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Multi-Criteria Monitoring & Evaluation Analysis of Integrated Flood Risk Management in Metro Manila

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Monitoring & evaluation (M&E) of the integrated flood risk management (IFRM) in Metro Manila has not been carried out since its inception. There is no monitoring agency in charge of the M&E activities for the adaptation to IFRM in the Philippines, and this resulted in the lack of baseline information and measurable indicators to be used for M&E activities. This study attempts to conduct an M&E of the IFRM in Metro Manila. The performance for the IFRM of each municipality in Metro Manila was appraised by the officers-in-charge of the local government offices related to disaster risk reduction. The qualitative judgments from the respondents were evaluated using a multi-criteria analysis approach based on priority ranking methodology to quantify the appraised performance for IFRM. The results show that several municipalities in Metro Manila are performing very well but with recognized limitations, and at least three municipalities requires serious attention because all components of the IFRM in these municipalities are gravely lacking. The results of the study can be used as baseline information for the M&E activities on IFRM in Metro Manila. The methodology proposed in this study is simple and systematic that can guide decision-makers and practitioners in evaluating the performance for the IFRM.

Key Words : *integrated flood risk management, Metro Manila, M&E, priority ranking methodology*

1. INTRODUCTION

In the last decades, the worst flooding in Metro Manila was brought by Typhoon Ondoy (internationally known as Typhoon Ketsana) in September 2009. Typhoon Ondoy affected 4,901,234 people with 464 fatalities, 529 injuries and 37 missings, and caused 7-meter flood depths in some parts of Metro Manila that resulted in damages amounting to almost Php 4.2 Billion[1]. The flood disaster from this typhoon led to the inception of the IFRM plan for Metro Manila since flood occurrences are expected to increase in the future. The IFRM aims to manage proactively flood risks by promoting more non-structural measures (e.g., land use regulations, resettlement, flood forecasting and warning) as a complement to proposed structural measures (e.g., dams, levees, and floodwalls)[2),3)]. The IFRM was formulated by the Department of Public Works and Highways (DPWH) in 2012, and it was based on disaster risk reduction management (DRRM) activities that have four main components: prevention, preparedness, response, and recovery/rehabilitation[3]. For each IFRM component, there are a number of proposed measures that aim 1) to reduce risk by proposing systems to resist, absorb, accommodate floodwaters for prevention 2) to build the capacities of the communities to anticipate, cope and recover from flooding for preparedness, 3) to provide life preservation on the event of the flood disaster for response, and 4) to recover from flood disasters for recovery/rehabilitation. DPWH proposed a total of 15 measures in the IFRM for Metro Manila, as shown in **Fig. 1**, in which 4, 7, 3, and 1 measure are under the prevention, preparedness, response, and recovery/rehabilitation components, respectively.

Despite the inception of an IFRM for proactive

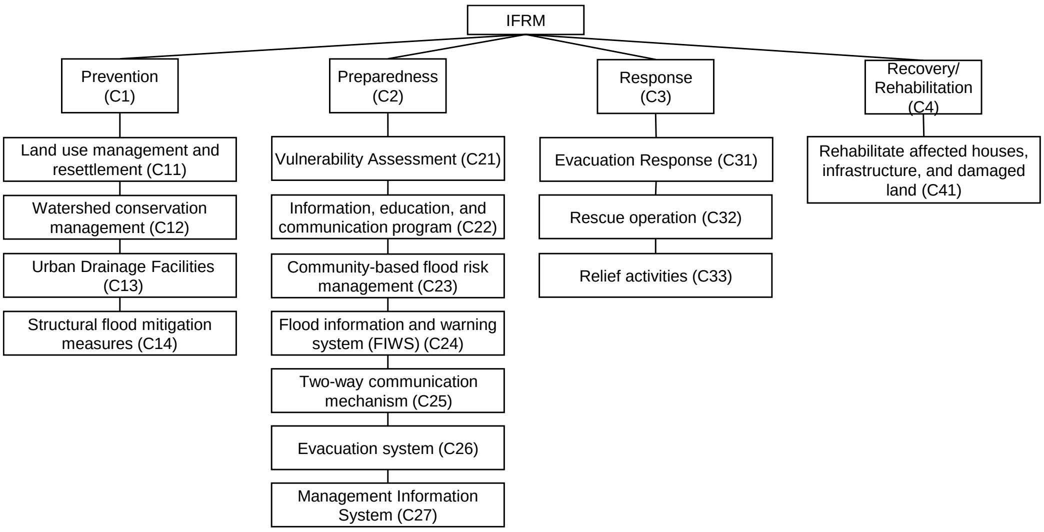


Fig.1 Components and sub-component indicators of the IFRM in Metro Manila[3] arranged according to priority ranking.

flood control and management in Metro Manila, there has been no monitoring & evaluation (M&E) schemes and activities on whether the measures proposed in the IFRM are being adopted accordingly by the municipalities in Metro Manila. The lack of M&E activities for IFRM is attributed to the lack of agency-in-charge of the regional implementation of the IFRM[4]. Thus, this resulted in the lack of measurable indicators for M&E of the IFRM and the lack of baseline information on flood management for each municipality in Metro Manila, except for the study conducted by the authors on the gap analysis in flood DRRM during Typhoon Ondoy[5),6].

