ASSESSMENT OF MANAGEMENT GAPS IN THE FLOOD MITIGATION AND FLOOD PREPAREDNESS STRATEGIES IN METRO MANILA, PHILIPPINES

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In this study, the gaps in the Metro Manila's flood management systems were assessed using a multi-attribute gap analysis method that utilizes actual experiences of the municipal local governments (MLG) during the 26 September 2009 floods brought by the tropical storm Ondoy. The data were collected from each of Metro Manila's MLG using a questionnaire, while physical observations were collected through field inspection during the aftermath of the storm. The gap indices in the flood management components were semi-quantitatively estimated by means of a multi-attribute decision-making approach. Using the gap indices, the flood management systems of each of the municipalities was ranked and can be used as basis for government prioritization scheme. The identification of gaps in the management strategies provides valuable insights that can help improve the flood management frameworks in Metro Manila as well as in other highly urbanized flood-prone areas in the Philippines.

Keywords: multi-attribute gap analysis, flood disaster risk reduction management, Metro Manila.

Introduction

Flood mitigation and flood preparedness strategies are among the main components of urban flood disaster risk reduction management systems (Shaw, et al., 2010). In the case of Metro Manila, the extreme downpour brought by the tropical storm (Ondoy) that struck its core areas in September 2009 left a massive devastation (Rabonza, 2009) in most of the megacity's flood prone areas despite the public's general awareness of the flood hazards along the flood-managed zones. This unfortunate event, however, presents an opportunity to investigate and assess the effectiveness of the flood risk management (FRM) strategies being used in Metro Manila.

In a few days after the tropical storm Ondoy, a needs assessment (The World

Bank, 2009) was made to qualitatively assess the flood management system of the affected areas. Quantitative assessment, however, can provide more objectivity in the decision-making and can help evaluate the individual gaps in the flood management systems in Metro Manila, which is valuable in the creation of a strategic management improvement plans for flood risk reduction.

Gap assessment is as a time-based and intent-driven planning strategy that uses past information and desired outcomes as bases for improvement (Liedtka, 1998), which in essence imply that in developing or improving a management system, the formulation of strategy should be based on facts and goal-oriented.

The quantitative evaluation of gaps is recently being used in various sorts of management strategies, such as in the information technology research (Zhang and Zhang, 2007) and public transport systems (Currie, 2010). The rapid changes in the environment in recent years and the gradually evolving societies have perhaps created the demand for more effective management strategies. Hydrological issues precipitated by climate change have brought into surface various deficiencies in the flood risk management systems in many parts of the world (e,g, Islam et al., 2010; Lopez et al., 2012; Crabbe and Robin, 2006). This paper focuses on the evaluation of the gaps in the flood risk management system in Metro Manila, and the identification of priority tasks and priority flood-prone areas.

The flood risk management systems in Metro Manila are basically comprised of several components with varying importance. To find the gaps in each component and to aggregate into crisp values, a multi-attribute decision-making (MADM) approach was used. MADM is a kind of multi-criteria decision analysis approach that deals with problems that have several discrete evaluation attributes with different weights (Hwang and Yoon, 1981).

MADM is widely regarded for its robust applicability in various fields of studies (Liu et al., 2011; Lin et al., 2008), particularly those that require comparison of performance between a set of alternatives. The use of gap analysis combined with MADM approach, however, is still not well explored in the literatures. Figure 1 shows the flow of the multi-attribute gap assessment process used in this study. The attributes and sub-attributes were enumerated and were assigned weight factors according to importance. Performance scores were given to each attribute according to the information provided by the municipal local government (MLG) representatives in the questionnaire. The gap indices were calculated using the equivalent weight values and performance scores. Priority flood risk management components and priority flood prone areas have been identified using the gap index values. The results in this study that can be used to propose strategic improvements in the flood risk management systems in Metro Manila.

