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ENVIRONMENTAL ASSESSMENT OF FLOOD MITIGATION STRUCTURES IN METRO MANILA, PHILIPPINES USING THE RAPID IMPACT ASSESSMENT MATRIX (RIAM) TECHNIQUE

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An environmental impact assessment (EIA) that provides the means to measure and compare project impacts, and which can easily be re-evaluated, is highly useful in the strategic planning of structural flood mitigation measures (SFMM). SFMM are essential in the sustainable development of flood-prone urban centers. In Metro Manila, Philippines, the EIA methods for planned SFMM do not provide sufficient tangible results, which make it difficult to compare and re-evaluate the impacts between SFMM alternatives. Thus, this study proposes the use of the rapid impact assessment matrix (RIAM) technique to systematically and quantitatively evaluate the environmental impacts of planned SFMM in Metro Manila. The RIAM was slightly modified to fit the requirements of this study. Results indicate that the EIA by RIAM can provide a clear view of the impacts associated with the implementation of SFMM projects.

Key Words **:** *environmental impact assessment, structural flood mitigation measures, rapid impact assessment matrix, Metro Manila*

1. INTRODUCTION

Structural flood mitigation measures (SFMM) are regarded as major infrastructure works that have significant roles in the sustainable development of flood-prone urban centers1). In view of the effects of climate change, many key cities in Southeast Asia (e.g. Jakarta in Indonesia, Bangkok in Thailand and Metro Manila in the Philippines), have been put to higher risks from more devastating floods, thus making SFMM valuable and preferable among flood management schemes in alleviating urban flood risks2). SFMM are primarily designed to reduce the risks of disasters and optimize developmental benefits along flood-prone areas, however, these measures could still generate negative impacts that may affect the natural hydrology and ecological processes3) of the receiving environment. The conduct of environmental impact assessment (EIA) during the early planning stages is thus necessary. Faced with urgency and limited resources4), decision-makers would need to seek the appropriate EIA techniques to formulate the necessary actions based on informed decisions.

In the Philippines, EIA is being carried out mandatorily on SFMM projects. The EIA methods commonly used are generally descriptive and qualitative in nature5). These methods are similar to the EIA methods (i.e. adhoc and simple checklist methods) described by Lohani *et al.*6) The ad hoc

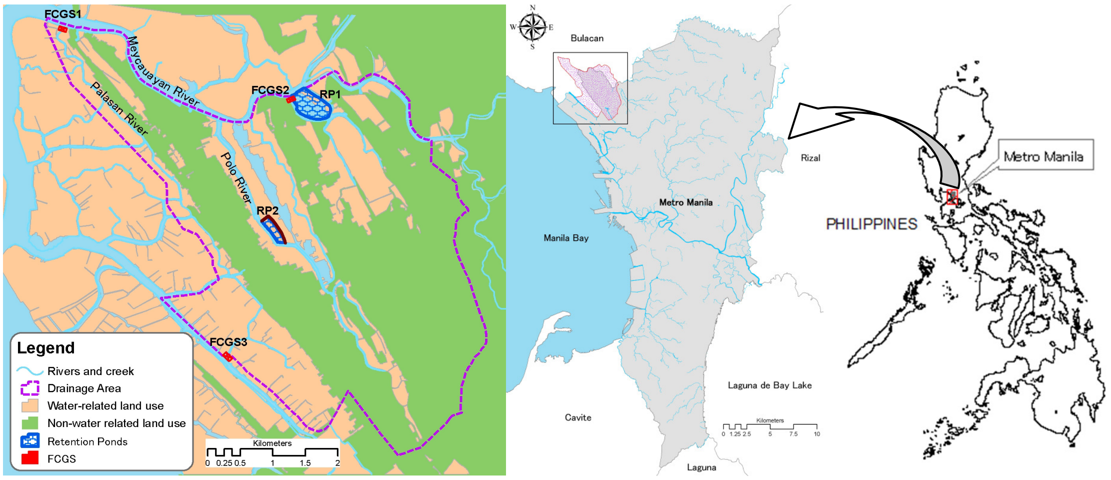

Fig.1 Map showing the geographical location of Metro Manila (right), the study area (middle) and the location of the planned SFMM (left) indicated by RP1, RP2, FCGS1, FCGS2 and FCGS3.

method is a non-structured approach that generally relies on the "experience, training and intuition" of the assessing expert. The problem with the ad hoc method is that it generally fails to provide the means to organize meaningfully considerable amounts of information about the biophysical, social and economic environment. It merely describes the pertinent information of the impacts without much regard to its importance and magnitude. This process of assessment is non-replicable, thus making the EIA conclusions difficult to review or even criticize.