The most widely used M&E approaches are input-output (I/O) based evaluations, process-based evaluations, evaluation of behavioral change, and economic evaluations[7], among others[8]. The I/O evaluations aim at the attribution of outcomes and impacts[9]. Process-based evaluations measure progress against feedback[10], while behavioral change evaluations focus on the contribution of influence[11]. Economic evaluations, on the other hand, focuses on the economic benefit of adaptation[12]. The selection of the most appropriate M&E approach depends on the objectives and the indicators to be monitored. However, M&E in DRRM is rarely done because the majority of the efforts for DRRM have focused on calculations of risk and identification of vulnerable communities[7]. Also, M&E activities related to DRRM, such as the IFRM, is a challenging task to evaluate because outcomes, economic evaluations, effectiveness, and efficiency are usually measured at the event or after the disaster. Thus, the aforementioned M&E approaches may not be suitable for M&E of the IFRM in Metro Manila, and a different approach is needed, especially when there are no measurable indicators that can be used for the IFRM.

Given these circumstances, this study aims to determine the current performance for IFRM at each municipality in Metro Manila by presenting an approach for the M&E. This is the first attempt to conduct an M&E for the IFRM, so we utilize the 15 proposed measures in the IFRM shown in **Fig. 1** as indicators for M&E, which are relatively more and different from the indicators in our previous study[5),6]. For the monitoring of these indicators, selected practitioners at each municipality in Metro Manila are to qualitatively appraise the indicators by carrying out a series of interviews and surveys. The interview and survey with the practitioners is a laborious and time-consuming process, because a special endorsement or connection with the government offices is needed for them to cooperate willingly, and selection of the experts or resource persons who can assess all the components of the IFRM is challenging.

In order to determine the performance for IFRM in each municipality, it is imperative to aggregate the qualitative appraisals in each indicator. For this task, we have applied a multi-criteria decision analysis (MCDA) approach for the evaluation and aggregation of the qualitative appraisals. The MCDA provides a systematic methodology to account multiple criteria in order to support the decision maker in the ranking, selection, or comparison of alternatives[13]. The main advantage of this method is its wide applicability to various field of study and quantitative and qualitative data can be used. The evaluation of the performance for IFRM needs to take into account multiple criteria (component and measures) while simultaneously accounting for the criteria's relative importance. The fuzzy TOPSIS method that we applied in our previous study[6] can also provide such evaluation, but this method is more suitable for gaps analysis, in which the gap is the distance to the ideal point. Thus, the MCDA approach is a suitable method for this study as it enables evaluation of the performance for IFRM in a simple, straightforward, and transparent way. To conduct the MCDA, we are to apply the priority ranking methodology, in which the components and indicators are ranked according to priority or relative importance. The ranking of the components and 15 measures (indicators) was not carried out when the IFRM for Metro Manila was formulated. However, the priority ranking is a crucial task because the IFRM components follow a sequence of activities: before, during, and after a flood disaster. Similarly, the indicators within each component also follow an order according to relative importance or prerequisite activities. Then, the components and indicators are given weight scores based on this priority ranking, in which greater weight is assigned to more significant components and measures. The weight scores of the components and indicators are aggregated with the qualitative appraisals to result in a quantitative index that determines the performance level according to the linguistic appraisals described in the next section.

The application of MCDA based on priority ranking methodology for the M&E of an IFRM has not been explored, as far as the authors know. This approach is intended to provide a rapid comparative assessment and aggregation method where data is limited to qualitative or imprecise data. The multi-criteria M&E analysis for the IFRM provides a reasonable means to carry out rapid and transparent comparative assessments, which enables cognizance of the priority areas (municipalities) and components that needs more attention and resources.

2. METHODOLOGY

(1) Study Area

Metro Manila, the capital region of the Philippines, is located on an isthmus between Manila Bay and Laguna Lake, shown in **Fig.2**. Metro Manila is composed of 17 municipalities and encompasses an area of 619.57 km^2. Flooding is a perennial problem in Metro Manila because it is situated in one of the widest floodplains in the country. Flood occurrences are intense and frequent during the typhoon season, from June to October, when the Philippines typically receives 80% of its annual rainfall. There are about three to four incidents of above gutter-height flooding in Metro Manila annually, and these are usually caused by typhoons, monsoon rains, and even torrential rains[3]. The flood depths in the region can range from a gutter-height inundation, usually due to torrential rains that can cause traffic congestion, to more than 5-meter inundation due to heavy storms or super typhoons that can cause extensive property damages and numerous fatalities.

