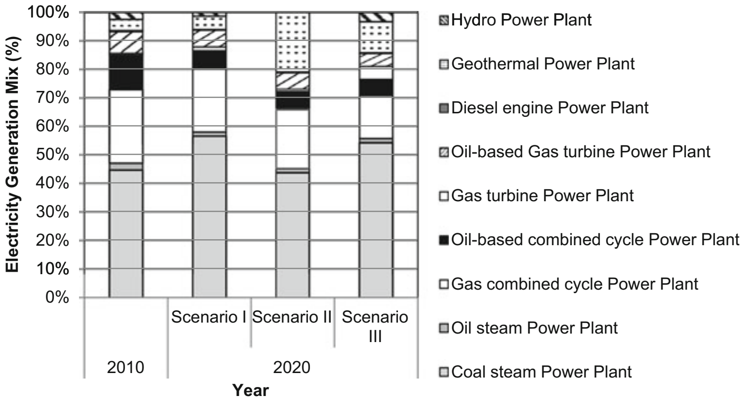

Fig. 8.14 Generation mix of power plants in JAMALI region, 2010–2020

etc. The configuration of electricity generation in 2020 under Scenario I, which mainly comes from coal steam power plants by 57 %, with 22 % of gas combined-cycle power plants, 6 % of oil-based combined-cycle power plants, 6 % of oil-based gas turbine power plants, etc. In Scenario II, the domination of electricity generation from coal steam power plant decreases to 44 % in 2020. This is compensated by the increase of geothermal-generating power plants from 5 % in the base-case scenario to 21 %. As is similar to the capacity mix of power plants resulted under Scenario III; generation mix is dominated by 54 % of coal steam power plants, followed by 15 % of gas combined-cycle power plants. The share of geothermal-generating power plants in Scenario III is 11 % which is between the results of Scenarios I and II.

Based on the generation mix result, the strategy to limit CO_2 emission in Scenario II has resulted in the increase of electricity generation from geothermal power plants in 2020 as one of the renewable energy sources. The share of generation from renewable energy power plants, such as geothermal and hydro power plants in Scenario III, is lower than Scenario II. This is due to the fact that the electricity demand in Scenario III is already lower than Scenario II. Therefore, the generation mix is not changed significantly toward high renewable energy that power plants share in order to lower CO_2 emission. This is also related to the dispatch order of power plant which is based on the lowest marginal operating cost. As the electricity demand decreases, while the coal steam power plant is available, the system gives priority to coal steam power plants to dispatch before renewable energy power plants. Consequently, the share of renewable energy power plant in Scenario III is lower than Scenario II.

8.4.1.4 Fuel Mix

Fuel mix demonstrates the share of each fuel consumed in the activities of producing electricity. The result of fuel mix for base-case scenario electricity generation of JAMALI region is shown in Fig. 8.15. The fuel consumption in Scenario I is dominated by coal which increases from 263 million BOE in 2010 to around 643 million BOE in 2020 due to the FTP that relies mainly on coal-fired power plants.

Figure 8.16 depicts the composition of consumption for each fuel type resulting from three scenarios in 2020. The fuel mix under Scenario I in 2020 comprises 61 % of coal, 18 % of natural gas, 11 % of high speed diesel (HSD), 8 % of geothermal, and 2 % of MFO. Fuel mix of Scenario II in 2020 is dominated by 41.8 % of coal, followed by 31.9 % of geothermal, 14.9 % of natural gas, 10 % of HSD, and 1.4 % of MFO. On the other hand, fuel mix of Scenario III in 2020 is highly dominated by 63.1 % of coal while the share of geothermal is decreased to 8.5 %. The remaining

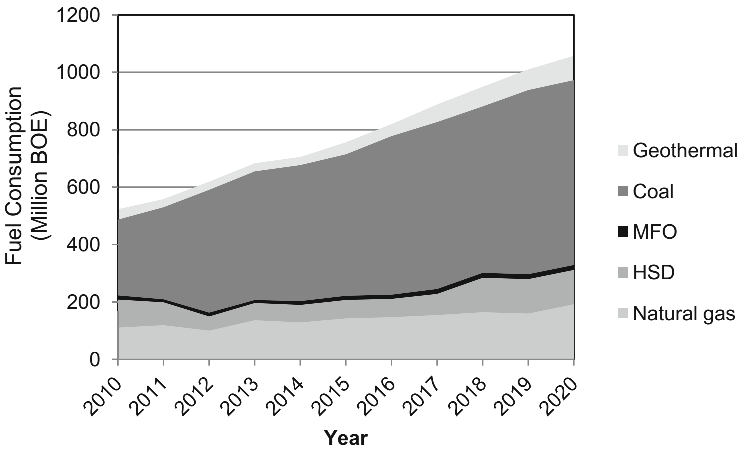

Fig. 8.15 Fuels of power plants in JAMALI region for Scenario I, 2010–2020

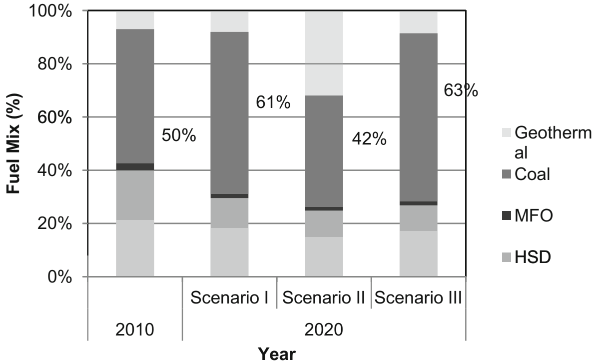

Fig. 8.16 Fuel mix of power plants in JAMALI region, 2010–2020

fuel mix resulted in Scenario III in 2020 is composed of 17.1 % of natural gas, 9.7 % of HSD, and 1.6 % of MFO.

The result for fuel mix of Scenarios II and III is similar, except for the share of coal in Scenario II that decreases to 41.8 %, which is compensated by the share of geothermal of 31.9 %. This is aligned with the result of generation mix for geothermal share in Scenario II in 2020. The share of coal in 2020 in fuel mix of Scenario III is close to Scenario I at 63.1 %. As is similar to the trend of generation mix, lower electricity demand in Scenario III leads to the relatively low renewable energy share and domination of coal in the fuel mix remains. This is due to the low efficiency of coal-fired power plants. The utilization of coal-fired power plants is due to the low price of coal. Therefore, the share of coal remains high.

8.4.2 CO_2 Emissions

IIEE developed the model in this study to provide the mitigation plan of high CO_2 emission attributed to the domination of coal-fired power plants. As shown in Fig. 8.17, CO_2 emission resulting from Scenarios I, II, and III in 2020 are 144 $MtCO_2$, 129 $MtCO_2$, and 129 $MtCO_2$, respectively. The low CO_2 emission under Scenario II is due to the limitation of emission as the constraint in the model which leads to the increase of renewable energy utilization for electricity generation. Further, the CO_2 emission under Scenarios II and III in 2020 is similar. Although Scenario III has lower electricity demand than Scenario II, the share of coal in the fuel mix of scenario III (63 %) is higher than in Scenario II (42 %), which is the reason why the CO_2 emission of Scenario III is similar to Scenario II.

The result of this study shows that increasing renewable energy in the electricity generation sector and demand-side management could mitigate CO_2 emission. In this case, both Scenarios II and III can mitigate CO_2 emission by 15 million ton by 2020 or a decrease of 10 %.

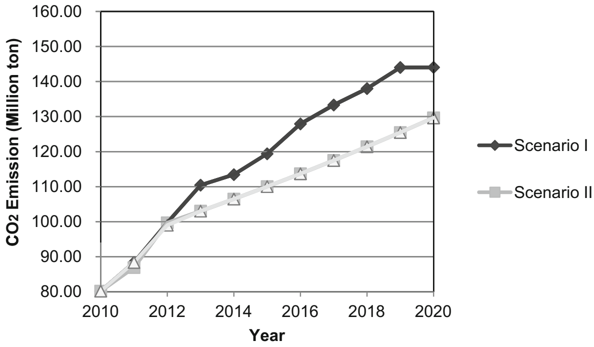

Fig. 8.17 CO_2 emissions of power plants in JAMALI region, 2010–2020

8.4.3 *Avoided Fossil Fuel Utilization*

This study shows that the reduction of CO_2 emission from electricity generation can be achieved by increasing the utilization of renewable energy or engaging the strategy of demand-side management. As a result, certain amount of fossil fuel can be reserved. Based on the result of Scenario II, the 10 % CO_2 emission reduction is equal to reserving 298 million BOE of fossil fuel compared to Scenario I due to the increased utilization of renewable energy.

8.5 Conclusion and Recommendation

This study presents three scenarios of alternative electricity planning and evaluates their impact on CO_2 emission by 2020. Those scenarios are examined using energy-modeling I2E3M. For all scenarios, coal is dominating the capacity and electricity generation mix. This is attributed to FTP 1 and FTP 2. In Scenario I, coal is used as primary energy for power generation as it has the lowest total cost for power generation. This is related to low operational costs of coal steam power plant comprising the maintenance cost and fuel cost. The results of I2E3M show that Scenario I has the base case with CO_2 emissions of 144 $MtCO_2$ in 2020.

In order to reduce CO_2 emissions like Scenario I, Scenario II is developed by adding more renewable energy share into the power sector. Consequently, CO_2 emission could be reduced to 129 $MtCO_2$ or a decrease of 10 % compared to Scenario I. However, it is important to note that the effort of limiting CO_2 emission by increasing renewable energy share in Scenario II causes a higher unit cost than Scenario I. This is attributed to the higher utilization of low emission power plants which generally have higher operational unit cost, such as geothermal power plant, mini/micro hydro power plants and combined-cycle power plant.

Scenario III is also designed in order to mitigate CO_2 emission from base-case scenario by implementing demand-side management program. The result of Scenario III reveals that the electricity demand is the lowest compared to the other scenarios. However, its CO_2 emission is the same as Scenario II. Both scenarios can reduce CO_2 emission by 10 % in 2020. This is because the share of coal in the fuel mix of Scenario III is higher than Scenario II. In other words, the result of this study shows that the impact of renewable energy utilization and demand-side management program on the CO_2 emission reduction is the same. It should be noted here that this analysis excludes the cost and benefit analysis for each scenario, which could be used as a basis to select the best scenario.

The results above demonstrate that renewable energy share in power sector plays an important role in reducing CO_2 emissions though it will lead to a higher unit cost of electricity generation. Despite the higher unit cost of electricity generation, the utilization of more renewable energy for power generation can give several benefits including:

- Increased electrification ratio with off-grid renewable energy power plants in the remote islands which currently have low electrification ratio due to the difficulties on the supply of fossil fuel
- Reduced distribution losses due to small isolated scattered system compared to the interconnected system
- Reserved valuable fossil fuel for the future generation

This study also shows the importance of demand-side management to reduce the required total installed capacity of power plants caused by lower electricity demand. Demand-side management is very beneficial to avoid developments of new power plants and should be included in PLN's development plan in the future in order to curtail electricity demand, mitigate CO_2 mission, and reserve for both carbon and non-carbon-based energy resources.

This study needs further analysis of the cost of CO_2 emissions reduction. The cost of CO_2 emission reduction is not addressed by this model; however, the role of renewable energy in power sector will lead to higher operational and unit costs of electricity generation.

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Chapter 9
Environmental Productivities and Carbon Abatement Costs of Manufacturing Sectors

Erik Armundito and Shinji Kaneko

Abstract The manufacturing sector is one of the most important sectors in Indonesia due to its enormous potential for creating job opportunities and its contribution to development. When the roles of manufacturing sector are expected to increase continuously, some considerable obstructions should be confronted, in particular the increasing pollution and the increasing domestic price of oil commodities. This chapter provides a baseline analysis of the total factor productivity (TFP) growth over time with and without considering CO_2 emissions and the estimation of carbon abatement cost of manufacturing sector from 1990 to 2000. The results show that the TFP with CO_2 emissions over time has grown faster than the TFP without CO_2 emissions for the most of all periods. The results suggested that when accounting for changes in pollutions as undesirable outputs, the average productivity growth is higher than the growth ignoring pollutions. The increased price of oil commodities might affect the environmental productivity and average carbon abatement cost of the manufacturing sector. Several sectors are identified to be ready for the implementation of a carbon tax in the future. The results also suggest that CO_2 emissions as undesirable outputs can be considered in measuring the manufacturing sector's productivity growth as a response to the climate change mitigation and energy-related policy. At the same time, technological improvement is expected to be a major concern for the manufacturing firms' long-term strategic planning after the changes in prices of oil commodities. Hence, the share of manufacturing sector to Indonesia's gross domestic product (GDP) and more job opportunities can be well maintained in the future.

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9.1 Indonesia's Manufacturing Sector Development

The abundance of fossil energy resources as well as a large population has been the foundation of development in Indonesia. However, since 2004, Indonesia has become a net oil-importing country if we consider the trade balance of both crude oil and petroleum commodities. In addition, as of 2013, Indonesia ranked as the 11th largest CO_2-emitting country after Canada (Global Carbon Project 2014). As a growing and developing country in Asia with a relatively large but young demographic structure, Indonesia will not only confront domestic policy challenges but will also begin to draw international attention after China and India in seeking a future development pathway that is less fossil energy resource dependent and that creates more job opportunities.

Although these challenges should be addressed by various sectors as declared by Indonesia's master plan of 2011, the manufacturing sector is one of the most important sectors due to its large potential for creating job opportunities. At the same time, there is concern regarding the increasing demand for energy generated by the economic development policy through further industrialization and development of the manufacturing sector. Currently, the total final energy consumption (TFEC) in the manufacturing sector represents 27.4 % of the TFEC of Indonesia in 2011, and this share has been growing steadily over the last two decades (IEA 2013).

As the international oil price has increased since 2000 and has remained high compared to prices in the 1990s, the government of Indonesia as a net oil-importing country started to gradually remove subsidies for energy commodities starting in 2005. Consequently, the domestic price of oil commodities in Indonesia has been rising since this time, which has caused a significant financial burden for the manufacturing industry. Although economic instruments implemented within climate change mitigation policies such as a carbon tax have not yet been implemented in Indonesia, the recent rising price of domestic oil commodities can be seen as quasi-carbon regulation instrument because it has similar consequences.

This chapter reports empirical evidence of changes in the TFP of manufacturing firms in Indonesia over time from 1990 to 2010 with and without considering CO_2 emissions. The comparison of the TFP with and without considering CO_2 emissions across different sectors of the manufacturing industry aimed to identify firm reactions to changes in the prices of oil commodities. Further, the cost to reduce CO_2 emissions in the manufacturing sector, as the average carbon abatement cost, is estimated to examine the impact of future carbon regulations. Because carbon regulations have not been imposed during this study, the analysis of changes in TFP and carbon abatement cost are considered as baseline analysis.

It should be noted that although historical data for manufacturing firms in Indonesia are available from the datasets of annual manufacturing surveys conducted by the Indonesian Statistics Agency (Badan Pusat Statistik, BPS) for medium- and large-sized firms that employ at least 20 workers, the datasets contain inaccurate, incomplete, and erroneous data. Therefore, despite the availability of large sets of data, to the best of our knowledge, empirical studies of Indonesian-manufacturing firms are limited.

To overcome this constraint, first cleaned panel dataset are developed from the annual survey data of medium- and large-sized firms in the manufacturing sector of Indonesia between 1990 and 2010, which is used for the present analysis. Because the system of firm identity codes was changed between 2000 and 2001, it is impossible to construct continuous annual firm datasets between two periods, namely, 1990–2000 and 2001–2010. In addition, we found that some of key variables such as capital stock and energy consumption, which are necessary for the present analysis, are completely missing in the survey data for 1996, 1997, 2001, 2002, and 2007. Therefore, the cleaned and balanced panel datasets are constructed for only four periods: 1990–1995, 1998–2000, 2003–2006, and 2008–2010.

The datasets used in this analysis have several breaks, and the period before and after the Asian financial crisis is one of these breaks. Table 9.1 provides a summary of the key variables in the four analyzed periods to describe the contextual background of the present analysis. Period 1 from 1990 to 1995, which is the longest among the four analyzed periods in the paper, exhibited the highest average GDP growth rate at 7.9 %, and the growth rate of the manufacturing sector during this period was also the highest. Consequently, the share of the manufacturing sector to GDP increased from 21.6 to 24.5 %, and the share in total merchandise exports also increased from 35.5 to 50.6 %. In contrast, the growth rate of TFEC for Indonesia and the growth rate of the manufacturing sector grew less quickly than that for production, resulting in an elasticity of TFEC to GDP of 0.57 and 0.75, respectively. Although net crude oil exports and the share of fuel exports to merchandise exports have been declining during the period, trade surpluses of more than 30 million tons of oil equivalent (TOE) of crude oil were maintained. Overall, the last phase of the Suharto regime can be summarized as a time when the productivity and energy efficiency of the manufacturing sector was improved through an export-led industrialization policy.

Period 2 from 1998 to 2000 is characterized as an immediate post-economic crisis period and marks the beginning of democratic reforms after the Suharto regime. The per capita GDP in constant US dollars at 2005 prices moved to an even lower range compared to 1995, and the average GDP growth rate was only 2.8 % during the period. However, the manufacturing sector performed relatively better despite the negative effects of the financial crisis. The share of the manufacturing sector to GDP slightly expanded from 26.0 % to 27.1 % and that of exports to merchandise increased from 45.0 to 57.1 %. However, energy consumption in Indonesia sharply increased during this time, and the elasticity of

Table 9.1 Summary of key variables for four analytical periods

Variables	Unit	Source	Period 1 (6 years)		Period 2 (3 years)		Period 3 (4 years)		Period 4 (3 years)	
			1990	1995	1998	2000	2003	2006	2008	2010
Per capita GDP	USD at 2005 price	a	840.2	1129.1	1057.1	1086.1	1180.5	1324.5	1451.6	1570.2
GDP growth rate	%	a	7.9 %		2.8 %		5.4 %		5.4 %	
Growth rate of value added in manufacturing sector	%	a	10.6 %		4.9 %		5.2 %		3.5 %	
Share of manufacturing sector to GDP	%	a	21.6 %	24.5 %	26.0 %	27.1 %	27.3 %	27.2 %	26.1 %	25.2 %
Share of manufactures exports to merchandise exports	%	a	35.5 %	50.6 %	45.0 %	57.1 %	52.1 %	44.7 %	38.8 %	37.5 %
Share of high-technology exports to manufactured exports	%	a	1.6 %	7.3 %	10.4 %	16.4 %	14.8 %	13.5 %	10.9 %	9.8 %
Total final energy consumption (TFEC)	1000 TOE	b	79,817	99,513	107,332	120,323	128,043	139,427	139,686	156,113
Growth rate of TFEC	%	b	4.5 %		5.9 %		2.9 %		5.7 %	
Elasticity of total TFEC to GDP	–	a/b	0.57		2.07		0.53		1.05	
Energy intensity (TFEC/GDP)	TOE/USD at 2005 price	a/b	531.8	454.1	500.2	530.2	497.2	462.3	410.8	413.1
TFEC in manufacturing sector	1000 TOE	b	17,805	26,087	26,914	30,333	33,548	43,820	39,971	45,264
Growth rate of TFEC in manufacturing sector	%	b	7.9 %		6.2 %		9.3 %		6.4 %	
Elasticity of TFEC to GDP in manufacturing sector	–	a/b	0.75		1.25		1.80		1.85	
Energy intensity of manufacturing sector	TOE/USD at 2005 price	a/b	548.8	486.3	482.3	493.5	476.5	534.8	449.6	475.6
Net export of crude oil	1000 TOE	b	32,328	30,744	27,349	17,390	7043	(2860)	1350	(2171)
Net export of oil products	1000 TOE	b	8054	2675	1529	(4181)	(6896)	(11,598)	(15,860)	(20,722)
Share of fuel exports to merchandise exports	%	a	44.0 %	25.4 %	19.1 %	25.4 %	25.8 %	27.2 %	29.1 %	29.7 %

(a) World Development Indicators 2014, (b) IEA energy balance tables for non-OECD countries, 2013
GDP gross domestic product, *USD* United States dollar, *TFEC* total final energy consumption, *TOE* ton of oil equivalent

TFEC to GDP was 2.07, whereas the elasticity of the manufacturing sector was 1.25. Net crude oil exports started to decline from 27.3 to 17.4 million TOE, and the net export of oil products turned negative during this period.

Period 3 between 2003 and 2006 covers a politically significant transitional moment when President Yudhoyono became the first president of the country elected by a direct presidential election in 2004. Immediately after electing a new president, the Sumatra-Andaman earthquake and tsunami hit the country. The period first experienced a transition from positive to negative net oil exports considering both crude oil and oil commodities. Coincidentally, unprecedented and continuously soaring international oil prices finally forced the government of Indonesia to begin removing subsidies for oil commodities twice in 1 year in March and October 2005, doubling the prices for most oil commodities in the domestic market. Under these conditions, the manufacturing sector grew annually by 5.2 % on average, which was slightly lower than GDP growth. Meanwhile, the share of manufactured exports to merchandise exports dropped from 52.1 % to 44.7 %. The energy intensity of the country as measured by the ratio of TFEC to GDP greatly improved, while the energy intensity of the manufacturing sector worsened. It is expected that manufacturing firms faced a significant increase in energy costs.

Period 4 from 2008 to 2010 was in the middle of the 10-year presidency of Yudhoyono and of the global financial crisis. The adverse shock caused in Indonesia by the global financial crisis was relatively small, and the average GDP growth rate in period 4 was maintained, staying as high as that of period 3. However, the growth rate of the manufacturing sector slowed and the shares of the manufacturing sector to GDP and manufactured products to merchandise exports shrank. At the same time, dependency on imported oil commodities increased remarkably, whereas the average growth rate of TFEC in the manufacturing sector was 6.4 %, which is much higher than production growth, resulting in an elasticity of 1.85. Amid such circumstances, the overall energy intensity of manufacturing firms did not improve. Further subsidy removal was implemented in 2008, and it is likely that the additional burden put a strain on manufacturing firms.

9.2 Environmental Productivity of Manufacturing Sector

A number of studies have attempted to analyze changes in productivity dealing with multiple outputs including both desirable and undesirable outputs. Data envelopment analysis (DEA) is one of the commonly employed approaches measuring productive efficiency, known as a nonparametric frontier approach (Coelli 1995). The DEA develops a nonparametric envelopment frontier encompassing all sample data as observed points lie on or below the frontier. The points on the production frontier are considered as the efficient decision-making units (DMUs) and the points below the production frontier are regarded as inefficient DMUs. The efficiency of each observation is measured by calculating the distance between the observed level of production and the production frontier as solutions of a linear programming problem. However, the DEA method does not evaluate the shift in the frontier over time; instead the DEA only estimates the performance of DMUs in reference to the best practice frontier in a given year. The Malmquist productivity index is then introduced by adjusting the DEA application for multiyear observations alternately between t and t+1 to account for this shift in the frontier and allows measuring changes in productive efficiency over time. The index-measuring changes in productive efficiency are then regarded as TFP growth, which can be further decomposed into efficiency change (catch-up) and technical progress (frontier-shift).

Several ideas and methods have been proposed to incorporate undesirable outputs into the DEA approaches while assuming asymmetrical treatments of disposability between desirable outputs and undesirable outputs when production possibilities are defined (Färe et al. 1989). Among inputs, desirable outputs, and undesirable outputs, efficiency improvement strategy for inefficient DMUs is assumed by holding one or two of them. For example, the input orientation refers to the strategy, where how much inputs can be reduced while holding both desirable and undesirable outputs unchanged is considered (i.e., Färe et al. 1996). Some suggest bad orientation strategy, where how much bads can be reduced while holding inputs and desirable outputs unchanged is considered (i.e., Tyteca 1997). Tyteca (1997) also considers the other strategy, where how much bads and inputs are reduced while holding desirable outputs unchanged. Following the earlier method of simultaneous change in desirable outputs and undesirable outputs following hyperbolic function where fixed inputs are assumed, Chung et al. (1997) proposed an application of directional distant function as well as a productivity index known as the Malmquist-Luenberger productivity index. The directional distant function (DDF) defines the strategy where desirable outputs and undesirable outputs are simultaneously changed. While the efficiency measurement with DDF model in a single year is measured as the Luenberger productivity index, alternate application of the DDF models between t and t+1 for measuring Luenberger productivity index in a way that the Malmquist productivity index is constructed can generate the Malmquist-Luenberger productivity index. Therefore, the Malmquist-Luenberger productivity index can be further decomposed into efficiency change (catch-up) and technical progress (frontier-shift).

Table 9.2 summarizes the results of the selected literatures measuring the TFP growth without considering CO_2 emissions of the Indonesian-manufacturing sector using firm-level data for the period between 1970 and 2000. Although specific periods and numbers are not exactly the same and comparable, general shifts in TFP growth before and after the middle of the 1980s are commonly and consistently reported. Moreover, TFP growth seems to have continued until 1997, at which point the Asian economic crisis hits the Indonesian economy. Suharto's relinquishing presidential office in 1998 evidences the seriousness of the adverse effects from the Asian financial crisis on the Indonesian economy, and this crisis also caused significant turbulence and confusion in measurements of TFP growth.

The Malmquist-Luenberger productivity index is applied to estimate the productivity change over time with considering CO_2 emissions in manufacturing firms. Because no definite climate change mitigation policies such as carbon regulations

Table 9.2 TFP growth measurements without considering CO_2 emissions using firm-level data for the Indonesian-manufacturing sector

Authors	Methods	Periods	Annual TFP growth (%)
1. Timmer (1999)	Growth accounting method	1975–1981	1.10
		1982–1985	0.10
		1986–1990	7.90
		1991–1995	2.10
		1975–1995	2.80
2. Aswicahyono and Hill (2002)	Growth accounting method	1976–1980	1.10
		1981–1983	−4.90
		1984–1988	5.50
		1989–1993	6.00
		1975–1993	2.70
3. Vial (2006)	Cobb-Douglas production function	1976–1980	1.50
		1981–1983	−0.10
		1984–1988	5.10
		1989–1993	8.00
		1976–1996	3.50
4. Ikhsan-Modjo (2006)	Stochastic production frontier	1988–1992	2.70
		1993–1996	2.90
		1997–2000	−0.60
		1988–2000	1.60

have been imposed in Indonesia, an assumption that considers the disposability of CO_2 emissions as undesirable outputs is not a free activity that must be made. The productivity without considering CO_2 emissions is also calculated using the Malmquist productivity index. The comparison of the productivity change over time with and without considering CO_2 emissions will define the TFP environment.

The datasets used for the analysis in this chapter are obtained from annual manufacturing survey by BPS. For the present analysis, Armundito and Kaneko (2014) have developed a cleaned panel dataset to address data quality problems. As a result, four periods of cleaned and balanced panel datasets are obtained: 1990–1995, 1998–2000, 2003–2006, and 2008–2010. Considering the number of firms for each sector, only 18 out of the 23 sectors are employed for the analysis. To avoid price changes over time, GDP deflators are applied to convert these series of datasets into constant prices based on the year 2000. Additionally, to convert the currency from Indonesia's rupiah to the US dollar, the currency rate for the year 2000 is applied.

Data on quantities of inputs, desirable outputs, and undesirable outputs are required to estimate productivity change over time using the Malmquist productivity index and the Malmquist-Luenberger productivity index. All firms are assumed to share the same production processes, characterized by the production of one desirable output and one undesirable output. Values added to manufacturing production and CO_2 emissions are considered to be the proxies for desirable and undesirable outputs, respectively, whereas capital, labor wages, and raw materials are considered as inputs. The value added v is measured as the difference between the total sales revenue of a firm and the total cost of components, materials, and services in millions of US dollars. Capital k is measured by the replacement value of fixed assets in thousands of US dollars. Labor wage l is measured as the total salary and other incentives for all workers, including production workers and other workers in thousands of US dollars. Raw material m is measured as the total materials used to produce a unit of output in thousands of US dollars. Finally, both direct and indirect CO_2 emissions are measured as the most common type of gas emitted from the burning of fossil fuels used in manufacturing firms in tons CO_2 equivalent. Direct and indirect CO_2 emissions are calculated from fuel combustion in the manufacturing sector based on the Intergovernmental Panel on Climate Change (IPCC) guidelines (Eggleston et al. 2006). Further, Indonesia's currency rate has devalued since 1998 and a high inflation rate occurred in 1998, resulting in a monetary value for some variables in periods 3 and 4 that are smaller than the monetary value in periods 1 and 2. The descriptive statistics of the variables used for this chapter is shown in Table 9.3.

Under two assumptions of disposability of undesirable outputs, the Malmquist productivity index is applied to estimate the TFP without CO_2 emissions over time, and the Malmquist-Luenberger productivity index is employed to measure the TFP with CO_2 emissions over time. A summary of the estimation results based on the average annual basis for the period 1 from 1990 to 1995 is presented in Table 9.4. Of the measurements without CO_2 emissions, the average productivity index score is 1.0014, implying that the annual TFP without CO_2 emissions over time for the manufacturing sector increases by 0.14 % over the entire period. This annual TFP score is obtained as the weighted mean of all sector's TFP score as the number of firms is different for each sector. On average, this growth is due to the increase in efficiency change by 0.97 % and the decrease in technological progress by 0.01 %. Based on the sector-by-sector analysis, considerable variation across sectors is observed. The sector that exhibits the highest productivity growth is motor vehicle, trailers, and semitrailers (1.64 %), and the sector with the lowest growth is fabricated metal product and equipment (−0.07 %). Furthermore, for the measurement with CO_2 emissions, the weighted mean of TFP score is 1.0198, indicating that the annual TFP with CO_2 emissions over time for the manufacturing sector increases by 1.98 % over the entire period. This increasing growth is considerably higher than the growth of TFP without CO_2 emissions. This average TFP with CO_2 emissions over time is due to an increase in efficiency change (7.69 %) and technological progress (5.87 %). The sector that shows the highest productivity growth is other nonmetallic mineral product (11.1 %) and the sector with the lowest growth is chemicals and chemical product (−2.7 %). At the same time, the average TFP environment score for the period 1 is 1.0184, suggesting that environmental productivity increases by 1.84 % annually.

The productivity measurement for the period 2 from 1998 to 2000 is presented in Table 9.5. The average of the weighted mean productivity index score is 0.9933, indicating that the annual TFP without CO_2 emissions over time for the manufacturing sector dropped by 0.67 % over the entire period. The growth is triggered by the

Table 9.3 Descriptive statistics of the variables used

Variable code	Description	Unit	Mean	Standard deviation
Period of 1990–1995				
K	Capital	Thousands of US dollar	450.80	1691.45
L	Labor wage	Thousands of US dollar	263.94	873.13
M	Raw material	Thousands of US dollar	607.63	2774.68
V	Value added	Thousands of US dollar	317.11	1370.26
CO_2	CO_2 emissions	Tons CO_2 equivalent	584.88	2113.26
No. of observations 9336				
Period of 1998–2000				
K	Capital	Thousands of US dollar	352.88	1530.00
L	Labor wage	Thousands of US dollar	86.35	404.82
M	Raw material	Thousands of US dollar	596.34	3302.94
V	Value added	Thousands of US dollar	381.29	3211.77
CO_2	CO_2 emissions	Tons CO_2 equivalent	666.49	2229.87
No. of observations 4668				
Period of 2003–2006				
K	Capital	Thousands of US dollar	127.14	408.26
L	Labor wage	Thousands of US dollar	86.27	216.78
M	Raw material	Thousands of US dollar	236.26	1489.42
V	Value added	Thousands of US dollar	119.65	583.46
CO_2	CO_2 emissions	Tons CO_2 equivalent	282.02	1434.19
No. of observations 3296				
Period of 2008–2010				
K	Capital	Thousands of US dollar	120.00	441.86
L	Labor wage	Thousands of US dollar	84.76	253.55
M	Raw material	Thousands of US dollar	298.67	1924.40
V	Value added	Thousands of US dollar	119.50	385.95
CO_2	CO_2 emissions	Tons CO_2 equivalent	243.63	1054.26
No. of observations 2472				

increase in efficiency change (1.58 %) and the decrease in technological progress (1.94 %). Based on the sector-by-sector analysis, the sector that shows the highest productivity growth is textiles (0.49 %), and the sector with the lowest productivity growth is paper and paper product (−3.04 %). For the measurement with CO_2 emissions, the weighted mean of TFP score is 1.0652, implying that the annual TFP with CO_2 emissions over time increases by 6.52 % over the entire period. This increasing growth is also significantly higher than the growth of TFP without CO_2 emissions. This remarkable growth is caused by the increase in efficiency (8.06 %) and technological progress (5.68 %). The sector that demonstrates the best performance is rubber and plastics product with the productivity growth of 20.47 %, and the sector with the worst performance is paper and paper product with the decrease of productivity by 2.22 %. Meanwhile, the TFP environment score for the period

Table 9.4 Average annual changes in productivity growth and its components for the period 1

Sector	TFP growth without CO_2 emissions			TFP growth with CO_2 emissions			TFP Env
	M	EFFCH	TECH	ML	EFFCH	TECH	
Food products and beverages	1.0041	0.9990	1.0080	1.0303	1.1903	1.5534	1.0261
Tobacco	1.0102	1.0431	0.9722	1.0199	1.1650	0.9346	1.0096
Textiles	1.0073	1.0259	0.9902	1.0052	1.1220	1.0507	0.9980
Wearing apparel	0.9985	0.9886	1.0115	1.0174	1.0305	1.0115	1.0189
Tanning and dressing of leather	0.9907	1.0465	0.9520	0.9402	1.1152	0.8797	0.9491
Wood and products of wood and plaiting	1.0027	1.0118	0.9915	0.9783	1.0507	0.9713	0.9757
Paper and paper products	1.0094	1.0205	0.9947	0.9915	1.0964	0.9463	0.9823
Publishing, printing, and reproduction	0.9943	0.9931	1.0020	1.0154	1.1494	0.9776	1.0212
Chemicals and chemical products	1.0053	0.9982	1.0106	0.9730	0.9372	1.1142	0.9679
Rubber and plastics products	1.0050	0.9999	1.0099	0.9797	1.0146	1.0938	0.9748
Others nonmetallic mineral products	0.9916	1.0070	0.9871	1.1110	1.1159	1.0953	1.1205
Basic metals	1.0318	1.0346	0.9980	1.0165	1.0182	1.0433	0.9852
Fabricated metal products and equipment	0.9903	1.0041	1.0031	0.9924	1.0795	1.0858	1.0021
Machinery and equipment	1.0017	1.0360	0.9739	1.0327	1.2134	0.9832	1.0310
Electrical machinery and apparatus	1.0070	0.9630	1.0548	1.0065	0.9444	1.1185	0.9995
Motor vehicle, trailers, and semitrailers	1.0164	1.0005	1.0195	1.0105	0.9965	1.0517	0.9943
Other transport equipment	1.0101	1.0124	1.0113	1.0619	1.1018	1.1400	1.0513
Furniture and manufacturing	0.9923	0.9898	1.0074	0.9971	1.0436	1.0061	1.0049
Weighted mean	1.0014	1.0097	0.9999	1.0198	1.0769	1.0587	1.0184

2 is 1.0724, suggesting that environmental productivity increases by 7.24 % annually.

