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Economic efficiency of community-based flood risk management: An empirical study from Indonesia

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Abstract

Flood risk management are considerably influenced by several factors, such as all sources of flooding, social circumstances, policy and even the potential for local economic growth. To encourage government, business, community and other parties to continue investing in flood risk management projects, it is necessary to give understanding that the projects can also provide economic benefits through systematic predictions and assessments of costs, benefits and social values, especially on flood-affected communities. This study aims: (1) to develop knowledge and understanding on small-scale flood risk management project in Malang City, Indonesia, and; (2) to assess the economic efficiency of the project investment considering all benefits, both monetary and non-monetary. The research method is a mixed method combining quantitative questionnaires (N = 53 from 162 families) with qualitative in-depth interviews (N = 10) and field observations. The runoff discharge and the inundation depth were calculated using hydrology and hydraulic analysis, while the economic efficiency was analysed using cost benefit analysis (CBA). The results show that the community-based flood risk management system can reduce the flood risk up to 30% compared to before the implementation of that system. This system also provides direct financial benefits through the use of drainage channels for fish and vegetables farming. It causes the increase of the net social benefit about 70–90% and the net present value (NPV) greater than zero ($NPV > 0$). Therefore, the project investment is recommended to be proceeded.

Key words: *community participation, cost benefit analysis, economic efficiency, flood resilience, flood risk management, urban drainage*

INTRODUCTION

Flood characteristics are very sensitive to the impacts of climate change and to the detailed nature of these changes [GERICKE, SMITHERS 2014; WIKANTIYOSO, TUTUKO 2013]. Nowadays, designers have low self-confidence in their projections of flood change figures. The magnitude and frequency of rainfall resulting from climate change inevitably causes flooding and inundation, so that risk assessment in urban areas during extreme precipitation is needed [KASPERSEN, HALSNÆS 2017]. Flood and inundation always occur in urban areas, particularly at road intersections [SEDYOWATI *et al.* 2018]. Uncontrolled urban development has considerably led to a lack of open space areas, potentially resulting in high volume surface runoff. There have been many studies and efforts to overcome urban flooding, including the use of permeable pavement [COLLINS *et al.* 2008; LUCKE 2014; NICHOLS *et al.* 2014; SEDYOWATI *et al.* 2017]. However, flood control infrastructure has not significantly reduced the global flood risk, as indicated by the greater average annual flood events and losses, 2000–2015 [OECD 2016]. The considerable obstacles to flood control efforts are that there are more reactive responses, such as emergency response and recovery, than proactive responses [TINGSANCHALI 2012]; focus is more on structural steps rather than non-structural steps [SAYERS *et al.* 2013]; lack of giving a greater role and authority to the community [WEHN *et al*. 2015] and facilitating multi-stakeholder engagement WMO/GWP 2006]; and there is no specific adaptation approach for each different region related to the development of urban flood resilience systems [DIEPERINK *et al*. 2016]. Non-structural measures have the advantage of being environmentally friendly and economically efficient, but their effectiveness is sensitive to the socio-economic context and government behaviour [DAWSON *et al*. 2011].

It is necessary to change the paradigm of controlling floods from conventional methods to modern methods. There have been a variety of concepts applied to reduce flood risk from hard engineering basics to softer basics, such as integrated flood management, flood risk management (FRM), risk sharing in flood management [WMO 2013] and flood resilience systems [SAYERS *et al*. 2013]. For improving the effectiveness of management and to reduce loss of life and property, reactive responses should be shifted to proactive responses. Proactive disaster management requires more participation from stakeholders, such as government, non-government and private institutions, and community participation. This implicates more effort and time, higher budgets, and more equipment, facilities and human resources, leading to the integration of both long-term and short-term programs for flood disaster management [TINGSANCHALI 2012]. In some cases, flood damage can be minimized if the urban system has several protective measures implemented, with the community in it being able to regulate itself so that there is no greater damage. This form of system is adapted to be able to accept interference from lessons learned from past events. Differences in urban systems (institutions, levels of urbanization, assets, existing risk cultures, and financial readiness) contribute to various levels of disturbance created during and after floods, and reflect on flood resilience in urban systems [BATICA, GOURBESVILLE 2014]. In community-based flood risk management, lack of financial resources, in some communities, has encouraged the occurrence of the ‘aid dependency' syndrome which could be an obstacle to the success of the program. A lack of project sustainability and local ownership has also emerged as a major challenge. Identified challenges explain the boundaries and direct the way in which repairs are needed, thus offering valuable contributions to the existing knowledge base [ŠAKIĆ TROGRLIĆ *et al*. 2018].