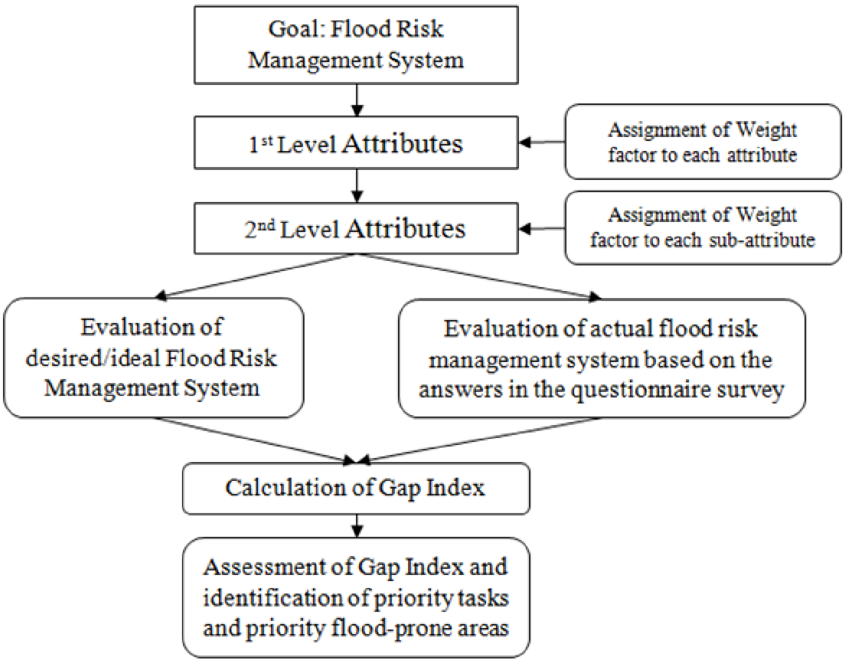


Figure 1: Process diagram of the multi-attribute gap assessment

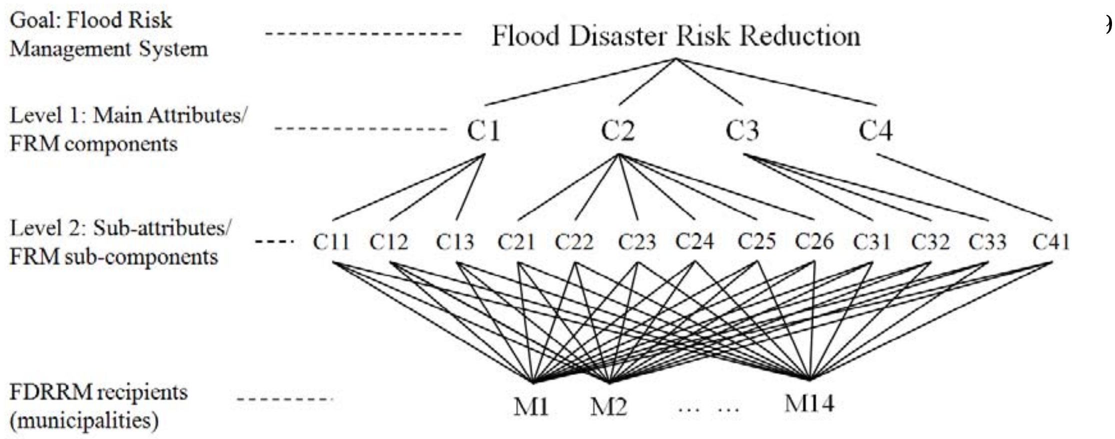
Post-Flood Needs Assessment

Metro Manila has the highest population and population density among the Philippines' administrative regions (National Statistics Office, 2007). It is also the country's political and economic center. Despite being the confluence of major services in the country, floods have consistently affected Metro Manila's economic growth. Inundations would regularly occur in Metro Manila, which consequently results to heavy inundation and traffic, leading to the suspension of many industry and commercial office hours (Page, 2000).

On 26 September 2009, Metro Manila was hit by the tropical storm Ondoy that resulted in unmitigated floods, which led to loss of lives, losses in agriculture and damages to properties (Rabonza, 2009). In October 2009, the questionnaires were developed and distributed to all the MLG units in and around Metro Manila as part of a post disaster needs assessment to evaluate the extent of the tropical storm's impact. The MLG representatives assessed their respective flood risk management systems based on their experience during three different time frames: before, during and after the flood disaster. The inquiries essentially covered flood mitigation and flood preparedness components in the Metro Manila flood risk management systems.

