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ECONOMIC AND ADAPTATION COSTS OF CLIMATE CHANGE: CASE STUDY OF INDRAMAYU, WEST JAVA INDONESIA

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Abstract

Climate change is already occurring. In Indonesia, many evidences such as changing rainfall patterns in many parts of the country (e.g., Sumatra and Java) indicate the impacts of global climate change on Indonesian climate. This new climate regime eventually will influence water availability in many parts of the country. This paper discusses economic loss (unit cost) incurred on major economic sectors (i.e., agriculture, fishery, drinking water, and health) of Indramayu districts – West Java Indonesia due to flood and drought as an approximation to quantify potential economic consequences of climate change. The estimation was based on discussions with the local authorities and communities (field survey) in 2008. The unit costs were estimated based on rice production loss (agriculture), milk fish and prawn production loss (fishery), additional costs for clean water supply (drinking water), and additional incidences of dengue fever (*DBD*) and diarrhea (health). Seven adaptation options and their estimated costs are also proposed to cope with flood and drought in the region. The options are: construction of a reservoir, change of cropping pattern, rehabilitation of irrigation canals, improvement of irrigation canals (cementing the canals), improvement of drainage system, normalization of rivers, and implementation of system rice intensification (SRI). Potential benefits from each adaptation are also discussed. Such discussion, together with estimated adaptation costs, will be useful for further evaluation to measure the net benefits from each adaptation, which can be helpful to assist decision makers in choosing plausible adaptation options for their region.

Keywords: climate change, economic costs, adaptation

BIAYA EKONOMI DAN ADAPTASI PERUBAHAN IKLIM: STUDI KASUS KABUPATEN INDRAMAYU, JAWA BARAT, INDONESIA

Abstrak

Perubahan iklim telah terjadi. Di Indonesia, dampak perubahan iklim global dapat dindikasikan dengan adanya perubahan pola curah hujan yang terjadi di berbagai daerah, misalnya Sumatera dan Jawa. Perubahan pola hujan tersebut pada akhirnya dapat mempengaruhi ketersediaan air di berbagai daerah. Tulisan ini membahas kerugian ekonomi (biaya satuan) yang terjadi pada sektor utama perekonomian (pertanian, perikanan, air minum dan kesehatan) di Kabupaten Indramayu - Jawa Barat, akibat dari kejadian banjir dan kekeringan yang digunakan sebagai pendekatan untuk mengukur dampak ekonomi yang terjadi akibat perubahan iklim. Penilaian dampak tersebut didasarkan pada diskusi dengan pemerintah daerah dan masyarakat setempat saat survey lapang di tahun 2008. Perkiraan biaya satuan didasarkan pada kerugian produksi beras (pertanian), produksi ikan bandeng dan udang (perikanan), biaya tambahan untuk penyediaan air bersih (air minum), insiden tambahan penyakit demam berdarah dan diare (kesehatan). Untuk mengatasi banjir dan kekeringan di wilayah tersebut, diusulkan tujuh pilihan adaptasi serta perkiraan biayanya. Adaptasi tersebut adalah: pembangunan waduk, perubahan pola tanam, rehabilitasi saluran irigasi, peningkatan saluran irigasi (penyemenan/penguatan saluran), peningkatan sistem drainase, normalisasi sungai, dan implementasi *system of rice intencification* (*SRI*). Potensi manfaat dari masing-masing adaptasi juga dibahas dalam tulisan ini. Hasil diskusi dan perkiraan biaya adaptasi yang dibahas di dalam tulisan ini, diharapkan dapat dimanfaatkan sebagai bahan dasar untuk kegiatan lanjutan yang terkait dengan penilaian manfaat atau keuntungan berbagai pilihan adaptasi, sehingga dapat membantu para pembuat keputusan dalam memilih berbagai pilihan adaptasi yang sesuai dengan daerahnya.