Risk management is one of potential instrument for development. Financial system has an important role in managing risk. The more financial instruments, less financial crises [World Bank 2013]. Collaboration of risk sharing between governments at all levels and all stakeholders, and risk information policies and funding priorities are key components for developing policies and actions based on these risks so that effective flood risk management is realized [ASCE 2014]. The benefit assessment framework is designed to help flood risk management practitioners consider a broader range of responses to flood risks and to communicate their decisions more effectively [CLARKE *et al.* 2015]. The benefits of developing a flood control facility only consider the value of damage prevention benefits calculated based on direct and indirect costs to reduce flood risks and losses [MLIT 2005]. A study was conducted to develop a decision-making framework for determining the time and optimal investment choices for flood protection projects [GOMEZ-CUNYA *et al.* 2020]. Effective coordination between government sectors is essential to building an integrated approach to financial management of flood risk that considers the best use of public resources [OECD 2016]. Actions to reduce risk of flooding and increase flood resilience with limited resources require decision support tools such as cost benefit analysis [MECHLER *et al.* 2014].

Cost benefit analysis (CBA) aims to make policy decisions that can be better informed and more consistent. It provides economic efficiency and effectiveness through systematic predictions and assessments of social costs and social benefits [BOARDMAN *et al.* 2018] in response to current climate change and to anticipate climate change in the future [VAN DER POL *et al*. 2017]. Policy with positive social benefits is economically more efficient than no projects [HAVEMAN, VEIMER 2001]. The higher the risk of flooding and the more sustainable the company plans, the company will invest more in flood protection because sustainable planning leads to national economic growth [GRAMES *et al.* 2019]. CBA also functions as a tool for finding facts together and reaching consensus on 'best' solutions involving various types of government, many private stakeholders, local citizens and businesses [BOS, ZWANEVELD 2017]. In some cases, direct economic costs can exceed their direct economic benefits. For this reason the analysts will leave it up to the authorities to decide whether national guard or other non-quantitative benefits are worth the cost [JENKINS *et al*. 2011]. In an uncertainty parameter like flood, it is important to analyse the robustness of the system to identify the impact of flood risk reduction interventions on system behaviour [MENS *et al.* 2011].

Malang City, which is in the highlands and is crossed by five rivers whose topographies have excellent flow characters with hilly topographical conditions [WIKANTIYOSO, SUHARTONO 2018], should not have significant flood problems. However, rapid development of the city and changes in the characteristics of the rain due to climate change has inevitably caused flooding and inundation during the rainy season. The local government has applied many flood prevention efforts, but until now it has not seen optimal results. To encourage the government, business, community and other parties to continue contributing in flood risk management projects, it is necessary to give understanding that flood control projects can also provide direct economic benefits, especially for flood-affected communities. For example, the construction of drainage channels not only provides non-monetary benefits such as sense of security and comfort, but also can provide monetary benefits through diversification in the use of the drainage channels. This can increase the interest of related parties, such as the government, the private sector, and other sponsors to invest in flood control projects. There are some benefits that can be calculated as cost effectiveness in every investment given.