The simple checklist method, on the other hand, is more structured, elaborate and more systematic compared to the ad hoc method. It typically displays a list of environmental parameters that are evaluated against a set of assessment criteria6). This method, however, fails to provide the necessary guidelines on how the impacts are to be measured and interpreted6), which essentially precludes the transparency of the whole process7). According to Villaluz8), one way to advance the EIA system in the Philippines is to select methods that can provide better transparency to help "maintain the impartiality of the entire EIA process".

An EIA that provides for the quantitative analysis of subjective judgments can help address the limitations of the two traditional EIA methods mentioned above9). Such concepts are fundamental in the rapid impact assessment matrix (RIAM) technique. The RIAM technique is a semi-quantitative impact assessment approach that utilizes standardized evaluation criteria and rating scales7). It has been favored in many case-studies10),11) in various sectors primarily due to its simplicity and robust application.

In spite of its numerous applications, there has been no reference, as far as the authors know, of its application in the EIA of SFMM in any part of the world. In the Philippines, however, it has never been used for any type of project. The Philippines can benefit from adopting this technique, thus it is imperative to provide references of its application using a local SFMM project as a case study. It is necessary however to ensure the conformity of the RIAM method with the general impact assessment approach prescribed in the Philippine EIA system.

This paper primarily explores the benefits of using the RIAM technique in the evaluation process of SFMM by examining the results of the EIA of selected planned SFMM in Metro Manila. Furthermore, a slight modification of the RIAM technique is proposed not only to enhance the transparency and sensitivity of the evaluation process, but also to cope with the requirements of the EIA system in the Philippines. These modifications are intended to improve the outcome of the EIA, but may also find application in other infrastructure projects. The next section introduces the basic profile and environmental conditions of the study area. The subsequent sections elaborate on the RIAM method and its proposed modifications, followed by a demonstration of its application. The impacts of selected planned SFMM were analyzed for possible environmental mitigation. The final section offers some recommendations and conclusions with the aim of providing valuable insights for decision makers, planners and policy-makers for the improvement of the EIA system for SFMM in the Philippines.

2. ENVIRONMETAL SETTING

Metro Manila is the Philippines' center for political and economic activities. **Fig. 1** shows the geographic location of Metro Manila. Metro Manila is situated in a semi-alluvial fan that opens to Manila Bay on the west and Laguna de Bay Lake on the southeast. Metro Manila is considered to be the most densely populated12) urban center in the

Table 1 Salient features of the proposed SFMM.

Code	SFMM type	Description of activities	Area (ha)	Size (m^2)
RP1	Retention Pond	Increase existing capacity by excavating to an average of 1.5 m depth	22	-
RP2	Retention Pond with embankment	Construct a pond by excavation to an average depth of 2.0 m and install embankment	5	-
FCGS1	Flood Control Gate Structure	Installation of steel roller gate with pump station	-	20
FCGS2	Flood Control Gate Structure	Installation of steel roller gate with pump station	-	20
FCGS3	Flood Control Gate Structure	Installation of steel roller gate with pump station	-	20

country. Despite the high economic activity[13)], progress in many parts of this region is slowed down by floods that are frequently caused by monsoon rains and typhoons during the months from May to October[14)]. Recent floods have been devastating, causing loss of lives and massive damages to properties[15)].

This paper focuses on the drainage area (~20 km^2) located in the north-northwest part of Metro Manila, as shown in **Fig. 1**, with a population of approximately 160,000. This drainage area is included in the priority flood mitigation program of the Philippine government[16)], which is aimed to considerably reduce the annual damages caused by floods, lessen the incidents of water-borne epidemics, and provide pleasant living conditions for the residents of Metro Manila. Its topography lies on flat and low-lying coastal plains with ground elevation ranging from 0 to 1.5 m above mean sea level. It has a mixed land-use comprising of commercial and industrial districts, residential areas and fishponds. The average annual rainfall is less than 3,000 mm[16)]. The river system has limited aquatic biota due to the poor water quality conditions. Garbages, particularly commercial plastics, are often observed deposited along the riverbanks or floating along the river channels. Mangroves can be found near the river mouth. Due to the very poor discharge capacity of the study area, floods easily manifest every rainy seasons, contributing to the slow economic growth of affected municipalities.

To improve the drainage conditions, retention ponds and flood control gate structures (FCGS) were proposed under the Metro Manila flagship program on flood mitigation[16)]. **Table 1** shows some of the salient features of the proposed SFMM. The locations of these structures are shown in **Fig. 1**. A small number of settlers can be found along the proposed retention pond designated as RP2 in **Fig. 1**. The authors evaluated the environmental impacts of the 5 SFMM using the RIAM method.