Kata kunci: perubahan iklim, biaya ekonomi, adaptasi

Climate change has been acknowledged as a serious global environmental problem that poses a challenge to human livelihoods. Its impacts on a wide range of economic sectors (IPCC, 2007) have shifted our understanding to view climate change not only as an environmental problem but also as a social problem (Barnett, 2010). In Indonesia, the existence of climate change was indicated by changing patterns of rainfall in many parts of the country, such as Sumatra and Java (MoE, 2007). An increase in climate related hazard such as flood and drought within the recent decades has also been observed. Boer and Subbiah (2005) reported that the frequency of massive drought increased over the last 40 years compared to the previous decades, i.e. from once in three or four years to once in two or three years. Similar observations have also been made for flood: about 530 floods, which occurred in nearly all provinces of Indonesia, have been reported within the period 2001-2004 (MoE, 2007). This increase in the frequency of flood and drought may be associated with the increasing frequency of ENSO (El-Nino-Southern Oscillation – refers to El Nino and La Nina) due to global warming (Timmermann, et al. 1999). ENSO, which significantly affects regional climates in many tropical countries (Vecchi and Wittenberg, 2010), has been frequently linked to cause climate extreme events such as heavy rainfall and prolong drought in Indonesia.

Understanding the potential consequences of climate change, devising adaptation strategies to cope with potential impacts of future climate change is a necessity. Unfortunately, a wide array of uncertainties surrounding climate change impact assessments (Winkler, et al. 2011) causes a difficulty in making the right decision to select proper adaptation strategies to climate change. Consequently, climate change adaptations should be taken as no-regret interventions (Heltberg, Siegel, and Jorgensen, 2009) as implementation of adaptation strategies will incur additional costs (Tamirisa, 2008). The additional costs required for climate change adaptation highlight the needs of economic estimation for climate change impacts and potential benefits from the implementation of adaptation measures. However, such estimation is rarely investigated in Indonesia.

This paper discusses economic costs of climate change drawn from a field survey conducted in Indramayu regency, located in the north coastal area of West Java - Indonesia, as a case study. This region was selected because flood and drought were identified as the two main climate-related problems in the region. Tamkani and Boer (2005) stated that flood and drought contributed about 86% of rice production loss in Indramayu which was way more than pest and diseases (about 14%) during the period of 1997-2003. Indramayu government in their website,http://www.indramayukab.go.id/profil/49-kondisi-wilayah.html, clarified that the topographical condition of Indramayu, which is relatively flat (0-2% slope) and close to the sea (0-18 m above sea level), is the reason why Indramayu is vulnerable to flood and drought during wet and dry season, respectively.

Per unit economic loss (i.e., unit costs) was estimated by calculating unit costs of damages during flood and drought for four major economic sectors in Indramayu. The estimations were based on rice production loss (agriculture), milk fish and prawn production loss (fishery), additional costs for clean water supply (drinking water), and additional incidences of two major health problems in Indramayu, i.e., dengue fever (*DBD*) and Diarrhea (health). The approach assumed climate change contributed to increase the frequency of climate extreme events such as heavy rainfall and prolong drought as described above. It is important to note this paper is not intended to calculate economic costs of the regional climate change impacts as such evaluation requires impact models to estimate the consequences of climate exposures to economic activities in the region such as numbers of agricultural areas and fishery ponds affected by flood and drought. Nevertheless, the unit costs presented in this paper provide information with which climate change impacts on the regional economy can be estimated when the impact models are available.

Seven adaptation options and their estimated costs were proposed to cope with flood and drought. The options are: construction of a reservoir, change of cropping pattern, rehabilitation of irrigation canals, improvement of irrigation canals (cementing the canals), improvement of drainage system, normalization of rivers, and implementation of system rice intensification. The dam construction was proposed with the understanding that Indonesian government was planning to build Jati Gede dam (Colenco and Indrakarya, 2000) to control water supply in Indramayu. This government initiative was encouraging as individuals and societies might not have adequate capacity to incorporate all social costs of adaptation (Burton and Lim, 2005). Additionally, responses from government to devise a policy for adaptation have been endorsed internationally (Smit and Skinner, 2002).