This study aims to develop knowledge and understanding of small scale flood risk management project in Malang City, Indonesia, that by retrofitting the infrastructure, the project not only has social benefits but can also provide economic benefits; and to assess the cost effectiveness of community-based flood risk management investment considering all benefits, both monetary and non-monetary.

MATERIAL AND METHODS

DESCRIPTION OF STUDY AREA

The study area is located on a floodplain in Malang City, Indonesia, namely Glintung Kampong RW 5. This village is also known as Glintung Water Street (GWS). The name of GWS was triggered by the function of its roads which turn into channels during heavy rain, particularly on roads which are located within a radius of ±100 m from the river. With an area of 8.2 ha and a population of 810 people, this area is categorized as a high-density settlement, with about 9,900 people per km^2. Since the beginning of 2000, almost 50% of the region experienced flooding in each rainy season with an average flood height of 0.5 m and a maximum of 1.5 m (Phot. 1, 2). There is a large channel about 10 m wide at the South boundary, a highway at the West, a dense neighbouring kampong to the North and a railroad to the East. Those three boundary areas have higher elevation than Glintung Kampong causing this area to be like a water pond in the rainy season. The condition is worsening because there is a backwater flow when the water level in the channel increases and the channel water then overflows into the kampong.

Photo 1. Flood mark at the Glintung Water Street (phot. *L. Sedyowati*)

Photo 2. Resident and the inundation (phot. *L. Sedyowati*)

RESEARCH METHOD

This study combined a quantitative method using questionnaire distribution (N = 53 from 162 families) with a qualitative method using in-depth interviews (N = 10) and field observations. The quantitative method was used as empirical research to find out the community's concern for the environment, people's behaviour that affects flood risk, and community awareness and involvement in flood risk management, including their responses to government programs to reduce flood risk. Questionnaires were also used to examine the flood risk and the level of community resilience toward facing the floods that frequently occur. In-depth interviews were undertaken to find out the willingness of the community to stay in the floodplain, the flood losses that have occurred over the past 10 years, and the community values employed in its flood resilience system. Field observations were conducted to understand the existing community flood resilience system, the interaction of local communities with local government and related agencies, and the creativity, innovation and potency of the local community in developing cost effectiveness.

Questionnaires. The questionnaire consisted of seven question categories to find the attitudes and behaviour of the community as follows: (1) community awareness of and participation toward protecting the environment; (2) understanding of the causes of floods; (3) understanding of the risk of flooding that occurs around the residence; (4) flood emergency response; (5) understanding of risk management and flood resilience systems; (6) flood warning system; (7) responses to flood control efforts from the government. Respondents consisted of two groups, namely groups of community leaders and community groups. The questionnaire distribution was initiated by conducting a focus group discussion (FGD) followed by all stakeholders involved included the local women organization namely PKK. The completion of the questionnaire was carried out through direct interviews with respondents and the answers directly filled in the appropriate column. Questionnaire data were then analysed using correlation, determination and regression analysis tests.

In-depth interview. In-depth interviews were only conducted with 10 community leaders, namely: RW Chairman (one person), PKK RW Chairman (one person), RT Chairpersons (five people), Takmir Masjid Chairman (one person), Karang Taruna Chairman (one person), elders (one person) and related local government agencies. Interviews were also conducted to explore the role of relevant agencies in developing community potential towards food security, environmental sustainability and the facilities provided.

Field observation. To obtain the data needed, observations were undertaken according to a schedule agreed upon by the community and the interviewer with the following provisions in place: (1) during heavy rains with the inundation depth reaching 1 m, observations were conducted at drainage channels and where streets functioned as flood ways; (2) when there is no rain, observations were conducted at the drainage channel that also functions as a fish pond; (3) Observations also conducted at the community meeting activities with related agencies (Photo 3), community health centre, local women organization's meetings, religious activities, youth activities and community services. The data were then analysed using correlation test and regression analysis to find the validity and the reliability of the data, and the relationship of the parameters observed. Evaluation of changes in flood risk due to additional treatment, both structural and non-structural programs, is carried out with measurements before and after the program. Results from in-depth interviews and field observation (qualitative results) were also used to verify the quantitative result from questionnaire data, so as the results of the quantitative analysis can be generalized.