The productivity measurement for the period 3 from 2003 to 2006 is presented in Table 9.6 as the average TFP without CO_2 emissions score is 1.0050. The average TFP score indicates that the annual TFP without CO_2 emissions over time increases by 0.50 % over the entire period. The increase of efficiency change (0.49 %) and technological progress (1.55 %) are the sources of this TFP growth. Tobacco is the sector that shows the highest productivity growth (4.45 %), whereas textiles sector is the sector that exhibits the lowest productivity growth (1.71 %). At the same time, the weighted mean score of TFP with CO_2 emissions is 1.0036, implying that the annual TFP with CO_2 emissions over time increased by 0.36 % over the entire

Table 9.5 Average annual changes in productivity growth and its components for the period 2

Sector	TFP growth without CO_2 emissions			TFP growth with CO_2 emissions			TFP Env.
	M	EFFCH	TECH	ML	EFFCH	TECH	
Food products and beverages	0.9933	1.0163	0.9774	1.0603	1.2147	0.8838	1.0674
Tobacco	0.9979	1.0054	0.9923	1.0129	1.0670	0.9754	1.0150
Textiles	1.0049	1.0105	0.9965	1.0448	1.1088	0.9967	1.0397
Wearing apparel	0.9985	1.0236	0.9797	1.1001	1.2215	0.9992	1.1017
Tanning and dressing of leather	1.0002	0.9941	1.0108	1.0559	0.9083	1.4272	1.0557
Wood and products of wood and plaiting	0.9953	0.9746	1.0243	0.9778	0.7279	1.5209	0.9824
Paper and paper products	0.9696	0.9944	0.9825	0.9286	0.8073	1.2034	0.9577
Publishing, printing, and reproduction	0.9754	1.0192	0.9641	0.9674	0.9221	1.0727	0.9918
Chemicals and chemical products	0.9947	1.0293	0.9703	1.1403	1.0646	1.0855	1.1464
Rubber and plastics products	0.9941	1.0109	0.9875	1.2047	1.1510	1.0871	1.2118
Others nonmetallic mineral products	0.9952	1.0039	0.9933	1.1013	1.1688	0.9872	1.1066
Basic metals	0.9939	1.0757	0.9339	1.0869	1.4516	0.8474	1.0936
Fabricated metal products and equipment	0.9825	1.1075	0.8949	1.0471	1.5578	0.7498	1.0657
Machinery and equipment	0.9774	1.0396	0.9440	0.9954	1.1737	0.9150	1.0184
Electrical machinery and apparatus	0.9795	0.9774	1.0043	1.0224	0.9711	1.0791	1.0439
Motor vehicle, trailers, and semitrailers	0.9903	0.9726	1.0199	1.0516	0.9376	1.1286	1.0619
Other transport equipment	1.0010	1.0067	0.9972	1.0212	0.9297	1.1017	1.0202
Furniture and manufacturing	0.9978	1.0220	0.9784	1.0091	1.0678	0.9622	1.0113
Weighted mean	0.9933	1.0158	0.9806	1.0652	1.0806	1.0568	1.0724

period. The increase in efficiency change (7.18 %) and technological progress (7.57 %) are the engines of this TFP growth. The sector that shows the highest productivity growth is wood and product of wood and plaiting (11.37 %), and the sector with the lowest growth is chemicals and chemical product (−19.67 %). On average, the TFP environment score for the period 3 is 0.9986, suggesting that environmental productivity decreases by 0.14 % annually.

The productivity measurement for the period 4 from 2008 to 2010 is shown in Table 9.7. The average of the weighted mean productivity index score is 1.0311, implying that the annual TFP without CO_2 emissions over time increases by 3.11 % over the entire period. The growth is due to the increase in efficiency change by 0.33 % and in technological progress by 3.65 %. The sector with the highest

Table 9.6 Average annual changes in productivity growth and its components for the period 3

Sector	TFP growth without CO_2 emissions			TFP growth with CO_2 emissions			TFP Env.
	M	EFFCH	TECH	ML	EFFCH	TECH	
Food products and beverages	0.9991	0.9724	1.0286	1.0100	0.9201	1.1757	1.0109
Tobacco	1.0445	1.0883	0.9698	1.1102	1.7478	0.8695	1.0629
Textiles	0.9829	0.9917	0.9940	0.9698	0.9885	1.0951	0.9867
Wearing apparel	0.9956	1.0288	0.9701	1.0064	1.3685	0.9862	1.0109
Tanning and dressing of leather	1.0438	1.0262	1.0169	1.0460	1.0516	1.0048	1.0021
Wood and products of wood and plaiting	1.0098	0.9497	1.0813	1.1137	1.0586	1.2980	1.1029
Paper and paper products	1.0042	1.0073	0.9967	1.0074	1.0321	0.9822	1.0032
Publishing, printing, and reproduction	1.0042	1.0073	0.9967	1.0074	1.0321	0.9822	1.0032
Chemicals and chemical products	0.9906	0.9726	1.0226	0.8033	0.7201	1.2626	0.8109
Rubber and plastics products	1.0140	1.0428	0.9764	0.9827	1.4561	0.6780	0.9691
Others nonmetallic mineral products	1.0001	0.9653	1.0385	0.9714	0.8091	1.2040	0.9712
Basic metals	1.0370	0.9432	1.1123	1.0719	0.9100	1.2206	1.0336
Fabricated metal products and equipment	1.0345	0.9963	1.0450	0.9685	0.8542	1.2306	0.9362
Machinery and equipment	1.0229	0.9871	1.0360	1.0435	0.9220	1.1443	1.0201
Electrical machinery and apparatus	1.0443	1.0774	0.9854	1.0548	1.2721	0.9612	1.0100
Motor vehicle, trailers, and semitrailers	1.0280	1.0108	1.0176	1.0367	1.0575	1.0440	1.0084
Other transport equipment	1.0055	1.0374	0.9726	1.0418	1.0333	1.0084	1.0361
Furniture and manufacturing	1.0003	0.9836	1.0185	1.0160	1.0583	1.2153	1.0157
Weighted mean	1.0050	1.0049	1.0155	1.0036	1.0718	1.0757	0.9986

productivity growth is electrical, machinery, and apparatus (6.72 %), and the sector with the lowest growth is tanning and dressing of leather (0.06 %). Furthermore, the measurement of TFP with CO_2 emissions results in a weighted mean of TFP score of 1.0523, suggesting that the annual TFP with CO_2 emissions over time increases by 5.23 % over the entire period. The growth is generated by the increase in efficiency change (1.77 %) and technological progress (11.83 %). The sector that shows the highest productivity growth is basic metals (14.73 %), and the sector that presents the lowest productivity growth is tobacco (0.89 %). The TFP environment score for the period 4 is 1.0206, implying that environmental productivity increases by 2.06 % annually.

Table 9.7 Average annual changes in productivity growth and its components for the period 4

Sector	TFP growth without CO_2 emissions			TFP growth with CO_2 emissions			TFP Env.
	M	EFFCH	TECH	ML	EFFCH	TECH	
Food products and beverages	1.0167	0.9672	1.0524	1.0450	1.0338	1.1743	1.0279
Tobacco	1.0178	0.9742	1.0454	0.9911	0.9483	1.1034	0.9738
Textiles	1.0209	0.9432	1.0853	1.0482	0.8590	1.2842	1.0267
Wearing apparel	1.0257	1.0027	1.0283	1.0506	1.0228	1.0659	1.0243
Tanning and dressing of leather	1.0006	0.9825	1.0198	1.0433	1.0420	1.0203	1.0426
Wood and products of wood and plaiting	1.0106	1.0217	0.9903	1.0437	1.2793	0.8615	1.0327
Paper and paper products	1.0302	0.9352	1.1086	1.1013	0.9327	1.2866	1.0690
Publishing, printing, and reproduction	1.0368	0.9064	1.1480	1.1205	0.8171	1.4283	1.0807
Chemicals and chemical products	1.0622	1.0002	1.0675	1.0875	0.9524	1.1803	1.0238
Rubber and plastics products	1.0408	1.0099	1.0370	1.0543	1.0127	1.0979	1.0130
Others nonmetallic mineral products	1.0345	1.0613	0.9794	1.0499	1.1142	0.9681	1.0148
Basic metals	1.0333	1.0542	0.9798	1.1473	1.0788	1.0463	1.1103
Fabricated metal products and equipment	1.0277	0.9560	1.0801	1.0571	0.7765	1.4569	1.0286
Machinery and equipment	1.0378	1.0756	0.9841	1.0484	1.1844	1.0512	1.0102
Electrical machinery and apparatus	1.0672	1.0750	0.9991	1.0582	1.0682	1.0525	0.9916
Motor vehicle, trailers and semitrailers	1.0475	1.0374	1.0121	1.0634	1.0838	1.0027	1.0152
Other transport equipment	1.0349	1.0461	0.9904	1.0565	1.1154	0.9563	1.0209
Furniture and manufacturing	1.0583	1.0111	1.0492	1.0627	0.9977	1.0929	1.0042
Weighted mean	1.0311	1.0033	1.0365	1.0523	1.0177	1.1183	1.0206

The comparisons between the entire periods enable to evaluate the impact of the policy implemented or economic circumstances as a contextual background of this analysis on manufacturing performance. The export-led industrialization policy implemented in the period 1 resulted in the highest level of the GDP growth rate and the growth rate of manufacturing sector and also positively influenced the growth of the TFP with CO_2 emissions. In this period, the growth of the TFP with CO_2 emissions over time was tenfold than the growth of the TFP without CO_2 emissions. The TFP environment over time in the period 1 also shows positive moderate growth.

Considered as immediate post-economic crisis period and the beginning of democratic reforms during the period 2, the growth of the TFP with CO_2 emissions over time was the highest. At the same period, the decline of average GDP growth and the growth rate of manufacturing sector from the previous period have resulted in the negative growth of TFP without CO_2 emissions. Meanwhile, the TFP environment over time in the period 2 also exhibited the highest growth, even surpassing the TFP with CO_2 emissions over time. The remarkable achievement of environmental measure in this period is consistent with the notable increase of the manufactures exports' share to merchandise export and the share of high-technology exports to manufactured exports.

Period 3 is regarded as a period of politically significant transitional moments, and the government of Indonesia began to remove subsidies for oil commodities. During the period 3, the growth of TFP with CO_2 emissions over time dropped sharply compared with the previous period. Several sectors, particularly for the high energy-intensive sectors, are negatively affected by the increase in prices of oil commodities. The TFP with CO_2 emissions over time of the high energy-intensive sectors such as food and beverages, textiles and its related industry, chemicals and chemical product, rubber and plastics product, and other nonmetallic mineral product sectors present considerable decline in this period. Only basic metal sector shows an insignificant decrease. The effort in reducing CO_2 emissions seems to have further pressures due to the increase in prices of oil commodities. A similarly worsened performance was also experienced by the TFP environment over time as the growth dramatically declined to reach a negative level. In contrast, TFP without CO_2 emissions over time indicated a positive growth. Almost all of the sectors show a notable increase of this TFP, except for textiles and wearing apparel sectors. Despite the increase in energy costs, the growth rate in the manufacturing sector increased from the previous period. The possible conditions and measures taken by manufacturing sectors in this period are as follows: energy intensity is high, no investment for new clean technology, or firms pay the increase of energy cost.

Furthermore in the period 4 when the global financial crisis took place, the growth of all TFP over time demonstrated remarkable increase compared with the period 3. Compared to the previous three periods, the growth of TFP without CO_2 emissions over time was the highest in this period even though the level of growth was still lower than the TFP without CO_2 emissions over time. At the same time, the TFP environment over time has also grown at the level as equal as to that in the period 1. The possible conditions and measures taken by manufacturing sectors in this period are fuel switching, energy saving, and investing for new technology. The economic and political policies implemented by the government during this period were able to address the adverse effects of the global financial crisis in Indonesia, particularly in the manufacturing sector. Overall, it is observed that the TFP with CO_2 emissions over time has grown faster than the TFP without CO_2 emissions for the periods 1, 2, and 4. The faster growth of the TFP with CO_2 emissions over time is consistent with Domazlicky and Weber (2004), Färe et al. (2001), and Kumar (2006) that suggested that when accounting for changes in pollutions as undesirable outputs, the average productivity growth is higher than the growth ignoring pollutions. The TFP with CO_2 emissions over time lower than the TFP without CO_2 emissions was observed in the period 3. However, in general, the manufacturing sector showed the best performance in the period 4, characterized by the positive

Table 9.8 Sectors that have been ready for carbon tax implementation

No	Sector	TFP environment	
		Period 3	Period 4
1	Food products and beverages	1.0109	1.0279
2	Wearing apparel	1.0109	1.0243
3	Tanning and dressing of leather	1.0021	1.0426
4	Wood and products of wood and plaiting	1.1029	1.0327
5	Paper and paper products	1.0032	1.069
6	Publishing, printing, and reproduction	1.0032	1.0807
7	Basic metals	1.0336	1.1103
8	Machinery and equipment	1.0201	1.0102
9	Motor vehicle, trailers, and semitrailers	1.0084	1.0152
10	Other transport equipment	1.0361	1.0209
11	Furniture and manufacturing	1.0157	1.0042

growth level for all TFPs, including the positive growth level of its component, efficiency change, and technological progress. Efficiency change is the source of productivity growth in the periods 1 and 2, whereas technical progress is the basis of productivity growth in the periods 3 and 4. The higher productivity growth with CO_2 emissions provides a clear suggestion to policy makers that environmental damages can be considered in economic and manufacturing developments.

Considering the potential impact of carbon tax implementation on manufacturing sector in Indonesia, several sectors are indicated to have been preparing for the implementation. Table 9.8 shows several sectors that are ready for carbon regulations based on the positive growth of TFP environment in the periods 3 and 4 after the increasing price of oil commodities. In particular, 11 outstanding sectors have been noted to be the best performing sectors which show the positive response to the changes in prices of oil commodities by maintaining the positive growth of TFP environment. Even though in general the increase price of oil commodities has greatly affected the high energy-intensive sectors, food products and beverages, paper and paper products, and basic metals demonstrate that the impact has been well managed.

9.3 Carbon Abatement Cost

When a manufacturing firm produces some desirable products, undesirable products are commonly also produced as by-products of production processes. Traditional production theory does not model joint production of desirable and undesirable outputs. Efficiency measurement only considered desirable outputs. Färe et al. (1989) established the basis for an extension of the traditional analysis of efficiency to consider undesirable output. They took into account the impact of environmental regulation on firm's performance by considering different assumptions on the disposability of undesirable outputs. Chambers et al. (1998) introduce directional distance function approach, which is the extension of Shephard's input and output distance function, providing a basis for representing the joint production of desirable and undesirable outputs. The flexibility of this representation of the technology is a remarkable feature that enhances its usefulness in policy-oriented applications. One of the advantages of the directional distance function is that it helps in measuring not only environmental efficiency but also pollution abatement cost arising from environmental regulation. Moreover, time-consuming, costly survey, and data collection from all firms are not necessarily needed when we want to analyze a pollution abatement cost.

Hernandez-Sancho et al. (2000) applied the methodological approach to measure efficiency impacts on firm performance in several scenarios related to environmental regulation and found that firms would have to sacrifice important amount of potentially desirable outputs in order to reallocate inputs into waste reduction. Mandal and Madheswara (2010) employed directional distance function in measuring environmental efficiency within a joint production framework of both desirable and undesirable outputs. The empirical results show that when faced with environmental regulations, a firm has the potential to expand desirable output and contract undesirable output with the given inputs. Färe et al. (2001) interpreted the cost of regulation as the foregone output for diverting some of the productive resources toward pollution abatement activities. Picazo-Tadeo et al. (2005) also define the cost of regulation in terms of lower feasible expansion of good output resulting from environmental regulation that prevents free disposal of undesirable outputs. Mandal and Madheswara (2010) argue that a regulation has a potential cost in terms of lower feasible expansion of desirable output as compared to the unregulated scenario.

This chapter put an assumption that it can ideally consider several environmentally hazardous elements, generated by manufacturing sector, as a vector of different kinds of solid, liquid, and air pollutions with CO_2 being the most important element of it. Therefore, under the ceteris paribus condition, the increase of CO_2 emissions must increase in environmental degradation. In the absence of any information about the other relevant components, as it can be easily understood, ceteris paribus is not an invalid assumption in this regard. So, in our opinion, reducing CO_2 emission could be termed as environmental efficiency. Table 9.9 presents the average carbon abatement cost of manufacturing sector as a foregone profit of a manufacturing firm to reduce CO_2 emissions for all periods in US dollar per ton CO_2. The data used in the estimation of average carbon abatement cost are presented in Table 9.3. Values added to manufacturing production and CO_2 emissions are also considered to be the proxies for desirable and undesirable outputs, respectively, whereas capital, labor wages, and raw materials are also considered as inputs.

When the export-led industrialization policy was implemented in the period 1, the average carbon abatement cost of the manufacturing sector is 430.99. It is observed that the average carbon abatement cost has constantly decreased since the beginning of the period 1. However, the average carbon abatement cost suddenly increased from the middle of the period 1. The sector that shows the highest average

Table 9.9 The average carbon abatement cost of Indonesia's manufacturing sector for all periods, in US dollar

Sector	Periods			
	1990–1995	1998–2000	2003–2006	2008–2010
Food product and beverages	70.96	41.14	109.70	138.69
Tobacco	3408.38	2596.82	3445.35	4110.90
Textiles	150.71	77.07	1188.18	489.46
Wearing apparel	589.72	385.86	414.51	754.16
Tanning and dressing of leather	604.79	733.04	88.08	513.52
Wood and product of wood and plaiting	168.93	133.50	521.09	448.25
Paper and paper product	503.75	232.28	1220.33	1011.38
Publishing, printing, and reproduction	338.46	143.33	391.48	528.31
Chemicals and chemical product	194.66	216.18	364.80	509.53
Rubber and plastics product	63.51	26.77	84.53	129.07
Others nonmetallic mineral product	207.61	117.27	93.73	129.48
Basic metals	200.98	183.12	359.36	171.79
Fabricated metal product and equipment	197.55	206.14	270.01	715.80
Machinery and equipment	1178.82	303.86	298.87	757.26
Electrical machinery and apparatus.	316.58	293.35	837.01	1462.83
Motor vehicle, trailers, and semitrailers	956.11	313.57	436.48	713.18
Other transport equipment	418.34	298.82	851.89	1623.64
Furniture and manufacturing	298.33	208.56	1529.72	1899.49
Sector average	430.99	306.86	419.72	495.81

carbon abatement cost is tobacco (3408.38) and the sector that presents the lowest average carbon abatement cost is rubber and plastics product (63.51).

During the period 2 as the immediate post-economic crisis period and the beginning of democratic reforms, the average carbon abatement cost of the manufacturing sector is 306.86. The average carbon abatement cost in the period 2 decreased by 28.8 % from the previous period. The sector with the highest average carbon abatement cost is tobacco (2596.82), and the sector with the lowest average carbon abatement cost is rubber and plastics product (26.77).

Period 3 is regarded as the period of politically significant transitional moments, and the government of Indonesia began to remove subsidies for oil commodities. As the consequence of the removing subsidies, the price of oil commodities increased. During the period 3 the average carbon abatement cost of the manufacturing sector is 419.72 which increased 36.77 % from the period 2. The sector that shows the highest average carbon abatement cost is tobacco (3445.35), and the sector with the lowest average carbon abatement cost is rubber and plastics product (84.53).

Furthermore in period 4, when the global financial crisis took place, the average carbon abatement cost of the manufacturing sector is 495.81. The average carbon abatement cost in the period 4 increased by 18.12 % from the period 3. The sector that exhibits the highest average carbon abatement cost is still tobacco (4110.90), and the sector with the lowest average carbon abatement cost is rubber and plastics product (129.07).

In general, the average carbon abatement cost of manufacturing sector from 1990 to 2010 presents moderate fluctuation due to the economic and political policies implemented by the government which strongly influenced the manufacturing sector performance. In the periods 1 and 2, when the price of oil commodities was still subsidized by the government, the manufacturing sector on average has to give up 430.99 US dollar and 306.86 US dollar of its profit to abate 1 ton of CO_2 emissions, respectively. When the price of oil commodities increased in the period 3, on average, the manufacturing sector will allocate 419.72 US dollar of its profit to reduce 1 ton of CO_2 emissions. Furthermore, 495.81 US dollar are required if the manufacturing sector aims to cut 1 ton of CO_2 emissions in the period 4. The increase of efficiency and average carbon abatement cost might be associated with the conditions that firmly increase the production of desirable outputs but reduce less CO_2 emissions; no new technology investment, or the technology improvement does not have any significant impact on CO_2 emissions reduction. The fluctuation of this average carbon abatement cost is consistent with the trend of value added because the measurement of carbon abatement cost is based on forgone profit and the amount of CO_2 emissions.

Based on the sector-by-sector analysis, there is no empirical evidence that the high energy-intensive sectors (food products and beverages, textiles, chemicals and chemical products, other nonmetallic mineral products, and basic metals) have higher average carbon abatement cost for all periods. The sector that has the lowest average carbon abatement cost for all periods is rubber and plastics product. The conditions that may explain the lowest average carbon abatement cost are that rubber and plastic product sector increases the production of desirable outputs and simultaneously reduces more CO_2 emissions. On the contrary, the sector that demonstrated the highest average carbon abatement cost is tobacco. As the majority of cigarette industry in Indonesia still applies a handmade production, technology improvement might be rarely required. Because most of the CO_2 emissions are not generated from its main production processes, the cost to reduce CO_2 emissions in tobacco sector is expensive.

The measurement of average carbon abatement cost provides an obvious description of which sectors have a greater burden of reducing CO_2 emissions during its production process. The average carbon abatement cost of each sector which resulted in this study might be different from other literature due to the method and approach applied. The type of technology used, the sort of energy consumed, or the efficiency measure taken could be the main cause of the amount CO_2 emissions. In the future, if the trend of declining carbon intensity can be maintained and value added can be improved, the average carbon abatement cost can be continually decreased.

9.4 Conclusion

This chapter provides a baseline analysis of TFP growth over time with and without considering CO_2 emissions and the estimation of carbon abatement cost of manufacturing sector from 1990 to 2000. Regarding the current data problems and the missing key variable data, the cleaned and balanced panel datasets are constructed only for four periods: 1990–1995, 1998–2000, 2003–2006, and 2008–2010. The employment of the four periods of the cleaned and balanced panel datasets enables to evaluate the impact of the policy implemented or economic circumstance during each period. An assumption that undesirable outputs are weakly disposable is taken because Indonesia has not implemented carbon regulations.

The main findings of this paper can be summarized as follows. First, on average, the TFP with CO_2 emissions over time has grown faster than the TFP without CO_2 emissions particularly for the periods 1, 2, and 4. The increased price of oil commodities might affect environmental productivity. Second, the increased price of oil commodities might affect environmental productivity, in particular, for the high energy-intensive sectors. Third, 11 sectors are identified to be ready for the implementation of carbon tax based on the positive growth of TFP environment in the periods 3 and 4 after the increasing price of oil commodities. Fourth, the average carbon abatement cost has increased as the price of oil commodities increased, particularly in the period 3. Fifth, the sector that has the lowest average carbon abatement cost for all periods is rubber and plastic product, and the sector that demonstrated the highest average carbon abatement cost is tobacco. There is no empirical evidence that the high energy-intensive sectors have higher average carbon abatement cost for all periods.

The results suggest that CO_2 emissions as undesirable outputs can be considered in measuring manufacturing sector's productivity growth as a response to the climate change mitigation policy. At the same time, technological improvement is expected to be a major concern for the manufacturing firms' long-term strategic planning after the changes in prices of oil commodities. Hence, the share of manufacturing sector to Indonesia's GDP and more job opportunities can be well maintained in the future.

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Chapter 10
Consumer Behavior and Ecolabeling

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Abstract Rapid development of voluntary and mandatory ecolabeling has occurred since the government enacted national standardization in 2000, including mandatory energy-saving labeling schemes (public labels) for compact fluorescent lamps (CFL) and air conditioning (AC). Some top AC producers attached their own energy-saving label (private label) to attract green consumers. Energy efficiency programs challenge certain barriers to its implementation, e.g., phasing out energy subsidies and encouraging consumers to utilize energy efficiently. To understand how consumers react to the energy efficiency labeling applied to AC products, this chapter reviews some policies carried out and some barriers faced by the government on the ecolabels and energy conservation through energy efficiency labeling scheme and presents a case study of consumers and preferences toward AC products conducted in Greater Jakarta. The study revealed that the main decision-makers regarding electronic household appliances are mainly adult males with advanced education and high income who live in a house without split AC installed but have the intention to purchase it. Brand of origin, guarantee, and public and private labels have positive impacts on consumer preferences in buying AC products. Implementation of a public label can improve the marginal utility of potential consumers living in either high-penetration AC markets or low-penetration AC markets who have a high intent to buy. Both public and private labels have good synergy, which improves consumer preferences in buying split AC when the labels are implemented together with an energy subsidy removal policy. On average, willingness to pay for AC products with public and private labels is approximately 378 USD and 163 USD, respectively. Both labels in the market can generate a potential total social economic value of approximately 635 million USD and 274 million USD, respectively. Subsidy removal will increase the values by 36 % and 81 %, respectively.

Keywords Energy conservation • Energy efficiency • Ecolabeling • Air conditioner • Willingness to pay • Economic valuation • Greater Jakarta • Indonesia

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10.1 Current Policy Developments of Ecolabels

The Government of Indonesia (GoI) has established voluntary and mandatory ecolabel schemes to attract green consumers and conserve and sustain the environment and energy resources. The ecolabel schemes involve labeling and certification being awarded to a product that meets specific Indonesian national standards (SNIs) for a specified product category, including forest and agriculture, electronic household appliances, and construction.

The government has accelerated development of ecolabeling by endorsing the National Standardization Regulation, mandating the establishment of a National Standardization Agency in 2000 (Indonesia 2000). One of its main functions is to formulate and determine a national standardization system and guide to enhance protection of consumers, businesses, and citizens, in particular for their safety, security, and health, as well as for environmental conservation.

The agency formulates national standards with related technical institutions, based on single or multiple criteria proposed and agreed upon by all stakeholders. The standards will be the basis on which to develop regulations and facilities for labeling and certification compliance for registration, quality testing, verification, coaching, and monitoring. To carry out quality testing and verification, GoI established a national accreditation committee (KAN), which is responsible for authorizing independent accreditation institutions that check and verify whether a product fulfills the given standards and quality. It also appointed assessment and testing institutions to conduct laboratory tests as one of the requirements before releasing ecolabel certification.

10.1.1 Multi-criteria Ecolabels

Initially, ecolabels were developed as a voluntary movement to answer global concerns regarding how to address environmental issues while maintaining sustainable development. The labels assess the comprehensive throughput life cycle of a product (GEN 2004), from raw material procurement, the production process, distribution, sales, and marketing to product usage and recycling. They are issued based on a verification process, either carried out by a third party (Type I) in compliance with ISO 14024 with multiple criteria or self-declared by the producer (Type II) for single-criteria fulfillment with ISO 14021 (ISO 2012). So, in purchase decision-making, they can help consumers identify environmentally friendly products or those that are less harmful to the environment. Another environmental declaration, named ecolabel Type III, was created to accommodate quantified environmental information on a predetermined basis, as defined in ISO 14025 (ISO 2012). Its main purposes are to support primarily business-to-business communication and to make comparison between products that have similar functions and purposes easier.

Fig. 10.1 Two types of ecolabels in Indonesia (Source: Ministry of Environment)

The first two types of ecolabel have been deliberated on and developed over the last decade in Indonesia. However, the implementation of these ecolabels seems to be slightly slow in progress because there is no strong regulation or guidelines in the market. Because of this, the Ministry of the Environment (MoE) created Regulation No. 2 Year 2014 to strengthen the general guidelines for ecolabels developed by KAN No. 800–2004. It regulates how to attach ecolabels on products, following the implementation of Law No. 32 Year 2009 regarding environmental protection and management. The labels declare that a product has complied with certain environmental aspects, including raw material and resource procurement, the production process, distribution, product usage, and/or product disposal.

Currently, there are two different types of labels, as shown in Fig. 10.1 (MoE 2014), “Ekolabel Indonesia” (Type I) and “Ekolabel Swadeklarasi Indonesia” (Type II). The “Ekolabel Indonesia” is granted to a product that has been certified by an ecolabel certification institution accredited by KAN. “Ekolabel Swadeklarasi Indonesia” is awarded to a product based on a verification result that is conducted by a verification institution registered in MoE for one or several specific environmental aspects claimed by producers, importers, distributors, retailers, trademark owners, or other interested parties.

10.1.2 Single-Criteria Ecolabel for Energy Efficiency

Indonesia has changed its paradigm from one that concerns with supply-side management to one that focuses to a larger degree on demand-side management to address some challenges, such as increasing energy demand, energy price volatility, and inefficient energy usage, by developing policy and implementing programs regarding energy conservation (IEA 2014). These energy conservation measures are to fulfill certain objectives in the national energy conservation master plan (RIKEN), which was initially created in 1995 and revised periodically (BAKOREN 2005). It seeks to lower energy intensity on average by 1 % per year through 2025 by finding energy-saving potential for the top energy-consuming sectors, including targets for the residential sector between 15 and 30 % and for the commercial sector between 10 and 30 % (DEN 2014). Additionally, it was planned to achieve energy elasticity of less than 1 % in 2025, as stated in President Regulation no. 5 Year 2006 regarding national energy policy (Indonesia 2006), by optimizing the energy mix in 2025 to reduce the share of fuel to less than 20 % and increase the share of other types of energy sources.

The energy conservation programs received greater attention and support after the government enacted Law No. 30/2007 regarding the development of an institutional framework for making energy policy as well as supporting an energy conservation plan. It mandates the formation of a national energy council (NEC), which was established in 2008, to formulate national energy policy (NEP). Based on the formulated NEP, the government established a National Energy General Master Plan as a basis for the National Energy Conservation Master Plan. The law regulates that all stages of energy management have to accommodate energy conservation and utilize existing energy sources efficiently. Therefore, implementation of the law encourages the government and citizens to conserve energy for downstream and upstream activities and provides incentives and disincentives to support the implementation of energy efficiency and conservation programs.

The government created Regulation No. 70 in 2009 to further explain how energy conservation will be implemented in general, as mandated by the law. The regulation defines the responsibility for all stakeholders in energy conservation, all stages of energy conservation activities, energy efficiency standards and labeling, providing information and consultative services on energy efficiency, giving incentives and disincentives, and the direction and supervision of industries and commercial sectors including energy audits. Then, the Minister of Energy and Mineral Resources issued regulations to offer guidance for implementing and executing the government regulations in the market.

Moreover, the government established a new Directorate General of New Renewable Energy and Energy Conservation (DGNREEC) in 2010 under the Ministry of Energy and Mineral Resources (MEMR) to accelerate the development and implementation of energy conservation policies. The current roles and responsibilities of the DGNREEC are mainly to formulate and coordinate policy, strategy, guidelines, and technical assistance for new/renewable energy and national energy conservation programs as well as energy efficiency standards and labeling. The National Energy Conservation Master Plan formulates policies related to the DGNREEC (APEC 2012), such as establishing energy efficiency targets, increasing social awareness on efficient energy usage and behavior, implementing energy management, and applying efficient technology and energy systems, as well as providing incentives to suppliers and users of efficient appliances and equipment. Afterward, those policies are realized in 20 strategic programs, including programs to develop mandatory minimum energy performance standards (MEPS) for industry, building, electronic household appliances, and equipment and to affix labeling for energy-saving levels for the electronic household appliances.

Fig. 10.2 Energy efficiency labels in Indonesia (Reproduced from http://labelhematenergi.ebtke.esdm.go.id/esl/)

The Ministry of Energy and Mineral Resources adopted and developed an additional third-party labeling scheme, the Energy STAR label, that focuses on a single aspect of energy conservation and saving by identifying highly efficient electronic household appliances and equipment, as shown in Fig. 10.2. It is called “Hemat Energy” or energy-saving label, with the number of stars indicating how efficient the appliance is or how much energy can be saved in using the appliance (MEMR 2014a). To phase out inefficient products in the market, it establishes minimum energy performance standards, named SKEM, for electronic household appliances and equipment.