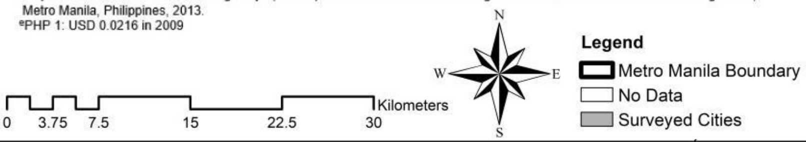
(2) M&E appraisal at the municipalities in Metro Manila

The authors organized a team of researchers to carry out interviews and surveys for each municipality in Metro Manila from December 2019 to February 2020. The target respondents were the local government units (LGUs) in Metro Manila, particularly the practitioners or the officers-in-charge of the: City Disaster Risk Reduction Management Office, Engineering Office, and City Environment and Natural Resources Office. The respondents from these offices were chosen because they are specifically mandated to be in-charge of the DRRM activities for their respective LGU, whereas in our previous study, the respondents were the affected people during the Typhoon Ondoy disaster. Out of the 17 municipalities in Metro Manila, 13 municipalities have completed the interviews and surveys during the mentioned time frame of investigation. The 13 municipalities and their baseline conditions are shown in **Fig.2**.

The interview and survey aim to capture the performance appraisal at each IFRM component and indicators with respect to the baseline conditions at each municipality. The IFRM plan developed by DPWH for Metro Manila has four main components (C1~C4), and each component contains specific measures (e.g., C11~C14 for C1 component) totaling to 15 measures, as shown in **Fig.1**. For this study, we utilized these 15 measures as the sub-component indicators, which are to be appraised by the practitioners. In this study, we utilized six linguistic performance appraisals to specifically describe the performance level for each municipality, which is twice as much of the linguistic terms we used in our previous study[5,6] to carry out a very rough appraisal on the gap analysis. Other studies have used only five linguistic terms to rate indicators or criteria, e.g., groundwater sustainability assessment[14] and fuzzy analysis[15),16]. For this study, we have added one more linguistic term to denote no changes or no improvement at all, which was not often considered on the appraisal. These six linguistic appraisals are explicitly described in **Table 1**, and these descriptions aims to aid the practitioners in selecting the most appropriate appraisal for each indicator. During the interview and survey, the practitioners were asked to select only one out of the six linguistic performance

Code	Municipality	Area (km²)	Population as of 2015 Census[a]	Poverty incidence among population[a] (%)	2018 Revenue[b] (10³ USD[c])	Damage from Typhoon Ondoy[d]	
						Inundated area (%)	Direct Damage (10⁶ USD[e])
M1	Caloocan City	53.33	1,583,978	4.7	108,457	21.3	98
M2	Las Piñas City	32.02	588,894	1.7	56,804	33.6	29
M3	Malabon City	15.96	365,525	1.7	32,539	86.3	62
M4	Marikina City	22.64	450,741	1.9	108,314	73.8	80
M5	Muntinlupa City	41.67	504,509	1.1	126,593	6.0	13
M6	Navotas City	11.51	249,463	3.4	128,315	44.6	14
M7	Parañaque City	47.28	665,822	0.9	127,212	35.9	45
M8	Pasig City	31.46	755,300	2.7	652,101	78.1	94
M9	Pateros City	1.76	63,840	2.5	4,465	54.0	17
M10	Quezon City	165.33	2,936,116	2.4	1,312,683	20.6	158
M11	San Juan City	5.87	122,180	0.8	58,572	37.1	13
M12	Taguig City	45.18	804,915	0.8	227,507	38.1	55
M13	Valenzuela City	45.75	620,422	0.5	91,248	47.5	46

[a]Philippines Statistics Authority (PSA). http://www.psa.gov.ph/content/highlights-philippine-population-2015-census-population
[b]Commision on Audit (COA). https://www.coa.gov.ph/phocadownload/userupload/Annual-Financial-Report/lgu/2018/2018_AFR_Local_Govt_Volume_I.pdf
[c]PHP 1: USD 0.0191 in 2018
[d]Department of Public Works and Highways (DPWH). Master Plan for Flood Management in Metro Manila and Surrounding Areas, Metro Manila, Philippines, 2013.
[e]PHP 1: USD 0.0216 in 2009