Gap Analysis by MADM

In this study, the multi-attribute analysis of gaps follows three steps, the first step consists of enumerating the attributes and sub-attributes (also referred to in this paper as flood risk management components)(Figure 1). The main attributes are identified as Prevention, Preparedness and Response (Shaw et al., 2010). Simonovic (1999)



C1: Prevention, C2: Preparedness, C3: Response, C4: Recovery

C11: Presence of flood zoning, C12: Presence of structural flood protection (dikes, dams/weirs, pumping stations, flood diversion channels, etc.), C13: Presence of waste management system, flood database system

C21: Institutional framework, C22: Vulnerability assessment, C23: Emergency response mechanisms, C24: Communication systems, C25: Public education and flood hazard awareness, C26: Emergency response capability

C31: Warning dissemination, C32: Evacuation response, C33: Emergency response and rescue operations

C41: Recovery/Rehabilitation

M1~M14: local government units in Metro Manila
(M1: Malabon City, M2: Caloocan City, M3: Navotas City, M4: Valenzuela City, M5: Makati City, M6: Pateros, M7: Pasig City, M8 Taguig City, M9: Marikina City, M10: Quezon City, M11: Manila City, M12: Las Pinas City, M13: Paranaque City, M14: Muntinlupa City)

Figure 2: Hierarchical structure for evaluating the performance of the flood risk management system in Metro Manila

indicated that post flood recovery is also one of the important components in flood management, thus we include Recovery in the main attributes. Figure 2 shows the sub-attributes of each of the main attributes. As shown in this figure, the sub-attributes shall be assessed for all the MLG units.

The weighted scores of the attributes are often assigned in a subjective manner (Zhang et al., 2007; Fernandez and Lutz, 2010). In this paper, we propose a weighting system based on importance. Weighting by importance was done by assigning ranks to each group of attributes as positive integer values from 1 to *p*, where *p*, is the number of criteria (or sub-criteria) within the same group. For example, consider Level 1 attributes in Figure 2, C1, C2, C3 and C4 have the ranks of 1, 2, 3 and 4, respectively, where 1 indicates highest importance. The relative importance of each criterion was subjectively determined based on 1) order of need prior to the occurrence of disaster, i.e. Prevention attribute is expected to have the highest risk reduction compared to Recovery attribute, where the disaster has already occurred; and 2) when the attribute/sub-attribute is most likely a requirement to complete the other attributes/sub-attributes. The weighted scores are calculated based on the rank, where the sum of the weighted scores in each group of attributes is equivalent to 1.0. The weighted scores, W_a and W_{sa}, of the i^{th} attribute and j^{th} sub-attribute, respectively, were determined using the following expressions:

$$W_{a,i} = (n - r_i + 1) / R_i \tag{1}$$

$$W_{sa,i,j} = (n_i - r_{i,j} + 1) / \sum_{j=1}^{n_i} R_{i,j} \tag{2}$$

where, n is the total number of attributes and n_i is the total number of sub-attributes; r_i and $r_{i,j}$ are priority ranks of the *i-th* attribute and *j-th* sub-attribute; R_i and $R_{i,j}$ are the sums of all r_i and $r_{i,j}$, , respectively, in a group of attributes. The equivalent weight, $W_{eq,i,j}$ was calculated for each sub-attribute based on the product of the weighted scores of the attributes and sub-attributes, as shown in Eq. 3:

$$W_{eq,j} = W_{a,i} * W_{sa,i,j} \quad (3)$$

Table 1 shows the priority ranks and weighted scores of each attribute and sub-attribute, with computed equivalent weights corresponding to each sub-attribute.