METHOD

Study Area

The estimation of economic costs was drawn from a field survey conducted in Indramayu regency in 2008. Geographically, Indramayu lies on 107° 52´ - 108° 36´ E and 6° 15´ - 6° 40´ S along the coast of north Java island. This regency consists of 31 districts, 307 villages and 8 sub-districts with total area of 204,011 hectares. The dominant land use type is irrigated rice field (about 59.5% of the total area), followed by plantation (15.8%), settlement (8.8%), fish ponds (6.2%), rainfed rice field (6.1%), and others (3.7%) (Indramayu Government 2012). Based on Indramayu's location, this regency has a tropical climate environment with mean daily air temperature about 22.9-30 ºC and relative humidity about 70-80%. Annual precipitation is about 1,587 mm with numbers of wet days about 91 days.

The survey team, composed of climatologists, hydrologists, GIS analysts, economists, and social scientists (experts) and research assistants, collected economic information related to rice production, fish production, drinking water supply and health based on interviews with the local authorities and communities. The interviews were conducted through face to face with the local residents and focus group discussions with the local authorities and communities. There were about 63 local residents coming from 16 districts (Figure 1) who participated in the survey. Most of them were farmers (67%), and the others were local entrepreneurs, government and private employees. The team also visited eight local institutions (i.e., agencies for agriculture, fishery, water, health, public works, transportation, highway construction and maintenance, disaster management, and trade) to obtain information on economic loss due to drought and flood. This approach was part of a technique known as participatory integrated assessment (PIA) (Salter, Robinson, and Wiek, 2010) which has been employed as an alternative to explore climate change adaptation strategies. For example, Tarnoczi and Berkes (2010) interviewed farmers in Alberta and Manitoba Provinces of Canada to explore sources of information for climate change adaptations particularly those related to soil and water conservation practices. Surveys have also been applied for investigating the main problems that might inhibit implementation of climate change adaptations in the Nile Basin of Ethiopia (Deressa et al. 2009) and in the Limpopo River Basin of South Africa (Gbetibouo, 2009).

Calculation of Unit Costs

Per unit economic loss was estimated separately for each sector (i.e., agriculture, fishery, water supply, and health) based on the survey results. Damaged costs associated with flood and drought were the proxy that we employed to estimate the unit costs of potential climate change impacts on the regency. Secondary data from previous study (Colenco and Indrakarya, 2000) were also employed to complete the estimation.

Agriculture loss was mainly approached based on rice fields damaged during flood and drought. The unit costs were estimated from the amount of financial resources that had been spent by farmers to grow rice or its production value (i.e., price multiplied by yield). The loss estimation due to flood and drought was a little bit different. For flood, it was determined based on crop growth development when they were exposed to flood. If flood streaked at the early stage of crop development, farmers would do replanting after the flood finished. In the case of drought, there was no planting as there would not be sufficient water in the fields.

The economic loss for fishery sector was estimated based on the production costs for cultivating prawn and milk fish, two major commodities for fish industry in the region. The loss was mostly due to flood which could flush fish ponds. Based on the survey, it was found that drought could increase water salinity; however, its impact on prawn or milk fish production was not clear. Fish farmers usually would not sow fish or prawn if they had anticipated drought condition.

For drinking water, the loss was equal to the total additional costs required to supply clean water during flood events. The occurrence of floods would increase the turbidity of the raw water and this would increase cost for processing water. The additional cost for processing water during flood events was estimated based on historical data from 2000-2007 obtained from State Owned Water Resources Company (PDAM Indramayu). The additional cost (per day of flood) was calculated by multiplying additional cost average required for processing water during flood events, which usually occurred on days in February, and volume of water sold at that time.