Photo 3. Field observation with the Public Works Agency officer (phot. *L. Sedyowati*)

HYDROLOGICAL AND HYDRAULICS ANALYSIS

Hydrological analysis was carried out to determine runoff discharge which causes inundation at the study site. Runoff discharge was calculated using the rational method with rainfall data obtained from the Indonesian Meteorological, Climatological, and Geophysical Agency (Ind. Badan Meteorologi, Klimatologi, dan Geofisika – BMKG) with a data length of 10 years, 2009–2018. Catchment area was measured using Google Maps and field surveys. Runoff coefficient was determined based on the type of land use in the drainage area, the average was then calculated. Hydraulics analysis was used to determine the capacity of the drainage channel built by the government as an investment in flood control at the study site. Channel capacity was calculated using the Manning formula with technical data according to channel specifications. The decrease in runoff discharge due to the construction of drainage channels is the subtraction result of runoff and capacity discharge, and is also mentioned as uncontrolled discharge. Inundation depth was then estimated using ratio of the inundation volume and inundation area, whilst the inundation volume was calculated by multiplication between runoff discharge and rain duration.

COST BENEFIT ANALYSIS (CBA)

According to BOARDMAN *et al*. [2018], CBA is a method for assessing a policy by measuring within the limits or financial terms the value of all consequences of a policy for all members of the community. In general, CBA is applied to government interventions relating to policies, programs, projects, regulations, demonstrations and others. CBA aims to help social decision making and to increase social value, or more technically, improve allocation efficiency. Therefore, CBA is focused on social costs and social benefits for all members of the community. The overall value of a policy is measured by net social benefits (*NSB*). *NSB* is calculated by subtracting benefits from costs ($NSB = B - C$). Measurement of net social benefits, costs and benefits refers to a benchmark that is usually a status quo condition, i.e. there is no change in the current policy. Net benefits, costs and social benefits are measured based on changes in the status quo policy conditions. There are two types of CBA, namely ex ante (before) and ex post (retrospect/ retroactive). Ex ante CBA is done before the decision is made to implement a project or policy, so that it will provide a recommendation whether resources will be allocated to a particular project or policy or not. Ex post CBA is done after the project or policy is completed, or at the end of the project, so that it will provide information on whether the project or policy is a good idea or not. Project that take many years to complete, the impacts often continue for years after initial construction. In such cases, for any continuing policy or project, the government analysts may want to conduct a CBA sometime after the policy or project starts but before it is completed. Such studies are sometimes referred to in media res CBA or post-decision analysis. The CBA try to answer the question: is this project or policy continuation a good idea? An in media res CBA can be made at any time after the decision to carry out a project has been made (but before it is completed). An in media res CBA might recommend termination or modification of certain projects or policies. Sensitivity analysis were then undertaken for determining how the discount rate will impact on social benefits (*PVB*) and social costs (*PVC*) at the end of a project in its present value. The net social benefit (*NSB* or *NPV*) = $PVB - PVC$. If $NPV > 0$ it means that project continuation is a good idea, and if $NPV < 0$ the project should be terminated.

In this study, there were an in media res CBA that try to decide whether the flood reduction project as part of the flood risk management program in the study area will be continued or not. The discount rate used for sensitivity analysis is in the range of 5.0–7.5% based on Bank Indonesia data released within last five years downloaded at January 29, 2020, source: https://pusatdata.kontan.co.id/makroekonomi/bi_rate.