However, the implementation of the labeling scheme has progressed slowly. Currently, energy efficiency labeling has regulated the implementation of mandatory energy-saving labeling schemes for compact fluorescent lamps (CFL) and air conditioning (AC). Energy-saving labels for CFL are implemented in the market with reference to Ministerial Regulation No. 6 Year 2011, which was then revised by No. 18 Year 2014, regarding the application of energy-saving labels for self-ballasted lamps. The energy-saving labels for AC are regulated by Ministerial Regulation No. 7 Year 2015 regarding MEPS implementation and affixing energy-saving labels for air conditioning appliances. For other electrical appliances, the DGNREEC in collaboration with the relevant stakeholders is still developing MEPS based on the Indonesia National Standard (SNI) in addition to determining technical energy performance testing standards (EPTS) for electronic household appliances, as shown in Table 10.1 (APEC 2012).

Table 10.1 SNI standards of electrical appliances and devices

No.	Product	SNI EPTS
1	Ballast (magnetic)	SNI IEC 60929-2009
2	Compact fluorescent lamp (CFL)	SNI IEC 60969-2009
3	Incandescent lamp	SNI IEC 60432-1-2009
4	Room air conditioner – single split wall mounted	SNI 19-6713-2002[a]
6	Household refrigerator	SNI IEC 15502-2009
7	Clothes dryer	SNI IEC 60456-2009
8	Electric iron	SNI IEC 60311-2000
9	Vacuum cleaner	SNI IEC 60312-2009

[a]Adapted from ISO 5151:1994

10.1.3 Criteria for Public "STAR" Label for CFL and Air Conditioning

The current criteria for the energy-saving level for CFL were defined in more detail over a wider range of products (MEMR 2014b) than was the case for previous regulation, as shown in Table 10.2. The criteria are differentiated by the power consumption level and lighting color rating, which previously accommodated a lighting color rating of only 6,500 K. The regulation also clearly defines the responsibilities of all stakeholders, such as governments, producers, importers, and conformity assessment institutions, i.e., laboratories, inspection bodies, and certification bodies.

Recently, the government determined the criteria for the energy-saving level and minimum energy performance standards for air conditioning appliances, in particular for single split wall-mounted appliances with a cooling capacity maximum of 27,000 BTU/h for both inverter and non-inverter types (MEMR 2015). The criteria for the energy-saving level are calculated based on the energy efficiency ratio (EER), which compares the air conditioning capacity (BTU/hour) with power consumption (Watt). The certificate of energy saving verified by product certification institutions declares that the certified appliance has fulfilled MEPS (8.53 EER) with the defined levels of energy saving in Table 10.3. Calculating the EER value for an AC non-inverter is carried out under full operation, while the EER value for the AC inverter is a weighted average of 0.4 EER value under full operation and 0.6 EER value under 50 % operation.

10.1.4 Private "Self-Claimed" Label

In the market, some prominent producers have launched products with new technology related to energy saving and energy efficiency. Monitoring ad materials on TV and Print from Jan 2012 to Jan 2013 indicates that they disclosed the level of energy

Table 10.2 Criteria of energy-saving label for CFL

	Efficacy value (lumen/watt)							
	Kelvin color rating: 2,700–4,440 K				4,400–6,500 K			
Power consumption (watt)	★ (1 star)	★★ (2 star)	★★★ (3 star)	★★★★ (4 star)	★ (1 star)	★★ (2 star)	★★★ (3 star)	★★★★ (4 star)
≤8	<34	≥34	≥44	≥54	<33	≥33	≥43	≥53
>8–15	<38	≥38	≥48	≥58	<37	≥37	≥47	≥57
>15–25	<42	≥42	≥52	≥62	<41	≥41	≥51	≥61
>25–60	<46	≥46	≥56	≥66	<45	≥45	≥55	≥65

Table 10.3 Criteria of energy-saving label for air conditioning

★ (1 star)	★★ (2 star)	★★★ (3 star)	★★★★ (4 star)
$8.53 \leq \text{EER} < 9.01$	$9.01 \leq \text{EER} < 9.96$	$9.96 \leq \text{EER} < 10.41$	10.41 EER

Fig. 10.3 Private "self-claimed" labels in the market

saving and energy efficiency that could be generated by using the new products, and exposed it by attaching private labels on the product packaging and conducting campaigns in the marketplace, as shown in Fig. 10.3. In contrast, the label indicates the total energy that can be saved based on the company's claim and testing with different standards, without verification or a performance test from an independent institution. The utilization of a private label can encourage consumers who are concerned about energy efficiency to buy the privately tested product, but it can also confuse consumers who are trying to compare two products, because of unstandardized saving rates.

10.1.5 Energy Efficiency Label for Green Building

MEMR has also developed a guidance book of energy efficiency for building developers and owners, energy efficiency technical guidelines, and case studies based on SNI building standards that cover four categories (APEC 2012) as follows:

- Building envelope: determining criteria and procedures of building envelope design and energy efficiency standards (SNI 03-6389-2000)
- Air conditioning systems: determining technical calculation, selection, measurement, assessment, and energy efficiency standard (SNI 03-6390-2000)
- Lighting system: providing lighting guidelines for optimal and efficient operation (SNI 03-6197-2000)

– Energy audit procedure: determining procedures of energy audit for office, hotel, shopping center, hospital, apartment, and residential building (SNI 03-6196-2000).

The Jakarta local government implemented a mandatory green building program to create an approach to building maintenance that addressed certain aspects of saving, maintaining, and utilizing efficient resources (City 2012). The regulation strengthens the voluntary green building certification, Greenship, initiated by Green Building Council Indonesia (Hutapea 2014; Jakarta Capital City 2012). It is applied to both new and existing buildings (office, commercial, and apartment) with a total floor size between 10,000 and 50,000 m^2. The criteria for the new building include energy efficiency, water efficiency, air quality, land and waste management, and management of the building during construction. The existing criteria cover energy efficiency and conservation, water efficiency and conservation, air quality, and the operations management of the building. The local government enforces the regulation as one of the requirements to issue a building permit or certificate of building proper function.

10.2 Challenges of Implementing Energy Conservation and Efficiency Programs

The efforts to achieve the target of energy conservation and efficiency are facing barriers that need to be addressed before making progress. The barriers to creating highly efficient technology and to implement energy efficiency programs (IEA 2014) can be categorized into five groups, including the following:

– External barriers: rapid growth in energy demand and energy-supply distraction
– Consumer barriers: lack of intention to utilize energy efficiently and low participation in energy efficiency training
– Regulatory, assessment, and enforcement barriers: lack of policy or regulatory instruments e.g. high-energy subsidies, low capacity for enforcing energy efficiency policy and regulation, limited testing laboratories, and lack of coordination among government institutions
– Private sector barriers: low capacity for defining and developing energy efficiency projects and lack of manufacturing and servicing for energy-efficient products
– Financial barriers: lack of smart financing mechanisms or incentives for energy efficiency projects and limited funding for energy efficiency programs

Low energy prices due to energy subsidies not only increase a country's financial burden but also deter the promotion of energy efficiency measures. Rapid growth in energy-demand and energy-supply difficulties in recent decades has caused total energy subsidies to grow year by year. Although the subsidy from the energy tariff for electricity continues to be removed gradually, the current energy policy of the

Indonesian government still provides it for several segments of electricity customers, including affluent households and small-medium industries. Therefore, the government still allocates a large amount of its budget for energy subsidies, especially for electricity. In 2012, the total electricity subsidy was 10.33 billion USD, approximately 11 % higher compared to the previous year (PLN 2012, 2013). Since 2013, the total subsidy has been reduced by 2 % annually (PLN 2014, 2015).

The number of consumers who are aware of energy saving and efficiency is growing, but they still lack the desire to utilize energy efficiently. As shown in Table 10.4, more than 80 % of consumers are aware that saving electricity means saving energy (BPS 2013). Three out of four of them use efficient lamps in their home to reduce electricity expenses, but one-fourth of consumers still have a little or no intention to utilize electricity efficiently. This is potentially caused by the low electricity price and low participation in any training/consultation regarding electricity saving and renewable energy usage. Therefore, the government needs to address the barriers by phasing out subsidies on energy prices, except where they contribute to social welfare policies, and conducting education campaigns for all potential consumers of electronic household appliances and equipment.

Since the planning of energy conservation and efficiency programs in 1995, the development of related policy and regulations has been slow. The government has tried to address the barriers to regulation, assessment, and enforcement first by enacting the Energy Law in 2007 and Energy Conservation Regulation in 2009 and then by establishing a new directorate for energy conservation. However, there are some challenges that still need to be resolved, especially in implementing energy efficiency labeling (EEL) schemes, such as determining energy efficiency standards, enhancing capacity for enforcing energy efficiency policy and regulation, and developing new testing laboratories. To strengthen coordination among related

Table 10.4 Attitudes of electricity usage

	Province			
Attitudes of electricity usage	Jakarta	West Java	Banten	Total
Agree that saving electricity means saving energy	86.21	80.44	79.21	81.37
Ever participated in any training/consultation regarding electricity saving and renewable energy usage	6.44	4.57	5.50	5.98
Use energy-efficient lamp in house				
All lamps installed	77.47	46.84	56.50	61.09
More than 50 %	14.77	26.48	23.50	23.35
Less than 50 %	3.18	16.57	14.26	9.89
Not use currently	4.58	10.12	5.74	5.67
Have reduced electricity usage	51.65	41.75	36.30	38.23
Save money	95.35	95.04	95.46	93.99
Environmental awareness	3.21	1.74	2.18	1.54
Limited electricity supply	1.44	3.22	2.36	4.47

Source: BPS (2013)

government institutions on energy efficiency, it was recommended to establish a permanent interministerial framework on energy conservation and efficiency (APEC 2012).

To develop capacity in the private sector, the government can develop and strengthen the regulation for supporting wider contributions, especially from domestic energy service companies (ESCO), in energy management by building their capacity (e.g., financing) and certifying their energy managers (APEC 2012). In energy audits, the government can work with the private sector through government-private partnership programs. However, this kind of partnership faces obstacles in financing because the financing capacity of the private sector is low.

The financial barriers that pose a challenge to energy efficiency programs can be resolved by facilitating investment from the private sector in energy efficiency by collaborating with financial institutions in developing innovative financing instruments and creating expertise in energy efficiency project financing (IEA 2014). However, this requires policies for financing mechanisms to start energy efficiency projects and to provide soft loans, specialized credit lines, guaranteed funds, and revolving funds from commercial or developing banks (Hutapea 2014). The government also needs to provide up-front financial incentives for energy projects, for example, special taxation reform (APEC 2012).

10.3 Consumer Behavior and Preference Toward Environmental Issues and Energy Efficiency Labeling

One case study is presented in this chapter to provide other insights regarding attitudes and behavior toward recent environmental issues and energy efficiency labeling, as well as possible changes in the purchasing behavior of urban consumers in response to a hypothetical case in which an authorized energy efficiency labeling scheme is introduced. The study is focused on the most important home appliances, air conditioner product category, that consume large amounts of electricity (JICA 2008; Hilmawan 2011). It is based on primary data from a consumer behavior and preference survey that was conducted in greater Jakarta in July 2013 and included 360 face-to-face interviews with the main decision-makers for electronic household appliances, representing 3.3 million decision-makers in the population of the region living in a household with a electricity capacity between 900 and 2,220 AV.

10.3.1 Profiling of Respondents by Split AC Ownership and Purchase Intention

Regarding AC ownership and purchase intention, the respondents can be divided into three groups, existing users only, existing and potential users, and potential users only. The existing users only represents 0.8 million main decision-makers of household appliances who installed split AC in their house but have no intention to purchase new split AC in the next 1 year. The existing and potential users stand for the decision-makers who owned split AC in their house and intent to purchase new split AC in the future, with its population about 0.4 million. While the potential users only describe consumer segment that have not owned split AC but plan to purchase split AC in the future. This group has the biggest population approximately two million in the market place.

According to Table 10.5, obviously only the segment of potential users only has different demographic features compared to both existing users only and existing-potential users. Generally, the decision-makers of this segment are in middle age, mainly 30–39 years old, and with middle education, i.e., at least a high school. They have a tendency to work in the nonformal sector, e.g., blue-collar jobs, and have a low personal income.

On the other hand, the other segments of existing users only and existing and potential users have similar characteristics; in particular, they are seniors and have a high education level. With regard to gender, the decision-makers of the existing and potential user segment are likely males who work in formal sectors with high income. On the contrary, in the segment of existing users only, there is a tendency for the main decision-makers to be females who neither work nor pay for household appliances owned.

Regarding the household figure, both the existing user only and existing and potential users segments have similar characteristics, especially in terms of a higher monthly income and expenditures for daily needs, groceries, and electricity. Their monthly household income is larger by more than 10 % compared to all respondents. Their regular expenditures for daily needs and groceries are more than 1.16 times higher than those for all respondents. In addition, they consume 40 % more electricity than all respondents.

10.3.2 Attitudes Toward Environmental Issues

The decision-makers of the target households generally have large concerns for environmental issues, considering their responses towards six mainly concerned statements on global climate change and other environmental issues (Ward et al. 2011). Figure 10.4 confirms that the average scores (scale 1–6) of all statements are more than 4, meaning they agree with and support the statements related to environmental issues. Respondents give a higher score (on average more than five point) for statement 4 (science and technology will come up with effective

Table 10.5 Households profiled by air conditioner ownership and purchase intention

Variables	All	Existing users only	Existing and potential users	Potential users only
Total sample	360	112	70	178
Population '000 (weighted)	3,316	828	421	2,067
Gender (%) Male/female	60/40	50/50	72/28	61/39
Age group (%) 20–29 years old/30–39 years old/40 + years old	7/41/52	5/31/64	7/26/67	7/48/45
Relationship (%) Head of household/housewife/others	66/31/3	60/38/2	76/24/0	66/31/3
Education level (%) Non-university/university	73/27	57/43	57/43	83/17
Occupation (%) Formal/nonformal/not working	60/19/21	58/15/27	87/2/11	56/24/20
Average personal Income in million IDR/month	2.75	2.77	3.90	2.51
Average HH income (MHI) in million IDR/month	4.02	4.45	4.87	3.68
Average HH expenditure (MHE) In million IDR/month	2.96	3.44	3.60	2.63
Average electric spending (MEE) In million IDR/month	0.24	0.35	0.34	0.17
MEE/MHI (%)	5.9	7.8	6.9	4.7

Source: Field survey, all respondents as base (underlined number ≥1.1 times the base)

ways to combat global climate change) and statement 5 (we need more government regulations to force people to protect the environment). This is higher than the other statements, and this indicates strong concern for global climate change and belief in the importance of government regulations to address environmental issues.

Households with electricity capacity of 2,200 VA always give higher scores compared to other capacity groups, except for statement 2. On the other hand, the households with 900 VA have more interest in statement 2, implying that the preference of this group is an indirect message to manufacturers to provide eco-friendly products.

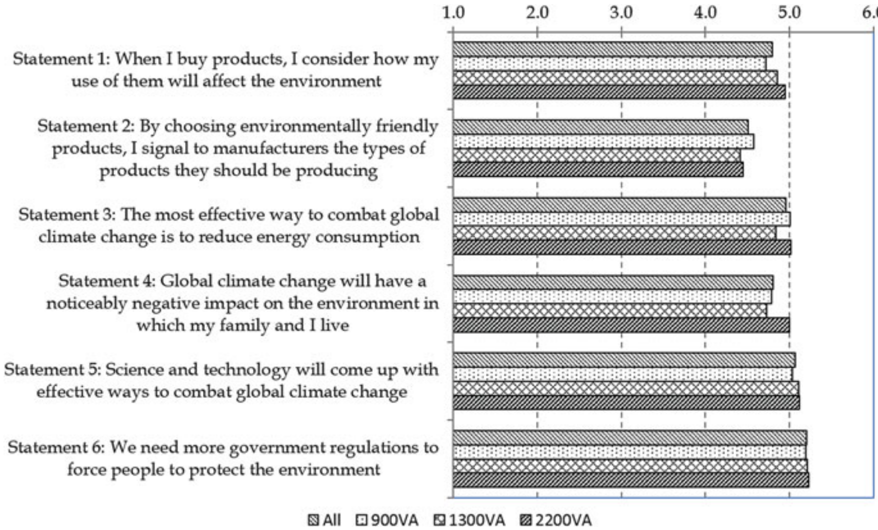

Fig. 10.4 Attitudes toward environmental issues across electricity capacity (Source: Field survey, all respondents as base)

10.3.3 Attitudes Toward the Campaign on the Private Self-Claimed Label

Table 10.6 shows that half of the respondents are aware of the campaigns for energy efficiency and self-claimed labels provided by private companies. The respondents of the households with electricity capacities of 1,300 VA and 2,200 VA are likely to be more aware than all respondents, while the households with electricity capacity of 900 VA have a slightly lower awareness than all the respondents. Among the people who are aware of the campaigns, only half of them pay attention to energy-saving labels promoted by the companies.

More than 60 % of all the respondents believe that the campaigns are motivating them to purchase products with the private label, but only 46 % think that the label can be trusted. Compared to all respondents, the households with electricity capacity of 1,300 VA have a tendency to think that the self-claimed label can be trusted and can motivate consumers to purchase products with the private label.

10.3.4 Attitudes Toward the Public Label and Government Energy Conservation Campaigns

Table 10.7 shows that more than one-third of the respondents are aware of the campaigns for energy conservation programs for energy efficiency and energy saving conducted by the government. Decision-makers in households with

Table 10.6 Attitude to private self-claimed label campaigns

	All	900 VA	1,300 VA	2,200 VA
Total sample	360	120	120	120
Population '000 (weighted)	3,316	1,884	894	537
Campaign of private self-claimed label				
Awareness level (%)[a]	51	45	59	60
Give attention (%)[b]	52	48	57	56
Trusted (%)[a]	46	39	59	51
Motivated (%)[a]	62	58	72	58

Source: Field survey
Underlined numbers ≥1.1 times the base
[a]All respondents as base
[b]Among those who are aware of the issue

Table 10.7 Attitudes to government energy conservation programs

	All	900 VA	1,300 VA	2,200 VA
Total sample	360	120	120	120
Population '000 (weighted)	3,316	1,884	894	537
Energy conservation program, energy efficiency, and energy saving				
Awareness level (%)	36	30	46	42
Public "STAR" label (scoring 5–6)				
Helpful to differentiate products (%)	73	68	80	75
Motivated (%)	74	72	80	73

Source: Field survey, all respondents as base
Underlined numbers ≥1.1 times the base

higher electricity capacities have greater awareness, approximately more than 40 %. The levels, however, are still lower compared to similar campaigns conducted by the private companies, indicating that the government campaigns have lower exposure in the media than the private companies' campaigns.

Regarding the public "STAR" label, more than 70 % of the respondents think that the existence of the label helps differentiate easily between well-performing products and nonperforming products in the context of energy efficiency. In addition, more than 70 % of the respondents consider that the label is also motivating them to choose the product with the label attached. The figures are higher among households with an electricity capacity of 1,300 VA. It indicates that the public label is more trusted and motivated than private label to help the consumers determine and differentiate the efficient product, especially for decision makers who live in middle-class households.

10.3.5 Air Conditioning Usage and Behavior

Focusing on the split AC usage as shown in Fig. 10.5a, almost 70 % of all the existing users have only one room that has been installed with a split AC, especially those in

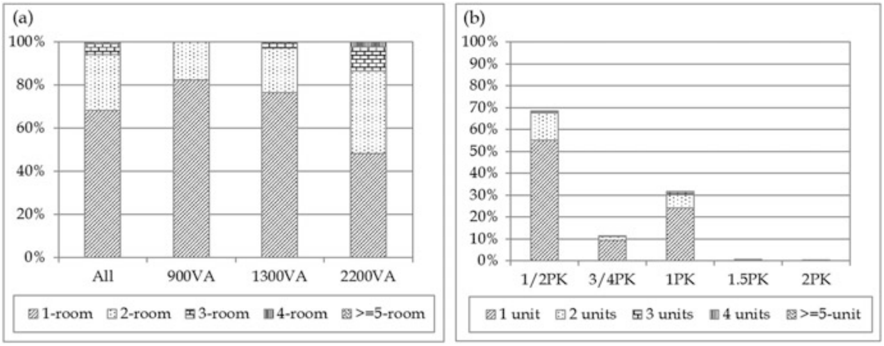

Fig. 10.5 (**a**) Total rooms installed with split AC across electricity capacities, (**b**) total units owned by all respondents across split AC capacities (Source: Field survey, all existing users as base)

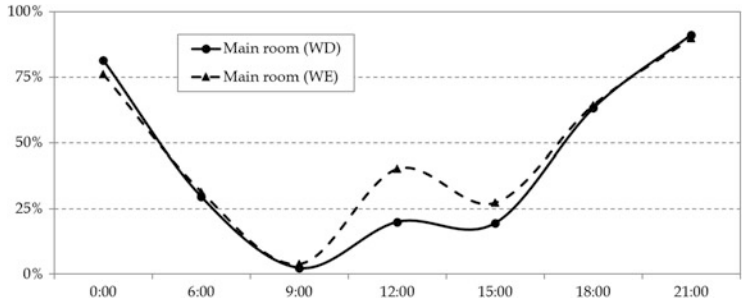

Fig. 10.6 Split AC usage in main bedroom per time band, weekend (*WE*) vs. weekdays (*WD*) (Source: Field survey, all existing users as base)

households with an electricity capacity of 900 VA (82 %) and 1,300 VA (77 %). In contrast, households with an electricity capacity of 2,200 VA commonly have more than one room installed with the split AC. This confirms the previous finding that the households with lower electricity capacity have fewer bedrooms in their house.

Regarding the compressor capacity of the split AC, respondents mainly prefer to own the smallest compressor capacity. Figure 10.5b shows that 1/2PK is the most preferable, as almost 70 % of the existing users prefer to own that capacity. This is followed by 1PK and 3/4PK, which is approximately 32 % and 11 % of the total market, respectively.

The existing users favor using split ACs from evening to morning instead of during the daytime. The peak time is approximately 9pm–11pm, while the lowest usage point is in the morning around 9am–11am. At noontime, there is a small peak but not as high as in the nighttime. The usage has a similar pattern between weekdays and weekends, except during noontime (12pm–2pm), for which the weekend is twice as high as weekdays as shown in Fig. 10.6.

Table 10.8 Average hours (h) and temperature of split AC usage

Split AC usage	Main bedroom	Other bedroom
Average hours/day		
Weekdays	8.41	2.52
Weekend	8.54	2.62
Average temperature (°C)	20.39	20.43

Source: Field survey, all existing users as base

The households usually use the split AC in the main bedroom and in other room on average approximately 8.4 h and 2.5 h per day, respectively. As shown in Table 10.8, during weekdays, the usage for both bedrooms is 8.41 h and 2.52 h and slightly higher during weekends, approximately 8.54 h and 2.62 h, respectively.

The temperature that is commonly set is on average approximately 20 °C. The figures are not different between the types of bedrooms; the main bedroom is set to approximately 20.39 °C, while the other bedroom is set to approximately 20.43 °C. These figures are lower than the regulated temperature for AC usage for households. In 2005, the Indonesian government regulated the setting of AC temperature in households with minimum 25 °C to save energy (MEMR 2005).

10.3.6 Consumer Preference Toward Energy Efficiency Labels

To understand how the consumer preference changes toward product attributes and energy conservation policy, hypothetical choice experiment was carried out to find out the impact of main attributes such as country brand origin, year of guarantee, energy efficiency labeling and price, and also the effect of electricity price increase and air conditioner capacity. Then utility model estimation was performed on NLogit software as shown in Table 10.9.

As expected, all main attributes excluding price positively affect to consumer preference. Both energy efficiency labels, the public "STAR" label and the private "self-claimed" label, have a significantly positive impact on the consumer preference. Individually, the STAR label and company self-claimed label have an impact of approximately 1.536 and 0.594, respectively. In addition, country brands reflecting product quality also have positive impact to improve the consumer preference, as well as the number of years of guarantee. In contrast, the implementation of electricity price hikes, which can potentially make the consumer preference decrease by 0.723 point.

Regarding the sociodemographic and attitudes, consumers who are graduated from university and living household with higher monthly electricity expense in the southern area have higher preference to purchase AC in the next 1 year. Furthermore the consumers who are aware of energy-saving campaign held by AC producers are more likely to have higher preference to purchase AC. Being aware of

Table 10.9 Summary of NLogit estimation for parameters of the mixed logit model

Variables	Estimate		t-value
Main attributes			
Price	−0.364	***	−2.774
Constant	3.736	**	2.165
Country B brands	0.744	***	6.327
Country C brands	0.646	***	5.283
Country D brands	0.044		0.329
Number year of guarantee	0.132	***	2.643
Public label (R)	1.536	***	5.282
Private label (R)	**0.594**	***	**3.291**
Demographic, socio, economic, attitudes			
Energy price increase	−0.723	**	−2.096
AC compressor capacity (ACCC)	0.002		0.041
Male	−0.991	***	−2.687
Age	−0.039	**	−2.147
University	1.920	***	3.191
High electricity capacity (2200AV)	−3.007	***	−4.314
Monthly household income	−0.010		−0.059
Monthly electricity expenses	14.483	***	4.870
Living in south area	3.781	***	5.595
Existing and potential user	0.642		0.957
High potential nonuser	1.358	***	2.775
Less potential nonuser	0.383		0.622
Aware of company energy-saving campaign (CESAware)	0.963	***	2.829
Aware of government energy conservation Campaign (ECC Aware)	0.304		0.946
Global climate change Preference	−0.111		−0.566
Eco-friendly product preference	−0.952	***	−5.131
Interactions			
Public label × energy price increase	0.495	**	2.311
Public label × ACCC	−0.010		−0.349
Public label × ECC aware	0.271		1.484
Public label × south area	−1.022	***	−4.911
Private label × energy price increase	0.482	*	1.918
Standard deviation of random variables			
Public label	0.704	***	3.854
Private label	0.563	**	2.254

The parameters are estimated based on the NLogit software
(R) Random Variables distributed normally
*** 1 % significance level, ** 5 % significance level, * 10 % significance level

energy conservation campaign conducted does not motivate the consumers to purchase AC. On the other hand, the main decision-makers, who are male with older age, probably have less preference to buy AC, as well as who concern about eco-friendly product.

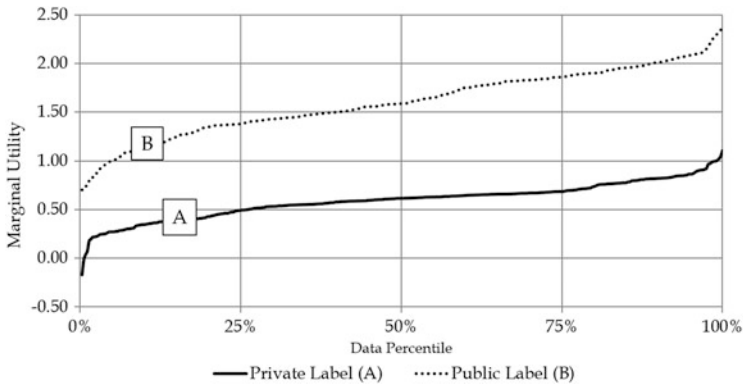

Fig. 10.7 Distribution of conditional parameter estimates for both EEL schemes (Source: Field survey and model estimation from NLogit Software)

The consumer preference toward AC product attached with both public and private labels is going higher if the government decided to increase electricity price by 15 %. As shown in Table 10.9, interaction between public label and electricity price increase could improve the consumer preference by 0.495 point, higher than the interaction between private label and electricity price.

Beyond any interactions, Fig. 10.7 indicates that the impact of the public label is approximately 2.5 times higher compared to that of the private label. The impact gap between the EEL schemes becomes wider over a larger data percentile. Considering the standard deviation as a random variable, the effect of the public label deviates normally within the range of 0.699 to 2.355, while the private label impact is within the range of -0.172 to 1.105.

In addition, the model reveals that there is only a significant negative interaction between public label and the southern area. Based on the conditional parameter estimate as summarized in Table 10.10, In all areas, the public label impact is approximately 1.438 and within the range of 0.533–2.189. The implementation of the public label in the northern area would keep the individual marginal utility stable at an average of approximately 1.604 points, but in the southern area, this will make the marginal utility decrease on average by approximately 0.581 points. The interaction between the private label and the southern area is not included in the model because it assumes that the private label provides equal marginal utility among people living both in the northern and southern areas, for an average of approximately 0.592, which is slightly higher than the impact of the public label in the southern area.

Although the impact of the private label in general is higher than the public label in the southern area, both labels cross at the 56 % data percentile point, as displayed in Fig. 10.8. This means that 56 % of total consumers with lower marginal utility are likely to give higher preference to the private label than the public label. On the other hand, the public label would likely have a higher impact than the private label among 44 % of the total population who have a higher marginal utility.

Table 10.10 Summary of marginal utility of EEL schemes by area, based on conditional parameter estimates

Marginal	Private	Public label		
Utility	Label	All	North	South
Mean	0.592	1.438	1.604	0.581
StDev	0.185	0.337	0.337	0.337
Min	−0.172	0.533	0.699	−0.324
Max	1.105	2.189	2.355	1.332

Source: Field survey and model estimation from NLogit Software

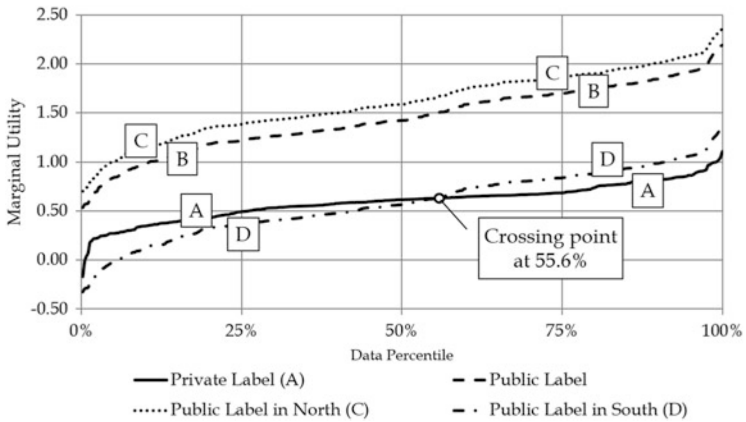

Fig. 10.8 Distribution of marginal utility for EEL schemes by area, based on conditional parameter estimates (Source: Field survey and model estimation from NLogit Software)

To generalize the impact of both EEL schemes to the population, we utilized unconditional parameter estimates, which are based on the generated data from a normal distribution with a mean and standard deviation of the respective EEL scheme. Figure 10.9 shows that under the assumption of both EEL schemes as random parameters, the crossing point between the private label and public label in the southern area is shifting to the 68 % point. Therefore, in general, in the southern area, the public label only has a higher impact than the private label among 32 % of the total population for potential or existing consumers of the split AC product.

The model indicates also that both EEL schemes and the scenario of an electricity price increase interact positively to enhance consumer preferences. In the same way, these positive interactions reject the hypothesis that the public label and energy subsidy work independently to influence consumer preferences and suggest that both policies could be implemented simultaneously with less concern for creating a decline in consumer preferences. The impact of an electricity price increase to the public label is slightly higher than to the private label, approximately 0.495 and 0.482, respectively.

Figure 10.10 shows that the electricity price increase shifts the lines of the unconditional parameter estimate mostly to the positive zone. This means that if the government removes the energy subsidy by increasing the electricity tariff by 15 % per year, all consumers would give positive marginal utility to a product

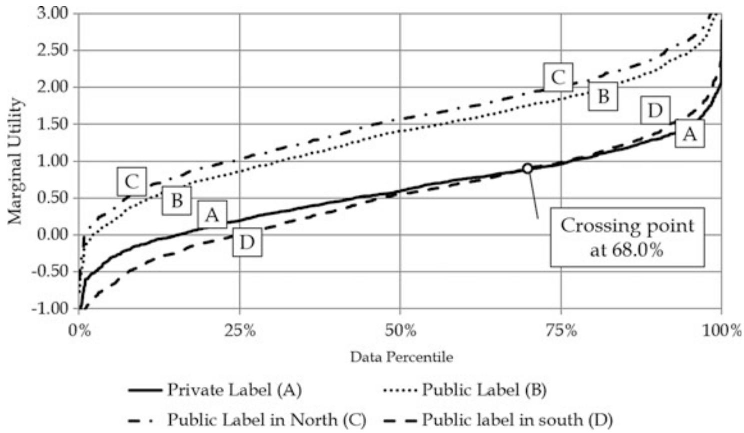

Fig. 10.9 Distribution of marginal utility for EEL schemes by area, based on unconditional parameter estimates (Source: Field survey and model estimation from NLogit Software)

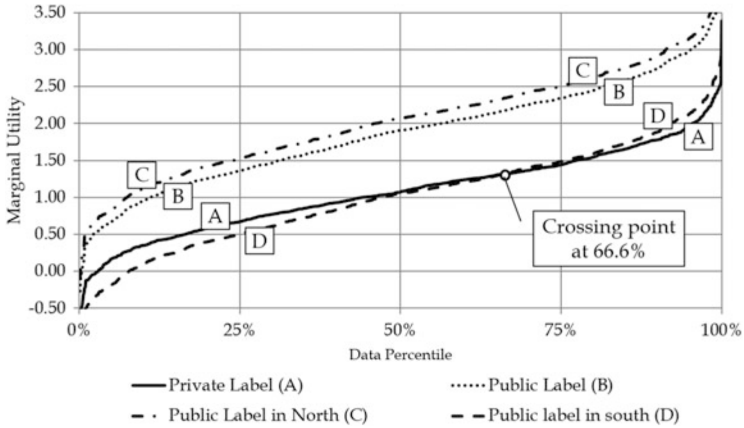

Fig. 10.10 Distribution of marginal utility for EEL schemes by area with electricity price increase, based on unconditional parameter estimates (Source: Field survey and model estimation from NLogit Software)

attached with either a public label or private label. However, the impact of public labels on a change in consumer preferences is higher than the private label. This policy also moves the crossing point to 66.6 %, meaning that, generally, 1.4 % of consumers who previously preferred to buy products attached with a private label change their mind and choose the product with the public label.