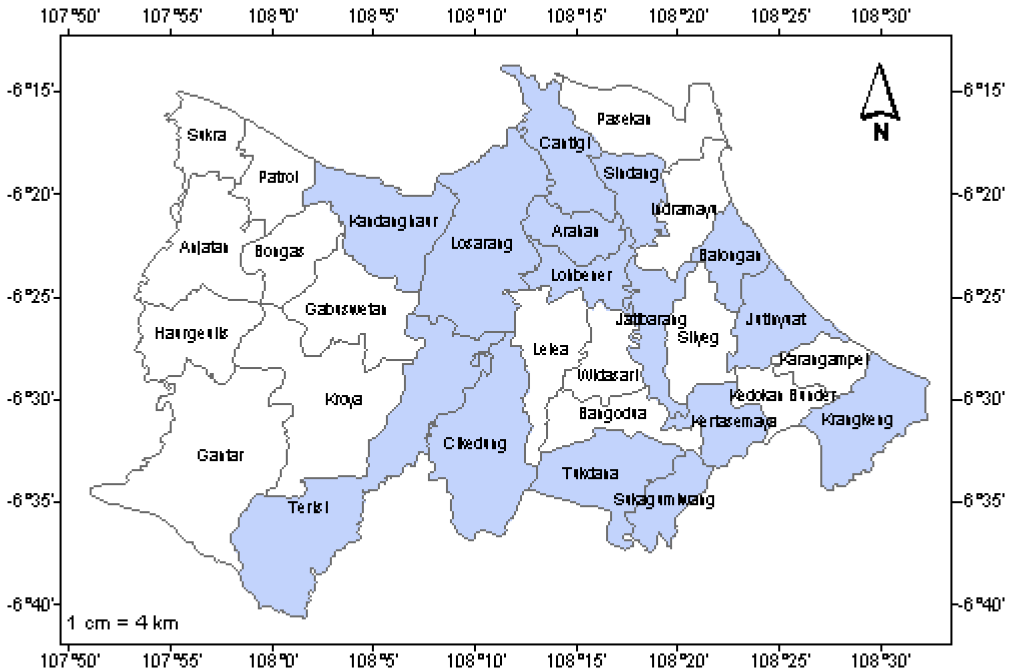
The loss for health sector was mainly approximated from additional incidences of *DBD* and diarrhea which could be more severe during flood events. The additional incidences were calculated based on historical monthly data on *DBD* and diarrhea incidences from 2004-2008 provided by Environmental Health Division of Indramayu. The economic loss for each day of flood was approximated as follows (Murray and Lopez, 1996):

*Economic loss for illness = (Length of Illness in weeks/total weeks in a year)*the additional incidences per day of flood * GDP per capita per year.*

Economic loss for dead = Ratio of deaths per 100 incidence the additional incidences per day of flood* Normal Working Years in a life time*GDP per capita per year.*
Normal Working Years in a life time = Retiring Age (55 years) - Starting Age (18 years), and annual GDP per capita was assumed to be about 17,956,450 IDR or about 1,931 USD (USD rate was 9300 IDR) at the time of analysis.

Adaptations and Their Costs

Understanding the economic consequences of flood and drought in Indramayu, discussions with the stakeholders were held to identify potential adaptation options. The discussions identified that there were seven potential adaptation options to cope with flood and drought in the region, namely: construction of a



(Source: The image was prepared based on administrative boundary of sub-districts from Coordination Agency of National Survey and Mapping 2002)

Figure 1. Location of districts within Indramayu regency. Shaded areas indicate residential areas where participants were lived at the time of the survey

dam; change of cropping pattern; rehabilitation of irrigation canals; improvement of irrigation canals (cementing the canals); improvement of drainage system; normalization of rivers; and implementation of system rice intensification.

The additional cost required for implementing each option was estimated based on previous study related to an option or expert judgment on the unit cost required for implementing an adaptation at the time of analysis. The total investment for each option was calculated by multiplying the unit cost and the expected areal coverage that would be impacted when an adaptation is implemented. Detailed potential benefits from each option which could be very helpful for estimating the net benefits from implementing such adaptation were drawn from focus group discussions.