RESULTS AND DISCUSSION

RELATIONSHIP BETWEEN VARIABLES

In the initial step, the research variables have not been distinguished between independent variables and dependent variables. All question categories as mentioned above were the variables used in this research as follows: 1) awareness and participation ($X1$); 2) understanding the causes of floods ($X2$); 3) understanding the flood risk ($X3$); 4) flood emergency response from the local government ($X4$); 5) flood resilience and risk management ($X5$); 6) flood warning system ($X6$); 7) responses to government programs ($X7$). The correlations between variables were analysed using a correlation test. Data analysis was based on three categories or groups of the respondents: 1) community leaders (N = 10); 2) male respondents (N = 26); female respondents (N = 17).

High correlation values of the community leader group (presented in Table 1) are shown by the relationship between: $X4$ (flood emergency response from the local government) and $X6$ (flood warning system), where $r = 0.92$; $X5$ (flood resilience and risk management) and $X6$ (flood warning system), where $r = 0.89$; $X3$ (understanding the flood risk) and $X5$ (flood resilience and risk management), where $r = 0.87$; $X2$ (understanding the causes of floods) and $X7$ (responses to government programs), where $r = 0.82$; and $X4$ (flood emergency response from the local government) and $X5$ (flood resilience and risk management), where $r = 0.81$. These results indicate that $X5$ is the most significant parameter and has a strong correlation directly with other parameters, those being $X3$, $X4$, $X6$.

Table 1. Correlation test result (r) for categories of investigated social groups

Variable	$X5$	$X3$	$X4$	$X6$
Community leader category				
$X5$	1.00			
$X3$	0.87	1.00		
$X4$	0.81	0.78	1.00	
$X6$	0.89	0.68	0.92	1.00
Male category				
$X5$	1.00			
$X3$	0.59	1.00		
$X4$	0.50	0.70	1.00	
$X6$	0.29	0.27	0.71	1.00
Female category				
$X5$	1.00			
$X3$	0.76	1.00		
$X4$	0.89	0.72	1.00	
$X6$	0.46	0.57	0.62	1.00

Explanations: $X3$ = understanding the flood risk, $X4$ = flood emergency response from the local government, $X5$ = flood resilience and risk management, $X6$ = flood warning system.
Source: own calculation.

The relationships between $X5$ (as dependent variable) and $X3$, $X4$ and $X6$ (as independent variables) are shown in Figure 1. Regression analyses were then used to figure out the relation model between those parameters, and how $X3$, $X4$ and $X6$ influence $X5$. Based on the initial result from community leader group, the relationship was then expressed by developing a linear function.

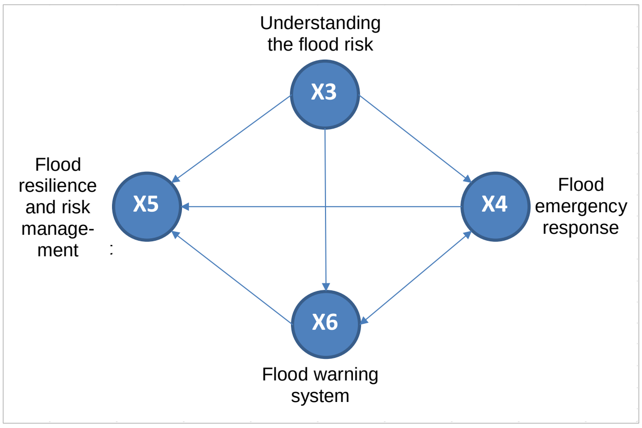

Fig. 1. Relationships between variables; source: own study

The relationship models of flood resilience and risk management parameter ($X5$) for leader category, male category, and female category respectively, are as follows:
1. $X5 = 0.74X3 – 1.01X4 + 1.03X6$
2. $X5 = 0.29X3 + 0.19X4 + 0.22X6$
3. $X5 = 0.35X3 + 0.38X4 + 0.05X6$

Where, $X3$ is parameter of understanding of the flood risk, $X4$ is parameter of flood emergency response from the local government, and $X6$ is parameter of flood warning system. The regression statistics and the result of model test using Nash–Sutcliffe efficiency (NSE), root mean square error ($RMSE$), and mean absolute error (MAE) for each respondent category are as shown in Table 2.