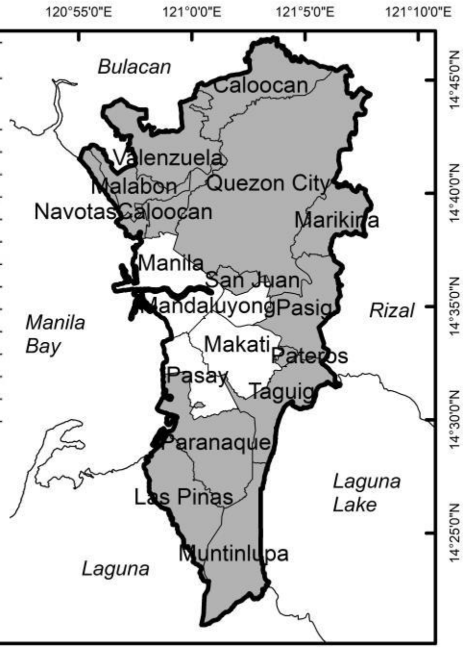


Fig.2 Location map and baseline conditions at each municipality in Metro Manila, Philippines.

appraisal to describe the current performance on the IFRM sub-component indicators. In addition to the appraisals, we asked additional queries that served as evidence that support their claim for the appraisals.

(3) Multi-criteria M&E analysis of the IFRM

Decision-makers often encounter multiple objectives and conflicting requirements when solving a problem[5),6)]. The MCDA approach based on priority ranking methodology is often considered for solving such problems. Thus, we employed this method for the M&E of the IFRM in Metro Manila.

The first stage of the multi-criteria M&E analysis is the ranking of the components and sub-components indicators of the IFRM. The ranks are positive values from 1 to *p*, where, *p* is the number of component and sub-component indicators within the same group. Rank 1 has the highest importance within the group, while *p* is the lowest. The ranking of the components and sub-component indicators is based on the priority ranking or relative importance. In our previous study on the gap analysis of the flood disaster risk reduction[5),6)], the relative importance was determined subjectively based on the 1) order of need prior to the occurrence of a disaster, and 2) prerequisite activities, i.e., when an indicator is a prerequisite activity of succeeding indicator. Based on these two criteria, we also subjectively determined the priority ranking for the components and sub-component indicators of the IFRM. The components are arranged according to the highest and lowest rank from left to right in **Fig. 1**. Hence, prevention (C1) component ranks higher than response (C3) component since measures for prevention lessens or limits the adverse impact of flooding, whereas measure for response provides life preservation of affected population before, during, or immediately after a flood disaster. In the same way, the sub-component indicators are also ranked according to the two criteria, and they are arranged according to the highest and lowest rank from top to bottom within the same group in **Fig. 1**. Thus, the land use management and resettlement (C11) ranks higher than structural flood mitigation measures (C14) because the IFRM prioritizes to “keep people away” from water rather than to “keep water away from

Table 1 Appraisal for the IFRM sub-component indicators.

Linguistic Performance Appraisal	Description	Appraisal Score (S)
Bad	No improvement or changes	0
Poor	Minor improvement with few signs of forward action in plans or policy	1
Fair	Some improvement, but without systematic policy and or institutional commitment	2
Good	Institutional commitment attained, but achievements are neither comprehensive nor substantial	3
Very Good	Substantial achievement but with recognized limitations in capacities and resources	4
Excellent	Comprehensive achievement with sustained commitment in capacities at all levels	5

people".

The second stage is the determination of the weight based on the priority ranking of the components and sub-component indicators. The sum of the weight for the component and sub-component indicators within the same group is equal to 1. The weight of the components (W_i) and sub-component indicators (W_{ij}) are determined by the following equations[5]:

$$W_i = (n - R_i +1)/\sum_{i=1}^{n} R_i \tag{1}$$

$$W_{ij} = (n - R_{ij} +1)/\sum_{j=1}^{n_i} R_{ij} \tag{2}$$

where, n is equal to 4 representing the number of components in the IFRM, n_i is the number of sub-component indicators within the same group, R_i and R_{ij} are the priority ranks of the i^{th} component and j^{th} sub-component indicator. Then, an equivalent weight score for each sub-component indicator ($W_{eq,ij}$) is determined by the following equation:

$$W_{eq,ij} = W_i \times W_{ij} \tag{3}$$

The third stage is the calculation of the IFRM M&E index for each municipality of Metro Manila. First, the linguistic appraisal performance was converted to corresponding appraisal scores shown in **Table 1**. Then, the weighted appraisal score ($P_{m,ij}$) based on the qualitative appraisal for each municipality (m) and for each IFRM component indicator (ij) is calculated as follows:

$$P_{m,ij} = W_{eq,ij} \times S_{m,ij} \tag{4}$$

where, $S_{m,ij}$ is the appraisal score for the j^{th} sub-component indicator of m^{th} municipality.