RESULT AND DISCUSSION

Agriculture

Economic loss per hectare of rice production due to flood in Indramayu is equal to the number of financial resources that has been spent for cultivating rice. According to the survey, costs for rice production were spent on sowing, cultivating and harvesting (Table 1). Sowing costs refer to the number of financial resources required for seed preparation and planting. Cultivating costs are defined as the spending related to maintaining crop growth and development such as pesticide and fertilizer application. Harvesting costs are the financial resources required for harvesting and post-harvesting process so rice is ready to be sold.

The survey found that usually if flood occurs, farmers would do replanting after the flood event finished. This strategy was particularly taken when flood events occurred during sowing periods. Therefore, the economic loss refers to the amount of money that has been spent for sowing, about IDR 2,000,000. Furthermore, if flood events occurred during cultivating, but farmers are still able to do replanting; the loss is associated with the total spending for sowing and cultivating, about IDR 4,500,000 (Table 1).

However, if flood events happened for relatively a long period so that farmers could not do replanting, the economic loss is equal to the production value of rice, average rice yield multiplied by rice price (Table 1). This approximation was preferred to only the total spending for rice production (i.e., total costs of sowing, maintaining and harvesting), because rice supply would be impacted due to loss of rice production, not only delayed in the case where replanting is possible. The replanting might not be possible particularly when floods damaged rice during the harvesting period as there would be not adequate time for replanting rice on that planting season. Generally, Indramayu has three planting seasons according to the irrigation scheduling. This system rules the coverage of irrigation area for each planting date with a total of irrigated area up to 60,000 hectares during the wet season and the first dry season and 30,000 hectares during the second dry season (Table 2).

Table 1. Rice Production in Indramayu

Data and Information	Values
***Price of rice* (IDR/kg)**	2400
***Yield* (Ton/ha)**	
• Wet Season	7.34
• Dry Season*	6.73
***Value* (IDR/ha)**	
• Wet Season	17,616,000
• Dry Season	16,148,000
***Costs* (IDR/ha)**	
• Sowing	2,000,000
• Maintaining	2,500,000
• Harvesting	1,500,000

Based on Colenco and Indrakarya (2000)

Under drought condition, farmers would not grow rice as there would be not enough water supply for planting especially for the dry season 2 (DS2). Damaged cost due to drought is equal to rice production value, i.e., price multiplied by yield. As with the case of impossible replanting due to long flood events explained above, the rice production value is suggested rather than total production costs that have been spent by farmers as rice supply or stock in Indramayu will decrease as a consequence of the rice production loss. This loss will eventually decrease Indramayu's income from agricultural sector (*economic loss to society*), and may increase the request for importing rice to meet the consumers' demand.

It is important to note, the estimation of economic loss either due to flood or drought is in IDR/hectare. This means estimation of damaged area due to flood or drought will be needed to

Table 2. Total of irrigation area and planting date for each planting season

Rice Planting Area / Irrigation Scheduling	Planting Season Area (Ha)			Planting Date		
	WS	DS1	DS2	WS	DS1	DS2
I	15,000	15,000	30,000	1 Oct	1 Feb	1 May
II	25,000	25,000	0	15 Oct	15 Feb	NA
III	20,000	20,000	0	1 Nov	1 March	NA
Total Area	60,000	60,000	30,000			

Source: Agricultural Office of Indramayu 2007

approximate the regional economic loss. The length of flood and drought will also affect the total damage. Only flood occurred with more than 5 consecutive days can cause production loss in regions, which are vulnerable to flood. The longer the flood occurrences, the larger the damaged area will be. Based on group discussions, more than 25 days consecutive flood may inundate all vulnerable area to flood. For drought, dry spell less than 10 days does not have any effect on yield; whereas, length of dry spell more than 25 days may damage crop yield completely. This length criteria hint that assumptions or formulations are needed to evaluate the potential damage related to the length of flood or drought.