According to the regression statistics data in the Table 2, the category of male respondents has the largest standard error of 38.6%, even though the coefficient of relation and the coefficient of determination are close to 100%. This shows that the three independent variables simultaneously have a strong influence on the observed variable. However, because the relationship between variables in the

Table 2. Results of regression analysis and model test

No.	Category of respondent	Coefficient	Regression statistics	Model test values		
				NSE	MAE	$RMSE$
1	leader N = 10	$X3$ = 0.74 $X4$ = –1.01 $X6$ = 1.03	r = 0.997 r^2 = 0.994 SE = 0.203	0.83	0.14	0.17
2	male N = 26	$X3$ = 0.29 $X4$ = 0.19 $X6$ = 0.22	r = 0.984 r^2 = 0.969 SE = 0.386	0.67	0.30	0.36
3	female N = 17	$X3$ = 0.35 $X4$ = 0.38 $X6$ = 0.05	r = 0.992 r^2 = 0.985 SE = 0.265	0.73	0.18	0.24

Explanations: $X3$ = parameter of understanding of the flood risk, $X4$ = parameter of flood emergency response from the local government, $X6$ = parameter of flood warning system, SE = standard error.
Source: own study.

male category is relatively weak (as shown in Table 1), it causes a significant error. Thus, the male group did not have a significant influence on flood resilience and risk management. On the contrary, the standard errors for the community leader group and female group are both relatively low, about 20%. This shows that the use of linear equations to express the relationship between independent variables and the dependent variable is appropriate. It also indicates that community leaders and women have significant influence on the system of flood resilience and risk management that has already been built in the community. Data obtained from the results of in-depth interviews and field observations also considerably show the same results. Women play a greater role in every activity that is carried out, both by the community leaders and by the relevant agencies. This is in accordance with the Dublin Principles in 1992 Number 3 which states that "Women play a central part in the provision, management and safeguarding of water" [Cap-Net, GWP, UNPD 2005]. Only a few men were actively involved in environmental management activities, especially regarding the flood resilience systems that have been built within the community. These results also verify the quantitative analysis result of the male category, that there is a limitation of men's roles on the flood resilience system and in risk management.

It can be summarised that there has been a flood risk management system. The system consists of the community (flood-affected and non-flood-affected community), community social values (mutual harmony, mutual cooperation, creative), drainage channels and its additional economic benefits, and a simple flood resilience system.

RUNOFF DISCHARGE AND INUNDATION DEPTH

To accommodate the rainfall uncertainties, there are two runoff discharge approaches for estimating the inundation depth in the study area, i.e. 2-year and 5-year return period runoff discharges (Q_2 and Q_5 respectively). Hydrological and hydraulic analysis calculations using a series of 10-year daily rainfall data and heavy rainfall duration about 30–60 minutes obtained the following results:

1) Q_2 = 10.24 $m^3 \cdot s^{-1}$, Q_5 = 12.73 $m^3 \cdot s^{-1}$, and the drainage channel capacity = 7.00 $m^3 \cdot s^{-1}$,
2) uncontrolled discharge for 2-year return period = 3.24 $m^3 \cdot s^{-1}$, causing inundation area of 0.95 ha, inundation depth of 20–50 cm, and flood losses consisted of damages to buildings and interior, motorcycles, electrical appliances, furniture, livestock, and vegetables gardens, with total losses approximately 94 million Rupiah[1)].
3) uncontrolled discharge for 5-year return period = 5.73 $m^3 \cdot s^{-1}$, causing inundation area of 1.42 ha, inundation depth of 50–100 cm, and flood losses consisted of damages to road, buildings and interior, vehicles (car and motorcycles), electrical appliances, furniture, livestock, and vegetables gardens, with total losses approximately 125 million Rupiah.
4) the more frequent inundation depth in the study area is 50–100 cm.