Table 2 Sample list of potential environmental impact sources in the evaluation of the SFMM.

Environ. Categories	Project Phase	PEIS	Nomen-clature
PC	Pre-construction	Land/soil disturbance due to site clearing	PC-P-1
	Construction	Change in land use	PC-C-1
BE	Construction	Aquatic habitat	BE-C-1
	Construction	Wildlife and terrestrial impacts	BE-C-2
SC	Pre-construction	Involuntary Resettlement	SC-P-1
	Construction	Air quality	SC-C-1
EO	Operation	Property and infrastructure	EO-O-1
	Operation	Local revenue and economy	EO-O-3

3. THE RIAM METHOD

The impacts of the SFMM were evaluated against 28 potential environmental impact sources (PEIS). **Table 2** shows a sample list of PEIS used in this study. Each of the PEIS falls under one of the 4 environmental categories[7)]: Physical/Chemical (PC), Biological/Ecological (BE), Social/Cultural (SC) and Economics/Operational (EO). Typically, the grouping of PEIS stops here, but in this study, the RIAM method is slightly modified to further sub-group the PEIS in terms of project phases, since project phasing can improve the outcome of the EIA by allowing the evaluation of a wider scope of impacts, which in turn benefits the formulation of environmental management plans. The typical project phases of SFMM include pre-construction, construction, operation and abandonment phases. In this study, the abandonment phase was not evaluated, since the SFMM are considered to complement the development plans and programs of the Philippine national government whose aim is to provide a long-term solution to the perennial flooding and inundation problems within the study area. The PEIS thus are labeled as follows: [environmental category] – [project phase] – [environmental component number]. The environmental component number is used to identify each PEIS under each project phase in a particular environmental category. **Table 2** shows a sample list of the PEIS with the nomenclature used in this study. The distribution of PEIS in the environmental categories is 5, 8, 12 and 2 for PC, BE, SC and EO, respectively.

The RIAM method has provisions for the semi-quantitative evaluation of PEIS using a set of standardized assessment criteria (AC). Unlike the simple checklist approach[6)], the evaluation of the AC in RIAM is clearly explained by a standardized scoring procedure[7)]. The AC is categorized into 2

Table 3 Assessment criteria[7)] of Group A.

Assessment criteria	Scale	Description
A1 (Importance of Conditions)	4	Important to national/international interests
	3	Important to regional/national interests
	2	Important to areas immediately outside the local condition
	1	Important only to the local condition
	0	No Importance
A2 (Magnitude of change)	3	Major positive benefit
	2	Significant improvement in status quo
	1	Improvement in status quo
	0	No change/status quo
	-1	Negative change to status quo
	-2	Significant negative disbenefit or change
	-3	Major disbenefit or change

Table 4 Assessment criteria of Group B showing the original[7)] and slightly modified criteria.

Assessment criteria	I Original		II Slightly modified	
	Scale	Description	Scale	Description
B1 (Permanence)	-		0	No change/ not applicable
	1	No change/ not applicable	1	Negligible change
	2	Temporary	2	Temporary
	3	Permanent	3	Permanent
B2 (Reversibility)	-		0	No change/ not applicable
	1	No change/ not applicable	1	Negligible change
	2	Reversible	2	Reversible
	3	Irreversible	3	Irreversible
B3 (Cumulative)	-		0	No change/ not applicable
	1	No change/ not applicable	1	Negligible change
	2	Non-cumulative/ single	2	Non-cumulative / single
	3	Cumulative/ synergistic	3	Cumulative/ synergistic

Table 5 Conversion table of environmental scores to range bands[7)].

Range Bands	*ES*	Description
+*E*	+72 to +108	Major positive change or impact
+*D*	+36 to +71	Significant positive change or impact
+*C*	+19 to +35	Moderate positive change or impact
+*B*	+10 to +18	Positive change or impact
+*A*	+1 to +9	Slight positive change or impact
NI	0	No identified impact
NC	0	Negligible change
-*A*	-1 to -9	Slightly negative change or impact
-*B*	-10 to -18	Negative change or impact
-*C*	-19 to -35	Moderate negative change or impact
-*D*	-36 to -71	Significant negative change or impact
-*E*	-72 to -108	Major negative change or impact

groups (*A* and *B*). **Table 3** shows the description of the *A* group, while **Table 4** shows the description of the B group. The *A* group consists of the Importance Criterion (*A1*) and Magnitude Criterion (*A2*), while the *B* group consists of the Permanence Criterion (*B1*), Reversibility Criterion (*B2*) and Cumulative Criterion (*B3*).