10.4 Potential Ecolabel Enhancement by Consumer Behavior Change

Under the assumption of both EEL schemes as random parameters, this study calculated a distribution of marginal WTP for each EEL scheme by area and electricity price increase, as summarized in Table 10.11. The marginal WTP of the public label is on average approximately 378 USD per potential consumer and within the range of −209 USD to 940 USD. In the northern area, the public label could generate even higher marginal WTP of approximately 423 USD per potential consumer. However, the marginal WTP becomes smaller if implemented in the southern area, falling to approximately 142 USD. The latter figure is lower than what the private label can generate, which is approximately 163 USD per potential consumer and within the range of -411 to 799 USD.

The implementation of the subsidy removal makes the generated marginal WTP increase across all EEL schemes by a similar incremental level of approximately 133–136 USD. The marginal WTP of the public label in total would increase to approximately 514 USD per potential consumer. In the northern area, it could expand to approximately 559 USD per potential consumer, while in the southern area, it only increases to 278 USD per potential consumer. The marginal WTP of the private label would rise to 296 USD per potential consumer.

Under the assumption of both EEL schemes as a random parameter, Table 10.12 shows that the total social economic value (SEV) of the public label is approximately 635 million USD. This comprises the total SEV in the southern and northern areas, which are approximately 39 million USD and 596 Million USD, respectively. The total economic value of the public label is more than twice as much as the total SEV generated by the private label (274 million USD).

The energy subsidy removal on which the government increase electricity price by 15 % annually could enhance significantly the total SEV generated previously by all EEL schemes. The total SEV generated by the private label would increase by 81 % to 497 million USD. The public label could increase total SEV by 36 % to

Table 10.11 Summary of marginal WTP for EEL schemes by area and electricity price increase, based on unconditional parameter estimates

	Marginal	Private	Public label		
	WTP (USD)	Label	All	North	South
Without subsidy removal	Mean	163	378	423	142
	StDev	154	192	192	192
	Min	−411	−209	−164	−445
	Max	799	940	985	704
With subsidy removal	Mean	296	514	559	278
	StDev	154	192	192	192
	Min	−279	−73	−28	−309
	Max	932	1,076	1,122	840

Source: Field survey and model estimation from NLogit Software

Table 10.12 Summary of potential economic value generated by labeling schemes, based on adjusted model 3

Type of label	#Potential users ('000)	Average marginal WTP in USD		Total social economic value in million USD		
		No price increase	Electricity price increase	No price increase	Electricity price increase	% Change
Total private label	1,681	163	296	274	497	81 %
Total public label	1,681	378	514	635	864	36 %
Public label in north area	1,408	423	559	596	788	32 %
Public label in south area	273	142	278	39	76	96 %

Source: Field survey and model estimation from NLogit Software

864 million USD. The contributions from the northern area and southern area would be 32 % and 96 %, respectively.

From an economic point of view, the public "STAR" label can be implemented to replace the private "self-claimed" label to generate higher economic valuation in the market. The label can be implemented together with the current energy policy of removing the electricity subsidy to generate more social economic value in the region. However it is suggested to improve current strategy of energy conservation campaign, especially for the public label implementation, through conducting more EC campaigns in highly penetrated AC market (north area) and focusing on high-intention segments in low AC market (south area), supporting the establishment of certification institution and encouraging the market players to adopt the new system developed for the public label.

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Chapter 11
MRT as Climate Policy in Urban Transportation

Siti Maimunah and Shinji Kaneko

Abstract Since the transportation sector is one of the main contributors of GHG emissions in Indonesia, having a clear direction of climate policy is very important. Developing mass rapid transit (MRT) as the climate policy in urban transportation is urgently needed since it can encourage people to use public transport. However, some policies seem conflicting, either encouraging or discouraging people to use public transport. Therefore, balancing conflicting policies is important. Fuel subsidy is such policy that hampers potential impacts of the MRT being currently under construction in one of the most congested cities in the world, Jakarta. Describing the current transport policies in Jakarta as well as the current commuters' behavior on transport mode choices is a basis to deliver the appropriate policies. Repeated choice experiments for private vehicle commuters in Jakarta on preferences if they would be willing to shift to MRT once it becomes available have been conducted before and after the removal of the fuel subsidy. The mixed logit models revealed that the scale of impacts on probability to shift for MRT due to subsidy removal is significant compared to the best available feasible options for MRT service improvements. Moreover, after the actual implementation of the fuel subsidy removal, more motorcycle commuters are willing to shift compared to the hypothetical scenario of the fuel subsidy removal. Shifting from using cars or motorcycles to MRT also can reduce the CO_2 emission. Under the assumptions that MRT will be operated by electric-based systems and the CO_2 emission is negligible, the shifting of commuters from cars and motorcycles can reduce the CO_2 emission by 10.52 % per year, using the year 2013 as the base year. Moreover, because of the fuel subsidy removal, the reduction of CO_2 emission will be higher, up to 13.28 % per year.

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Keywords MRT • Climate policy • CO_2 emission reduction • Logit model • Mixed policy scenarios

11.1 Overview of Climate Policy in the Transportation Sector

Indonesia as a developing country has sustained high economic growth rate over the last decades and faced rapid urbanization. The improved economy as well as high urbanization has placed enormous tension on the transportation sector because of low mobility, traffic congestion, etc. Uncontrolled growth in road traffic especially dominated by the private vehicles, both cars and motorcycles, is now visible in the metropolitan and big cities in Indonesia.

The tremendous increase in the number of vehicles on the roads has led to increased oil consumption and increased greenhouse gas emissions. Transportation has a big contribution to the GHG emission. In Jakarta, the transportation sector is the second largest contributor to GHG emission after industry sector. Figure 11.1 shows the percentage of GHG emissions based on the sector.

However, Indonesia is also still behind in terms of infrastructure, especially the development of mass public transports. The current Indonesian President has committed to speed up the infrastructure development by signing a Presidential Regulation (Perpres) which is still in process. The development of Mass Rapid Transit (MRT), Light Rail Transit (LRT), and other types of mass public transports

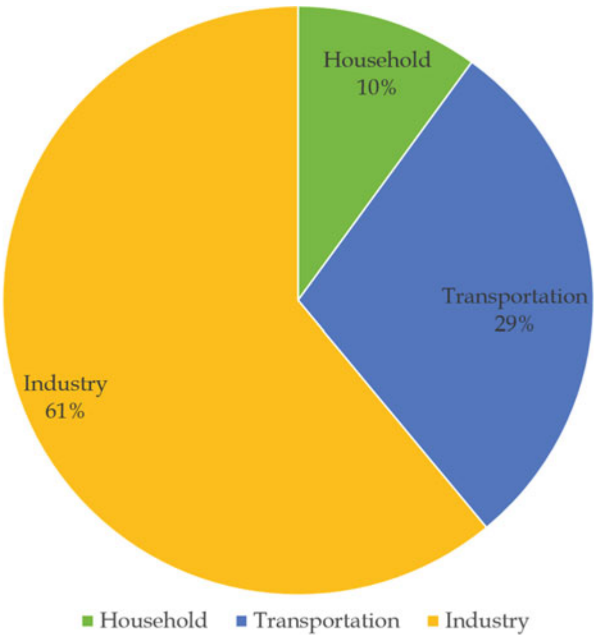

Fig. 11.1 Source: Ministry of Environment Indonesia (2013)

is needed to immediately ease the daily traffic congestion in metropolitan cities in Indonesia such as Jakarta, Surabaya, Bandung, and others. However, the stressed development of public transportation would not only be facilitated in Java, but also it will officially open construction of railway networks in Sulawesi and Papua.

The development of mass public transport in the cities including Jakarta is the action of implementation and part of MRV (measuring, reporting, and verification) in the mitigation of pollution from the transportation sector. By implementing some programs of mitigation action in the transportation sector including the development of the MRT as the Jakarta Government's project and supported by National government, it is expected to reduce the CO_2 emissions.

11.2 Overview of Jakarta MRT Development

As the MRT became one of the targets in 2020, the first stage of the MRT project has been started in 2013, and it is estimated to be completed by the end of 2016. The MRT visions are improving the mobility and quality of life. Mobility means how the people could be moving around, in and out of the city, in a comfortable and safe manner to conduct their business and social activities (MRT Jakarta 2013a). The development also must be focused on creating a public transport to move people efficiently and effectively to their destinations. The MRT system was not designed to "solve" traffic jam that would not possibly be solved by the MRT system alone. Integration and coordination with other transportation systems, land use policy, and development based on transportation (transit-oriented development) are also needed. Improving quality of life is possible by reducing the air pollution caused by vehicles or motorbikes, if people trust our services with their transportation needs. By improving the mobility as well as the quality of life, it is expected to realize Jakarta as a modern city with world-class standards of operational excellence.

The MRT mission is providing sustainable excellent service in terms of safety, convenience, and reliability. Safety is not just how to handle crime, but also crisis handling due to a natural or man-made disaster. MRT Jakarta will design, exercise, and improve its risk management activities to handle these crises. MRT Jakarta will approach convenience using the human senses: the eyes, ears, nose, skin, and mouth. Eyes, means spotless clean, all areas under MRT Jakarta management must be spotlessly clean, not just toilets, but also lifts, elevators, hallways, etc. All signs must also be clear and concise but informative. All layouts are easy to understand. Reliability could be simplified as "walk the talk." When we say the train will be arriving in 5 min, it will be arriving in just that, not more and not less. In this advanced modern airport in the world, when we arrive at this airport, we could go out from the plane and get a taxi in just 15 min. This requires correct design, continuous improvement, and discipline.

The benefits are expected for the Jakarta MRT development to increase transport capacity of passengers, to reduce travel time, to mitigate air pollution, to reduce

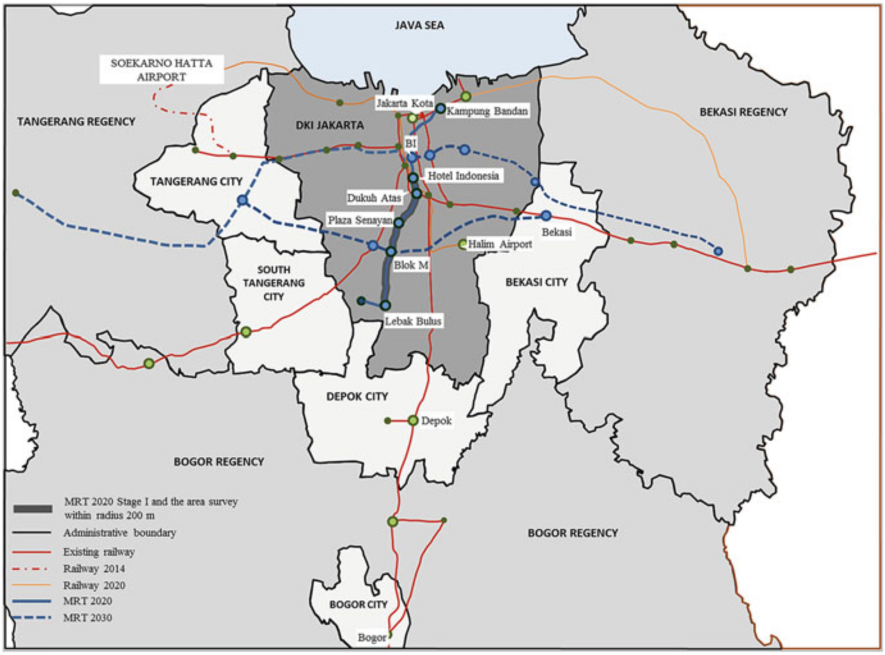

Fig. 11.2 Source: General Plan of Railway Network in JaBoDeTaBek 2014–2030, Directorate General of Railway, Ministry of Transportation Indonesia, modified by author

traffic accidents, and to improve the country's investment climate and consequently further enhance social and economic development (MRT Jakarta 2013b). The MRT will connect the south and the north area of Jakarta and it is predicted to be operating by the end 2020. The other routes of the MRT will connect the east and west areas of Jakarta, and it is predicted to be finished in 2030. The map of MRT development is depicted in Fig. 11.2.

The first MRT route is targeted to be operating in 2020 and it is divided into two stages: the first stage will connect from Lebak Bulus to Bundaran Hotel Indonesia over 15.7 km with 13 stations consisting of 7 elevated stations and 6 underground stations, and the second stage will be further stretched from Bunderan Hotel Indonesia to Kampung Bandan with a total length of 8.1 km with eight underground stations. All MRT construction is expected to finish at the end of 2018. The first stage of MRT stations and classification of area development along MRT route are described in Fig. 11.3.

The MRT as the mass public transport is targeted to carry about 412,000 passengers daily. Although this number is quite small if it is compared to the total trips in Jakarta that reach about 15 million trips per day. But in the near future, the MRT capacity can be increased and the MRT network can also be expanded to connect the east and west areas of Jakarta. In the current plan of MRT, each train will have six carriages with a total capacity of approximately 250 passengers per

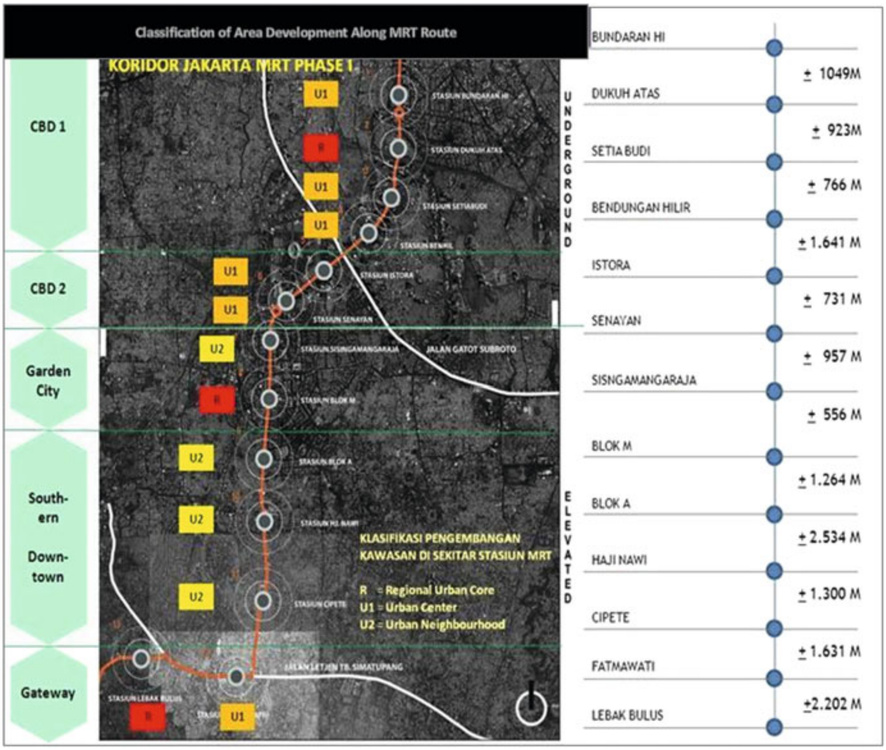

Fig. 11.3 Source: MRT Jakarta (2013b)

carriage. The MRT will be operated from 05.00 am to 00.00 am with shorter headway, and the speed is better as well as the parking facilities which will be available at all MRT stations. This is to support the park-and-ride system of commuters who have private vehicles, either cars or motorcycles.

The total cost of the MRT construction is about 1.44 billion USD (MRT Jakarta 2013b), of which 1.2 billion USD is financed by loan. The payment will be shared between the Jakarta province budget (30 %) and the national budget (70 %). The remaining 0.24 billion USD is shared between the Jakarta province budget (58 %) and the national budget (42 %).

Although it is not possible in the near future, the current plan acknowledges the following needs in the long run: (1) the MRT will be integrated with the other public transport modes such as city buses, BRT, and the Jabodetabek railway system, (2) supporting facilities such as adequate pedestrian and parking spaces at all MRT stations will be provided for the park-and-ride system, and (3) commercial and public buildings will be constructed near the MRT stations.

11.3 Transportation Policy in Jakarta

Jakarta as the metropolitan city attracting daily commuters who mostly depend on the private vehicles, either cars or motorcycles, faces traffic congestion the whole day. The commuters not only come from the inside of Jakarta areas but also from surrounding cities, Bogor, Depok, Tangerang, and Bekasi, commonly called Bodetabek. The total number of commuters who come from the Bodetabek can reach about two million people (BAPPENAS and JICA 2004). It can be indicated from the total population of Jakarta during the day which can increase to approximately 12 million, compared to its registered population of about 10 million.

The Jakarta provincial government has been trying to solve these problems. The government of Indonesia (GoI) also steps in to support due to the chronic traffic congestion. Some policies that have been implemented are:

1. Provision of mass public transports such as BRT and Jakarta, Bogor, Depok, Tangerang, and Bekasi (Jabodetabek) railway.
2. A "Three-in-one" system in the CBD has been implemented since 2003 based on the Jakarta Governor Decision Number 4104, 2003.
3. Parking management related to the parking areas and charges, based on the Jakarta Governor Decision Number 120, 2012.

The policies pose transport demand and supply management. Transport demand management (TDM) such as parking management via the annual permit cost, parking fee per hour, limitation of parking space and location of parking lots, greatly gives impacts on mode choice to use public transport such as bus (Rotaris and Danielis 2014). Rotaris and Danielis (2014) also argue that the provision of fully subsidized public transport would have a large effect on mode choice.

Regarding the provision of BRT, it deliberates, in turn, the role of intelligent transportation system (ITS) technology in prompting the operational efficiency, technical performance, and cost issues of BRT. By this condition, BRT gives some impacts on travel behavior change, traffic environment, and property development (Deng and Nelson 2013). It is also one of the key measures for promoting sustainable mobility.

11.4 Current Commuters' Behavior Toward Transportation Chosen

The data from National Socio-Economic Survey of Indonesia shows that the travel distance of commuters during the last 6 years is getting farther, especially within the range 10–29 km. There are some possibilities: the commuters cannot get any houses inside of Jakarta areas because of being already full or the prices of houses in the middle of Jakarta areas are not affordable. And also the urbanization is still high, the buffer areas of Jakarta, Bodetabek become the targets to get houses. This

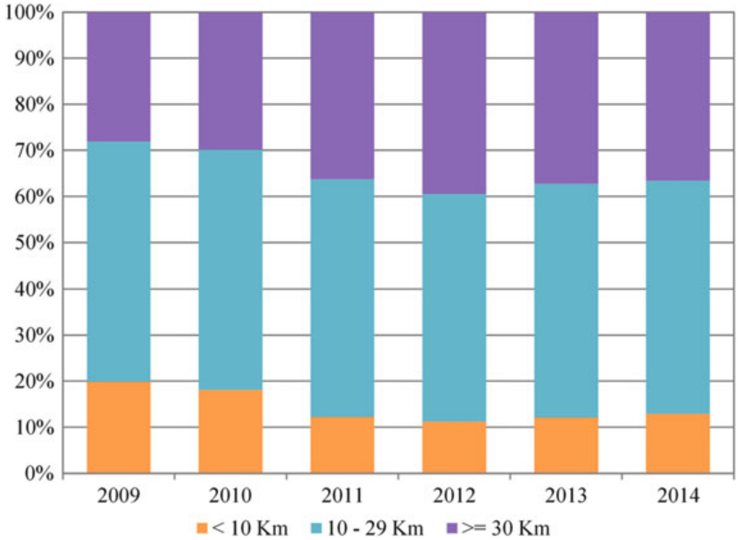

Fig. 11.4 Source: Author analysis, 2015

is very common in the metropolitan area where they are working in the middle of the city and living outside of the city. Figure 11.4 shows the travel distances of commuters in the last 6 years.

The common situation of the metropolitan cities in developing countries is the lack of public transportation provision. Private vehicles are still the most favorite modes to be chosen to commute. At present, the modal share of public transportation in 2013 is about 16 %. It is not surprising that motorcycles have the highest share among the commuters who use the vehicles.

If it is compared to the modal share in 2011 and 2013, although within 2 years, it can be seen that the share of public transport is going down by 3 % from 17 to 14 %, but the share of motorcycles is increasing by 5 % from 37 to 42 %. In general, the share of private vehicles has increased (Fig. 11.5).

It is reasonable and common that most of the people depend on the private vehicles for daily commuting. It is because by driving cars, it can give people autonomy because it is more convenient and reliable and increases their accessibility (Hiscock et al. 2002). Another reason for driving cars is to get psychological benefits such as mastery, self-esteem, feelings of autonomy, protection, and prestige (Ellaway et al. 2003). A case study in Hong Kong shows why people depend on cars: after having a car, it will change their lifestyle, and a car becomes necessary (Cullinane and Cullinane 2003).

Making a group by income level of transport mode choice shows very clear evidence that the car users come from the high-income level. The low-income group mostly uses public transports. Interestingly, the motorcycle is preferred by people with all ranges of incomes. Even the high-income people still prefer to choose the motorcycle for their commuting. For the lowest income group, the

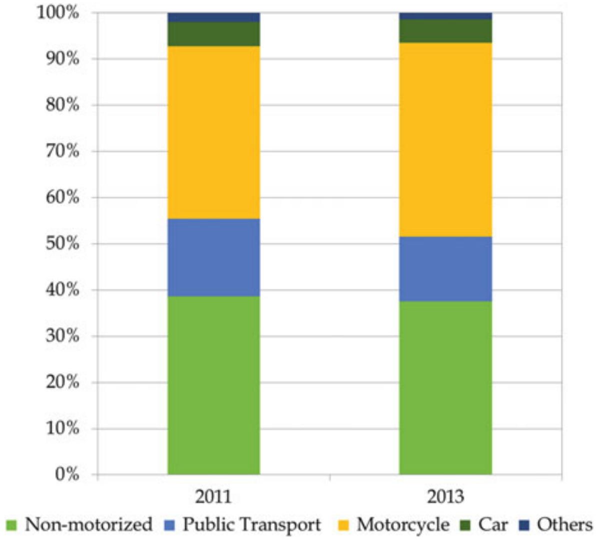

Fig. 11.5 Source: Author analysis, 2015

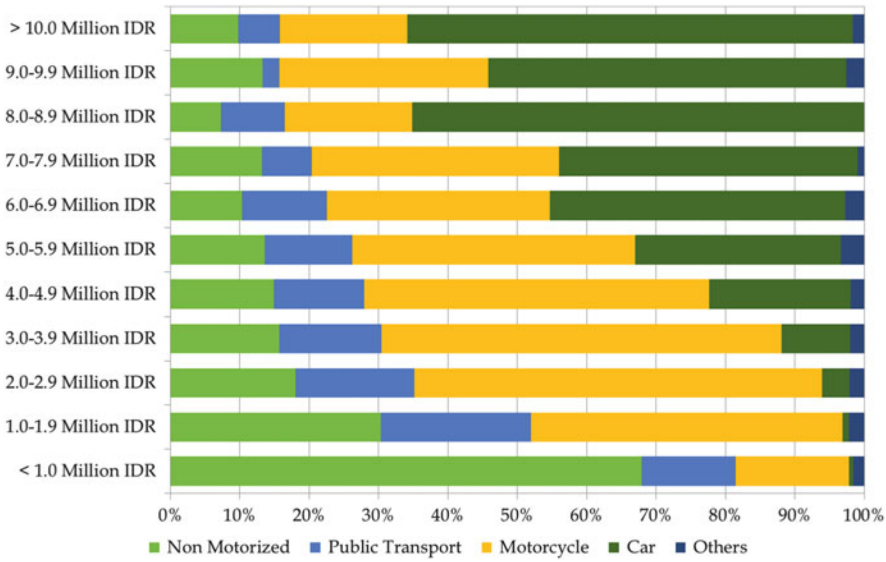

Fig. 11.6 Source: Author analysis, 2015

nonmotorized share is very high. Comparing the share of motorcycle and public transport, motorcycle share is always higher in all ranges of income groups. The small share of public transport is proven. Figure 11.6 depicts the modal share based on commuters' income.

Table 11.1 The parameter estimation of MNL of current transport mode chosen

Transport chosen[a,b]		B	SE	Wald	Df	Sig	Exp (B)
Car	Intercept	−8.297	0.826	100.862	1	0.000	
	Transport cost/ expenditure	1.199	0.623	3.704	1	0.054	3.317
	Education	0.500	0.032	243.974	1	0.000	1.649
	Worker	1.585	0.688	5.312	1	0.021	4.877
	Student	−16.549	8021.924	0.000	1	0.998	6.498E–08
	Housekeeper	1.823	1.158	2.477	1	0.115	6.189
	South Jakarta	−0.274	0.270	1.031	1	0.310	0.760
	East Jakarta	−0.101	0.256	0.156	1	0.693	0.904
	Central Jakarta	−0.541	0.287	3.545	1	0.060	0.582
	West Jakarta	0.464	0.264	3.088	1	0.079	1.590
Motorcycle	Intercept	−8.297	0.826	100.862	1	0.000	
	Transport cost/ expenditure	1.199	0.623	3.704	1	0.054	3.317
	Education	0.500	0.032	243.974	1	0.000	1.649
	Worker	1.585	0.688	5.312	1	0.021	4.877
	Student	−16.549	8021.924	0.000	1	0.998	6.498E–08
	Housekeeper	1.823	1.158	2.477	1	0.115	6.189
	South Jakarta	−0.274	0.270	1.031	1	0.310	0.760
	East Jakarta	−0.101	0.256	0.156	1	0.693	0.904
	Central Jakarta	−0.541	0.287	3.545	1	0.060	0.582
	West Jakarta	0.464	0.264	3.088	1	0.079	1.590

Source: Author analysis 2015
[a]The reference category is public transport
[b]The parameters estimated for bicycle and pedestrian are not shown in this table

The estimation of work travel demand of commuters can be explained by implementing multinomial logit (MNL) as shown in Table 11.1. Since the chi-square test of the model is significant at 1 %, the model can be used to predict the work travel demand. The model confirms that the cost by using a car is highest compared to using public transport, but by using motorcycle, the cost is not significantly different than using public transport. The education of private vehicle users, both car and motorcycle users, is higher than the education of public transport users. The workers prefer to use private vehicles rather than public transport. People who are living farther from their work places try to avoid using public transports to save travel time. It is shown by the commuters who live in West Jakarta that they prefer to use cars to commute, and the commuters who live in the Central Jakarta less prefer to use cars, because most of the business areas as well as the government offices are located in the Central Jakarta.

11.4.1 Private Vehicle Users' Attitudes

Regarding the private vehicle users' attitude toward current transport chosen, Table 11.2 shows the reasons to have and use cars for daily commute. The three main reasons are it being more comfortable, being more flexible, and being more helpful for carrying things. The first reason is also supported by the second reason that is flexibility. In the people's mindset, by using public transportation, it is difficult to change the transportation modes to reach their destination. Some people try to find out the easiest and fastest way by using the taxi motorcycle, called "ojek" in Indonesia. Although these taxi motorcycles are nonformal public transportation due to no rules to regulate it, people prefer to use it with all the risks.

Table 11.3 shows the list of reasons why people want to have and use motorcycles including the rank of each reason. The first main reason for using motorcycles is it can save time. Then, the second and third main reasons are following the reasons for the car users, which are them being more comfortable and giving more flexibility. That is true by using motorcycles it can be faster to reach the destination because the traffic congestion in Jakarta has become worse recently. The fact that using a motorcycle is the fastest way to commute is supported by the data that the average speed for using motorcycle is about 33 km per hour, where the average speed of using cars and bus is about 21 km per hour and 17 km per hour, respectively (Suryo et al. 2007).

The data also describes that 63.3 % of respondents have at least one car and some, 8.1 % respondents, have more than one car. Respondent perception of the necessity of having a car is that 64.4 % said totally necessary and 35.0 % said quite necessary. This number is higher than the respondent perception in Hong Kong

Table 11.2 The three main reasons why respondents have and use a car for daily commute

Reasons	Important ranking			Total	Weight score[a]	Rank of weighted score
	1st	2nd	3rd			
Don't like public transport	7	9	12	28	51	6
Helpful for carrying things	5	5	9	19	34	8
Take children to school and other activities	15	9	10	34	73	5
Public transport not available	1	1	2	4	7	10
Improves status	3	3	6	12	21	9
Flexibility	19	35	40	94	167	3
More comfortable	12	50	33	95	169	2
Saves time	104	36	23	163	407	1
Just a habit	7	27	37	71	112	4
Disability in HH	7	5	8	20	39	7

Source: Author analysis, 2015

[a]Weighted scores are calculated by multiplying the first rank by 3, the second rank by 2, and the third rank by 1

Table 11.3 The three main reasons why respondents have and use a motorcycle for daily commute

Reasons	Important ranking			Total	Weight score[a]	Rank of weighted score
	1st	2nd	3rd			
Don't like public transport	7	9	12	28	51	6
Helpful for carrying things	5	5	9	19	34	8
Take children to school and other activities	15	9	10	34	73	5
Public transport not available	1	1	2	4	7	10
Improves status	3	3	6	12	21	9
Flexibility	19	35	40	94	167	3
More comfortable	12	50	33	95	169	2
Saves time	104	36	23	163	407	1
Just a habit	7	27	37	71	112	4
Disability in HH	7	5	8	20	39	7
Company motorcycle	7	9	12	0	0	11

Source: Author analysis 2015

[a]Weighted scores are calculated by multiplying the first rank by 3, the second rank by 2, and the third rank by 1

which is 38 and 46 % for totally necessary and quite necessary, respectively (Cullinane and Cullinane 2003). However, if it is compared to the result from a household survey in UK conducted in 1990, it is slightly lower. They found that the necessity of cars in UK was about 69 % (Cullinane 1992).

During the survey it is also questioned what made them avoid using cars for commuting, while giving some factors and asking them to give responses to each factor by score, from very much (score 5) to not at all (score 1). Table 11.4 displays their responses, where the traffic congestion is the most deterring reason to avoid driving a car, and then the second and third rank is related to parking, both parking cost and parking availability at the destination and the unreliability of parking. The stress of driving is also in the fourth rank that could deter people from driving. Moreover, the traffic congestion is the most significant factor that deters respondents to drive a car compared to parking costs and the parking availability. Regarding toll and petrol costs, they are not the most deterring factors from driving a car. Because the toll and petrol cost in Indonesia is cheaper compared to other countries and still affordable by people. Furthermore, the petrol cost is still subsidized by the government and the price is about 0.6 USD per liter recently.

The results for motorcycle users regarding the factors that deter from driving a motorcycle is shown in Table 11.5 Traffic congestion is still in the first rank, but it is accompanied by the stress of driving. Driving a motorcycle is much more stressful compared to driving a car because the safety is very low. Then, the next factors are related to the parking: the second rank is parking cost, the third rank is parking availability, and the fourth rank is the unreliability of parking.

Table 11.4 Rank of factors deterrence from driving a car

Factors	Not at all	Not very much	Neutral	Quite a lot	Very much	Average	Rank
Traffic congestion	7	22	14	54	83	4.02	1
Parking costs at destination	3	35	59	55	28	3.39	2
Parking availability at destination	2	37	54	63	24	3.39	2
Unreliability of parking availability	1	44	62	59	14	3.23	3
Toll cost	5	49	85	37	4	2.92	6
Petrol cost	4	44	68	57	7	3.11	5
Route unfamiliarity	8	89	64	18	1	2.53	7
Stress of Driving	9	39	65	55	12	3.12	4

Source: Author analysis 2015

Table 11.5 Rank of factors deterrence from driving a motorcycle

Factors	Not at all	Not very much	Neutral	Quite a lot	Very much	Average	Rank
Traffic congestion	15	21	21	42	81	3.85	1
Parking costs at destination	8	37	48	50	37	3.39	2
Parking availability at destination	2	41	66	50	21	3.26	3
Unreliability of parking availability	3	50	64	47	16	3.13	4
Petrol cost	16	72	61	27	4	2.62	6
Route unfamiliarity	7	49	55	54	15	3.12	5
Stress of driving	15	21	21	42	81	3.85	1

Source: Author analysis 2015

The number of cars and motorcycles will increase continuously as well as the travel distance is significantly increased. Since the quality of public transport services is not improved yet, commuters prefer to shift to drive motorcycles for daily commuting. The provision of integrated public transports is still limited. Only bus rapid transit (BRT), known as TransJakarta, is integrated with the Jabodetabek railway at some points. It makes it quite difficult for people to change to other types of transportation modes. The punctuality of public transports is also very low, and even many public transports do not implement the fixed schedule. As a result, the congestion is getting worse, and pollution from transportation is also increased.

In addition, petrol cost, which is partly still subsidized by the government, is one of the factors deterring people from driving. Although now Indonesia has become a net oil importing country, the government is still giving subsidies especially for transportation fuel such as petroleum. This condition discourages people not to leave their vehicles due to low operational cost by using it. Congestion and parking facilities such as the availability, reliability of the parking place, and the parking price become the most common factors that people do not want to use their cars and motorcycles. Obviously almost in every building including offices and malls, they provide parking facilities for cars and motorcycles. Even, if the small shops do not have a parking area, people can use the pedestrian for parking their vehicles or on-street parking that is very cheap.