Finally, the IFRM M&E index (ρ_m) for each municipality is determined by aggregating the $P_{m,ij}$ as follows:

$$\rho_m = \sum_{i=1}^{n}\sum_{j=1}^{n_i} P_{m,ij} \tag{5}$$

3. RESULTS AND DISCUSSION

A multi-criteria M&E analysis of IFRM in Metro Manila was attempted in this study. The current performance for the IFRM was determined by conducting a series of interviews and surveys at the 13 municipalities of Metro Manila. **Table 2** shows the summary of the non-weighted appraisal scores for each indicator and municipality. The box-whisker plot of the results in **Table 2** in terms of indicator performance is shown in **Fig.3,** in which the top and the bottom line represents the standard deviation, and the line passing through the box represents the average non-weighted appraisal score. The whiskers extend to the minimum and maximum non-weighted appraisal scores for each sub-component indicator.

Among the 15 sub-component indicators, one indicator, C33 (relief activities), has surpassed the "Very Good" (Indicator Performance = 4) level, and two indicators, C24 (flood information and warning system) and C32 (rescue operation) have also almost reached this level according to their average scores, as seen in **Fig. 3**. Based on the interviews, C33 has improved significantly because the majority of the municipalities have a protocol for relief activities and a stockpile of emergency supplies (e.g., blankets, tents, and medical supplies) for a rapid relief response. The C24 and C32, on the other hand, are performing almost at a "Very Good" level but some municipalities still encounter constraints in implementing this indicator, such as failure to disseminate warnings to the marginalized communities; resistance and uncooperative individuals during the rescue operations; difficulty on evacuation during the night time; and the challenge to transport surging evacuees to evacuation centers.

It is also seen in **Fig. 3** that the sub-component indicator C12 (watershed conservation management) is drastically low compared to other indicators, and its average score narrowly surpassed the "Fair" (Indicator Performance=2) level. The low performance in C12 was attributed to the "0" appraisal scores at four municipalities (M3, M5, M7, and M9) and "1" appraisal score at M1 (Caloocan City). According to the practitioners of the four municipalities that have "0" appraisal scores, watershed conservation management was "not applicable" to their municipalities due to geographic location and non-existence of dams within their administrative boundary. Practitioners at M1 who appraised "1", on the other hand, explained in the interview that they are constrained with the coordination mechanisms with responsible agencies for watershed conservation management because there are no permanent representatives from concerned parties or agencies.

Overall, almost all sub-component indicators have surpassed the "Good" (Indicator Performance=3) level, but according to the definition of this level in **Table 1**, the achievements are still not comprehensive or substantial. Thus, this indicates that it is still necessary to improve almost all sub-component indicators. There is also a particular need to reform C12 at those municipalities that had considered this

Table 2 Non-weighted appraisal scores for each sub-component indicators (S_{mij}) at the 13 municipalities in Metro Manila.

Code	C11	C12	C13	C14	C21	C22	C23	C24	C25	C26	C27	C31	C32	C33	C41
M1	3	1	2	2	3	4	3	4	4	3	3	3	3	3	1
M2	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4
M3	4	0	3	4	3	3	4	4	3	3	3	3	3	4	3
M4	4	3	3	4	4	4	4	5	4	4	4	4	5	4	4
M5	5	0	3	4	3	3	3	3	3	3	3	3	4	5	4
M6	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4
M7	4	0	4	4	4	4	3	4	3	4	4	4	4	4	4
M8	3	3	3	4	3	3	3	4	3	3	3	3	3	3	3
M9	3	0	4	4	3	4	0	4	3	3	3	3	3	3	3
M10	4	3	3	3	4	3	4	4	5	5	5	4	5	5	4
M11	3	3	4	4	4	5	3	4	5	2	4	5	5	5	4
M12	3	3	3	3	3	3	3	3	3	3	4	3	3	5	3
M13	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4