[1)] USD 1 = IDR 13,800 (date: January 29, 2020).

EXISTING FLOOD RESILIENCE SYSTEM

Based on cultural and historical heritage values, the community built their own flood resilience system that combines structural and non-structural measures to improve their environmental, social and economic quality. The structural components consist of a drainage channel that is utilized for fish and vegetable farming, as shown in Photo 4; water level indicator, sluice gate for controlling the flood, and pump station to escalate water to the closest receiving water body, as shown in Figure 2. The non-structural measures consist of early warning of natural floods – acknowledging the sound of lightning as a sign of heavy rain – evacuation routes to safe areas, assistance of neighbouring homes that are not flooded for shelter, helping each other when cleaning up flooding impacts. This system can reduce the flood damage, as stated by BATICA and GOURBESVILLE [2014] that flood damage can be minimized if the urban system has several protective measures implemented, with the community in it being able to regulate itself so that there is no greater damage.

Photo 4. Drainage channel utilized for fish and vegetable cultivation (phot. *L. Sedyowati*)

Fig. 2. Simple flood resilience structure; source: own elaboration

ECONOMIC EFFICIENCY

In this study, the purpose of cost benefit analysis (CBA) is to improve social welfare by maximizing efficiency of resources allocation for flood risk reduction project. The CBA is used to assess whether the government intervention by constructing drainage channel at the study area is more economically efficient than no intervention.

Actions to reduce risk of flooding and increase flood resilience with limited resources also require decision support tools such as cost benefit analysis [MECHLER *et al.* 2014]. There are two feasible alternatives of flood risk reduction project, one built with retrofitting the channel for fish and vegetables farming, and one without. The CBA was initialized by identifying the whole cost and benefit of the flood resilience system and risk management that have already implemented, both monetary and non-monetary values. The benefits consist of reduction of damage cost (repair of buildings and interior damage, road, vehicles, electrical appliances, furniture, etc.), reduction of business interruption cost in the flooded area, reduction of community activity disturbances cost in the flooded area, revenue from drainage channel utilization for fish and vegetable farming, revenue from guests visits to project location which are currently known as food security villages. Whilst the project costs consist of drainage channel construction costs, cost of retrofitting the channel for utilized as fish and vegetables farming, cost of operation and maintenance. Sensitivity analysis were then undertaken to decide whether the project will be continued or not.

The cost benefit analysis was undertaken based on 5-year runoff discharge (Q_5) and in three conditions, as follows:

1) "status quo" condition: no investment for flood risk management program;
2) condition 1: drainage channel construction (110 m length) without retrofitting the channel for fish and vegetables farming, and implementation of the simple flood resilience system to minimize the flood risk;
3) condition 2: drainage channel construction (110 m length) with retrofitting the channel for fish and vegetables farming, and implementation of the simple flood resilience system to minimize the flood risk.

Financial benefits are obtained from: (1) the harvesting of fish and vegetables that thrive by utilizing remaining water from fish farming as a simple recycling system, see Photos 5 and 6 and; (2) reduction of: damage cost, business interruption cost, and community activity disturbances cost.

The drainage channels in the study area were constructed and operated since 2018. The designed life time of the project is at least six years, so that the project is still

Photo 5. Vegetables farming by recycling water from drainage channel (phot. *L. Sedyowati*)

Photo 6. The simple recycling system (phot. *L. Sedyowati*)

continuing. An *in media res* CBA or post-decision analysis is used to evaluate the feasibility of the project. All benefits and costs are assumed to be an annual fixed value, except investment and installation costs paid only in the first year. Calculation of the present value was based on the discount rate prevailing in Indonesia, which is in the range of 5.0–7.5%. Therefore, the discount rates used for the sensitivity analysis were 5%, 6%, 7%, 8% and 10%.