In this study, to clearly designate *no change* (or *not applicable*) in the evaluation of the *B* criteria, the impact descriptor *no change/not applicable* is re-assigned to the scale value 0, while the scale value of 1 takes the impact description *negligible change*, as shown in column II of **Table 4**. The impact descriptor *negligible change* was proposed to distinguish "insignificant impacts" from the "significant impacts" and "no impacts", which is not clearly delineated in the original procedure. As pointed out by Kuitunen *et al.*[17)], the evaluation of the *B* criteria becomes difficult when the significance of impacts "seems to vary and whose characteristics also vary", necessitating the need for disambiguation. To address the ambiguity of the varying impact significance (particularly in the assessment of the *B* criteria) the impact descriptor *negligible change* (which represents non-significance) is included in the evaluation options. These modifications, as a result, enhance the sensitivity and transparency of the RIAM method.

Using the scales determined in each of the AC, the environmental score (*ES*) is calculated according to the standard RIAM procedures using a simple formula[7)]:

$$ES = (A1 \text{ x } A2) \text{ x } (B1 + B2 + B3) \tag{1}$$

The *ES* is used to classify the impact in terms of the degree of change, which is indicated by a range band (*RB*). The ranges are defined by conditions in the *A* and *B* groups that serve as indicators for the change in impacts. The setting of the range bands is explained in detail by Pastakia[18)]. **Table 5** shows the corresponding range bands with description for each computed *ES*[7)]. For example, a PEIS with a computed *ES* of 38 would fall within the range band [+D]. In response to the slight modification made in **Table 4**, the range band [N] is replaced with [NI] and [NC], where [NI] stands for no identified impact and [NC] stands for negligible change. Both [NI] and [NC] have an *ES* of 0. The range band [NI] is given when all the AC values are zero, while the range band [NC] applies when there is at least one non-zero value in any of the assessment criteria.

4. EIA USING THE RIAM TECHNIQUE

Table 6 shows a sample of the project evaluation using the RIAM technique. The study was carefully carried out by a multi-disciplinary team that has a combined experience of more than 10 years in the conduct of engineering design and environmental assessment of SFMM in the Philippines. Using the

Table 6 Sample results of the EIA of SFMM using the RIAM technique.

	RP1							RP2							FCGS1							FCGS2						
Nomenclature	A1	A2	B1	B2	B3	ES	**RB**	A1	A2	B1	B2	B3	ES	**RB**	A1	A2	B1	B2	B3	ES	**RB**	A1	A2	B1	B2	B3	ES	**RB**
PC-P-1	0	-1	1	1	1	0	NC	1	-1	3	2	2	-7	-A	1	-1	1	1	0	-2	-A	1	-1	1	1	0	-2	-A
BE-C-1	1	-1	2	1	1	-4	-A	0	0	0	0	0	0	NI	1	-1	1	1	0	-2	-A	1	-1	1	1	0	-2	-A
SC-P-1	1	0	0	0	0	0	NC	1	-2	3	3	2	-16	-B	0	0	0	0	0	0	NI	0	0	0	0	0	0	NI
EO-O-1	2	1	2	1	1	8	+A	2	1	2	1	1	8	+A	1	2	2	1	1	8	+A	1	2	2	1	1	8	+A

modified procedures of RIAM described above, **Table 6** was created using collected information from actual field investigation and secondary data. The field investigation included environmental surveys (i.e. water quality, sediment quality, air quality and terrestrial surveys) and social (stakeholder perception) surveys. Other socially relevant concerns were acquired through focus group discussions participated by the stakeholders. Secondary data were acquired from related studies[16)], reports[5)], socio-economic profiles of local government units (LGUs), as well as from the on-site interviews of relevant government agencies and LGUs.

5. RESULTS AND DISCUSSION

Negative impacts often require serious attention from planners and decision-makers, since these eventually become the backbone of environmental management and monitoring plans, and sometimes the basis for the acceptance or rejection of a proposed project. In this section, more attention is given in the examination of negative impacts, with focus on the environmental categories (i.e. PC, BE, SC and EO) and project phases. Suggestions for the reduction of negative impacts are offered whenever deemed necessary and applicable. **Fig. 2** shows the summary of the environmental assessment using the RIAM technique.