However, by only making restrictions to discourage people in using private vehicles without any commitments from government to provide better public transport with better services is pointless. Now, Jakarta is constructing the MRT as the other alternative transport mode that is expected to give better services. Moreover, this also should be supported by other policies such as park-and-ride system, where parking areas are needed at the points of public transports stops. Other types of policies, such as transit-oriented demand, are also needed to be implemented.

11.4.2 Current Energy Consumption in the Transportation Sector and the Impacts on the Environment

Total fuel consumption in road transportation in 2013 had reached 2.6 billion tons for regular fuel and 0.8 billion ton for diesel fuel (Environmental Management Agency of Jakarta Province 2013). The road transportation dominated the fuel consumption. Table 11.6 describes the total vehicles based on the fuel types.

Road transportations contribute the highest emissions, for all types of emissions from vehicles such as dust, sulfur dioxide (SO_2), nitrogen dioxide (NO_2), hydrocarbon (HC), carbon monoxide (CO), and carbon dioxide (CO_2). From these types of emissions, CO_2 is the concerned because it contributes to greenhouse gas (GHG) emissions. The total CO_2 emissions from transportation sectors in 2013 are about 10.7 million tons and it is placed as the second largest contributor of CO_2. The CO_2 emissions were calculated based on the fuel consumption of moving vehicles either through road, air, or sea transport. However, the CO_2 emissions from road transport

Table 11.6 Number of vehicles based on types of fuel consumption in Jakarta 2013

No	Vehicle types	Number of vehicles		
		Regular fuel	Diesel fuel	Total
1	Car load	35,342	–	35,342
2	Passenger car	333,225	170,512	503,737
3	Bus	–	1,018,291	1,018,291
4	Truck	–	180,892	180,892
5	Three-wheeled vehicle	18,065	–	18,065
6	Motorcycle	10,825,973	–	10,825,973
Total		11,212,605	1,369,695	12,582,300

Source: BPLHD Jakarta 2013

account for about 76.1 % from total CO_2 emissions in the transportation sector (Environmental Management Agency of Jakarta Province 2013).

As a significant impact, Jakarta has been nominated as one of the most congested and polluted cities in the world (Cunningham and Cunningham 2010). The economic cost of congestion only for time losses was modestly estimated to be about 5.6 billion USD a year (Ministry of Economic Affairs and Japan International Cooperation Agency 2012) which accounts for approximately 5 % of GRDP of DKI Jakarta (Statistics of Jakarta Province 2014). In addition, the fuel consumption in the transportation sector in Jakarta was reported to be about 3,046,603 kiloliters in 2010 or about 58 % of total energy consumption (Ministry of Energy and Mineral Resources 2014). For the Jabodetabek area, the fuel consumption became 1.5 times Jakarta's fuel consumption. By this condition, the highest air pollution in Jakarta is from the transportation sector. If the impacts of traffic congestion include the energy consumption, pollution, and other social impacts, the losses will be much higher.

11.5 The Impacts of MRT Development on Commuters' Behavior

The main objective targeted by developing the MRT in Jakarta is to attract private vehicle users to shift to use public transportation for daily commute. Based on the theory, people choose the transport modes that give the highest value of expected utility (Noland et al. 1998). To make MRT successful, better services should be provided, if it is compared to current public transports or even with their utility in using private vehicles. It is also necessary to alter the comparative utilities between public transport and private vehicle use in a consistent way. By only providing MRT without sufficient simultaneous countermeasures to discourage private vehicle users would result in failure for solving the congestion.

To analyze the MRT development impacts and especially to know the changes of car and motorcycle behaviors, the author had conducted surveys along the roads where the MRT will be operated. The findings related to the sociodemography of the respondents covered are described in Table 11.7. The commuters who are using cars or motorcycles are in the productive ages with the average of 33 years old. Although if it is compared between car and motorcycle commuters, the motorcycle commuters are younger than car commuters on average. It is expected that the education level of car commuters is higher than the education level of motorcycle commuters. The average of personal income is about 454 USD and the motorcycle commuters have lower income, with the difference of about 209 USD.

It also shows that the average distance for commuters is about 17 km and that is not different between the car and motorcycle commuters. The travel time for motorcycle commuters is about 2.38 h and faster than car commuters that need 38.6 min more. All these variables related to the households and individuals are all

Table 11.7 Sociodemography of respondents

	Car commuters	Motorcycle commuters	All respondents
Total sample	180	180	360
Gender (%) male/female	44/56	61/39	53/47
Average of age/standard deviation/minimum/ maximum (year)	33.8/7.9/ 20/50	32.6/7.9/20/49	33.2/7.9/ 20/50
Average of education level	14.6/2.4	12.9/2.4	13.7/2.4
Occupation (%) employer/employee/others	31/58/11	22/68/10	27/63/11
Household size/median (person)	4	4	4
Average personal income/standard deviation (in USD/month)	558.4/ 290.6	349.8/201.7	454.1/ 270.8
Average household income/standard deviation (in USD/month)	971.1/ 275.0	650.0/312.4	810.6/ 334.9
Average distance from homes to offices/standard deviation (kilometers)	17.0/9.5	17.1/9.3	17.1/94
Average travel time/standard deviation (hours)	3.03/1.03	2.38/0.81	2.71/0.98

Source: Field survey, all respondents as base

included in the models to estimate the commuters' willingness to shift to MRT, either as dummy or continuous variables because these variables can affect the people's behavior (Ben-Akiva et al. 1991).

After having the two different models under the stated preference models based on 2013 and 2015 data, most of the parameters estimated have the same signs although some of the coefficients are different. The main attributes of choice cards which are frequency, speed, and parking availability at all MRT stations have the same impacts which can increase the commuters' willingness to use MRT. However, the magnitude of coefficients for the 2015 data is smaller, including the attribute cost. The main objective in this comparison is to know the impacts of the fuel subsidy removal policy scenario before and after the implementation. Based on the models, it can be seen that all policy scenarios are having negative signs, meaning that the policies can be used to discourage commuters in using their private vehicles, either cars or motorcycles. However, after the implementation of the fuel subsidy removal, the coefficient of the fuel subsidy removal scenario is not significant. The stressing confirmation about the fuel subsidy removal to the respondents did not give significant impacts. It seems the respondents are already aware of the current fuel price without subsidy.

Some variables which are part of the demographic and socioeconomic show the improvement in the significance. The dummy of motorcycle commuters is significant and positive. It means their willingness to use the MRT is bigger than car commuters after the fuel subsidy has been removed. The employer less prefers to shift to the MRT compared to the employee. Since in the first survey, the higher the education of respondents, the higher is their willingness to use the MRT. The significance and coefficient both in 2013 before the fuel subsidy is removed and in 2015 after the fuel subsidy is removed. The data in 2015 shows that the family income is getting significant. It indicates that the total income has been affected by the increase of fuel price. In Indonesia, the increase of fuel price has always gotten the negative reaction from people. As a consequence, the prices of goods and services are increased. By this condition, the total family income is affected not only in response to the increase of transportation cost but also the increase of other prices.

Another interesting finding is the travel time for both models is not significant. It can be caused by the current situation in Jakarta that has faced congestion all days, not only in the morning and after office hours. Household size for both models show the significant positive. In contrast the home location in Jakarta in 2015 data is not giving a significant sign. It can be indicated that for commuters who live in Jakarta, they prefer to shift to the MRT rather than using private vehicles.

The overall model, the SP model in 2015, is improved since the number of significant parameters is increased and also the McFadden Pseudo-R2 is higher from the SP model based on data in 2013. In detail, the comparison models are depicted in Table 11.8 below.

Based on this model, it can calculate the marginal utility of each attribute. Figure 11.7 shows the comparison of utility to keep driving before and after the fuel subsidy is removed. The implementation of policy scenarios decreases the commuters' utility to keep driving either cars or motorcycles. However, after the fuel subsidy is removed, the utility of the fuel subsidy becomes not significant anymore. From the figure, it can be seen that the utility to keep driving under the fuel subsidy removal scenario is not different with the utility to keep driving under no policies implemented. The interesting finding is the utility of car commuters has been changed after the fuel subsidy is removed. It is explained by comparing the car commuters' utility before and after the fuel subsidy is removed. On the other hand, the utility of motorcycle commuters after the fuel subsidy is removed is higher than before. It is still reasonable since motorcycles are very efficient in using fuel. The increase of fuel price did not affect their utility much. However, the utility is still decreasing if road pricing and joint policy are implemented.

Moreover, the fuel subsidy removal has been affecting the commuters' behaviors in choosing transport modes. From Fig. 11.8 the commuters' willingness to pay to use the MRT is much higher than before the fuel subsidy is removed. The parking availability at all MRT stations is getting important since the WTP of parking availability is at the highest. The commuters might have preference to drive their cars or motorcycles until the stations and need parking areas to park their vehicles, then continue to use the MRT to reach their offices. This system is called the park-and-ride system.

Table 11.8 Comparison the parameters estimated of stated preference models

	2013		2015	
Variables	Estimate	t-value	Estimate	t-value
Main attributes				
ASC	17.581**	2.376	12.280***	4.088
Frequency (R)	0.799***	2.666	0.143***	2.975
Speed (R)	1.257***	47.572	0.397***	7.473
Parking (R)	1.936***	7.317	1.942***	7.943
Cost	−0.171***	−15.116	−0.121***	−14.760
Policy scenarios				
RP	−7.676**	−2.206	−0.865*	−1.672
FS[a]	−7.341**	−2.107		
FSR[b]			−1.311	−0.632
JP	−8.438**	−2.485	−1.761**	−2.266
Current travel behavior				
Motorcycle	1.965	0.429	5.921**	2.487
TT	−1.325	−1.642	0.551	1.558
Demographic, socio−economic				
Employer	−2.436**	−2.048	−2.798**	−3.065
Student	−2.577	−1.059	−2.577***	−2.051
Age	−0.083	−1.199	−2.214**	−1.996
Education	0.584**	1.949	0.582***	3.771
Male	1.257	1.225	−1.907***	−3.178
Family income	0.002	0.987	−0.002**	−2.251
Hh size	1.099**	2.273	0.612***	2.645
Jakarta	−2.896**	−2.209	−1.134	−1.174
Interaction between vehicle type and policy scenarios				
Motorcycle*RP	−2.779	−0.686	0.448	0.355
Motorcycle*FS	−5.721	−1.352	−1.655	−0.491
Motorcycle*JP	−8.078*	−1.910	−5.365**	−2.172
Motorcycle*TT	−4.061*	−1.684	−0.869*	−1.651
Interaction between attribute and location				
Parking*jakarta	−1.212***	−4.473	−2.561***	−9.475
Derived standard deviations of parameter distributions				
Frequency	1.292***	6.503	2.706***	130.211
Speed	2.491***	186.953	2.228***	95.091
Parking	3.257***	5.225	0.169	0.198
McFadden Pseudo-R2	0.178		0.192	
Chi-squared	533.848***		574.581***	
Prob [ChiSqd > value]	0.000		0.000	

(R) Random variables distributed normally of mixed logit model
***Significant at 1 % level
**Significant at 5 % level
*Significant at 10 % level
[a]Fuel subsidy removal under scenario with the price 0.9 USD
[b]Fuel subsidy removal based on the current market price (confirmed to the respondents that the fuel subsidy has been removed)

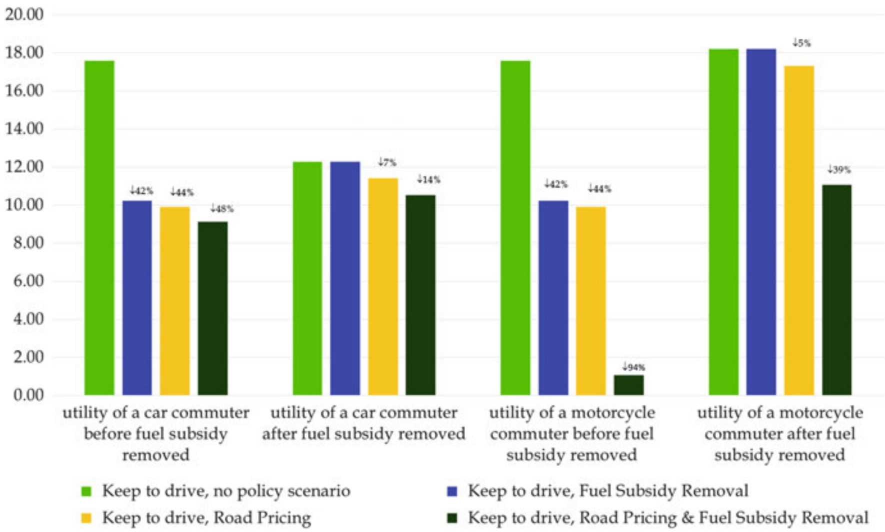

Fig. 11.7 Source: Author analysis, 2015

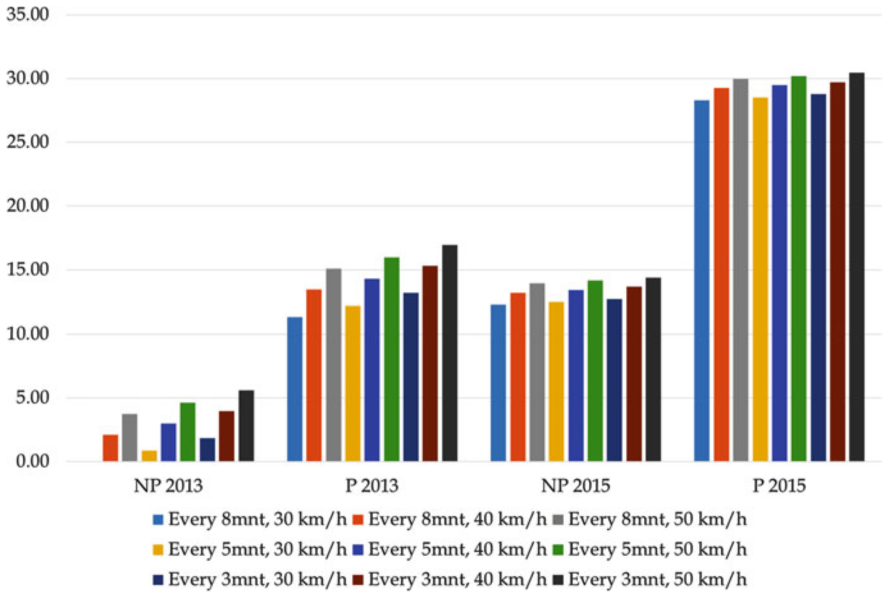

Fig. 11.8 Source: Author analysis, 2015

11.6 Potential Gains in Reducing the GHG Emissions

Since transportation has a big contribution to the GHG emission, especially from road transportation. By reducing the number of trips using private vehicles and shifting them to use public transportation such as MRT, it will have a potential impact in reducing GHG emissions. Commuting by public transportation can reduce carbon emissions and increasing the fuel price makes private vehicles' users more excessive. This section will show how much potential GHG emissions can be reduced after MRT operated under certain scenarios.

The transportation sector is a sector support of other sectors, such as the movement of commodities in the industrial sector; the movement of people in the household sector and the commercial activities of this sector are expected to continue to grow in line with the development of other sectors. The energy need in the transportation sector is dominated by fuel by more than 99 %. Table 11.9 depicts the detail of the fuel consumption in the transportation sector from 2005 to 2010. During 5 years it was growing about 8.1 %. From the table it can be seen that road transportation (90 %) has the highest fuel consumption compared to sea (8 %) and air transportation (2 %).

Generally, there are some factors that make the high energy especially the fuel consumption in the transportation sector. Those factors are people's behavior in driving, lifestyles, as well as the high growth rate of the vehicle numbers especially motorcycles and cars. The final energy use in the transportation sector is predicted to increase by about 12.8 % annually until 2025. Although, currently, the LNG, LPG, electricity, and bioethanol are very few in use in the transportation sector, it is

Table 11.9 The demand of fuel in the transportation sector (in energy unit)

Year	2005	2006	2007	2008	2009	2010
Aviation gasoline fuel	17	19	12	11	9	12
Aviation turbine fuel	13,682	14,303	14,845	15,526	16,262	20,779
Premium (gasoline lower octane)	96,863	92,901	98,847	111,377	121,226	130,486
Biofuel premium	0	9	326	257	617	0
Pertamax (gasoline higher octane)	1,450	2,947	2,752	1,736	3,478	3,985
Biofuel Pertamax	0	0	58	95	118	0
Pertamax plus (gasoline with highest octane)	579	748	921	669	829	971
Biodiesel	0	1,408	5,692	6,041	15,558	28,503
Kerosene	25	22	22	18	11	6
ADO (automotive diesel oil)	65,262	57,268	55,241	60,812	67,328	70,655
IDO (industrial diesel oil)	193	105	57	34	29	35
FO (furnace oil)	304	314	269	194	163	244
Total	178,375	170,044	179,042	196,770	225,628	255,676

Source: Ministry of Energy and Mineral Resources (2012) predicted that the growth rate in using these types of energy will be increased about 13.9 % annually (Ministry of Energy and Mineral Resources 2014). So because of the national government policy to reduce the fuel subsidy, it can happen to decrease the fuel consumption. All this prediction is assumed following the business-as-usual (BAU) scenario. However, if it is used non-BAU, the nonfuel energy use is expected to increase higher.

With high fuel consumption, it is not surprising that the transportation sector has been contributing significantly to GHG emissions. Technically, the emissions from vehicles are affected by some factors such as combustion engine, volume of cc, body drag, vehicle weight, and rolling resistance. Recently the hybrid cars which are the most efficient for fuel use have been developed, but in Indonesia, they are still rare.

There are some potential ways to reduce GHG emissions from the transportation sector, such as decreasing the growth in vehicle miles of travel, easing congestion and supporting more efficient land use patterns. Utilizing more public transportation is expected to support those ways, so it can reduce harmful CO2 emissions and create economic savings (reducing potential losses). These savings represent the beginning of public transportation's potential contribution to the national efforts to reduce greenhouse gas emissions and promote energy conservation.

Eliminating travel and also shifting to use public transportation can reduce the carbon footprint and conserve energy. Based on the American Public Transportation Association, one person, who is commuting alone by car and shifting to public transportation, can reduce one person's annual CO_2 emissions by 10 % in all GHG produced by a typical two-adult, two-car household. By eliminating one car and taking public transportation instead of driving, a saving of up to 30 % of carbon dioxide emissions can be realized.

Public transportation offers an immediate alternative for individuals seeking to reduce their energy use and carbon footprints. This action far exceeds the benefits of other energy-saving household activities, such as using energy efficient light bulbs or adjusting thermostats. Commuting by public transportation is one of the most significant actions to reduce the household carbon emissions. The increasing cost of fuel makes driving private vehicles even more prohibitive for many.

From the model estimated, it is predicted that there are about 57.8 % of car users and 56.3 % of motorcycle users that will shift to use MRT. It means there are about 222,097 cars and 188,353 motorcycles that will not pass the main roads or CBD areas in Jakarta, namely, Sudirman and Thamrin roads. By decreasing these numbers, the total emission reduction can be calculated, under the assumption that the emission from MRT per person is negligible (very small number). By using mobile combustion method, the total CO2 emission can be reduced from the people who shift to use MRT is about 1.14 tons annually.

Based on the calculation with the presence of MRT, the CO_2 emission can be reduced by about 10.52 % from the total current CO_2 emission from the existing vehicles in Jakarta. Because the CO_2 emission reduction calculated on this analysis is based on the number of commuters who are going to shift from cars or motorcycles to use MRT, the CO_2 emission reduction is only coming from cars and

Table 11.10 Total CO_2 emission reduction with the available MRT

Vehicle category *i*	EF_{kmv}	EF	Eby $(ton\text{–}CO_2/y)$	Epy $(ton\text{–}CO_2/y)$	Emission reduction (ER)
Motorcycle					
Gasoline	61	2,274	3,405,843	3,250,364	
Passenger car					
Gasoline	162	4,860	2,620,971	1,803,248	
ADO	156	4,684	631,416	631,416	
Car load					
Gasoline	65	1,334	59,930	59,930	
ADO	107	2,210	397,281	397,281	
Public passenger car/bus					
Gasoline	103	2,060	786,737	786,737	
ADO	183	1,221	1,088,013	1,088,013	
			8,990,190	8,043,989	10.52 %

Source: Author's calculation 2015

motorcycles. Other types of vehicles are assumed to be constant. The CO_2 emission reduction from cars is higher than from motorcycles, although the total number of motorcycles is about four times of the total number of cars. In fact the motorcycle is more efficient in consuming fuel than the car (Table 11.10).

After the fuel subsidy is removed, the change in the number of car and motorcycle commuters who want to shift to MRT is not so different, which is increasing by about 3 %. In addition, the population of cars and motorcycles that pass through the CBD has been increased. By using the same assumption of vehicle growth that is used to calculate the total economic value, it can calculate the changes of CO_2 emission reduction after the fuel subsidy is removed. Based on the data survey in 2015 and under some assumptions of the vehicle growth, the total CO_2 emission reduction will be only about 13.28 %. This means that there is an improvement of environmental benefits by removing fuel subsidy. If the success of MRT development can be followed by development in other types of mass public transportation, the CO_2 emission reduction can reach the level as well as the level targeted by the government from the transportation sector.

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Chapter 12
Less Emissions and Less Waste: An Economic Analysis of a Waste-to-Energy Project for Bekasi City

Savin Ven Johnson

Abstract Waste-to-energy (WTE) can be a potential solution for Indonesia allowing for improved waste management, reduced emissions, and less waste in landfills. An economic analysis comparing WTE and landfilling using Bekasi City, Indonesia, as a case study is examined. Waste amounts are projected for 2015–2035 with baseline costs and emissions estimated. Next, parameters for the WTE scenario are presented followed by economic analysis with IRRs calculated. Sensitivity analyses are also conducted to assess changes on the returns, given different relative price changes in future. The WTE scenario considers three incineration plant sizes and two major revenue sources – per ton of cleaning benefit and electricity sales – not currently implemented under two different scopes: independent introduction of WTE and its reference to current landfilling strategy. The results show that there are possible conditions that make WTE financially feasible especially larger scale of projects with large collection volumes. The IRRs would then be largely improved by further aggressive feed-in tariff policy. Waste management should not be viewed solely as private sector service but a public good with social costs and benefits taken into account, since environmental benefits also improve the IRRs. National-level initiatives such as the National Waste Policy and the feed-in tariff provide a push and pull strategy for innovation in WTE, but additional policies for enhancing environmental awareness of the citizens can help hasten WTE adoption.

Keywords Waste-to-energy (WTE) • Landfilling • Incinerator • Bekasi City • Feed-in tariff • Cost and benefit analysis • Sensitivity analysis

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12.1 Introduction

Unsanitary landfills and open dumpsites passively release large amounts of methane and carbon dioxide into the atmosphere. In Indonesia, where solid waste services and landfills are often poor quality, GHG emissions from waste are estimated to be 11 % of the country's total emissions, trailing behind land use/forestry and energy (Government of Indonesia 2010). Solid waste management system in Indonesia, including its landfills and dumpsites, is facing serious challenges. Current waste collection and disposal practices are no longer adequate for managing waste streams from a rapidly growing, urban population. In addition to emissions, there are other negative impacts from waste that include health and disease, environmental contamination, and fire and explosion risks. Indonesia needs a new waste management strategy that can reduce GHG emissions from waste and be both environmentally and economically sustainable. Waste-to-energy through incineration (hereafter referred to as WTE) has been proven to deliver such outcomes to developed countries such as Japan and Western European nations. This chapter presents an economic analysis of WTE in Indonesia, in both financial and environmental costs and benefits, to determine its feasibility for the government and society.

12.1.1 Background: The Waste Situation in Indonesia

A 2011 Australian Agency for International Development (AusAID 2011) study estimated that Indonesia generated 38.5 million tonnes of waste annually, with only 54 % actually collected and formally disposed in landfills (AusAID 2011). The remaining portion is burned, buried, or illegally dumped in rivers and ravines causing severe pollution and clogging to surrounding land and waterways. Indonesia has about 537 final disposal sites which is inadequate to serve its roughly 250 million people. The quality of these sites ranges from open dumps to semi-engineered landfills. Most disposal sites are operated as open dumps so there is insufficient soil cover and poor environmental protection measures, which allows for large quantities of methane and carbon dioxide to be generated and passively released into the atmosphere.

Local government units are responsible for managing the collection, transportation, and final disposal of municipal waste, but low political will, lean budgets, inadequate human resources, and lax regulation relegate waste to be a low priority on political agendas (Damanhuri 2005). Waste management is often approached in a piecemeal manner, whereby political leaders largely ignore lasting, higher costs solutions in favor of cheaper, stopgap measures. One example of this is when a local government buys more land and expands the landfill size. This stopgap measure is only effective given sufficient available land, but population growth and urbanization are making such strategies more difficult and costly.

12.1.2 Climate Change and Energy Security as Drivers for Sustainable Waste Management

Indonesia is the third largest emitter of greenhouse gas (GHG) emissions after China and the United States. The impacts of waste on climate change are drivers for improving waste management. Indonesia ratified the Kyoto Protocol in 1997, followed by the United Nations Framework Convention on Climate Change (UNFCCC) in 2004, which committed the government to reducing its emissions. Environmentally sustainable waste management is one of the target areas for reducing Indonesia's GHG emissions (GOI 2011). The main emission from waste is methane, which has 28 times the global warming potential of carbon dioxide (Global Carbon Project 2013).

Another driver for exploring alternative waste management options is the potential to generate energy from waste. In 2007, Indonesia switched from being a net energy exporter to an importer. To address the country's growing energy demand in a sustainable manner, the government is supporting the development of renewable energy sources, which includes energy from waste through incineration and methane gas capture.

The remainder of this chapter presents an economic feasibility study of WTE as sustainable waste management solution for Indonesia, using the city of Bekasi and its municipal landfill Sumur Batu as a case study. This study compares the costs and benefits to the local government and society of two final disposal scenarios: landfilling and WTE incineration. The analysis includes:

- *Assessing the public perceptions and preferences for waste management in Bekasi*
- *Evaluating landfilling and WTE in terms of economic and environmental costs and benefits*
- *Investigating parameters which make WTE a feasible alternative to landfilling*
- *Determining the range within those parameters that supports WTE feasibility*

12.2 Indonesia's Waste Management Policy and Institutional Framework

12.2.1 Indonesia's Waste Management Policy

Indonesia's Act No. 18, Regarding Waste Management, issued in 2008, was the country's first formal waste management policy. The act provided a vision for sustainable waste management and promotion of waste utilization for energy (GOI 2008). The objectives described in Act 18 are ambitious given that the policy has many weaknesses in the details. For example, it does not define what constitutes improper waste management, what is its definition of an "open dump," and what are the milestones and intermediate processes and objectives in closing open dumpsites. In 2013 all municipalities must end and close all open dumps, yet the year has come and gone and there has been little progress in Indonesia's waste management. In an interview with the Ministry of Environment's Waste Management Division, the official revealed that even though Act 18 stated criminal penalties, the Ministry lacks resources for monitoring and enforcing waste policies. In reality, criminal penalties are expected to be levied only if a major waste accident (trash landslide, fire, or major contamination) resulted in death. Thus, it seems cities are able to continue open dumping practices as long as no one dies from it.

12.2.2 Institutional Waste Management Framework

The waste management system in Indonesia differs from other countries. Local governments are responsible for waste management services but funding and resources are often inadequate, leading to low provision and quality of services for the public. For example, residential door-to-door waste collection is seldom provided by local governments because of high costs. More often, the communities must arrange their own waste collection without the local government's support. Figure 12.1 illustrates the typical waste management system in Indonesia, showing the services that the community self-organizes and services provided by the local government. Communities often pay informal waste pickers to collect and take away the waste. These informal collectors carry the waste to intermediate facilities where it is then picked up by a municipal waste truck.

Municipal financing for waste services is vague and varies from location to location. In some communities, fees for waste collection and transport are collected through utility bills, while other communities pay their waste fees through annual home-size assessments (Meidiana and Gamse 2010). These municipal fees, however, reflect charges for waste services from the transfer facility to the landfill and often do not include household collection and transfer to the intermediate facility.

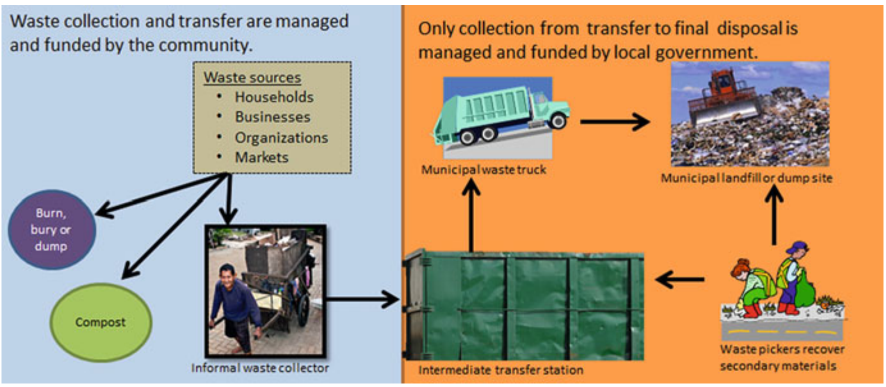

Fig. 12.1 Municipal waste management system in Indonesia (Chaerul et al. 2007)

The cost to the municipality for the collection of waste from the intermediate transfer stations, transportation to the landfill site, and proper treatment and disposal of the waste at the landfill is not sufficiently represented in the household annual taxes because the municipality must allocate funding from the general budget to finance waste services. Damanhuri (2005) found that Indonesian society fails to appreciate or have awareness of the total waste management system and, in result, do not pay the appropriate amount to properly dispose of waste. He notes

> *The ideal condition is that the collected retribution would afford all of operating cost and expenses required, including all of maintenance expenses and even any depreciation expenses. But the fact is that almost all of MSW management operators are experiencing fund deficit from their regular operation. There are some reasons they have been stated, including improper tariff structures, low appreciation of waste generators, including local governments themselves, to repay the service equivalent to the respective obligation.* (Damanhuri 2005)

12.2.3 WTE as an Alternative to Landfilling

Several studies have examined alternatives to landfilling in Indonesia. These alternatives include waste reduction through waste avoidance and recycling, composting, landfill gas capture, anaerobic digestion, and integrated solid waste management. Studies exploring WTE incineration in Indonesia have largely been overlooked because of the technology's high cost, Indonesia's unsuitable waste characteristics, and weak institutions and policies. The World Bank discussed (2000) concerns for incineration projects in developing economies, noting low heating value of the waste because of its higher organic and high moisture content, lack of resources and trained management, weak institutional arrangements, and unwillingness of the people or governments to pay or collect the sufficient revenue to recover higher costs for this complex type of waste treatment. WTE incineration in developing economies has been nonexistent in the past, but recent projects in China's cities are breaking ground for this new technology in Asia.

Based on the World Bank's 2010 WTE Guidelines, Indonesia was not a suitable candidate for WTE in 2010, and there was limited WTE implementation in developing countries. The 15-year-old WTE Guidelines may no longer be applicable to the current Indonesian context, and WTE technology has advanced since then. Incineration technologies can now be adapted to suit different types of waste. For example, incinerators can incorporate pretreatment to dry wet waste before it is fed into an incinerator. Political, social, and economic contexts of Indonesia have also changed. Indonesians have become more urban and affluent, making their consumption patterns, and consequently municipal waste characteristics, more similar to the developed countries.

Some studies have found WTE to be a superior strategy to landfilling. Research by Kaplan et al. (2009) found that burning waste and recovering energy is a more environmentally friendly strategy than burying waste and utilizing the landfill gas (LFG) for energy. The researchers compared life-cycle inventory emissions, on a per unit of energy, between LFG-to-energy with WTE incineration systems in the United States and found WTE produced less GHG emissions and generated more energy (one order of magnitude greater) than landfill gas capture for energy. Another study by Jamasb and Nepal (2010) found that WTE incineration had a carbon neutral effect with biodegradable materials because the emissions released from the combustion of this waste was equal to the amount taken out of the atmosphere in the production of the biodegradable object. In contrast, the authors noted that biodegradable waste sent to landfills would lead to a net increase of emissions because of landfill gases emitted during decomposition. The authors also note additional environmental benefits from WTE are the diversion of waste from landfills, extending landfill life spans, and the replacement of fossil-fuel-derived energy with WTE-derived energy.

WTE is a mature strategy in the developed world with limited but potential application in developing countries. WTE can provide a sustainable long-term solution for waste disposal with less impact on the environment than landfilling and deliver additional environmental benefits.

12.3 Bekasi Waste Management

This section summarizes findings from surveys in Bekasi City, to have basic understanding of current waste management in Bekasi City.

12.3.1 Description of the Study Area

Bekasi City is located on Java Island, approximately 30 km east of the capital Jakarta. It is the fourth most populated city, following Jakarta, Surabaya, and Bandung (World Population Review 2013). It was selected as the case study site because its population, waste characteristic, and challenges with waste management are conditions faced by nearly all urban centers in Indonesia, and thus findings and lessons extracted from the Bekasi study can be applied to other cities in Indonesia.

The population growth rate in Bekasi is much higher than the national growth rate of 1.2 % (World Bank 2013). Urbanization and domestic migration from other provinces into Bekasi City contribute to Bekasi's higher population growth. The population and waste trends for Bekasi are summarized in Table 12.1.

Bekasi operates one municipal landfill called Sumur Batu.[1] Sumur Batu landfill receives all collected waste from Bekasi residents and is managed by the Bekasi

[1] There is another landfill site located in Bekasi city called Bantar Gebang, but it is not operated by the Bekasi local government and receives waste only from Jakarta municipality.