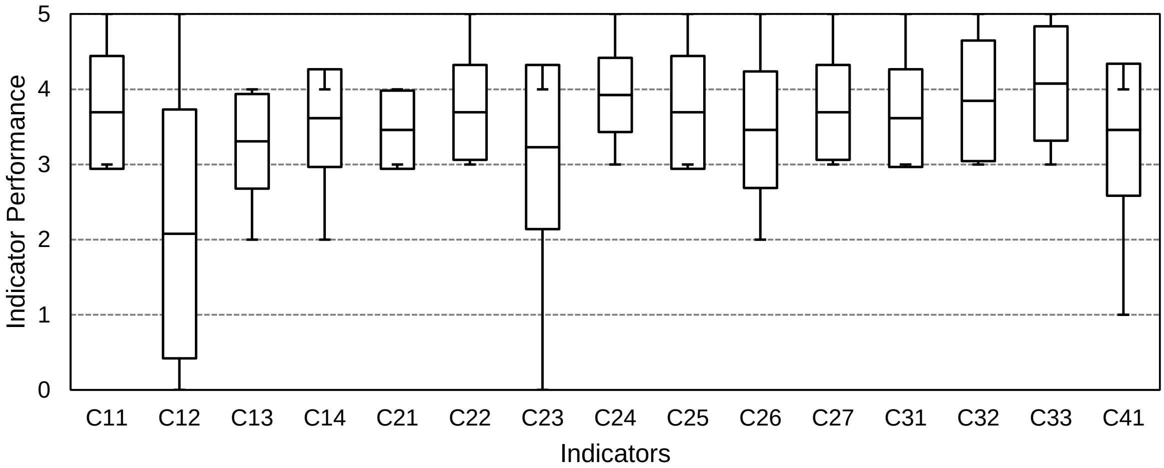


Fig.3 Box-whisker plot of the non-weighted appraisal score for each sub-components indicators.

indicator as “not applicable”.

Next, the IFRM M&E indices (ρ_m) of the 13 municipalities were calculated, as explained in Section **2.(3)**. In order to illustrate the method, the first stage is to do an objective priority ranking of the components and sub-component indicators. The ranks are shown in the rank column in **Table 3.** Then, the second stage is the calculation of the weight and equivalent weight for each sub-component indicator using Eq. (1) to Eq. (3). The weight for each component, the weight, and equivalent weight for each sub-component indicators are shown in W_i, W_{ij}**,** and $W_{eq,ij}$ column in **Table 3**, respectively. The third stage is the calculation of the ρ_m using Eq. (4) and Eq. (5). The non-weighted appraisal score ($S_{m,ij}$) and weighted appraisal score ($P_{m,ij}$) of 3 out of the 13 municipalities are shown in **Table 3** as an example. The ρ_m for these municipalities are also shown at the bottom-most row of **Table 3,** which was calculated by aggregating the $P_{m,ij}$ column. The summary of the ρ_m for the 13 municipalities is presented in **Fig.4,** in which the $P_{m,ij}$ of the four components are also shown.

Based on **Fig.4**, only one municipality, M2 (Las Piñas City), had surpassed the “Very Good” (ρ_m=4) level. The prevention component of M2 is the highest among the 13 municipalities, and this attributed to the high ρ_m since the other three components are relatively similar to the $P_{m,ij}$ in other municipalities. Although M2 has surpassed the “Very Good” level, this level indicates that there are still recognized limitations in capacities and resources despite having substantial achievements, as we have defined in **Table 1**. The practitioners at M2 have emphasized that they are still constrained by the limited workforce, equipment, and training when implementing the preparedness, response, and recovery/rehabilitation components. Thus, for this municipality, attention must be prioritized to these three components.

Meanwhile, four municipalities, M4 (Marikina City), M6 (Navotas City), M10 (Quezon City), and M11 (San Juan City), almost reached the “Very Good” level. The $P_{m,ij}$ of the four components in these cities are close to each, but the prevention component is relatively lower than M2, as seen in **Fig. 4**. According to the practitioners, programs for the prevention component are still underway, so their

Table 3 Priority rank, weight scores, non-weighted, and weighted appraisal scores of the IFRM sub-component indicators.

IFRM Component Code	Rank	Component Weight (W_i)	Sub-component Indicator Code	Rank	Sub-component Indicator weight (W_{ij})	Equivalent weight ($W_{eq,ij}$)	Non-weighted Appraisal Score ($S_{m,ij}$)			Weighted Appraisal Score ($P_{m,ij}$)		
							M1	M2	M11	M1	M2	M11
C1	1	0.4	C11	1	0.400	0.160	3	5	3	0.480	0.800	0.480
			C12	2	0.300	0.120	1	5	3	0.120	0.600	0.360
			C13	3	0.200	0.080	2	4	4	0.160	0.320	0.320
			C14	4	0.100	0.040	2	4	4	0.080	0.160	0.160
C2	2	0.3	C21	1	0.250	0.075	3	4	4	0.225	0.300	0.300
			C22	2	0.214	0.064	4	4	5	0.257	0.257	0.321
			C23	3	0.179	0.054	3	4	3	0.161	0.214	0.161
			C24	4	0.143	0.043	4	4	4	0.171	0.171	0.171
			C25	5	0.107	0.032	4	4	5	0.129	0.129	0.161
			C26	6	0.071	0.021	3	4	2	0.064	0.086	0.043
			C27	7	0.036	0.011	3	4	4	0.032	0.043	0.043
C3	3	0.2	C31	1	0.500	0.100	3	4	5	0.300	0.400	0.500
			C32	2	0.333	0.067	3	4	5	0.200	0.267	0.333
			C33	3	0.167	0.033	3	4	5	0.100	0.133	0.167
C4	4	0.1	C41	1	1	0.100	1	4	4	0.100	0.400	0.400
									IFRM M&E index (ρ_m)	2.579	4.280	3.920