The second step is the performance evaluation of each sub-attribute based on the questionnaires answered by the MLG units. Following the performance scoring (*PS*) used by Zhang et al. (2007), in this study, 3 categories were used, PS = [1.0 0.5 0.0]. A value of 1.0 indicates that the desired goal has been achieved, and aside from that, there is no known constraint that will contribute to future poor performance of the flood risk management system. A value of 0.5 indicates that the desired goal has not been achieved in the past despite having the flood risk management component in place. Lastly, a value score of 0.0 indicates that the desired flood risk management component has not yet been put in place. During the post-disaster needs assessment survey, 14 out of the 17 MLG units were assessed, and the assessment results were translated according to the definition of the performance scoring. Table 2 shows the scores of the 14 MLG units, with scores based on the self-assessment done by the MLG units.

Table 1: Weighting factors of the attributes and sub-attributes

Attributes (i)	Priority Ranks (r_i)	Weight Level 2 (W_a)	FDRR Sub-attributes (j)	Priority Ranks ($r_{i,j}$)	Weight Level 3 (W_{sa})	Equiv. Weight (W_{eq})
C1	1	0.4	C11	1	0.500	0.200
			C12	2	0.333	0.133
			C13	3	0.167	0.067
C2	2	0.3	C21	1	0.286	0.086
			C22	2	0.238	0.071
			C23	3	0.190	0.057
			C24	4	0.143	0.043
			C25	5	0.095	0.029
			C26	6	0.048	0.014
C3	3	0.2	C31	1	0.500	0.100
			C32	2	0.333	0.067
			C33	3	0.167	0.033
C4	4	0.1	C41	1	1.000	0.100

Table 2: Performance evaluation of the FRM sub-attributes

Sub-attributes	Performance Scores ($P_{i,j,k}$)													
	M1	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**M13**	**M14**
C11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
C12	0.5	0.5	1	0.5	1	0.5	0.5	1	1	0.5	0.5	0	0.5	0.5
C13	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C21	1	1	1	1	1	0	1	1	1	1	1	1	1	1
C22	1	0.5	0.5	0.5	1	0.5	0.5	0.5	1	1	1	1	0	0.5
C23	1	1	1	1	1	1	1	1	1	1	1	1	0.5	1
C24	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C25	0.5	1	1	1	0.5	1	1	1	1	1	1	1	1	1
C26	0.5	0.5	1	1	0.5	0	0.5	1	0.5	0.5	0	0.5	0.5	0.5
C31	0.5	1	1	1	0.5	0	0	1	0.5	1	1	1	1	0.5
C32	0.5	1	1	1	0.5	0	0	0.5	0.5	1	0.5	0.5	1	1
C33	0	0	1	0.5	0.5	0	0.5	1	0.5	0.5	0	0	0	0.5
C41	0.5	0.5	1	1	0.5	0.5	0.5	1	0.5	0.5	0.5	1	0.5	0.5

The third step is the calculation of the gap indices. The product of the equivalent weight, $W_{eq,i,,j}$, of each sub-attribute, and the performance scores, $P_{i,j,k}$, of the k^{th} MLG unit, represents the estimated actual performance of the FDRR measures. The gap index, $\Delta G_{i,j,k}$, is computed by taking the difference of the equivalent weight, $W_{eq,i,j}$, and the estimated actual performance of a sub-attribute ($W_{eq,i,j}$ * $P_{i,j,k}$), as expressed in this formula:

$$\Delta G_{i,j,k} = W_{eq,i,j} - W_{eq,i,j} * P_{i,j,k} \quad (4)$$

The gap index, ΔG_k of the k-th MLG unit, is calculated using the following expression:

$$\Delta G_k = \sum_{i=1}^{n} \sum_{j=1}^{n_i} \Delta G_{i,j,k} \quad (5)$$

The overall gap indices, $\Delta G_{FRM,i,j}$ of each of the FRM components are calculated using the following formula:

$$\Delta G_{FRM,i,j} = \sum_{k=1}^{N} \Delta_{i,j,k} / N \quad (6)$$

where N is the total number of the municipalities assessed, in this case $N = 14$.