Table 12.1 Population and waste data in Bekasi City

Year	Population	Population change	Waste collection (tonnes/year)	Daily waste collection (tonnes/day)	Annual waste collection change from prior year
2007	1,800,746	–	159,570	437	–
2008	1,793,924	−0.4 %	74,924	205	−53 %
2009	1,882,869	+5 %	102,059	280	+36 %
2010	2,084,420	+11 %	138,346	379	+36 %
2011	2,447,930	+17 %	144,121	395	+4 %

Source: Government of Bekasi City 2012

government. The Cleansing Department, or Dinas Kebersihan, is responsible for all municipal waste management services, including the management and operations of Sumur Batu landfill.

12.3.2 Sumur Batu Landfill

Sumur Batu landfill is located in southeast Bekasi occupying 12.5 ha (Fig. 12.2). The landfill began operations in 2003 and was initially designed as 10 ha with capacity to hold 2 million m^3 of waste. The original landfill design had four zones for waste and a leachate treatment facility. It had an expected life of 14 years (2003–2016) but the landfill reached capacity earlier than planned.

In 2012, the Bekasi government bought an additional 2.5 ha and expanding the landfill to 12.5 ha by creating a fifth zone allowing for an additional 500,000 m^3 (Fig. 12.3). After only 1 year, 40 % of the recently constructed Zone 5 was already full, and the remaining lifetime of the landfill was quickly dwindling. The city bought an additional 1.8 ha in 2013 from the neighboring community and began plans for the development of Zone 6. The city's long-term plan is to buy the land piecemeal with a maximum expansion to 50 ha and operational life span to 2031. Achievement of the long-term plan is questionable. Waste management officials interviewed noted that it is becoming more and more difficult to convince local residents to sell their land to be a landfill. Land prices are also increasing rapidly. The per unit land cost bought in 2013 was 30 % higher than per unit cost in 2012.

The landfill site has no weigh station. Waste amounts reported in official records are calculated based on the volume carried by trucks entering the landfill. Bekasi City is only able to collect about 40 % of the total generated waste in the city. The poor landfill conditions and limited space capacity make increasing the collection rate challenging (Fig. 12.4). Table 12.2 provides a summary of the background information reported in various reports about the landfill.

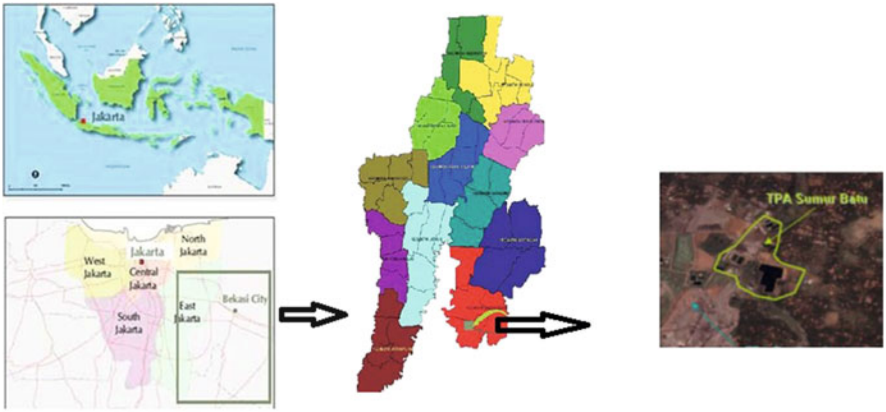

Fig. 12.2 Location of Sumur Batu landfill

Fig. 12.3 Workers preparing the fifth zone of Sumur Batu landfill

12.3.3 Survey of Bekasi Residents: Methodology

This analysis included a focus group discussion, questionnaire survey, and personal interviews to determine society's view on waste issues and interests in addressing the challenges.

Focus Group Twelve (12) focus group participants, comprising heads of villages and households, provided first-hand waste experiences and practices. This information informed the design and content of the survey questionnaire.

Fig. 12.4 Photo of overflowing waste in Sumur Batu landfill without soil cover

Table 12.2 Summary of Sumur Batu landfill data

Sumur Batu landfill background	Availability	Sources
Waste generation rate in Bekasi City	A. 7431 m^3/day	A. Rahim et al. (2012)
	B. 7227 m^3/day or 0.95 kg/capita given 1.9 million population	B. World Bank (2008)
	C. 5546 m^3/day	C. UNFCCC (2006)
Waste characteristics	80–85 % organic	World Bank (2008)
	20 % recyclable	
	Moisture content: high	
Waste collection rate estimation	A. Collection rate is estimated at 25–46 %; about 400 tonnes/day	A. Bekasi Cleansing Department interview, March (2013)
	B. 35 %: 2100 m^3/day or 631 tonnes/day	B. World Bank (2008)
	C. 58 % "coverage rate" or 3397 m^3/day	C. Rahim et al. (2012)
	D. Average truck trips to landfill: 1–2 trips per day	D. Bekasi Cleansing Department interview, March (2013)
Waste management annual budget and operations	IDR 26 billion or US$2.6 million in 2012	Bekasi Cleansing Department interview, March (2013)
	900+ staff, mostly street sweepers	
	IDR 6.26 billion or US$626,000 from "*retribusi*"	

Survey Questionnaire The objectives of the survey questionnaire were to: identify waste management and waste disposal activities, obtain a measure of the public's perception of the waste management services in Bekasi City, and provide information about current waste final disposal challenges and potential new waste management programs. There were 201 total respondents, comprising 160 households and 41 businesses. The survey questionnaire consisted of four sections, as described below:

- **Section I** Demographic Background: This section contained close-ended questions to collect demographic information and other attributes such as education, employment, and family size.
- **Section II** Waste Management Practices: This section contained questions regarding waste management practices, including disposal amounts and methods of disposal and costs related to disposal.
- **Section III** Evaluation of Waste Services: This section was aimed at collecting the respondents' assessment of the level of waste management services provided by the local government. Respondents were asked to evaluate, on a scale of 1 through 6, the different services and resources in waste management. It also included questions to determine what improvements he/she thinks are needed in the city and what priority waste management should be on the government agenda.
- **Section IV** Environmental Knowledge and Perceptions: This section sought to determine the respondent's perception about waste and the environment. This section contained statements about the environment and waste, and respondents were asked to rank their level of agreement or disagreement with the assertion.

Personal Interviews Face-to-face interviews were also conducted to better understand waste management policies, processes, and priorities. Individuals interviewed included bilateral donors, national ministry officials, experts from Indonesia's Waste Management and Climate Change working groups, and local government officials working in waste management.

12.3.4 Survey of Bekasi Residents: Major Findings

Findings from the questionnaire survey provided insight into Bekasi residents' level of awareness of the waste issue, their evaluation of the current level of services, and their interests in making changes or improvements to the status quo. There were 201 respondents, comprising 160 households and 41 businesses located in Bekasi City. The questionnaire surveyed respondents' demographic background, waste management practices, assessment of municipal waste services, and attitudes and knowledge towards the environment and waste. Key findings from the survey are that Bekasi society puts a high priority on waste management and is willing to support improvements in the system through a variety of financial schemes and application of new technologies. The findings for each section of the questionnaire survey are discussed below.

1. *Demographic and Income*

   The demographic data revealed that Bekasi residents are adults aged 31–40 years, with five or less members in their households and average monthly income of 2–3 million rupiah or US$200–300 per month (exchange rate is 10,000 IDR to 1 USD).

2. *Waste Management Practices*

   World Bank studies (2012) estimated that Indonesia generates about 0.78 kg/capita/day of waste. According to the survey, Bekasi residents generated more waste than Indonesia's average. Over half of the respondents (53 %) generate more than this per capita amount, if it is assumed that each household has four individual members (Fig. 12.5). The weight to volume conversion rate of 0.21 kg/L was applied (UNFCCC 2006).

   The survey also asked respondents if they sorted waste. Most people in Bekasi (95 %) do not sort their waste, and the number one reason for not sorting was lack of time (Fig. 12.6).

   Another interesting finding was that nearly all respondents, 195 out of 201, reported paying a small fee for waste services. The highest proportion of respondents (42 %) paid $1–2 per month (Fig. 12.7). It should be noted that these monthly payments are likely paid to informal waste collectors and not to the municipal government because of Bekasi's limited collection system and low collection rate.

3. *Public Assessment of Municipal Waste Services*

   Respondents were asked to evaluate the waste management services overseen by Bekasi Cleansing Department based on a scale of 1–6, with 1 representing

Fig. 12.5 Bekasi waste generation, $N = 201$

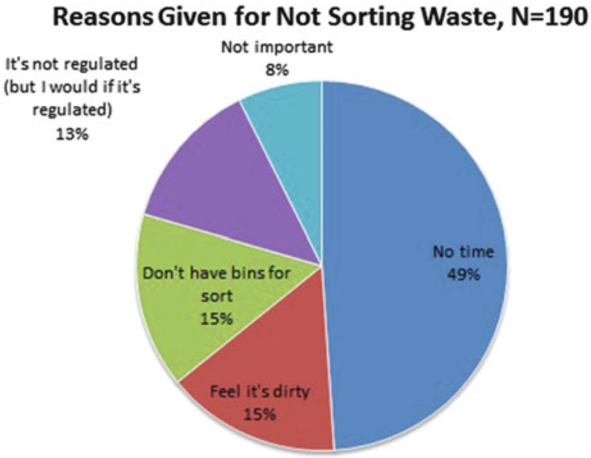

Fig. 12.6 Reasons given for not sorting waste

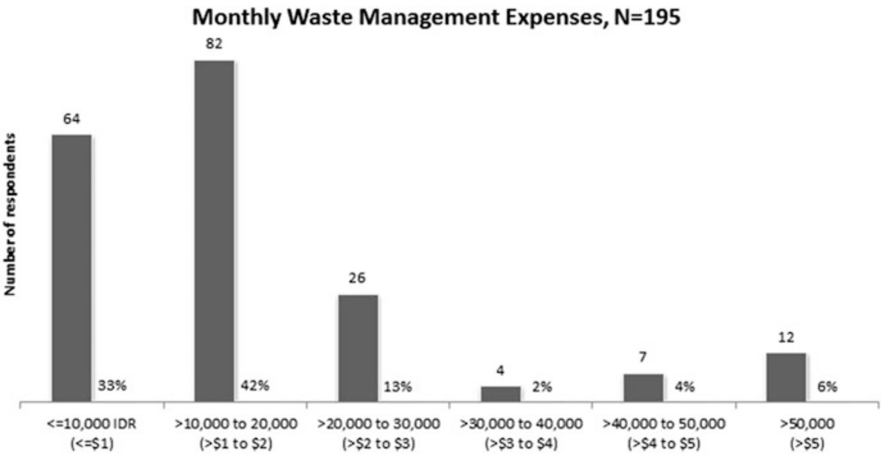

Fig. 12.7 Monthly expenses for waste management, $N = 195$

"Very bad" and 6 representing "Very Good," while 7 was reserved for respondents that did not know. Respondent evaluations are presented in Fig. 12.8. More than half of the respondents do not know the quality of the Sumur Batu landfill. The reason could be as Damanhuri (2005) noted out that public conception of all waste management services is incomplete because their experiences only go as far as the transfer stations.

4. *Attitudes and Knowledge of Environment and Waste*

   Respondents were also asked to rate how much they agreed or disagreed with statements about waste and environment. The findings from this section are presented in Fig. 12.9. Items of interest include a large majority of respondents

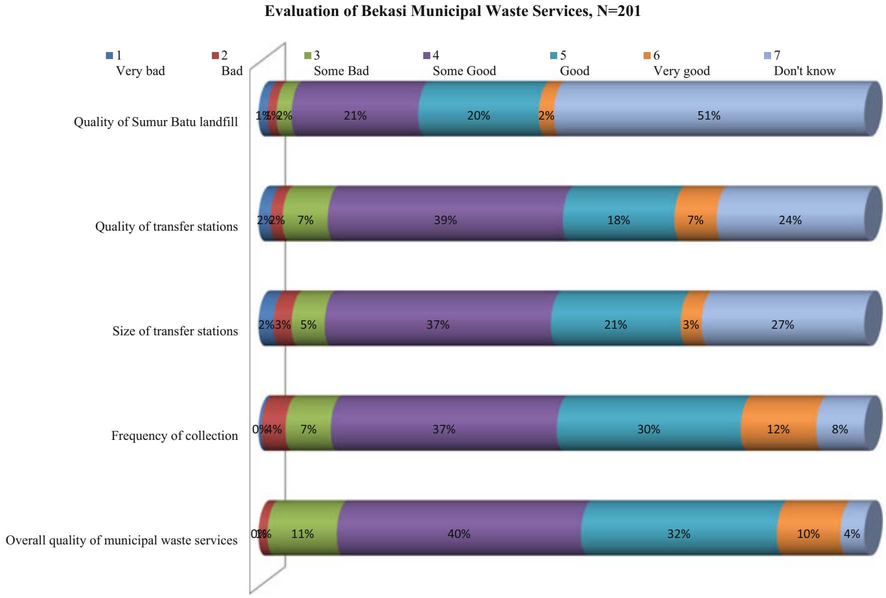

Fig. 12.8 Evaluation of Bekasi municipal waste services, $N = 201$

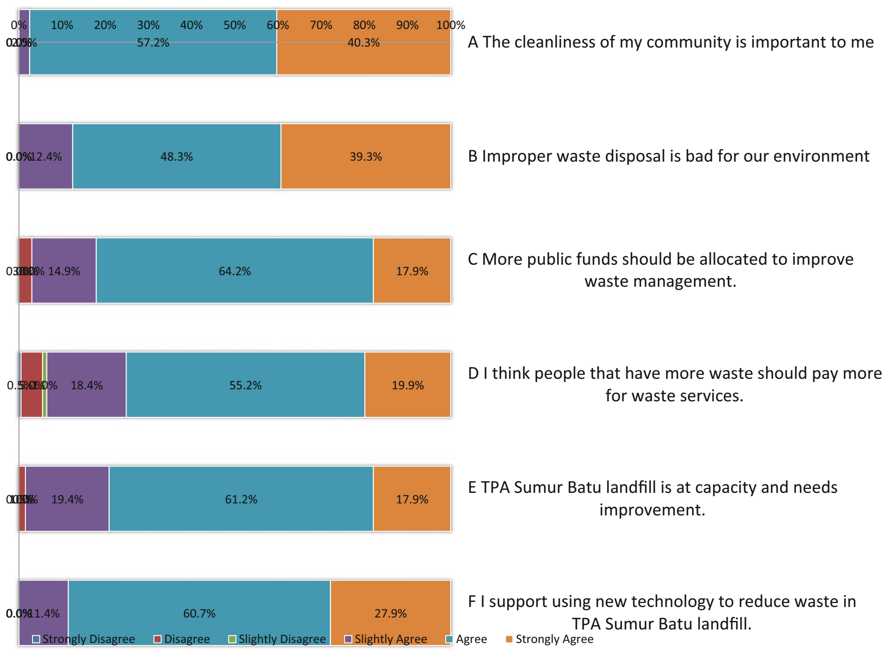

Fig. 12.9 Environmental awareness and preferences for waste management, $N = 201$

stating that the environment is important to them (97 %), and respondents also reveal an awareness that improper waste disposal can have negative effects on the environment. In terms of financial considerations, a majority of respondents support more public funding for waste management and higher payments for people that generate more waste, providing a potential signal to municipal officials and policymakers of the opportunity to increase municipal waste charges as well as apply a pay-as-you-throw charge policy. A majority of respondents (89 %) are also supportive of implementing new technologies such as WTE to address the waste issue.

12.4 Cost and Benefit Analysis

12.4.1 Scope and Framework

The cost and benefit analysis in this study incorporates data from a prior study by Hitachi Zosen (2012) for an incineration project in Greater Malang, Indonesia. Both Greater Malang and Bekasi City have similar population size and waste quantities, waste composition, and climate and topography. Because of these similarities, this study assumes technology and project development parameters in the Greater Malang study to be applicable for a WTE analysis in Bekasi City.

However, the Bekasi City analysis has some additional variations not considered in the Greater Malang study. The variations presented in the Bekasi analysis include:

(i) Three different plant capacity sizes, 800, 1200, and 2000 tonnes/day, are considered for each treatment scenario. Capital costs and electricity production vary for each of the above plant capacities, but operational hours and per unit operational costs are fixed at 8000 h and an operational cost of $35/tonne of waste. Financial parameters for the 800 tonnes/day facility were adapted from Hitachi Zosen's study, while the estimated costs for 1200 and 2000 tonnes/day plant capacities are estimated based on waste technologies' cost functions proposed by Tsilemou and Panagiotakopoulos (2006).

(ii) In contrast to Hitachi Zosen's financial analysis for Greater Malang which was conducted as a private sector investment project, the cost and benefit analysis for evaluating the economic feasibility of WTE in Bekasi City is performed under four different scopes as a public sector project, and benefits to the local and global society are evaluated. The first scope is regarded as baseline where WTE is introduced without considering any reference scenario and environmental dimensions (hereafter named as Scope1). Environmental factors are then considered and added to Scope1 analysis to become Scope1E. Since landfilling is the default technology under the current policy of Bekasi City, Scope2 examines WTE as alternative technology in reference to landfilling. Similar to Scope1E, the inclusion of environmental factors in Scope2 presents

Table 12.3 Detail items of cost and benefit analyses

	Scope1	Scope1E	Scope2	Scope2E
A. Cost items				
Waste collection costs	x	x	x	x
Capital cost of incinerator	x	x	x	x
Operating cost of incinerator	x	x	x	x
Landfilling costs for untreated wastes including land provision and operation	x	x	x	x
Methane emissions from landfilling of untreated wastes		x		x
B. Benefit items				
Cleaning benefits (waste collection fee or waste tax)	x	x	x	x
Revenue from electricity sales (avoided costs of power generation)	x	x	x	x
Avoided CO_2 emissions for power generation		x		x
Avoided landfilling costs including land provision and operation			x	x
Avoided methane emissions from landfilling				x

the fourth scope, Scope2E. As a common framework, the Bekasi City WTE analyses choose one of three different sizes of incinerator depending on the perspective of future collected waste in Bekasi City. Therefore, the following three assumptions are commonly applied to all four scopes:

(a) The period of analyses is 20 years from 2015 to 2035 as lifetime of incineration plant.
(b) Installation of technology is one time only, occurring in 2015, and will take 3 years for construction before the operation.
(c) When collected waste is more than the maximum capacity of incinerator, the excess waste will be disposed by landfilling, which incurs additional costs.

Detailed items of cost and benefit analyses for each of the four different scopes are summarized in Table 12.3.

12.4.2 Scenarios

One of the uncertain factors for waste management planning is future waste generation and waste collection quantities in the context of Bekasi City. To address these uncertainties, these analyses consider a range of future scenarios of collected waste, estimated according to population growth, per capita daily waste generation, and waste collection rate. This study considers lower bound and upper bound population growth scenarios in addition to the middle bound scenario.

- Lower bound scenario assumes 2 % annual population growth: The 2 % growth rate reflects population change from both natural growth and migration, as it is around 30 % lower than the result of combining Indonesia's current natural population growth of 1.2 % and urbanization rate of 1.7 % (Central Intelligence Agency "CIA" 2012). Consequently, Bekasi City's population in 2035 will reach around 4.1 million.
- Middle bound scenario assumes 3 % annual population growth: The 3 % growth rate is closer to the combination of the national growth rate and urbanization rate and is also consistent with the estimate made by Bekasi City's Regional Planning Board in 2012. Consequently, the population in 2035 will reach around 5.0 million.
- Upper bound scenario assumes 4 % annual population growth: The 4 % growth rate is a conservative upper bound estimate that is greater than the local government assumptions. Consequently, the population in 2035 will reach around 6.0 million.

The 2015 population figure is based on a 2 % growth assumption from the actual 2011 population of 2.4 million.

Accurate waste generation data is not available for Bekasi City. The city has record of only the waste collected and no information about uncollected waste (waste burned, buried, or dumped without the city's involvement). For collection data, the volume of waste collected and disposed in Sumur Batu landfill is not formally recorded, but rather estimated from the planned daily vehicle trips and capacity of the vehicle truck. Reported data is often not verified and this has led to different sets of data reported for the same period. At times, city-waste data are inflated to project greater effectiveness of the local government (Damanhuri 2005).

The methodology typically used for estimating waste generation (i.e., Khajuria et al. (2010)) includes the following determinates of municipal solid generation in Asian developing countries: population size, urbanization, gross domestic product per capita, and level of public awareness. The World Bank (1999) estimated a national waste generation figure for Indonesia of 0.52 kg/capita/day generation. This is a conservative estimate because figures for urban residents are known to have higher per capita waste generation figures. Projections for this section use 0.52 kg/capita/day as the baseline and lower bound scenario, whereas the middle and upper bound scenarios for future growth of waste generation are estimated.

In the lower bound scenario, per capita waste generation remains constant over the 20-year projection period at 0.52 kg/person/day. The middle bound scenario has per capita waste generation increasing by 0.5 % annually to account for people in Bekasi becoming more affluent each year and therefore consuming more and generating more waste each year. As a result, per capita waste generation will reach 0.575 kg/person/day in 2035. In the upper bound scenario, per capita waste generation increases by 1 % each year, because of greater income growth and urbanization. As a result, per capita waste generation will reach 0.634 kg/person/day in 2035. Waste generation projections are calculated as the product of population size and per capita waste generation.

Waste collection rate is defined as the proportion of waste that is collected and disposed of by the municipal government to the total generated wastes. The Bekasi City government seeks to achieve an 80 % collection rate; that is, it aims to more than double its present 37 % collection rate by 2020.

Lower, middle, and upper bound collection scenarios are also estimated from the current baseline rate of 37 %, corresponding with no change in the collection rate, an increase of 2 % annually in the collection rate, and an increase of 3 % annually, respectively. Consequently, the collection rate with 2 % annual growth rate will increase to 55.0 %, whereas that with 3 % annual growth will reach to 66.8 %.

Upper bounds of population growth (4 %) and growth of per capita (daily) waste generation (1 %) give the upper boundary of the waste generation scenario, whereas lower bounds of population growth (2 %) and growth of per capita waste generation (0 %) give the lower boundary of the waste generation scenario. In addition, we also have a middle bound of waste generation scenario (3 % for population growth and 0.5 % for growth of per capital waste generation) that correspond to the middle bound of waste generation scenario. Finally, we have three scenarios of waste generation, namely, LG low growth, MG middle growth, and UG upper growth.

Similarly, upper, middle, and lower boundaries of future waste collection rate (LC low collection, MC middle collection, and HC high collection) are incorporated into the three waste generation scenarios that result in nine combinations of collected waste volume. Thus, we have nine scenarios of collected waste volume as shown in Table 12.4.

Annual capacities of incinerators considered in this study are three types: small size capable of processing 800 ton/day of waste (292,000 ton per year), medium size with 1200 ton/day capacity (438,000 ton per year), and large size with 2000 ton/day capacity (730,000 ton per year). After removing LG-HC, which is very close to UG-LC, ten possible scenarios for the introduction of incinerators are created (Table 12.5). As explained earlier, for some of the scenarios, collected waste exceed the capacity of incinerators and therefore landfilling for the excess collected waste become necessary.

Table 12.4 Scenarios of collected wastes volume

	Collected wastes volume in 2035 (ton)	Annual growth rate of collected wastes volume (2015–2035) (%)
LG-LC	287,508	2.00
MG-LC	386,110	3.52
LG-MC	427,221	4.04
UG-LC	517,297	5.04
LG-HC	519,271	5.06
MG-MC	573,740	5.59
MG-HC	697,358	6.62
UG-MC	768,676	7.14
UG-HC	934,296	8.19

Table 12.5 Scenarios of introduction of incinerator

	Scenarios of waste collection volume	Size of incinerator	Year when landfilling becomes necessary
WC2.00-SS	LG-LC	Small	–
WC3.52-SS+	MG-LC	Small	2027
WC3.52-MS	MG-LC	Medium	–
WC4.04-MS	LG-MC	Medium	–
WC5.04-MS+	UG-LC	Medium	2032
WC5.04-LS	UG-LC	Large	–
WC5.59-LS	MG-MC	Large	–
WC6.62-LS	MG-HC	Large	–
WC7.14-LS+	UG-MC	Large	2035
WC8.19-LS+	UG-HC	Large	2032

12.4.3 Assumptions and Key Parameters

The environmental costs in the landfill scenario are based on the projected emissions from landfilling, in tCO_2e, calculated using first-order decay (FOD) model of IPCC (2006). The emissions are then converted to a financial value by multiplying each tonne of CO_2 by an assumed global market carbon price.

The waste composition from Sumur Batu was used as the input parameters for the FOD model emission estimations, but some slight adjustments were made by the author: The composition study conducted by the Bekasi Cleansing Department of Bekasi City government combined food and garden waste together, but the FOD model required the separation of the two types of waste. Therefore, in the FOD model emission estimation, food waste was set at 59.19 % and garden waste was set at 4.34 %. A summary of the waste composition input values used in FOD model is given in Table 12.6.

Other key parameters used in the cost and benefit analyses are summarized in Table 12.7, of which cost data is used as values of the initial year. From the cost of waste collection, solid waste management operational expenses for Bekasi City in 2013 are US$ 2,830,650. The revenue to support these expenses comes from *retribusi*, which are formal waste fees paid by homeowners to the local government, and funds from the general revenue account. The *retribusi* amount supports about 13 % of the operational budget. This study assumes that the gap between the *retribusi* collected and total waste collection operational expenses, the remaining 87 %, are covered by the general budget allocation. The amount of waste collected in 2013 is estimated at 183,476 tonnes, a 3 % increase from the 2012 collection estimate. According to Bekasi City government, in a US$ 2.83 million operational budget, the largest share was transportation (41 %), followed by landfill operations (31 %), collection (25 %), and finally transfer station operations (3 %). This study uses the government expenses for transportation, collection, and transfer station

Table 12.6 Parameters for IPCC FOD model

Item	Value	Unit	Note
Composition of landfilled wastes			
Wood and wood products	7.06	%	Bekasi City government
Pulp, paper, and cardboard (other urban sludge)	4.23	%	Bekasi City government
Food, food waste, beverages, and tobacco (other than sludge)	59.19	%	Bekasi City government
Textiles	6.39	%	Bekasi City government
Garden, yard, and park waste	4.34	%	Bekasi City government
Nonorganic wastes	18.79	%	
DOC			
Wood and wood products	0.43	–	IPCC (2006)
Pulp, paper, and cardboard (other urban sludge)	0.40	–	IPCC (2006)
Food, food waste, beverages, and tobacco (other than sludge)	0.15	–	IPCC (2006)
Textiles	0.24	–	IPCC (2006)
Garden, yard, and park waste	0.20	–	IPCC (2006)
k			
Wood and wood products	0.035	–	IPCC (2006)
Pulp, paper, and cardboard (other urban sludge)	0.070	–	IPCC (2006)
Food, food waste, beverages, and tobacco (other than sludge)	0.400	–	IPCC (2006)
Textiles	0.070	–	IPCC (2006)
Garden, yard, and park waste	0.170	–	IPCC (2006)

operations in addition to private collection expenses for estimating waste collection costs at 12.39 USD per ton at the initial year.

Furthermore, 31 % of government expenses for waste management is used for landfill operations in 2013, which is used for estimating landfilling costs as 4.73 USD per ton at initial year. Regarding the land provisions, there are two major items for the associated costs, namely, acquiring cost for one new hectare of land and the associated capital costs for expanding the landfill, including road construction, leachate piping, and waste water treatment. According to Bekasi City government from the experiences of recent expansion, land procurement cost is \$300,000 per hectare and the associated capital costs are assumed to be \$115,000 per hectare, respectively.

WTE incineration burns waste and produces energy in the process. The incineration process reduces waste volume by 80–95 %, and bottom ash (the resulting residue) is buried in a landfill. WTE has both greater capital and operational costs than landfilling, but researchers have found that benefits, social benefits in particular, are greater for WTE than landfilling. WTE has lower net emissions; has less

Table 12.7 Summary of key parameters of initial year

Item	Value	Unit	Source
Cost of waste collection	12.39	USD per ton	
Average private cost of waste collection	1.70	USD per ton	From our survey
Average public cost of waste collection	3.90	USD per ton	25 % of government expenses in 2013
Transfer station operations	0.52	USD per ton	3 % of government expenses in 2013
Transport from transfer stations to landfilling	6.27	USD per ton	41 % of government expenses in 2013
Landfilling			
Land procurement	300,000	USD per hectare	Bekasi City government
Other associated capital costs to additional land	115,000	USD per hectare	Bekasi City government
Operational costs	4.73	USD per ton	31 % of government expenses in 2013
WTE			
Capital cost of incinerator (small, 800 ton/day)	125	Million USD	Hitachi Zosen (2012)
Operational costs of incinerator (small, 800 ton/day)	35	USD per ton	Hitachi Zosen (2012)
Power generation capacity (small, 800 ton/day)	14	MW	Hitachi Zosen (2012)
Capital cost of incinerator (medium, 1200 ton/day)	202	Million USD	Tsilemou and Panagiotakopoulos (2006)
Operational costs of incinerator (medium, 1200 ton/day)	29	USD per ton	Tsilemou and Panagiotakopoulos (2006)
Power generation capacity (medium, 1200 ton/day)	24	MW	Tsilemou and Panagiotakopoulos (2006)
Capital cost of incinerator (small, 2000 ton/day)	298	Million USD	Tsilemou and Panagiotakopoulos (2006)
Operational costs of incinerator (large, 800 ton/day)	25	USD per ton	Tsilemou and Panagiotakopoulos (2006)
Power generation capacity (large, 2000 ton/day)	50	MW	Tsilemou and Panagiotakopoulos (2006)
Full operational hours	8000	Hours per year	Hitachi Zosen (2012)
Selling price of electricity (power generation costs)	105	USD per MWh	Government of Indonesia (2013)
Emissions			
Carbon emission coefficient of power grid in Indonesia	0.891	tCO_2/MWh	Hitachi Zosen (2012)
Social cost of carbon	16	USD/t-CO_2	US EPA (2015)
Cleaning benefits			
Per ton of cleaning benefits of Bekasi City	15.43	USD/ton	Bekasi City government

risk of pollution to air, water, and soil; extends the capacity and lifetimes of existing landfills; and provides renewable-sourced energy (Jamasb and Nepal 2010; Dijkgraaf and Vollebergh 2003). In this study, the parameters that enable WTE to be feasible in Bekasi are assumed, based on previous work by Hitachi Zosen's Greater Malang Feasibility Study (Hitachi Zosen 2012). Bekasi's population and waste growth projections are much higher than Malang's; therefore, two additional incinerator capacities are evaluated for Bekasi. With these parameters, the financial and economic internal rate of return for each of the collection and the plant capacity scenario is compared and evaluated to determine which investment is best suited for Bekasi. Operational costs are assumed to vary from $35, to 29, to 25/ton of treated waste for the different plant sizes, small, medium, and large, respectively, based on the cost functions proposed by Tsilemou and Panagiotakopoulos (2006). Selling price of electricity generated by WTE is taken from the study of Hitachi Zosen (2012), originally from the price of electricity purchased by state electric company PT Persero from waste-based power generation (Government of Indonesia 2013). The Government of Indonesia does not have a proactive feed-in tariff policy at present; the value is regarded to be close to the current power generation costs in Indonesia. In addition, avoided carbon emissions from the power sector in Indonesia are also considered as environmental benefits due to introduction of WTE. The emission intensity of carbon is taken from the study of Hitachi Zosen (2012).

The social cost of carbon is referred from the 2015 figure from the United States Environmental Protection Agency (US EPA 2015). The social cost of carbon is meant to be a comprehensive estimate of climate change damages. The value in future is affected by the assumption of the discount rate, and thus the value in midterm of this study's analytical period, 2025, is used for reference in this analysis. The initial baseline value is set as $16 under the high discount rate at 5 %. Here, carbon emissions from WTE are not considered since most of the fuels for the incinerator can be assumed to be organic materials.

Lastly, per ton of cleaning benefits of waste disposal in this study is regarded as current financial burden for the residents in Bekasi City. As a fairly modest estimate, the value is measured as solid waste management operational expenses for Bekasi City per ton of collected wastes in 2013.

12.4.4 Sensitivity Analyses for the Future Price Changes

This study also applies sensitivity analyses for future price changes in several key parameters. To be more specific, the analysis examines four key parameters of price, namely, land price, cleaning benefits, electricity price, and social cost of carbon as shown in Table 12.8. As a part of Jakarta Metropolitan Area, Bekasi City faces land constraints and expected increase in the environmental awareness of city residents in the future, while procurement cost of incremental land for landfilling is expected to rise. The environmental awareness and income growth will also affect willingness to pay for waste disposal services and increase public support for waste

Table 12.8 Parameters of sensitivity analyses

	Baseline	S1	S2	S3	S4	S1+S2	S1+S2+S3	S1+S2+S3+S4
Land price	0 %	5 %	0 %	0 %	0 %	5 %	5 %	5 %
Cleaning benefits	0 %	0 %	5 %	0 %	0 %	5 %	5 %	5 %
Electricity price	0 %	0 %	0 %	5 %	0 %	0 %	5 %	5 %
Social cost of carbon	$16	$16	$16	$16	$76	$16	$16	$76

management by the government. Thus the benefits of waste management will be also expected. Since Indonesia has become a net oil importing country since 2004 and is highly dependent on fossil fuels for generating electricity, it can be assumed that there will be increases to the cost of power generation in future. The commitment to climate change mitigation by the government would propel the shift of energy sources of power generation to renewable resources and therefore increase the cost of power generation. It is highly uncertain for social cost of carbon, and thus it is worth examining a higher price of the social cost of carbon as well. The price of $76 in 2014 is estimated based on impacts of carbon emissions in 2025 under the assumption of lower discounting rate at 2.5 %. For understanding the impact of relative price increase in those parameters, 5 % annual increases in those prices, which accounts for 2.65 times increase for 20 years, are used in addition to the higher estimate of social cost of carbon.