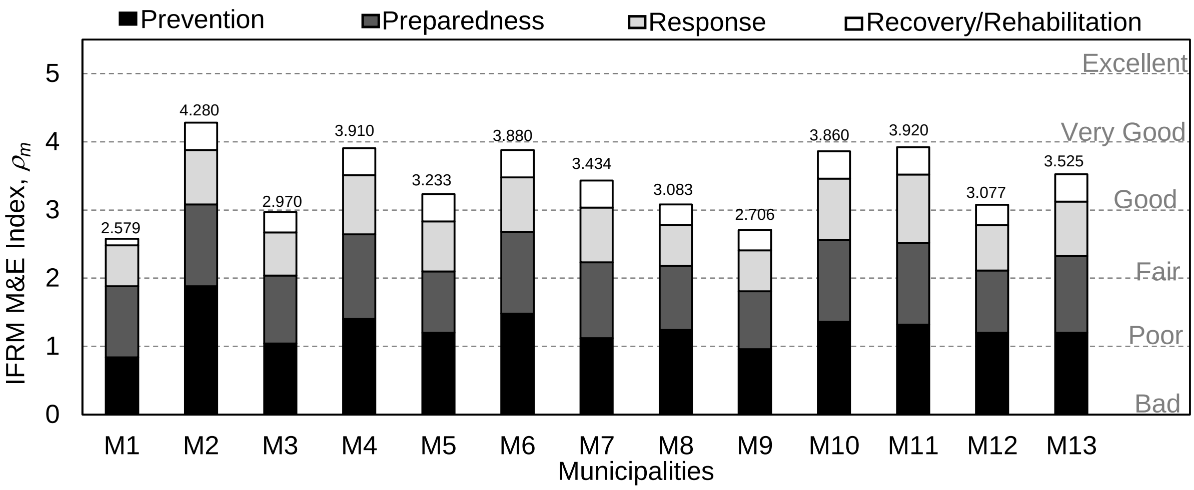


Fig.4 IFRM M&E indices for the 13 municipalities in Metro Manila.

achievements for IFRM are currently not yet comprehensive.

It is also seen in **Fig.4** that there are three municipalities, M1 (Caloocan City), M3 (Malabon City), and M9 (Pateros City) that did not reach the"Good" (ρ_m=3) level but had surpassed the "Fair" (ρ_m=2) level. M1 has the lowest ρ_m, and it is 1.701 lower than the highest value (ρ_m=4.280). The $P_{m,ij}$ of all the components in M1 are low, especially the prevention and recovery/rehabilitation component compared to the other municipalities, as seen in **Fig. 4**. According to the practitioners at M1, the lack of political will among the high officials for prevention and recovery/rehabilitation components resulted in the non-recognition of flooding as a severe issue at their municipality. Similar to M1, practitioners at M3 have identified the lack of political will as the leading cause to the low performance for IFRM. The practitioners at M9, on the other hand, have stressed that the lack of municipality income (seen in **Fig. 2**) that can be used for the implementation of the IFRM was the cause for low performance.

Overall, the results of the multi-criteria M&E analysis show that all municipalities have surpassed at least the "Fair" level. However, the interpretation of the IFRM M&E index values between ρ_m=2 (Fair) and ρ_m=4 (Very Good), as defined in **Table 1,** indicates that there are some improvements towards the implementation of the IFRM, but the results and achievements are not comprehensive or substantial.

Thus, the results suggest that almost all municipalities in Metro Manila still need to improve their capacities for IFRM.

4. CONCLUSIONS

This study is a first attempt to determine the performance for IFRM at each municipality in Metro Manila. A multi-criteria M&E analysis was formulated in order to determine, quantify, and compare the performance for IFRM at the 13 surveyed municipalities. The qualitative data in this study was acquired by conducting a series of laborious interviews and surveys. Then, an MCDA approach based on priority ranking methodology was applied, and this provided a systematic solution for in the assignment of weights and for the aggregation of the qualitative appraisal. This approach had rapidly and transparently evaluated the performance level as a quantitative M&E index for each municipality.

Through the multi-criteria M&E analysis, it was determined that the majority of the municipalities had surpassed the “Good” level, in which one municipality even surpassed the “Very Good” level. The results also revealed that three municipalities were performing below the “Good” level, which may imply that they require more support and attention. On the other hand, the performance of the indicators is also within the “Good” level except for the watershed conservation and management.