Table 3 represents that the social cost for investment of constructing the drainage channel of IDR 178.54 mln (or USD 12,938) can provide total social benefits for condition 1 and condition 2 respectively IDR 82.15 mln and IDR 108.43 mln in a year, include income from fish and vegetable farming which reached IDR 26.28 mln or USD 1,904 for condition 2. Whilst the social cost was divided into two category: 1) investment and installation cost of

Table 3. Calculation of cost benefit analysis and sensitivity analysis, in million Rupiahs

No	Components	Condition	
		1	2
Social benefit			
1	reduction of damage cost	43.75	43.75
2	reduction of business interruption cost in the flooded area	24.00	24.00
3	reduction of community activity disturbances cost	14.40	14.40
4	revenue from fish and vegetable farming	0.00	26.28
Total benefit (B), in a year		82.15	108.43
Social cost			
1	investment of drainage channel (110 m length)	178.54	178.54
2	installation cost for fish and vegetables farming	0.00	15.22
3	operation and maintenance of drainage channel	6.00	6.00
4	operation and maintenance of flood resilience system	9.60	9.60
Total annual cost (C), in a year		15.60	15.60
Analysis for 6-year designed life time of the project			
1	*NPV* (discount rate 5%) = *PVB* – *PVC*	159.25	277.42
2	*NPV* (discount rate 6%) = *PVB* – *PVC*	148.72	262.73
3	*NPV* (discount rate 7%) = *PVB* – *PVC*	138.68	248.72
4	*NPV* (discount rate 8%) = *PVB* – *PVC*	129.12	235.39
5	*NPV* (discount rate 10%) = *PVB* – *PVC*	111.30	210.54

Explanations: NPV = net present value, PVB = social benefits, PVC = social costs.
Source: own calculation, USD 1 = IDR 13,800 (date: January 29, 2020).

IDR 193.76 (= 178.54 + 15.22) mln in first year; 2) annual cost of IDR 15.60 (= 6.00 + 9.60) mln. *NPV* is the amount of benefits obtained up to the 6th year minus the total investment costs and annual costs up to the 6th year by taking into account the discount rate. For all discount rates, the *NPV*s indicate greater than zero (*NPV* > 0). It means that the project can be continued. Retrofitting the channel for fish and vegetables farming with the installation cost of IDR 12.55 mln can increase the net social benefit about 70–90%. It indicates that collaboration of risk sharing between governments at all levels and all sectors, and all stakeholders is key components for developing policies and actions based on the risks so that effective flood risk management is realized [OECD 2016; TRAVER (ed.) 2014]. Therefore, government investment in the future on flood control programs to this kampong will provide both social and economic benefits.

CONCLUSIONS

The community has the values of local wisdom, namely mutual cooperation and harmony, which have been firmly planted because of the cultural heritage and educational outcomes of traditional parenting. These values further underlie the development of natural resilience and flood risk management systems. The community also has demonstrated creativity, innovation and high productivity as it has developed fish and vegetable farming by utilizing drainage channels and water left over from fish farming to fertilize plants. The robustness of flood risk management system is shown by the resilience of the people facing flooding, and post-flood recoveries in each flood event with varying magnitude. Within the study area, frequent flooding with a depth of 50–100 cm did not encourage the community moving to another place. The community can even benefit economically from drainage channels used for fish and vegetable farming.

The current flood control project does not only reduce the level of flood risk by up to 30%, but also provides economically efficiency resulting from the flood risk management system of up to 90% throughout the 6-year effective life time of the project. Women have an important role in flood resilience and the risk management system because in Indonesia many women do not work so they have more time to take care of the household and to participate in social activities. Optimizing the role of women in the future becomes a necessity. This is also a lesson learned for the government and other parties concerned, that the local community have a readiness to negotiate actions regarding flooding. This can alleviate the burden and responsibility of the government or other parties in dealing with flood problems. Gradually, the government role may be shifted to that of only a facilitator. Further studies are needed, especially in the wider area or in other areas with different community characteristics, so that a model of the relationship between flood risk management and geographical location and community characteristics can be developed.

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