12.5 Findings from Cost-Benefit Analyses

The results of cost and benefit analyses are summarized in Fig. 12.10. Overall, the cost and benefit analyses reveal that the scale of waste collection significantly matters when seeking better IRRs of WTE projects in Bekasi City. Second, there are feasible conditions that enable IRRs to be financially acceptable, which this study sets at 6 % IRR or greater. The value of 6 % is used as capital cost of private investment for incinerators in the study of Hitachi Zosen.

Scope1 under baseline scenario gives large negative IRRs in most of scales of waste collection except WC8.19-LS+, suggesting that WTE is not economically feasible if it is private investment project. Even if environmental costs and benefits are considered and thus the IRRs are improved in Scope1E, dominant values of IRR remain in the negative range. When the project is evaluated in reference to the existing landfilling policy in Scope2 and Scope2E under the baseline scenario, the results are largely improved, having higher IRRs and more scenarios turn to be positive IRRs. However, even the best case of WC8.19-LS+ in Scope2E does not reach 4 % IRR, which is far below from the financially feasible threshold of 6 %.

One of the serious concerns on sustainable waste management and at the same time important motivation for introduction of WTE in Bekasi City is land scarcity

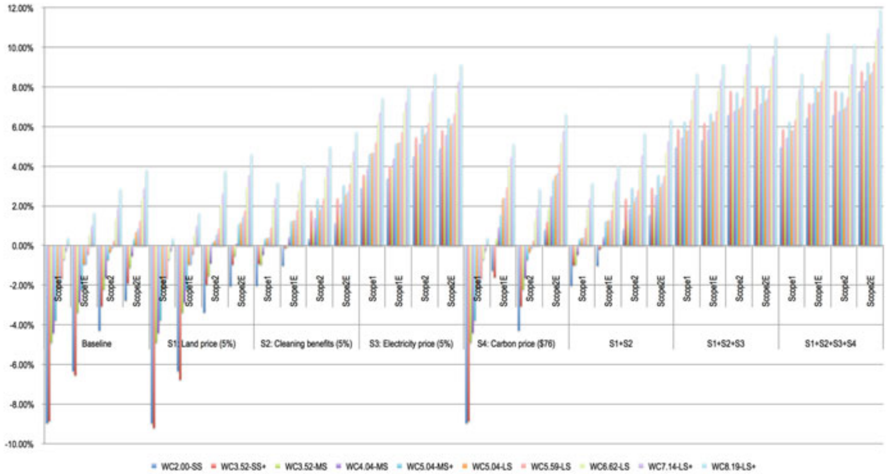

Fig. 12.10 Sensitivity analyses of internal rate of return (IRR) for WTE

and land availability for landfilling. Therefore, relative increase in the price of land for landfilling would likely occur in the next 20 years in Bekasi City. The impact of 5 % annual price increase relative to other prices on the IRRs is shown under the S1 sensitivity scenario. Naturally it does not affect Scope1 and Scope1E, whereas it does affect Scope2 and Scope2E although the higher IRRs still do not reach at 6 %. In Scope2 and Scope2E, a medium size of WTE plant turns to be positive from negative when it compares between baseline sensitivity scenario and the S1 sensitivity scenario.

As discussed earlier, the benefits of properly disposing wastes can be increased due to income growth and development of environmental awareness. The S2 sensitivity scenario examines the effect of cleaning benefits on IRRs, when economic value of per ton of collected wastes increase at 5 % annually. The effects on IRRs are larger than land price in particular; it affects on Scope1 and Scope1E to large extents. Many cases of the scale variations turn to be positive from negative, and in Scope2 and Scope2E when the projects are evaluated in reference to the current landfilling policy, all of the cases in scale variations become positive. Even these significant improvements in IRRs, the best case under Scope2E, WC8.19-LS+ remains slightly below 6 % IRR feasibility threshold.

The cost of power generation is another concern in the long run in Indonesia, where large dependency on oil resources will face price increase due to expansion in imports of oil commodities. The third factor in the sensitivity analyses is power generation cost, which can be realized also by an aggressive policy of a feed-in tariff, where the society bears the financial burden for the electricity generated by other sources than fossil fuels. The S3 sensitivity scenario analyzes the effects of increases in electricity price on IRRs with 5 % annual increase. It has remarkable effects making all cases positive, even some cases in scale variations, regardless of the differences in scope, appear to be more than 6 %. It is worth mentioning that under Scope1, three scales as WC6.62-LS, WC7.14-LS+, and WC8.19-LS+ demonstrate more than 6 % IRRs, suggesting that a private investment project can be considered for larger scale when electricity price will be largely increased. If we count the benefits from the existing landfilling policy with WC5.04-MS+ under Scope2, medium-size project becomes also very close to the acceptable threshold of private investment project, as the IRR is 5.98 %.

The last factor for sensitivity analyses is the social cost of carbon. While the baseline sensitivity scenario employs $16 per ton of CO_2 emissions which is derived from the assumption of higher discount rate at 5.0 % in 2025, the value of $76 per ton of CO_2 emissions deriving with assumption of lower discount rate at 2.5 % is used for comparison in the S4. Since this is the environmental factor, differences appear only in Scope1E and Scope2E. Although the large increase in social cost of carbon makes most of the IRRs double, only one case under Scope2E goes beyond 6 %.

The rest of the scenarios in the sensitivity analyses are the selected combinations among S1, S2, S3, and S4. The results reconfirm the scale of impact of electricity price. The combination of S1 and S2 was not sufficient in pulling the IRRs to a level of acceptability. Moreover, when S3 is added in the combination, even smaller scale projects become financially feasible no matter if the evaluations are compared to the landfilling or not and environmental factors are considered or not.

12.6 Conclusion and Discussion

Inadequate municipal waste management practices and the poor quality of disposal sites contribute to waste becoming one of the main sources of greenhouse gas emissions in Indonesia. In shifting waste management strategies from landfilling to WTE technologies, it may be possible to reduce net GHG emissions while also providing financially feasible and environmentally sustainable waste management. This study presented an economic analysis of WTE and compared it to continued landfilling, using Bekasi City as a case study. From the analysis presented in the earlier sections, the following conclusions for landfilling and WTE are drawn for Bekasi City.

Under the status quo, the local government is providing a low level of waste management services, and this is reflected in the low collection rate, poor management of the Sumur Batu landfill, and insufficient waste payments paid to the municipality. Findings from interviews, focus group discussion, and random questionnaire survey reveal that society wants change with the current waste management situation and to elevate waste management to a higher policy priority. The survey findings also show that Bekasi City constituents are willing to support improvements in waste management, including alternative waste management strategies.

In Bekasi City, the existing landfilling and open dumping practices are unsustainable, both economically and environmentally. When the analysis is expanded to include the environmental costs of landfill emissions, there is a social cost valued at $312–571 million over 20 years. If the trend of high population growth continues, Bekasi City's landfill area would increase at 1.7–3.7 times over its current size.

Given landfilling's unsustainability, this study considered WTE as an alternative final disposal method and evaluated its costs and benefits to the local government and the greater society. While WTE has higher investment and operational costs, this study found that there are possibilities to make social benefits to be financially feasible as compared to the necessary costs. Financial benefits can also be substantial with the appropriate policies, such as a feed-in tariff. Moreover, when compared to the current landfilling strategy, there are also possibilities to have economically feasible projects without having a feed-in tariff, which are relatively larger projects.

The scenarios considered in the analyses included three different-sized WTE incineration plants for Bekasi City – 800, 1200, and 2000 tonnes of waste per day treatment capacity. Capital and operational cost functions for each of these facilities assume varying economies of scale and are based on work by Tsilemou and Panagiotakopoulos (2006). Based on the initial parameters of $15.43 per capita cleaning benefits and $105 per MWh energy price, only the large facility with the largest collection volume of waste demonstrated feasible IRRs above the 6 % acceptable threshold. The results from the sensitivity analysis show that the price of electricity substantially impacts the IRRs; increasing the electricity price at 5 % annual increase made even the small facility financially viable. In revising the per capita cleaning benefits, even the largest facility size, 2000 tonnes/day treatment capacity, with favorable conditions for waste collection is not financially feasible. The sensitivity analysis also found that land price changing with 5 % annual increase have limited impacts on the IRRs.

The study found that environmental benefits play a limited role in impacting the IRRs. However, the financial and environmental benefits of WTE shown in this analysis are assumed to be independent of each other, but it is possible for financial and environmental benefits to impact one another. For example, financial returns from WTE can be used to enhance environmental benefits, such as allocating revenue from WTE electricity sales to support emission reduction programs. This study only considered environmental benefits from avoided landfill emissions, but there are additional induced environmental benefits from WTE. These include the emission reduction from replacing fossil-fuel-derived energy with renewable WTE-derived energy; environmental cost savings from avoided pollution to air, soil, and water by replacing landfilling with incineration; and social cost savings from an improved and sanitary WTE facility (Dijkgraaf and Vollebergh 2003; Jamasb and Nepal 2010).

The implementation of WTE for Bekasi City is ultimately dependent on policy measures at both the national and local government level. In developing countries, uncertainty with the achievement and effectiveness of domestic policies has constrained high-cost, high-tech investments like WTE incineration. It was assumed that the high technology costs of WTE and the required awareness and cooperation from the government and public would be a challenge for Indonesia (Aprilia et al. 2010).

However, with growing waste management challenges and increasingly negative impacts from landfilling to society and the environment, ignoring WTE as an option is unreasonable. WTE has the potential to reduce GHG emissions, provide a sustainable waste management strategy, and provide renewable energy. The discussion should no longer be about whether or not WTE will work for Indonesia, but rather about how to make it work.

It is insufficient to view waste management costs and benefits in only financial terms. Waste management is a public good that directly impacts public health and environment. A waste management project must be evaluated to also consider costs and benefits to society. The feasibility study conducted by Hitachi Zosen demonstrated that WTE incineration can be financially feasible for a private sector investor but does not go far enough to demonstrate its impact on society. An economic analysis such as this study focusing on the government and society as the beneficiaries is timely and relevant for Indonesia because, as of 2014, local governments are legally bound to cease open dumping practices and must find environmentally sustainable long-term solutions for managing municipal waste.

While the low waste collection rate points to the Bekasi City municipal government as failing its citizens in providing waste management services, Bekasi constituents can also be viewed as failing to appreciate the true value of waste management. Aprilia et al. (2010) found households are reluctant to pay more *retribusi* (monthly waste management fees) because they believe it is in excess of the value of waste services they are receiving. The questionnaire survey of Bekasi residents revealed that society had a low level of awareness about the Sumur Batu landfill conditions and consequently the hazards and risks stemming from inadequate landfill practices. As Damanhuri (2005) noted, society's low monthly waste payments reflect a truncated scope of waste services, seeing only waste disposal from their home to the intermediate transfer station, while neglecting to see the more costly services of collection from intermediate site, transport to final disposal site, and environmentally sustainable management of the landfill.

The low level of public awareness about waste management did not critically impact the economic analysis in this study but does reveal an important policy implication. Society's low level of awareness is reflected in the low price it pays for waste services. There is a possibility that with a greater level of awareness about the waste management process and environmental impacts, society will assign a higher value to waste services and support a higher price. As revealed in the questionnaire survey, society supports allocating more public financing to improve waste management services.

In the sensitivity analysis, the amount of revenue from beneficiaries impact WTE's rates of return. The local government could help to educate the public about the full scope of waste management services, from household collection to final disposal, and increase society's appreciation for waste services. With this greater societal awareness, financing policies such as waste tax or a feed-in tariff may become politically feasible. This study did not explore society's willingness to pay for improved waste services; therefore, the taxes and feed-in tariff are modestly assumed in the analysis. Further studies regarding willingness to pay for waste services can clarify these points.

At the national level, two key policies are providing the push and pull needed to support innovation in WTE. The first is the National Solid Waste Law (Act 18) which bans and criminalizes most of the current municipal waste practices operating in Indonesia. The law might significantly affect the benefit structure for the cases where the alternative options are evaluated in reference to the landfilling, thereby pushing local governments to seek alternative, sustainable waste management strategies. The second policy by the Ministry of Energy and Mineral Resources provides the pull needed for more investment in WTE by guaranteeing a premium price for energy derived from waste in the form of feed-in tariff.

Both national-level policies are critical but more can be done to hasten and enhance the development of WTE. The national government can conduct regular and stringent monitoring and require verifiable reporting to ensure that local governments are complying with the National Waste Policy. The national government can also remove subsidies for fossil fuels so that energy from waste becomes more competitive against traditional fuel sources.

Unlike in the past, Indonesia now has several drivers and opportunities for the promotion of WTE as a sustainable waste management strategy. The technological feasibility has been demonstrated by Hitachi Zosen's Greater Malang feasibility study, and it is hoped that this study has demonstrated the social imperative for waste-to-energy.

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Chapter 13
Use of Climate Information for Rice Farming in Indonesia

Riga Anggarendra, Cometta S. Guritno, and Mrinila Singh

Abstract Rice plays a significant role in Indonesia. It is a staple food of the country and has strategic importance for food security. Rice productivity is highly influenced by climate and its variability. As planting time is one of the most affecting factors, providing correct information for farmers at the right time is critical for successful rice farming. The Indonesian Ministry of Agriculture has developed a tool called "Integrated Cropping Calendar System (KATAM)" to support in increasing food production and helping farmers to adapt to the changing climate. KATAM provides useful information, such as the prediction on appropriate planting time, and recommendation on types of rice variety and fertilizer to be used. It also contains information on potential climate-related hazards, such as floods and droughts, which will help farmers to minimize climate risks. However, farmers are often unaware of this tool. This chapter addresses the opportunities and challenges associated with communication of KATAM with rice farmers in Indonesia. In this relation, it also describes an intermediary role of agricultural extension workers and the government initiative "Climate Field School."

Keywords Climate change adaptation • Rice farming • Climate information • Cropping calendar • Agricultural extension workers • Climate field school

13.1 Introduction

With five large islands (Sumatra, Java, Kalimantan, Sulawesi, and Papua) and about 13,667 small islands, Indonesia is the largest archipelago in the world with land area of 1.9 million km^2. It is also prone to climate-related perils because of its geographical setting and socioeconomic aspects. Historically, the country has

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suffered severe damages because of El Niño Southern Oscillation (ENSO) phenomena and extreme meteorological conditions. Impacts of climate change have been intensifying with an increasing number of extreme weather patterns and climate anomalies. Floods have been the most frequent hazard, followed by landslides, water or vector borne diseases, wind storms, forest fires, droughts, and high storm surge. Twenty most intensive hazards responsible for huge economic losses and human impacts have all occurred after the 1980s (Dewi et al. 2010).

Agriculture in Indonesia is strongly affected by ENSO and the associated interannual variations in precipitation (Dewi et al. 2010; Oktaviani et al. 2011). Of the 200 million ha of the land territory, 25 % is allocated for agricultural activities, which play an important role in the national economy, accounting for 15.4 % of the total gross domestic product. During Asian financial crisis, it helped recover the economy by lifting the exports substantially and absorbing many of the unemployed (Dewi et al. 2010). Within agriculture sector, rice plays a significant role in Indonesia. It is a staple food of the country and has strategic importance on affecting its food security. Some 40 % of arable land is wetland used for rice fields (Dewi et al. 2010). About 15 million farmers are involved in rice production and 220 million Indonesians consume it. Rice production and supply comes to a center stage for the policymakers in the discussion of Indonesia's food security (Oktaviani et al. 2011). ENSO is accountable for almost two-thirds of total variation in rice output. There have been changes in precipitation patterns, droughts, and flood cycles as a result of ENSO.

During the warm phase of the ENSO cycle, it frequently experienced dry climatic conditions and droughts. As a result, there has been agricultural production loss, impacting rural income, food prices, and food security as a whole (Naylor et al. 2007; Oktaviani et al. 2011). For example, during drought of 1997–1998, more than 800,000 ha of rice crop area was affected with loss of around three million tons (Subbiah and Kishore 2001). Furthermore, in El Niño years, it has become extremely difficult for farmers to decide planting time because it may eventually cause dry spells (Subbiah and Kishore 2001). Since Indonesia is a country where a number of islands are scattered, the climatic pattern cannot be generalized for all of its regions. A change in rainfall amount, shift of rainfall pattern, drought, sea level rise, and other changes remains unique to specific regions (Dewi et al. 2010). This brings the necessity for the prediction to be as local as possible.

The use of climate information by farmers has been the subject of a number of studies in the past (Vogel and O'Brien 2006; Rees et al. 2000; Sturges and Chimseu 1996; Obiora 2013). Among those identified by these studies as affecting the effectiveness of dissemination of climate information to farming communities, there are two factors that are commonly cited. One is the way in which climate information is communicated from a provider to end users. The other is the capacity of intermediaries (i.e., agricultural extension officers) in relaying information from a provider to users. Vogel and O'Brien (2006) indicated the importance of a two-way communication instead of one-way and top-down flow of information. They also indicated the importance of the role of intermediaries to translate the climate information into the language understandable by farmers, as well as to communicate users' needs with the information provider. Similarly, using Kenya as a study location, Rees et al. (2000) found the dissatisfaction by farmer communities and intermediaries with the quality and frequency of interaction with the government that provides climate information. They indicated the needs as expressed by farmers for interactive learning. Similar findings were given by Sturges and Chimseu (1996) and Obiora (2013), who studied the use of climate information in Malawi and Nigeria, respectively.

Interviews with several key stakeholders related to the communication of climate information with rice farmers, in particular the "Integrated Cropping Calendar System (*Sistem Informasi Kalendar Tanam Terpadu*, KATAM)," were conducted in six villages of Pasuruan, East Java (JICA 2014). The interviewees included the Ministry of Agriculture (MoA) as the producer of KATAM, the provincial Task Force on KATAM in East Java, agriculture extension officers who serve as intermediaries for the dissemination of KATAM, and farmers as users of KATAM. The interview indicates that farmers have almost never heard of KATAM. Even extension officers have only limited knowledge of KATAM.

This chapter will address the opportunities and challenges associated with KATAM. In reference to the factors affecting the use of climate information, as indicated above, this chapter will then describe an intermediary role of agricultural extension workers. It will also describe the "Climate Field School (CFS)" as a government initiative to promote two-way communication with farmers.

13.2 KATAM

KATAM is a tool provided by the government of Indonesia to secure food production in the framework of the national rice production enhancement program (*peningkatan produksi beras nasional*, P2BN). It is also intended to help farmers to adapt to the changing climate. It was first developed by the Indonesian Agency for Agricultural Research and Development (*Badan Penelitian dan Pengembangan Pertanian – Balitbangtan*) under the MoA in 2007. The first generation of KATAM was in the form of cropping calendar atlas, which showed the map with information of planting time for food crops (rice and horticulture) in the island of Java (Volume I, 2007), followed by Sumatra (Volume II, 2008), Kalimantan (Volume III, 2009), Sulawesi (Volume IV, 2009), Bali, Maluku, Nusa Tenggara, and Papua (Volume V, 2010).

The information produced during the period of 2007–2010 was semi-dynamic, where one of the three climate scenarios (La Niña/wet, El Niño/dry, and normal) was assumed to take place throughout the year. In reality, climate condition may fluctuate in every season or even month, causing the prediction to be not accurate. To address this problem, the MoA started to develop a dynamic KATAM in 2010, taking into account climate fluctuations by using monthly rainfall and seasonal forecasts by the Agency for Meteorology, Climatology and Geophysics (*Badan*

INTEGRATED CROPPING CALENDAR
PLANTING SEASON (MT) III 2014
KECAMATAN: PURWOSARI
KABUPATEN/MUNICIPAL: PASURUAN, PROVINCE: EAST JAVA
COMMODITY: PADDY AND HORTICULTURE AGROECOSYSTEM: FIELD
PRIMARY INFORMATION

Standard Field Area (ha) : 1,170
Prediction of Rainfall Characteristics : Above normal
Estimation of Area and Planting Start :

<table>
<tr><th rowspan="2">Commodity</th><th colspan="2">Planting Season I*)</th><th colspan="2">Planting Season II*)</th><th colspan="2">Planting Season III</th></tr>
<tr><th>Planting Area (ha)</th><th>Planting Start (dasarian)</th><th>Planting Area (ha)</th><th>Planting Start (dasarian)</th><th>Planting Area (ha)</th><th>Planting Start (dasarian)</th></tr>
<tr><td>Paddy</td><td>1,170</td><td>NOV I-II</td><td>1,082</td><td>MAR I-II</td><td>0</td><td>-</td></tr>
<tr><td>Corn/Soybean</td><td>-</td><td rowspan="2">-</td><td>88</td><td rowspan="2">MAR I-II</td><td>1,170</td><td rowspan="2">JUL I-II</td></tr>
<tr><td>Soybean</td><td>-</td><td>0</td><td>0</td></tr>
</table>

Note: * Prediction from the previous planting seasons

Fig. 13.1 Example of KATAM (Translated from http://katam.litbang.deptan.go.id/)

Meteorologi, Klimatologi, dan Geofisika, BMKG). In a dynamic KATAM, the climate scenario is updated for each planting season. In Indonesia, the planting season is generally divided into three periods: the first, second, and third planting periods (MT I, MT II, MT III). MT I usually takes place around September/October–January/February, MT II around February/March–May/June, and MT III around June/July–September/October (Fig. 13.1).

To further enhance its ability as a tool to help farmers in making decisions on their farming activities, more information has been added as follows: predictions on the average rainfall conditions for a planting season and the forecast on the start of planting time, information on potential threat of climate-related hazards in a particular area (flood, drought, and pest and disease attacks), recommendation on paddy variety as well as type and amount of fertilizer to be used to respond to those hazards, and information on the availability of farming machinery in the concerned area. With such information, KATAM is expected to provide opportunities for farmers to minimize climate risks.

To make sure that KATAM information can be accessed as widely as possible, an online system (www.katam.info) was launched in 2011. The MoA conducts a launching event for the published KATAM information 1 month before the start of each planting season so that the information can be disseminated to users on time. In this launching event, the MoA invites some local agricultural agencies (provincial level) and all of the Agricultural Technology Assessment Centers (*Balai Pengkajian Teknologi Pertanian*, BPTP). BPTP is a technical implementing unit of Balitbangtan, established at the provincial level under the decree of the Ministry of Agriculture. BPTP has the responsibility to disseminate KATAM information to users in the respective provinces.

Furthermore, the head of Balitbangtan issued a decree (No. 178.1/Kpts/OT.160/I/7/2012) on the establishment of “KATAM and Climate Change Task Force”

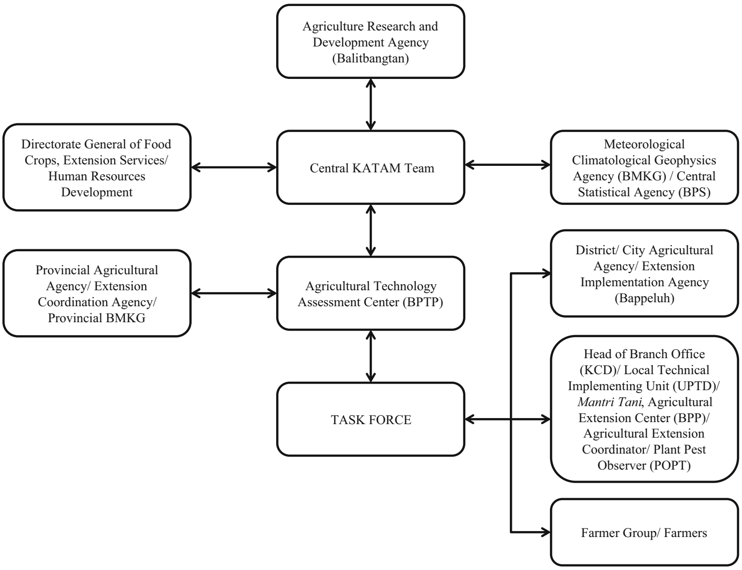


Fig. 13.2 Delivery process of KATAM (Adopted from Runtunuwu et al. 2013)

under each BPTP. The main responsibility of the Task Force is to coordinate the distribution of KATAM information with stakeholders. After each launching event, the Task Force organizes socialization and training programs by inviting stakeholders such as local agricultural agency (*Dinas Pertanian dan Tanaman Pangan*, Diperta) and extension implementing agency (*Badan Pelaksana Penyuluh*, Bappeluh) at regency/city (*kabupaten/kota*) level. Both Diperta and Bappeluh are responsible in disseminating KATAM to agricultural extension center (*Badan Pengola Polder*, BPP), which houses extension officers at sub-regency (*kecamatan*) level. These extension officers have direct contact with farmers/farmer groups at villages, thereby playing critical role to ensure that KATAM will reach farmer communities (Fig. 13.2).

Climate information is disseminated by the provincial Task Force, as mandated by the national government. At least once a year, the Task Force from each province is invited by Balitbangtan to attend a dissemination event, where the latest information of KATAM is given, including updated features and recommendations of dissemination. The Task Force will then decide on the methodology used for disseminating the information to farmers. As a limited number of farmers can access the Internet and a computer, the Task Force is expected, for example, to print out the web pages containing the climate information and distribute it to farmers. A mobile technology using short message service (SMS) and android application has also been introduced for farmers who have limited access to computer system, given the increasing adoption of smartphones in Indonesia. Some studies show that information and communication technologies can be effectively used to deliver climate and agricultural information to farming communities (Weiss et al. 2000).

The interviews with key stakeholders related to KATAM, conducted in six villages of Pasuruan, East Java, indicate that farmers have almost never heard of KATAM. Even extension officers have only limited knowledge of KATAM (JICA 2014). The following sections will describe an intermediary role of extension workers and the CFS as a government initiative to promote two-way communication with farmers.

13.3 Agricultural Extension Workers

Indonesia is a large country consisting of many islands. Communication between national and local governments is sometimes difficult. In the agriculture sector, widely distributed paddy fields in remote areas are a challenge to govern. The MoA communicates with local governments in several ways. For example, they invite representatives from all the provinces to a national meeting, workshop, or seminar. Provincial agriculture offices (*dinas provinsi*) then forward the concerned policy message to a lower level, namely, regency agricultural office (*dinas kabupaten*) and/or other related offices under their respective jurisdictions. Given the limited educational background of many farmers, it is sometimes difficult to disseminate new information to them. This necessitates extension workers, who are responsible to convey information and guide farmers. In Indonesian language, they are called "*penyuluh*," which means a "person who gives guidance."

Extension workers are civil servants at regency level, with a reporting responsibility to the concerned regency office. According to a regulation, each sub-regency/village (*kecamatan*) is entitled to have one extension worker. However, this is not the case in reality. Often, one extension worker has to take care of more than one village. The number of extension workers in Indonesia is 51,428 (BPS 2012), far from the number of sub-regency/villages (75,224). Communication with farmers thus continues to be a challenge.

In response, the government has tried several countermeasures, one of which was to assign extension workers in major paddy-producing areas in a concentrated and prioritized manner. However, the resulting information gap across locations became problematic. Recommendations to farmers on timing of planting and a type of fertilizer to be used, for example, were received by selected locations, while the remaining areas were only dependent on the capacity of their respective regency office.

Another countermeasure by the national government was the issuance of a regulation which stipulated an increase in the number of extension workers. Instead of recruiting new extension workers as a part of civil servants, these new extension workers are retained on contracts (*tenaga harian lepas*, THL). Their contracts are usually renewable each year and funded by the state budget (*Anggaran Pendapatan dan Belanja Negara*, APBN). In addition, there are also private and voluntary

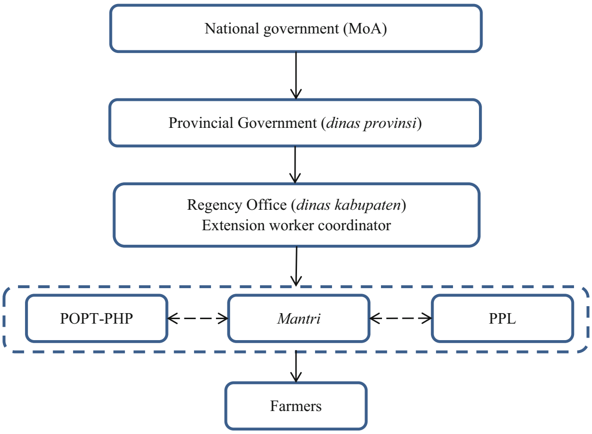


Fig. 13.3 Flow of guidance from national government to farmers (Adopted from Agriculture Ministerial Regulation No. 73/Permentan/OT.140/12/2007)

(*swadaya*) extension workers. This type of extension workers is regulated by a law, but their salaries are not borne by the government.

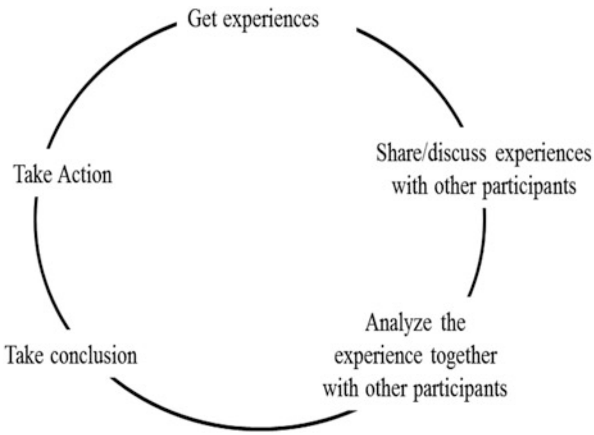
According to their responsibilities, agricultural extension workers are divided into three types: *penyuluh*, *mantri tani*, and POPT-PHP. Field guide officer, officially called *Petugas Penyuluh Lapangan* (PPL) and often called *Penyuluh*, provides general guidance. Farmers often seek advice from *penyuluh* when they face problems in the field. Agricultural field agent (*Mantri tani*) is a type of extension workers who are attached to particular government programs. They give information or advice on the concerned programs to *penyuluh* or directly to farmers. POPT-PHP is another type of extension workers who focus on crop pests and diseases. POPT-PHP stands for *Pengendali Organisme Pengganggu Tanaman-Pengawas Hama dan Penyakit* (Controller of Crop Disturbant Organism – Supervisor of Pests and Diseases). All of the above types of extension workers may be either civil servant, private, or volunteer. Figure 13.3 illustrates the relations of extension workers with national and local governments.

13.4 Climate Field School

The CFS was first introduced in Indonesia in 2005 by joint collaboration between the MoA, the BMKG, the Bogor Institute of Agriculture (IPB), and the Asian Disaster Preparedness Center (ADPC). The regency of Indramayu, West Java, was selected for the first pilot location. The second pilot was conducted in the regency of Gunung Kidul, Central Java, in 2007 and followed by many others. (Boer 2013) (as cited in Leippert 2014) reported that a total of 941 CFS unit activities were conducted between 2007 and 2012. Up to now, the CFS activities continue as a part of government's program under the MoA and the BMKG.

The CFS has been extended from the "Farmer Field School," which was designed to guide farmers on integrated pest management (Boer et al. 2003).

Fig. 13.4 Continuous learning process of the CFS (Adopted from Boer et al. (2003))



A process of interactive discussion and learning by doing, led by facilitators, is the core of this program. Farmers learn regularly and interactively how to manage their farm through a series of classes, discussions, field observations, and practical experiments (Fig. 13.4).

There are three stages in the CFS process (Fig. 13.5). First is the Training-of-Trainers (ToT) to train field facilitators on the basic concept of climate forecasting and its application. The training is provided by experts from the MoA, universities, and/or research institution. Second, after the ToT is completed, the field facilitators (trainees of the ToT) work together with their trainers to develop the CFS modules, which are then tested. The third is actual training for farmers, which takes place during a planting season. The number of farmers trained in a single CFS activity is around 25–30, consisting of representatives from farmer groups and/or water user associations in the concerned area.

The modules that are used in the CFS are grouped into the following three main categories. The first contains modules about basic knowledge on climate information. Terminologies that are often used in seasonal climate forecast, including a concept of probability, are covered among others. The second category is concerned about how to use climate information for decision making on farming. Potential impacts of climate events on farming are studied. Participants also practice simulation exercises where they are provided with particular climate information and asked to discuss appropriate farming strategies. A module on soil and water management is also included. The third category is related to economic benefits from using climate information, with an expectation to give a positive incentive for farmers. These modules are used mainly in the first and second stages of the CFS, as indicated above, to enhance the capacity of facilitators. A simplified version of training materials is developed for farmers to ease their learning process.

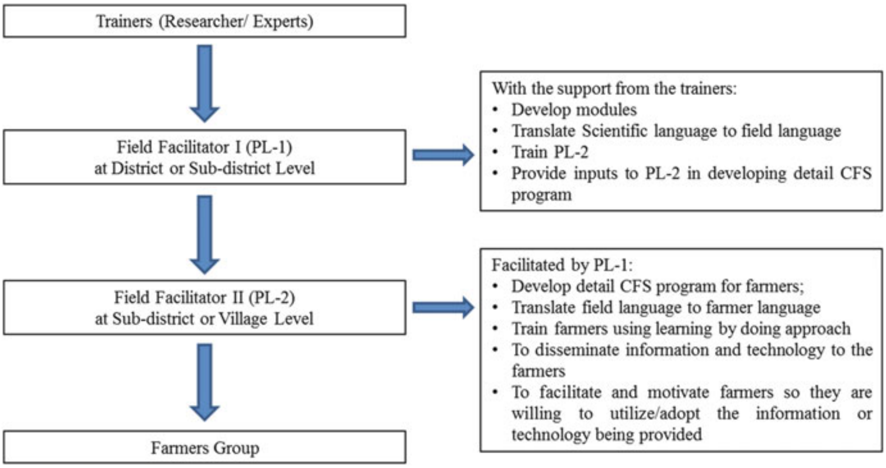


Fig. 13.5 CFS implementation structure (Adopted from (Boer et al. 2003))

13.5 Conclusion

This chapter described KATAM as a tool to provide climate information to farmers. Despite its opportunities, the use of KATAM by farmers is still limited, according to the interviews in the selected villages in East Java. In reference to the previous studies which indicated a capacity of information intermediaries and an extent of interaction as the factors that affect the use of climate information, this chapter also gave descriptions on the status of agricultural extension workers and the CFS as the government initiative to promote two-way communication.