Overall, the results suggest that continuous and close monitoring must still be conducted to ensure that all municipalities can perform at the “Very Good” level, at the least. To accommodate comprehensive results for the M&E of the IFRM, measurable or quantitative indicators should also be included in the future assessment.

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REFERENCES

1) World Bank, Tyhpoons Ondoy and Pepeng: Post-Disaster Needs Assessment, Manila, Philippines, 2010.
2) Singson, R. L.: Metro Manila Integrated Flood Risk Management Master Plan. http://www.gfdrr.org/sites/gfdrr.org/files/(SESSIO_%203)_Sec._Singson_(Philippines)_052413_DPWH_FLOOD_RISK_MANAGEMENT_(SECRETARY).pdf. (Accessed: June 20, 2020).
3) Department of Public Works and Highways (DPWH): Master Plan for Flood Management in Metro Manila and Surrounding Areas, Metro Manila, Philippines, 2013.
4) Mercado, J. M. R., Kawamura, A. and Amaguchi H.: Interrelationships of Flood Risk Management Barriers in Metro Manila, Philippines, *J. Japan Soc. Civ. Eng. Ser. G (Environmental Res)*, Vol. 74, pp. I_285-I_292, 2018.
5) Gilbuena, R.J., Kawamura, A., Medina, R., Amaguchi, H. and Nakagawa, N.: Multi-criteria gap analysis of flood disaster risk reduction management in Metro Manila, Philippines. *J. Japan Soc. Civ. Eng. Ser. B1 (Hydraulic Engineering)*, Vol. 68, No.4, pp. I_109-I_114, 2012.
6) Gilbuena, R., Kawamura, A., Medina, R. and Amaguchi H.: Fuzzy-based gaps assessment of flood disaster risk reduction management systems in Metro Manila, Philippines, *Water Environ. J.*, Vol. 33, pp. 443–458, 2019.
7) Villanueva, P. S.: Learning to ADAPT: monitoring and evaluation approaches in climate change adaptation and disaster risk reduction–challenges, gaps and ways forward, *Institute of Developmental Studies*, Discussion Paper 9 Brighton, United Kingdom, 2011.
8) Bours, D., McGinn, C. and Pringle, P.: Monitoring & evaluation for climate change adaptation and resilience: A synthesis of tools, frameworks and approaches, 2nd edition. *SEA Change CoP*, Phnom Penh and UKCIP, Oxford, 2014.
9) Yohe, G. and Tol, R. S.: Indicators for social and economic coping capacity—moving toward a working definition of adaptive capacity, *Glob. Environ. Chang*, Vol. 12, No. 1, pp. 25-40, 2002.
10) Horrocks, L., Mayhew J., Hunt, A., Downing, T., Butterfield R. and Watkiss, P.: Objective setting for climate change adaptation policy, *AEA Technology Environment with Stockholm Environment Institute and Metro-economica for Defra*, 2005.
11) Earl, S., Carden, F. and Smutylo, T: Outcome mapping: Building learning and reflection into development programs, *IDRC*, Ottawa, ON, CA. 2001.
12) Munasinghe, M., Meier, P., Hoel, M., Hong, S. W. and Aaheim, A.: Applicability of techniques of cost-benefit analysis to climate change, *Climate Change 1995: Economic and Social Dimensions: Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change*, pp. 145-178, 1996.
13) Giove, Silvio, Adriana Brancia, F. Kyle Satterstrom, and Igor Linkov. "Decision support systems and environment: Role of MCDA." In Decision support systems for risk-based management of contaminated sites, pp. 1-21. Springer, Boston, MA, 2009.
14) Bui, N.T., Kawamura, A., Du Bui, D., Amaguchi, H., Bui, D.D., Truong, N.T., Do, H.H.T. and Nguyen, C.T.: Groundwater sustainability assessment framework: A demonstration of environmental sustainability index for Hanoi, Vietnam, *J. Environ. Manage.*, Vol. 241, pp. 479-487, 2019.
15) Wu, H. Y., Tzeng, G. H. and Chen, Y. H.: A fuzzy MCDM approach for evaluating banking performance based on Balanced Scorecard. *Expert Syst. Appl.*, Vol. 36, No. 6, pp. 10135-10147, 2009.
16) Rabbani, A., Zamani, M., Yazdani-Chamzini, A. and Zavadskas, E. K.: Proposing a new integrated model based on sustainability balanced scorecard (SBSC) and MCDM approaches by using linguistic variables for the performance evaluation of oil producing companies. *Expert Syst. Appl.*, Vol. 41, No. 16, 7316-7327, 2014.

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