Fishery

A little bit different from agriculture, fishery production was more influenced by flood than drought. Discussions with stakeholders during the survey identified that the critical length of flood that created loss was flood with more than 15 days length of spell. About 1,119 hectares out of 22,977 hectares of total area for fishery production in Indramayu was vulnerable to flood. As with agriculture, the fish production stages were divided into three categories: sowing, maintaining and harvesting. There were three sowing and harvesting periods of fish production in the region. Sowing periods were in March, July and November; and harvesting periods were in June, October and February. The costs of production for farming prawn and milk fish are presented in Table 3.

Similar to the approach for estimating economic loss in rice production, the loss for fishery is equal to production costs that have been spent for fish production as long as farmers still have an opportunity for replanting fish. However, when flood events occur during harvesting, which cause insufficient time for replanting during that planting season, the total loss is the production value of prawn and milk fish per hectares. The production values were estimated by multiplying price for each fish commodity and yield (Table 4).

Table 3. Prawn and milk fish production costs

Components	Costs (IDR/ha)	
	Prawn	Milk Fish
• Sowing	1,500,000	1,400,000
• Maintaining	400,000	400,000
• Harvesting	350,000	350,000

Table 4. Prawn and milk fish economic value

Components	Values
Price (IDR/kg)	
• **Prawn**	55,000
• **milk fish**	9,000
Yield* **(**kg/ha)	
• prawn-extensive	80
• prawn-semi intensive	800
• milk fish	1,500
Production Value **(**IDR/ha)	
• prawn-extensive	4,400,000
• prawn-semi intensive	44,000,000
• milk Fish	13,500,000

Based on Colenco and Indrakarya (2000)

Unfortunately, we could not obtain information on prawn and milk fish yields per hectares from the survey as fish farmers did not record the yields. To estimate the production value, we used secondary data from previous study conducted by Colenco and Indrakarya (2000). This study reported that production of prawn and milk fish were about 80 and 1,500 kg/ha. This study also clarified that prawn production could be much higher for semi intensive management system with prawn yield could up to 800 kg/ha, but, the total costs would also be 5.5 times higher (about IDR 10,603,000 at the year of 2000 price) than extensive management system that produced prawn of about 80 kg/ha.

Information on different management system for prawn production (Colenco and Indrakarya, 2000) emphasizes that production value and total cost of prawn are sensitive to the choice of cultivated management system. Under the semi intensive management system, prawn production value is about IDR 44,000,000 (prawn price of 55,000 * yield of 800 kg/ha) with the total cost of about IDR 12,375,000 (the ratio cost of semi intensive to extensive management system of 5.5 * total prawn production cost obtained from the survey of IDR 2,250,000 (Table 3). This approximation of the total cost for semi intensive management system was made as the prawn production cost presented in Table 3 is much cheaper than that required for the semi intensive management system reported by the Colenco and Indrakarya study above. Thus, we assumed the total prawn production cost (Table 3) was for the extensive management system. Paying attention to the discrepancy of total costs and prawn yields for the semi intensive and the extensive management system, regional estimation of potential damaged costs for fishery production in Indramayu should carefully consider the choice of prawn production system at the time of analysis. This consideration is critical as the total economic loss will be sensitive to what management system fish farmers choose for cultivating prawn.

Drinking Water

As can be seen from Table 5, cost average for supplying clean water during flood events, which were frequently happened in February, is more expensive about IDR 927 per volume of water than the costs for the other months. Multiplying the additional cost with the daily amount of water sold during the month when floods regularly occurred (February) gives an estimation of about IDR 32.7 million per day additional cost, which is required for processing and supplying clean water to meet the consumer demand for water in Indramayu districts.

It should be understood that this estimation is for the total additional cost per day required for supplying clean water, not the total loss incurred for supplying clean water in Indramayu during flood events. To estimate the total loss, information on the length of flood is needed as the loss can be simply calculated by multiplying the additional cost per day with the flood length. For this purpose, impact models are required for modeling the flood length based on weather data as inputs.