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Chapter 14
Agricultural Risk Management: Lesson Learned from the Application of Rice Crop Insurance in Indonesia

Sahat M. Pasaribu and Abduh Sudiyanto

Abstract Climate change has negative impacts on production of food crops, especially rice, the staple food for the majority of Indonesians. The Government of Indonesia has to manage the agricultural development to adapt to climate anomalies and protect farmers' welfare. Agricultural insurance is introduced to share risks caused by perils and natural disasters. The pilot rice crop insurance has been successfully implemented in several rice-producing areas with positive responses from farmers. The sum insured by the indemnity-based insurance is six million Indonesian rupiah per hectare for one planting season, and the premium rate is set at 3 %. While 80 % of the premium is paid under the government subsidy scheme, the remaining 20 % is born by farmers themselves. Farmers who participate in this scheme are required to follow guideline on agricultural practices, while they are protected from crop damage caused by the named perils (flood, drought, pests, and disease). The partnership among the government as a regulator, insurance company as an insurer, and farmers as the insured needs to be further promoted to enhance the implementation of rice crop insurance.

Keywords Climate change • Indonesia • Agriculture • Rice • Insurance • Indemnity • Premium • Farmer protection

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14.1 Introduction

Food security has long been a priority of national development of Indonesia. Various policies and programs have been introduced to strengthen food production and improve risk management. However, climate change, increasing population, and growing food demand have posed challenges for food security. McCulloch (2008) indicates that nearly a quarter (24.8 %) of 53.5 million households in Indonesia is engaged in rice farming. On the other hand, Indonesian agriculture, in particular food production, is characterized by small-scale farming, with the average land ownership at around 0.3 ha. These farmers often lack access to working capital. As reported by Finkelstein and Calfant (1991), farmers are also risk averse to market prices and the consequent effects on their income. The government needs to provide a certain level of safety for farmers despite a range of these risks they face (Larson et al. 2004). The needs for agricultural insurance program have thus been increasing. When they experience harvest failures, farmers often have to rely on high-interest loans from money lenders in order to secure working capital for the following planting season. Agricultural insurance may mitigate such risk: The money to be paid on an approved claim, instead of a costly loan, may become available for the insured. Farmers are more likely to adopt new technology and improve farm practices when they are assured of compensation in case of harvest failures (Hazell 1992).

International experiences indicate that crop insurance is subsidized to a large extent by the government in the form of premium payment, reimbursement for some administrative expense of insurance companies, reinsurance, other financial supports, and technical guidance. The premium subsidy has been 60 % in the USA, 70 % in Canada, 50–60 % in the Philippines, and 58 % in Spain (Raju and Chand 2008). In 2003, a total amount of insurance premiums was estimated at 7.1 billion US dollars, equivalent to 0.6 % of farm gate value of agricultural production. The premiums are concentrated in North America (69 %), Western Europe (21 %), Latin America (5 %), Asia (3 %), Australia (1 %), and Africa (1 %) (Roberts 2005). Crop insurance exerted considerable influence on farmers' use of fertilizers and pesticides in the USA (Horowitz and Lichtenberg 1993). The insurance scheme was instrumental in reducing a proportion of non-borrowers among small farmers in India (Mishra 1994). Hazell (1992), on the other hand, observes that many of the risks insured under public insurance programs are essentially uninsurable and multi-peril crop insurance needs to be subsidized by the government.

The previous study in the context of Indonesia finds stakeholders' strong interest in rice crop insurance (Pasaribu et al. 2009a). Farmers, local government officials, farmer groups, NGOs, and other stakeholders are of the view that the national and provincial governments should take a lead, guide the implementation, and provide financial support in consideration of the national food security. Given the complexity associated with agricultural development, a pilot project for learning-by-doing was also recommended (Pasaribu et al. 2009b).

The pilot implementation of rice crop insurance has been initiated by the Ministry of Agriculture (MoA). It is designed in a way that monitoring and evaluation of each implementation stage is rigorously conducted. It is important to involve an insurance company so that they understand challenges as well as benefits and consider the resources that may become necessary, particularly in relation to distribution. A role of financial and banking institutions also needs to be considered (Pasaribu 2010). While indemnity-based insurance is piloted in Indonesia, potentials and possibilities of using other models need to be examined, since a variety of crop insurance models are currently applied in other countries, such as the models based on indemnity, yield, revenue, price, and weather index. In consideration of the findings from the pilot study and the reviews of relevant experiences in other countries, a recommendation for the framework and procedure of agricultural insurance, as well as a general guidance and its technical details, is developed. These outputs will help the implementation of the Law No. 19/2013 concerning Protection and Empowerment of Farmers, which has legitimized the introduction of rice crop insurance. Against this backdrop, this chapter aims to describe the latest status on the application of rice crop insurance in Indonesia.

14.2 Background

14.2.1 Relevant Policy Initiatives

The agricultural sector faces increasingly difficult challenges due to the negative impacts of climate change and variability. In the absence of appropriate risk management, climate anomalies and extreme events would result in harvest losses, forcing low-income farmers to reduce food consumption, sell productive assets, and stop sending children to school (Pasaribu et al. 2010). In this respect, the government has initiated the following countermeasures:

1. The program to help farmers affected by harvest failures in the form of direct compensation (*Bantuan Penanggulangan Padi Puso*, BP3) has been implemented since 2011 with mixed results. The drawbacks included excessive claims. Failures for financial compensations to reach the target recipients have also been reported.
2. The Presidential Instruction No. 5/2011 on the protection of national rice production against extreme weather condition has been issued. The relevant ministries and agencies were instructed to coordinate their works to anticipate and adapt to the impacts of climate change on rice production.
3. The Indonesian House of Representatives passed the Law No. 19/2013 concerning Protection and Empowerment of Farmers. In line with this Law, the MoA has started to consider rice crop insurance as an alternative to the current direct compensation scheme. The MoA has formed the Working Group on Agricultural Insurance since March 2011. The insurance program to be

examined is not limited to rice but also covers all the four subsectors of agriculture, namely, food crops, horticultural crops, livestock, and plantation.

14.2.2 Principles of Insurance

Insurance is the contribution of many who pay premiums to a few who suffer from certain perils. It is also considered as an instrument to convert variable and potentially large losses into fixed and much smaller costs of premium. Insurance is the mutualization of risks, and the rules and regulations are defined between the insured and the insurer in insurance policy, which contain the insurance principles as briefly outlined below:

1. Insurable interest

   The prospective insured has to demonstrate valid relationship with the object or interest to be insured. Insurable interest generally arises from the right of ownership or possession. This principle is intended to prevent any unrelated party to file a claim for insurance money illegally.
2. Utmost good faith

   The prospective insured is supposed to have a good knowledge about the property or interest to be insured, and therefore he or she is obliged to disclose material facts relating to it, if any. Misrepresentation of material facts may result in the insurance contract becoming void or claim rejection. This principle is intended to achieve fairness and equitability.
3. Proximate cause

   It must be confirmed that a given cause of loss be a dominant and effective one, not being interrupted by any other causes from another source. This principle is important in determining the cause of a loss when more than one cause is deemed to exist in a given event.
4. Indemnity

   The entitlement of the insured to a claim is limited to the value of his/her financial interests prior to any loss or the value as agreed to at inception of contract. Insurance does not allow any compensation more than the indemnity of the sum insured.
5. Subrogation

   This refers to a case where the insured is obliged to render to the insurer any right of recourse to another party who caused the loss.
6. Contribution

   This refers to a principle that claims should be shared with other insurance policy which covers the same objects at the time of loss. The insured is not allowed to claim double indemnity from another insurance policy.

14.2.3 Key Elements of Rice Crop Insurance

The key elements, vision, mission, and objective and purpose of rice crop insurance, have been formulated by the Working Group on Agricultural Insurance of the MoA in the following manner (Kementerian Pertanian 2012a):

1. The vision of the rice crop insurance program is to support the achievement of sustainability of rice farming within the national framework of agricultural development.
2. The mission is to provide compensation (indemnity) of losses caused by the named perils (floods, drought, pests, and disease), to promote productivity, increase farmers' income and welfare, while maintaining environmental sustainability within the national framework of agricultural development.
3. The objective is the establishment of partnership and cooperation on the basis of principle of utmost good faith among farmers as the insured and an insurance company as an underwriter, in light of supporting the sustainability of agricultural activities amid efforts to improve the competitiveness of agricultural products.
4. The purpose is to maintain the income and welfare of farmers through the provision of production costs through indemnity payment, in the event of a claim for damage caused by the above named perils.

14.2.4 Stakeholders' Benefits from Rice Crop Insurance

The benefits of rice crop insurance program for stakeholders are indicated below (Kementerian Pertanian 2012b):

1. The benefits for farmers are (a) to increase awareness on the risks that threaten agricultural activities and the ways of risk mitigation; (b) to promote knowledge and skills on farm and risk management; (c) to enhance access to finance; and (d) to increase income and welfare.
2. The benefits for insurance companies are (a) to build partnership with the government, (b) to develop micro-insurance on rice crop and other related business opportunities, and (c) to build a distribution network in rural areas, along with the development of human resources and infrastructure.
3. The benefits for provincial and regency agricultural offices are (a) to enhance knowledge and experiences on anticipation and control of risks inherent to rice farming; (b) to experience an insurance scheme and understand the relevant aspects, such as data and information required by insurers, damage inspection, and loss adjustment; and (c) to have experiences on monitoring of the implementation of insurance scheme.

14.3 Pilot Study of Rice Crop Insurance

14.3.1 General Framework

The MoA has initiated the pilot implementation of agricultural insurance to overcome the problems associated with direct compensation, while achieving protection and empowerment of farmers. Insurance will help farmers in transferring their risks. Under the pilot crop insurance, premium is paid partly by farmers themselves (20 %) and partly subsidized (80 %). The pilot insurance is based on indemnity which is determined on the basis of the national average cost of paddy production: Rp 6,000,000/ha of rice farm (approx. USD 1 = Rp 11,000). The calculation of indemnity in the event of loss or damage to rice farm is based on the formula set by the Directorate General of Food Crops of the MoA as follows: (1) light damage, intensity no more than 25 %; (2) medium damage, intensity between 25 and 49 %; (3) severe damage, intensity between 50 and 74 %; and (4) total damage, intensity equal to or more than 75 %. Under the pilot implementation, only when the damage intensity reaches 75 %, the insured will be entitled to receive the insurance payment. The 75 % threshold is justified, among others, on the notion that, with more than 25 % of rice fields that are still able to be harvested, farmers can recover their production costs to a certain extent.

As for risk pricing, the statistics of rice crop harvest failure due to floods, droughts, pests, and disease over the last 10 years (2003–2012) was used. An average of damage ratio of 1.543 % is assumed as a burning cost ratio, a ratio of losses that an insurer has to cover by contract to premium income. To arrive at premium, allowances for data inaccuracy, loss adjusted expenses, and catastrophe contingency are applied. Then, the operational loading as per insurance including acquisition, administration, and general costs is also calculated to arrive at 3 % flat premium rate. The rating structure is based on simple formulation without taking account of other variables as usually required for comprehensive rating studies, such as area data, weather, historical yields, and so forth.

A role of the government is critical in developing agricultural insurance models, building infrastructure, and guiding implementation across different levels. The government also needs to ensure that the concerned insurance firms have the capacity to execute the program with due observance to sound underwriting principles and commercial business practices. The efficient and effective implementation requires the partnership among related parties, such as the MoA as the national ministry in charge, insurance company as the insurer, farmer groups as the insured party, and provincial/regency agricultural offices who steer the program in their respective jurisdictions. A pilot implementation plan, which contains information on a set of functions and roles at national and local levels, has been developed, as shown in Table 14.1.

The expected outcomes from the pilot study include (1) positive changes in perceptions of stakeholders toward agricultural risk management, (2) improved awareness of farmers and local officials on the importance of farming protection

Table 14.1 Rice crop insurance pilot study plan

No.	Activities	Method of implementation	Output	Institutions involved
1.	Sharing information on agricultural insurance for food crops at national, provincial, and regency levels	Meetings and coordination	Understanding about agricultural and food crop insurance; strengths and weaknesses; benefits and contributions of related stakeholders	*At central level*: high-level officials from the MoA, the National Development Planning Agency (*Badan Perencanaan Pembangunan Nasional*, BAPPENAS), insurance company, research institutions, universities, and NGOs
				At regional level: local government offices, including local development planning agency (*Badan Perencanaan Pembangunan. Daerah*, BAPPEDA), farmer groups, insurance company, regionally owned enterprise (*Badan Usaha Milik Daerah*, BUMD), research institutions, universities, and NGOs
2.	Formulation of crop insurance model and technical and implementation procedure	Meetings, discussions, consultations, and drafting insurance mechanism and procedure	Documentation on mechanism and procedure on food crop insurance	Study team and insurance company
3.	Recruitment and training of selected representatives from related institutions and other stakeholders for the implementation of food crops insurance	Identification and training of personnel to be involved in the implementation	Trained human resources who are appointed to undertake the pilot study of agriculture/food crops insurance	Local government offices, BAPPEDA, agriculture offices, study teams, insurance company, and leaders of farmer groups

(continued)

Table 14.1 (continued)

No.	Activities	Method of implementation	Output	Institutions involved
4.	Implementation of pilot food crop insurance	Selection of the location, identification of participant farmers, and implementation management	Implementation of pilot crop insurance	Local government offices, BAPPEDA, agriculture offices, study team, insurance company, and leaders of farmer groups
5.	Monitoring and evaluation (M&E) of the pilot implementation	Using criteria and indicators to monitor and evaluate the implementation	Results of the M&E for improvement	Local government offices, BAPPEDA, agriculture offices, study team, and insurance company
6.	Further development of agricultural insurance	Extension of agricultural insurance coverage and participant farmers (locations and crops)	Extended area and coverage of agricultural insurance (locations and crops)	Local government offices, BAPPEDA, agriculture offices, study team, insurance company, and leaders of farmer groups

from unavoidable perils, (3) improved management practices and skills in rice farming, and (4) integrated risk management where risk premium may become considered as a part of cost for rice crop production.

The pilot study is intended to introduce rice crop insurance on a pilot basis and to assess whether the concept and technical guidelines of the scheme are operationally feasible, as well as whether they are understandable and acceptable by farmers, local agricultural officials, and an insurance company. Throughout the implementation, feedbacks are received from the stakeholders for the improvement and refinement of the scheme.

The first pilot study was carried out in cooperation with state-owned fertilizer companies under the program "Corporation-Based Improved Food Production Movement" (*Gerakan Peningkatan Produksi Pangan berbasis Korporasi*, GP3K). It was conducted in three provinces of West Java, East Java, and South Sumatra, covering about 1,000 ha in total. The insured were farmer groups. The insurance company operated this piloting activity through its branch offices in respective locations, while the MoA acted as a facilitator in coordination with the provincial/regency agricultural offices. The mechanism of the pilot implementation is shown in Fig. 14.1.

The rice crop insurance scheme under the pilot study is described as follows (Kementerian Pertanian 2012c):

1. The insured: (a) Farmers should be members of a farmer group with active management board, (b) farmers should follow recommendations from local

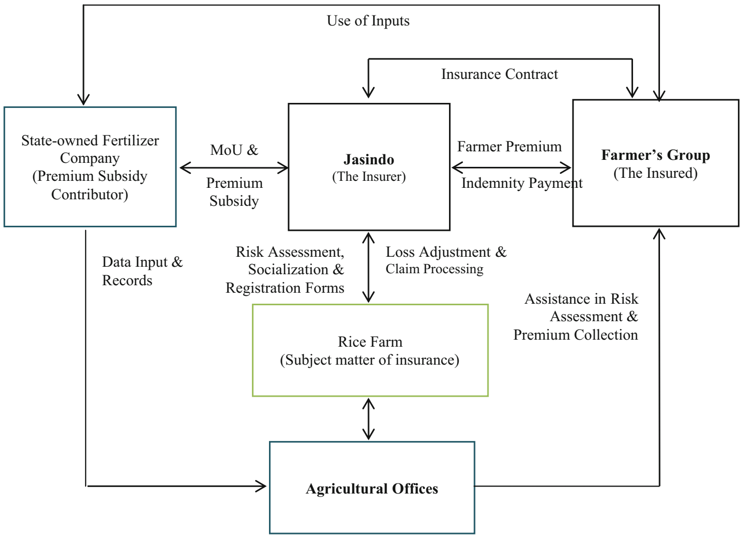

Fig. 14.1 Mechanism of rice crop insurance pilot study

agriculture office, and (c) farmers should comply with the terms and conditions of the insurance policy.

2. Subject matter of insurance: (a) Rice farmland of less than 2 ha size and tilled fields with clear boundaries, (b) the concerned farmland is not located in isolation from other rice fields, and (c) wetland that meets the requirements of irrigation and other technical standards.
3. Any one risk: Unit of risk is defined per farmer group, consisting of registered farmer members and enrolled as participants of insurance.
4. Farmer group: Smallest unit and a policyholder who will pay premiums and get insurance policy containing information on schedule and details of risks insured, among others.
5. Policy period: Period of insurance coverage commences on the date of planting and expires upon harvest.
6. Risks covered: (a) Flood, which is water inundation to rice farmland during the growth of rice plants in depth and over a period of time, causing damage; (b) drought, which is insufficient water required during the growth of rice plants, causing damage; and (c) pests and disease, which are organisms that attack, damage, interfere with growth, or cause death of rice plants.
7. Sum insured: The national average rice crop production costs of Rp 6,000,000/ha are the sum insured as agreed to.
8. Premiums: The rate of premium is 3 %. Given the sum insured of Rp 6,000,000/ha, the premium amount to be paid is Rp 180,000/ha. Under the subsidy scheme, farmers shall pay 20 % or Rp 36,000/ha, while a subsidy shall cover 80 % or Rp 144,000/ha.

9. Potential sources of premium subsidy: (a) State budget; (b) corporate social responsibility of state and/or private enterprises; and (c) lending institutions.
10. Claim: Claim is defined as damage to rice plants caused by insured perils, when equal to or more than 75 % of total acreage of any one rice plot is damaged, with equal to and more than 75 % damage intensity.
11. Loss adjustment: Site inspection is carried out by insured farmers, insurers, and local agriculture officers together. Damage is determined, based on which a claim report is prepared and submitted.
12. Claim payment: Upon completing assessment on claim reports, the insurance company issues a letter of approval. Payment of claims will be made within 14 working days upon such approval.

14.3.2 Application Procedure

The pilot study included the following activities: (1) information sharing, (2) farmers' meetings and registration, (3) premium payment, (4) insurance policy issuance, and (5) post-contract program on risk control. Once the pilot location is identified, a team appointed by the Working Group on Agriculture Insurance visits the concerned regency office to share information on the scheme and discuss steps to be taken. Farmer groups and individual farmers are invited to a session and provided an opportunity to learn and join rice crop insurance program. Each session is also attended by relevant stakeholders. The timing of planting season is the important point of consideration in the registration process. A failure to meet the planting time at the target location would affect the implementation of the insurance. These processes pose a logistical challenge and require mobilization of human resources. Local agricultural officers are proactively involved. For example, they collect cash payments for premium from farmers through door-to-door visits and send the collected payments to the insurance company's bank account (Fig. 14.2).

14.3.3 Claim Procedure

A notice of loss, when it occurs, is sent by the insured to the insurer through the appointed intermediary or agent. Affected farmers also send notice to local agricultural officers in charge. The agent and/or staff of insurance company visit the concerned location to inspect the damage. Loss adjustment is made as necessary, and the only damage that meets the criteria is submitted for the claim. The insurance company may appoint an independent loss adjuster to carry out the inspection and assessment. No limit has been specified on the time span between filing a claim report and claim approval. It depends on the number of files to be submitted and how fast they are processed. Claim payment, however, has to be

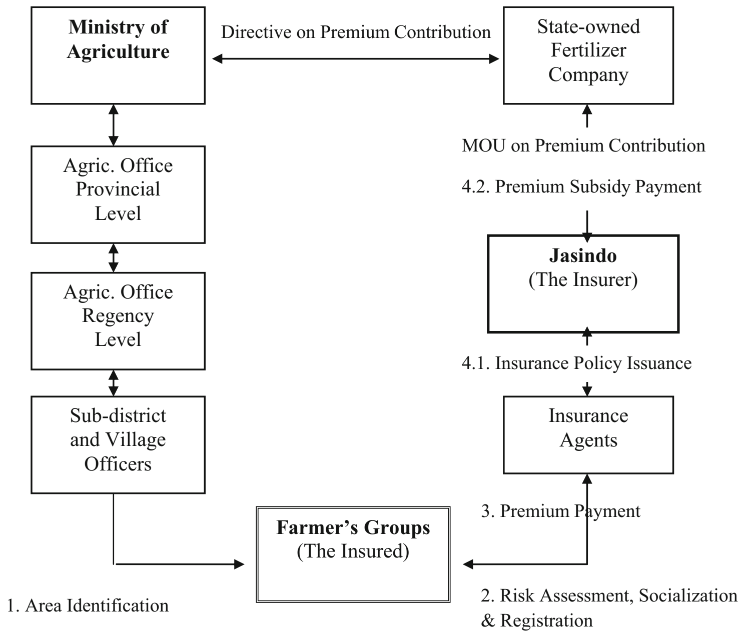

Fig. 14.2 Issuance of rice crop insurance policy

made within 14 working days after approval on the claim. The flow of claim is shown in Fig. 14.3.

14.4 Result of the Pilot Study

14.4.1 Planting Season of 2012–2013

Based on the coordination meeting hosted by the MoA with representatives from several provincial/regency offices, state-owned fertilizer companies, and the state-owned insurance company, the first pilot project was planned during the wet season of 2012 (from October 2012 to March 2013) at the selected locations in three provinces (Karawang in West Java, Tuban and Gresik in East Java, and Ogan Komering Ulu Timur in South Sumatra), with 1,000 ha targeted for each province. After all, the pilot activity did not take place in Karawang, but it was completed in Gresik, Tuban, and Ogan Komering Ulu Timur, covering 320 ha, 150.87 ha, and 152.25 ha of rice fields, respectively. For the total coverage of 623.12 ha, the total premium paid was Rp 112,161,600. The 20 % or Rp 22,432,320 was paid by farmers, and the remaining 80 % or Rp 89,729,280 was contributed by state-owned fertilizer companies. Table 14.2 summarizes the underwriting results.

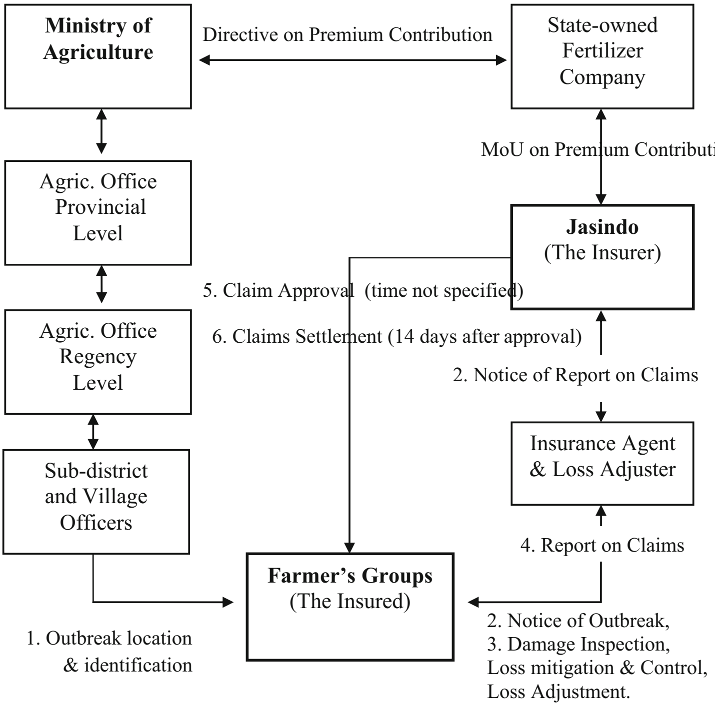

Fig. 14.3 Claim settlement

Table 14.2 Results of pilot rice crop insurance from October 2012 to March 2013

Location	Actual size (ha)	Premiums (Rp)	Claim damage (ha)	Claim amount (Rp)	Remarks
Karawang Regency (West Java)	0	0	0	0	Pilot project not materialized
OKU Timur Regency (South Sumatra)	152.25	27,405,000	7.28	43,680,000	Loss due to flood
					Most claims settled in 14 days
Tuban Regency (East Java)	320.00	57,600,000	80.00	480,000,000	Loss due to flood
					Most claims settled in 14 days
Gresik Regency (East Java)	150.87	27,156,600	–	–	No loss reported
Total	623.12	112,161,600	87.28	523,680,000	Loss ratio: 467 %

Table 14.3 Results of the pilot rice crop insurance from October 2013 to March 2014

No.	Locations	Target area to be insured (ha)	Actual size of insured (ha)	Claims filed (ha)
1.	Nganjuk	1,500	1,500	0
2.	Jombang	1,500	1,470	Caused by rat (16.50); flood (0.25); blast (0.84)
Total		3,000	2,970	17.59

14.4.2 Planting Season of 2013–2014

The locations of the first pilot study (Tuban and Gresik) are situated on flat land adjacent to the Bengawan Solo River. The inundation over the river bank caused flood damage. The second pilot study was conducted in the regencies of Nganjuk and Jombang in East Java Province, a flat lowland area with plateau and mountains located behind. This pilot implementation was supported by Japan International Cooperation Agency (JICA), as summarized in Table 14.3.

Climate change is projected to bring about changes in our environment, such as a possibility of increasing frequency and intensity in pest and disease infestation in agricultural fields. The historical records in the above pilot areas indicate no major attack by rat or blast in the past. According to farmers, however, there is an increasing trend of these outbreaks over the past two decades.

14.5 Discussion

14.5.1 Constraints

While the pilot implementation has been successful, some constraints have been identified as below.

1. Institutional challenge

   Agriculture insurance is considered to be a new product in Indonesia. Demand and supply are still low. Given the risks in the agricultural sector, it has rarely been considered as potential market by general insurance suppliers. Currently, with the initiative of the MoA, a draft on rice crop and livestock insurance policy has been approved by the Monetary Services Authority. Agriculture insurance products will be marketed as a national program, which will engage insurance companies, particularly the state-owned company.
2. Technical challenges

   The insurance industry has limited exposure to agriculture insurance. There is a substantial room to learn about types of risks, scope of coverage, premium rate calculation, claim handling, and other various operational aspects of agriculture insurance, as practiced internationally. Another challenge is a lack of adequate statistical data in the agricultural sector that enables to calculate and analyze the associated risks.

3. Operational challenges

    Insurance companies have limited business network in rural areas. Most companies have branch offices in some provincial capitals and small sales outlets at regency or sub-regency level, while most rice farmers own less than 1 ha of land. This indicates a high operational cost. This is also the reason why the current insurance scheme targets farmer groups instead of individual farmers.

4. Farmers' financial challenges

    Indonesian famers are generally poor. Before they harvest, they do not have sufficient financial capital, and therefore payment for insurance premium is not easy. Access to finance is very important in this respect. While the government has provided low-interest loan programs, insurance has not yet been introduced together with these loan contracts. According to the Law No. 19/2013, the MoA is under consultation with the Ministry of Finance on government subsidy for premium.

5. Insurance financial challenges

    In general, underwriters are hesitant toward agricultural insurance as they perceive it as too costly and too risky. The possibility of reinsurance by global companies may need to be explored in order for domestic insurers to reduce their risk exposure and maintain solvency. The applicability of mutual insurance scheme, as implemented in Japan, may also need to be examined.

6. Climate impacts and challenges

    Climate is one of the most pervasive risks to agriculture, impacting all aspects of the agricultural production and supply. In Indonesia, where a significant proportion of farmers are reliant on rain-fed agriculture, weather risks remain one of the major constraints on agricultural development. New crop varieties, inputs, production techniques, and management practices can, in some cases, minimize production risks. Farmers, however, continue to be affected by many uncontrollable weather-related events, including excessive or insufficient rainfall and extreme temperatures (Bryla and Syroka 2007). Those equipped with risk management products such as insurance can have greater access to financial services, such as credit and savings, and are more willing to use new technologies and/or practices. Their investments in agricultural activities become safer if the weather risks are better managed. Being encouraged by the progress of the weather risk market in the USA, Europe, and other developed countries, the MoA has begun studying the possibility of weather index-based insurance, while it pilots indemnity-based insurance.

Table 14.4 Summary of stakeholders' responses, East Java Province, 2014

No.	Measurement items	Objectives	Findings from responses	Actions required
1.	Perception on indemnity-based rice crop insurance	To know the level of officials' understanding about farmer protection and empowerment	1. Different level of understanding	1. Socialization is planned for officials at provincial and regency levels
			2. Officials at provincial and regency levels require intensive socialization	2. Materials for socialization include rice crop insurance procedures claim mechanism, as well as the Law No. 19/2013 and technical guidance
			3. Farmers understand technical matters but need more explanation about the implementation procedures in respect to different proposed perils	
2.	Preparation for application	To understand constraints in the preparation	1. Difficulties exist during registration process to collect 20 % premium payment from farmers	1. Given the importance of the registration process, the involvement of insurance agent is required
			2. Farmer group could transfer the payment to the insurer's bank account	2. Further consideration on payment transfer
			3. There is a need to explain in more detail about the insurance policy to farmers	3. Further explanation on insurance policy
3.	Implementation stage	To understand problems associated with technical and nontechnical application procedures	1. Officials and field officers take their roles in the implementation stage with minimum communication with the insurer	1. Communications among regency officials, extension officers, insurer's personnel, and the Working Group on Agricultural Insurance need to be strengthened
			2. Farmers rely on extension workers for the implementation of insurance, but interactions are limited	2. Government support is required especially for the operational costs of field officers

(continued)

Table 14.4 (continued)

No.	Measurement items	Objectives	Findings from responses	Actions required
4.	Suggestions for the improvement of rice crop insurance	To understand suggestions by officials on rice crop insurance scheme	1. Inclusion of rice crop insurance in local medium-term development plans	1. Rice crop insurance is continued; variation of the scheme could be discussed among the stakeholders
			2. It is suggested that cattle and specific horticultural crops be insured	2. Future prospects of farm protection are subject to the decision by the appropriate parties

14.5.2 Prospect and Future Steps

The continuation of rice crop insurance scheme is highly expected not only by farmers but also by local officials, as shown in their responses at group interviews (Table 14.4). This is in line with the study by Dick and Wang (2010), which indicates increasing interest of both the private sector and the government in risk management and insurance in order to promote agricultural investments.

The stakeholders' understanding about rice crop insurance is growing. Farmers express their request for insurance to extend its coverage for damage less than the 75 % threshold as well as other perils than currently named. Farmers also indicate that, if this would become the case, they might undertake an increased burden of premium payment. These views need to be thoroughly considered in designing the extension of insurance.

Given a gap in understanding on insurance among government officials and farmers, more efforts for dissemination of information about the Law No. 19/2013, technical guidance, and other related issues, such as outbreak control and claim mechanism, are requested. Besides field officers to work closely with farmers, the capacity of underwriters needs to be strengthened, particularly in relation to agricultural risk management, damage inspection, and loss adjustment. The resource constraints become even more acute if insurance program may be extended in terms of locations, commodities, and types.

Insurance is also considered as an instrument for capacity development for farmers, who are provided with guidance to maintain their farm most appropriately. With this guidance, for example, an indication of pests or disease infestation will be immediately communicated with fellow farmers and field officers. As revenues from sales of rice normally exceed the insurance money, even the insured do not expect any damage on their crops. It is also critical that insurance program will be included in local development plans in the concerned province and regency in order to make sure of synchronization with other development agenda and budget allocation.

14.6 Conclusions

The pilot rice crop insurance has been implemented in some of the rice-producing provinces with positive responses from farmers. It is aimed at protecting farmers, with the expected outcomes which include (1) protection of farmers against severe losses due to harvest failures, (2) improved farm management, (3) risk awareness and damage control, (4) increased crop production and productivity, (5) improved regional economic activities, and (6) agricultural employment opportunities. While agricultural insurance is one of the means of risk mitigation, it is also an instrument of capacity development for farmers. As a part of the requirement for participation in the scheme, farmers follow guidance on appropriate farming practices, such as adaptive crop varieties, efficient use of water, and balanced fertilizer application. Lessons learned from the pilot are utilized to improve the existing mechanism and procedure. Knowledge gap still exists among farmers and local officials, and more efforts need to be taken for information sharing and coordination. Despite such challenges that remain, however, the pilot implementation has been generally successful, which is a basis for replication and expansion in the future. A wider coverage of insurance may also provide more learning opportunities.

Acknowledgment The rice crop insurance pilot study was conducted by the MoA in partnership with the State Ministry of State-owned Enterprises' Fertilizers Companies during the 2012–2013 planting season. Since the 2013–2014 planting season, it has been implemented in collaboration with BAPPENAS under the support by "JICA Project of Capacity Development for Climate Change Strategies in Indonesia." The authors' gratitude is extended to the above organizations for the use of some materials. However, the content of this paper is under the authors' responsibility and does not represent the views of the abovementioned institutions.

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