Gap assessment

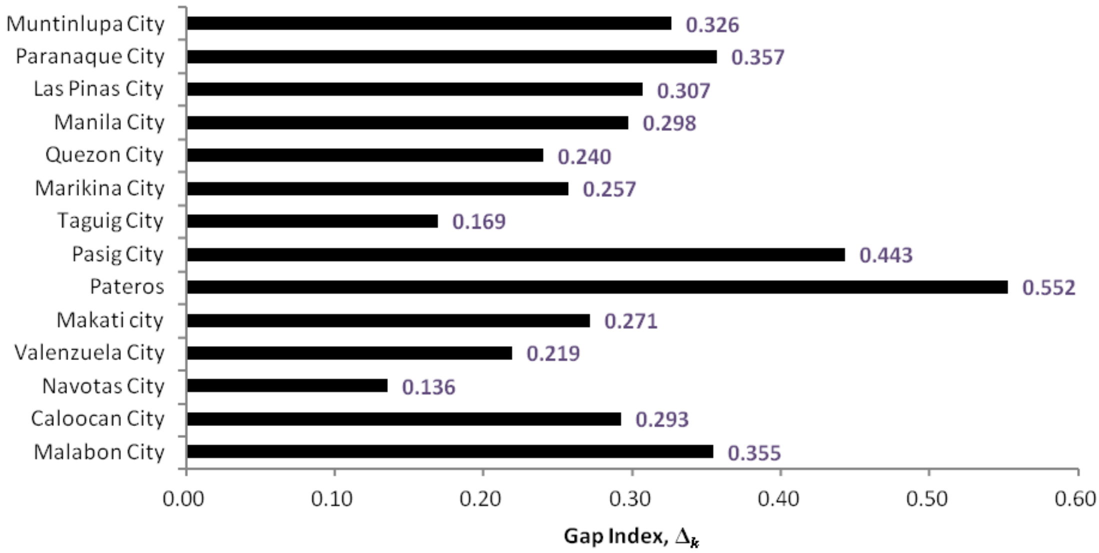


Figure 3: Gap index of the FRM system 14 MLG units in Metro

Figure 3 shows the gap index values, ΔG_k, of each municipality that was calculated using the equations (1) to (5). The variation of gap indices of the municipalities implies that there are different needs to improve the flood risk management systems within Metro Manila. In Pateros, the population is more than 62,000 residents (National Statistics Coordination Board, 2011), making it the second most densely populated municipality (next to Manila City) in the Philippines. Around 60% of Pateros is prone to 10 years return flood, however during the tropical storm Ondoy, almost 100% of its total land area was inundated by up to 2 meters, indicating that this municipality is highly susceptible to extreme floods events. Pateros, which is the smallest municipality in Metro Manila, was determined to have the highest gap index ($\Delta G_k = 0.552$), indicating that there is an urgent need to improve its FRM system compared with the other municipalities. On the other hand, the relatively smaller gap indices in Navotas City ($\Delta G_k = 0.136$) and Taguig City ($\Delta G_k = 0.169$) (Figure 3) indicate that the FRM system in these municipalities are substantially more established compared with the FRM systems of the other municipalities. The constraints in the FRM system in Navotas City and Taguig City can be mainly attributed to the problem with settlements along flood hazard zones (C11 in Figure 2). One way to cope with this issue is to require land use conversion along the identified flood hazard areas, which may result in the resettlement of some population.

Looking at the overall results of the gap analysis in Figure 3, all the gaps are fairly small ($\Delta G_k < 0.50$), except only for Pateros. This indicates that most MLG units are quite keen in reducing the effects of flood disasters despite the existence of various constraints, however, it also evident from Table 2 that most municipalities have issues implementing the emergency response and rescue missions (C33) during an extreme flood event. From the questionnaire, some of the reasons indicated are insufficiency in necessary equipment (i.e. rescue vehicles and communication instruments) for emergency response and lack manpower for rescue missions.