Health

Economic loss for health sector was estimated based on additional incidences of DBD and diarrhea. Table 6 shows that about 200 and 3,999 additional cases of DBD and diarrhea occurred during flood events compared to normal condition, respectively. These additional incidences cause economic loss to the society as the patients were unable to work either due to illness or dead. Our estimation shows that daily economic loss during flood events for DBD is much higher than that for diarrhea (Table 6). This estimation hints that plans and actions are needed to minimize the negative impacts particularly the additional incidences of DBD during flood events.

Adaptation Costs

The investments required for implementing each adaptation option are shown in Table 7. As can be seen from this table, the total costs are sensitive to the areal implementation of each adaptation option, except for the Jati Gede dam construction which had been planed by the Indonesian government (Colenco and Indrakarya, 2000). The investment required for the Jati Gede dam was based on Colenco and Indrakarya (2000); meanwhile, the unit costs for the other options were based on expert judgement and stakeholder discussions at the time of survey was conducted. Consequently, information on adaptation costs presented in Tabel 7 should be used with caution and adjustments may be needed.

Based on the total costs presented in Table 7, construction of Jati Gede dam is the most expensive adaptation option. However, the construction of dam (reservoir) will provide multiple benefits for the region. The reservoir will store water during rainy season and will release it during dry season for irrigating rice crop. Thus with the presence of the reservoir, more area can be irrigated. In addition, planting season can also be expanded from twice to three times a year. Based on the Colenco and Indrakarya study and consultation with Head of Indramayu Irrigation Office, under the absence of the reservoir, the normal cropping pattern was Rice-Rice-Fallow with the total planting area of 60,000 ha. On the other hand, under the presence

Table 5. Additional cost required for supplying clean water during flood events

Components	Units	Values
Average cost for February (when flood occurs)	IDR/m3	3,701
Average cost for the other months (excluding February)	IDR/m3	2,774
Water sold for February	M3/day	35235
Water clean loss production in case of flood	IDR/day	32,676,831

Source: The estimation was based on data obtained from PDAM Indramayu from 2000-2007

Table 6. Economic assessment for the health sector

Additional incidences of DBD	Cases	200
Average flood day	Days	10
The additional incidences per day of flood	case/day	20
Ratio of deaths per 100 incidence in case of DBD	%	4.36
Length of Illness in case of dengue fever[1]	Weeks	4
Economic loss per day of flood		
Illness	IDR/flood day	27,625,308
Dead	IDR/flood day	578,918,412
Total	IDR/flood day	606,543,720
Additional incidences of diarrhea	Cases	3,999
Average flood day	Days	10
The additional incidences per day of flood	case/day	399.9
Length of Illness in case of diarrhea[1]	Weeks	1
Economic loss per day of flood		
Illness	IDR/flood day	138,092,007
Total	Cases	138,092,007
Total Economic loss per day of flood	IDR/flood day	744,635,727

Source: Murray and Lopez (1996)

of the reservoir, the normal cropping pattern would be Rice-Rice-Upland crop with the total planting area of 90,000 ha for the wet season (WS) and the dry season 1 (DS1), and about 45 thousands hectares for planting upland crops called as "*Palawija*" such as soybean in the dry season 2 (DS2) (Table 8). The reservoir can also mitigate flood events in Indramayu, which eventually will reduce the potential loss on drinking water and health sector. The presence of Jati Gede dam can also be utilized for electricity generation.

The cost for the second adaptation (change of cropping pattern) can be adjusted based on expenses spent by farmers to cultivate their land. The cost may incur due to additional planting season. For example, the construction of Jati Gede dam will offer an opportunity for farmers to have the third planting season instead of two as discussed previously. In this case, based on the survey, most farmers indicated that they would sow upland crops known as "Palawija" such as soybean with a total cost of IDR 2.5 million.

The third and fourth adaptation option, i.e., rehabilitation and improvement of irrigation canal, will increase the irrigation efficiency. Further investigation is still needed to explore the feasibility of this option: for example, how much water can be reserved for other purposes when the irrigation efficiency increases. This evaluation is needed to properly measure benefits of implementing these options.