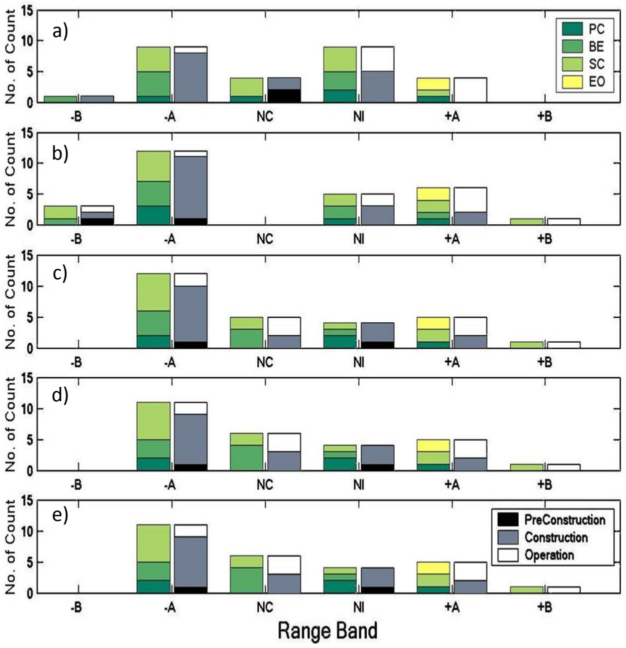

Fig.2 Summary of RIAM for the 5 SFMM: a) RP1, b) RP2, c) FCGS1, d) FCGS2 and e) FCGS3.

Fig. 2 shows the summary of the range bands in the form of histograms of RP1, RP2, FCGS1, FCGS2 and FCGS3. The impacts range from [-B] to [+B]. RP1 and RP2 exhibit similar characteristics and functions as indicated in **Table 2**; however they differ significantly in the RIAM profile of their potential impacts (**Figs. 2a** and **2b**). RP2, thus is expected to generate higher negative impacts both in the range bands of [-B] and [-A]. Majority of the potential negative impacts in RP1 occurs in the BE category, while RP2 affects mostly the SC category. This is perhaps due to the fact that RP1 already exists and will only be slightly modified to improve its capacity (as indicated by the higher counts of [NI] and [NC]), while RP2 is yet to be excavated, thus will affect heavily its closest vicinity. It is also worth to note that RP2 does not have impacts that may lead to negligible change [NC]. Even though RP2 has a high number of negative impacts, it is still expected to generate substantial benefits during the operation phase (as indicated by the higher [+A] and [+B] count in **Fig. 2b** compared with **Fig. 2a**). The negative impacts of RP2 can still be curbed by allocating sufficient resources in the project budget to properly compensate those who will be displaced during the project implementation. Other negative impacts in RP1 and RP2 are mostly temporary and reversible. For the FCGS, **Figs. 2c**, **2d** and **2e** are very similar. Most of the negative impacts are temporary and reversible and will not result to significant negative change. A number of positive impacts with high magnitude (i.e. A2 > 1) will occur during the operation of the FCGS facilities. The RIAM method however cannot provide a measure on the effects of the combined impacts of the 3 FCGS. The results can only imply that simultaneous operation of these facilities during a flood event will substantially benefit its immediate locality.

In general, most of the potential negative impacts are seen in the construction phase, while most of the positive impacts occur during the operation phase. For RP2, Majority of the negative impacts were observed in the SC category, perhaps this is due to the highly urbanized characteristic of the study area. Most of the open spaces are already converted for residential/industrial use and water-related land use (i.e. fish ponds). The results of this study can be re-evaluated and/or verified during the project implementation stage as part of the environmental management and monitoring activities.

The entirety of the EIA examination in this study shows that the evaluation process by RIAM has gone much further than the simple EIA methods used in the Philippines. The RIAM technique has shown capability to be impartial in the use of subjective judgments to achieve more meaningful results and made it easier to review the basis of the assessment during the examination of the EIA conclusions. There is however a limitation when examining the cumulative effects of co-located (with the same study area) projects, since this has not yet been developed in the RIAM technique.

6. CONCLUSION

This study has demonstrated the applicability of the RIAM technique as an alternative in the EIA of SFMM in the Philippines. The study also demonstrated the flexibility of the RIAM to cope with the modifications made to enhance the efficiency and transparency of the evaluation process. The inclusion of the impact descriptor *negligible impact* provided the means to distinguish the results that show “negligible impacts” with the results that indicate “no change“. Essentially, the RIAM technique complements very well with the general EIA process in the Philippines, making it highly viable for application in other project types. One clear limitation however exists: the degree of impact remains inconclusive when we try to examine the combined effects of co-located projects. In general, the EIA of SFMM by RIAM provides a simple but very effective means to identify the significance of potential impacts in a very transparent manner, leading to clearer and more meaningful EIA conclusions. The results of this study may be useful in the improvement of the EIA practice in the Philippines.

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