The overall gaps in the FRM components, calculated using Eq. (6) and then expressed in terms of percentage of each of the main attributes (C1, C2, C3 and C4), are summarized in Figure 4, while details of the attributes and sub-attributes can be found in Figure 2. Under the Prevention attribute (C1), flood hazard zoning requires the most attention. Structural flood mitigation measures (C12) are generally found inadequate in Metro Manila, which can improve when existing structures are rehabilitated or additional flood control infrastructures are put in place. Interestingly, most of the MLG respondents believe that indirect flood prevention procedures such as waste management and flood database systems (C13) are sufficiently within the desirable level. Under the Preparedness attribute (C2), many of the MLG units indicated that they do not have sufficiently emergency response capability (C26) due to lack of training and orientation on effective flood disaster emergency response. In second place is the flood vulnerability assessment (C22). Some MLG units indicated that they lack the necessary flood vulnerability assessment, thus, they are not aware on the extent of the damages an extreme flood event can bring in their jurisdiction. In contrast, most of the MLG respondents believe that their emergency communication system procedures are sufficiently in place, however, the availability of the necessary communication equipment for effective execution of these procedures is a different case altogether, as seen from the responses of the MLG representatives for the Response attribute (C3). Under the attribute C3, C33 was found to have the most gaps for reasons already discussed above. Along with gaps in the Warning dissemination (C31) and Evacuation response (C32), C3 has collectively the most number of gaps, which must be immediately addressed to avoid more severe damages while C1 and C2 are still being improved. Gaps in Recovery attribute (C4) on the other hand exist in less than 40% of the cases, however, flood insurance and disaster funds should still be promoted to improve the recovery rate in the event of unmitigated flood disasters.

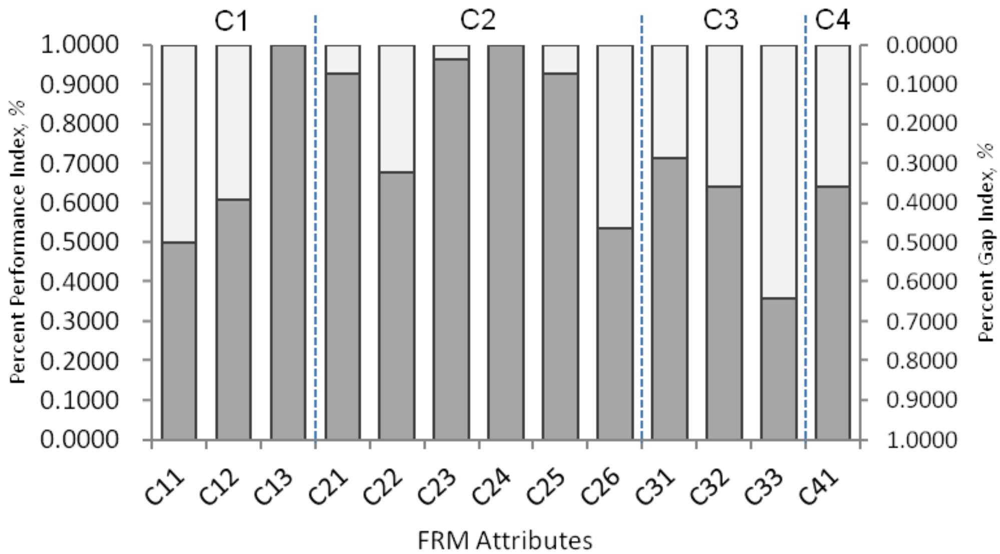


Figure 4: Comparative graph of FRM gap indices

Conclusion

This study describes the gap assessment of the FRM system in Metro Manila using a MADM approach. In this study, it was found that: (1) the gaps in the MLG unit-based flood risk management systems that were explained linguistically can be expressed and evaluated by quantitative means; (2) the overall gaps in the FDRR management systems in Metro Manila are relatively low, however, relocation of human settlement from known flood hazard zones will significantly reduce the impacts of extreme flooding; and (3) it was found that all the MLG units that were assessed would require serious attention, with Pateros obtaining the highest priority, in order to realistically achieve the desired flood risk management goals. Thus, the gap assessment using the multi-attribute decision making approach can provide useful insights to researchers and decision-makers alike. It is, however, necessary that the respondents (in this case, the MLG representatives) should diligently participate in the evaluation of their FRM system to acquire more acceptable results.

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