The fifth and sixth options (improvement of drainage system and normalization of rivers) are among the less expensive option in terms of total costs compared to the other adaptations. Improvement of drainage system will benefit to reduce the flood risk by increasing the capacity of drainage canal to flow water to the ocean. Normalization of rivers means removing sediment from river which eventually can increase the maximum capacity of river to discharge water and reduce the volume of overflow ('*luapan*').

The last adaptation option is proposed to change rice farming system in the region. System rice intensification (SRI) offers an alternative to grow rice with less water demand. Hasan and Sato (2007) reported that the implementation of SRI on farming rice in Eastern Indonesia (about 9,429 hectares) increased rice yield for about 78% with less water demand (reduced by 40%) and fertilizer application (reduced by 50%) compared to those required by the conventional system. The basic principle of SRI in water use is keeping rice field wet but not flooded or in other words applies irrigation intermittently. Please refer to Hasan and Sato (2007) for more detailed information on SRI.

CONCLUSION

In this study, we mainly focused on calculating unit costs associated with damages due to flood and drought as an approximation of evaluating potential impacts of climate change in Indramayu regency. Per unit economic loss was approximated for rice production, milk fish and prawn production, drinking water supply, and numbers of DBD and diarrhea incidences. The calculations were based on price in 2008, which hint the need for adjustments when using the results for future evaluation. We only employed secondary data on yields of rice, prawn and milk fish, and cost ratio between semi intensive and extensive prawn production system from Colenco and Indrakarya (2000), which we assume will not have any implication to readjust price used by the Colenco and Indrakarya's study to be consistent with 2008 price.

We also, once again, emphasize that the loss estimation is not purposed to quantify the total loss for the regional economy. Such estimation requires reliable impact models to evaluate consequences of flood and drought temporally and spatially. The models should be able to estimate the length of flood and drought as well as areas impacted by the two events. The development of such models is also encouraged particularly to be used for future climate change assessment. Using the models, we can project the frequency of flood and drought events in the region as well as the duration and damaged areas under certain climate change scenarios. This information is necessary for estimating the potential regional economic loss under the new climate regime.

For adaptation costs, it should be understood that social costs or potential conflicts incurred for certain adaptations are excluded from the discussion. For example, the dam development may request for resettlement which may take a long process. The increasing demand for water due to the expansion of planting season (DS2) may also result in potential conflicts as water demand for other sectors such as drinking water (i.e., domestic water demand) may also increase in the future. On the other hand, possible interactions between adaptations may also

Table 7. Cost estimation for each adaptation to cope with flood and drought in Indramayu

No	Climate change adaptations	Impact of each option	Investment costs (IDR/ha)	Area (ha)	Total costs (IDR.)
1	Construction of Dam	Water Supply	NA	4,803	2,200,000,000,000
2	Change of Cropping Pattern	Water Demand	2,500,000	45,000	112,500,000,000
3	Rehabilitation of irrigation canals	Irrigation Maintenance	3,500,000	45,000	157,500,000,000
4	Improvement of irrigation canals	Irrigation Efficiency	182,000	90,000	16,380,000,000
5	Improvement of drainage system	Sediment removal from Dam	150,000	4,117	617,550,000
6	Normalization of rivers	Normalization of river	300,000	4,117	1,235,100,000
7	Implementation of SRI	Water Demand	600,000	90,000	54,000,000,000

Table 8. Expected planting areas to agricultural farms in case of Jatigede dam presence

Rice Planting Area / Irrigation Scheduling	Planting Season Area (Ha)			Planting Date		
	WS	DS1	DS2	WS	DS1	DS2
I	12,798	12,798	11,820	1 Oct	1 Feb	1 May
II	16,498	16,498	10,682	15 Oct	15 Feb	15 May
III	60,895	60,895	22,498	1 Nov	1 March	1 June
Total Area	90,191	90,191	45,000			

enhance benefits of a particular adaptation option. Consequently, further evaluation on benefits from climate change adaptations proposed in this study should also pay attention to the potential side effects of each option.

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HALAMAN INI SENGAJA DIKOSONGKAN