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Interrelationships of Flood Risk Management Barriers in Metro Manila, Philippines

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An integrated flood risk management (FRM) plan was established in the Philippines for the first time in 2012 after the disastrous flooding brought by Typhoon Ondoy in 2009. It is a crucial task to identify and analyze the barriers that may hamper the effective implementation of the FRM plan. In this study, barriers to FRM were identified from a collection of literature related to flooding then interrelationships among barriers were analyzed by conducting a pairwise assessment by experts. Barriers to FRM in Metro Manila are found to be related to three aspects namely, governance, social and scientific resources aspects. There are 4, 3 and 5 barriers identified in the governance, social and scientific resources aspect, respectively. The barrier interrelationships were elicited by 5 carefully selected local experts and practitioners in the Philippines. The results of this study show that barriers in the governance aspect heavily influence all other barriers while the barriers on the social aspect have the least influence but strongly depends on the other aspects. The collective perception of the 5 local experts and practitioners also showed satisfactory understanding on the barriers in FRM. This study was able to identify and analyze the interrelationship of each FRM barriers which can provide insights to decision makers on how to overcome them.

Key Words : *barriers, flood risk management, Metro Manila*

1. INTRODUCTION

Metro Manila (MM), the capital region of the Philippines, is situated on the most frequent trajectory of typhoons and tropical storm. In fact, it is considered as the most at risk to climate impacts among the mega cities in the world, largely due to its exposure to tropical cyclones and flooding[1)]. Flooding has been the most disastrous and frequent natural disaster in MM. There are about 3 to 4 incidences of significant flooding that besets MM annually caused by typhoons, monsoon rains and even torrential rains[2)]. Flood depths in MM can range from a gutter-height inundation, usually due to torrential rains which can cause traffic congestion, to more than 5 meter inundation brought by storms or typhoons, which can cause extensive property damages and hundreds of fatalities[3)]. In the last decade, there are at least three notable disastrous flood occurrences that devastated MM. The region was hit by typhoon Ondoy (international name Ketsana) in 2009 and two monsoon rains locally known as “Habagat” in 2012 and 2016. Typhoon Ondoy incurred losses and damages estimated to be one billion dollars with fatalities of 747 and flood depths of 7 meters submerging even the high-class residential areas[4)]. These flood events have devastated MM and affected the region environmentally, socially and economically. Despite numerous mitigation measures that has been established since the early part of the 20th century[5), 6)], flood damages persists and flood vulnerability is increasing especially in the low lying areas of MM.

Due to the lack of preparedness, public outrage and political pressure from the onslaught of Typhoon Ondoy, the Philippine government started taking a proactive approach in disaster risk management and one of its first strategies was the development of a

Flood Risk Management (FRM) Masterplan for MM in 2012. The masterplan provides an integrated and strategic approach to flood risk management that will guide the government's decisions and investments over the next 25 years[7]. In an ideal setting, the masterplan can be executed unerringly, but in the complex Philippine setting, achieving a precise execution is almost impossible. In order to successfully execute and implement the integrated FRM plan, certain barriers that may act as hindrance must be identified first to devise appropriate resolution to them. However, most researches on FRM heavily concentrate on the hydrological processes[8]. There are also some advances on flood modelling using GIS[9] and the use of web-based stakeholder collaboration[10] and multiple criteria decision making[11, 12] for decision support systems. In the Philippines, very few notable studies were conducted in the last decade related to flooding in MM, e.g. the use of LiDAR data to flood modeling in MM[13], the gap analysis on flood management during Typhoon Ondoy[5, 8] and Environmental Impact Assessment by RIAM technique of structural flood mitigation measures in MM[14, 15].

Barriers are defined as obstacles that can be overcome with concerted effort, creative management, change of thinking, prioritization, and provision for financial and human resources[16]. Barriers in many complex problems, such as in the FRM, are often interrelated that may alleviate, augment, reinforce or even trigger another. Understanding the interrelationships of barriers is a crucial task reaching to reasonable measures to overcome them[17]. Although there are few studies that have briefly mentioned the barriers in FRM[18, 19], almost no study made an extensive effort to identify it and made an analysis on their interrelationships probably because these barriers are highly complex and difficult to analyze. Identification and analysis of barriers to FRM is an immensely significant topic for research especially in MM in order to execute the FRM plan and to diminish flood problems in the region.

This study tries to identify the barriers to FRM in MM and analyze their interrelationship. This study illustrates for the first time an approach on identifying and analyzing barriers to FRM which may be used by other developing countries with similar flood problems. A holistic approach is done on identifying barriers despite the lack of scientific records related to flooding and research on FRM in MM. These barriers are then analyzed by assessing the pairwise relationship among them. This is done by consulting experts and practitioners on flood control practice in MM. This approach captures the expert's heuristic knowledge to FRM.

2. BARRIERS TO FRM

(1) Identification of FRM barriers

Despite very limited collection of research related to flooding and very strict access to scientific records in MM, barriers to FRM were identified in a holistic manner by the authors capturing various facets of problems in FRM. A variety of data sources and literature were gathered in this study and these were used to carefully identify the barriers to FRM in MM. These barriers are identified if they are recurring issues and are cited at least once. The discussion on these barriers are presented in the succeeding sections.

(2) Questionnaire – based survey

The interrelationships of the barriers were determined by consulting experts in the flood management practice in the Philippines. The prepared questionnaire is designed for a pairwise relationship among barriers and is given to experts to establish barrier interrelationships. There are four types of relationships can be derived in each barrier. Applied on this study is a contextual relationship of the FRM barriers based on "influencing factors" type of relation. This type of relation means that one variable influences another variable. Four symbols were used to denote the pairwise relationship between barrier *i* and barrier *j*:

a) Symbol "+" denotes that barrier *i* influences barrier *j*
b) Symbol "-" denotes barrier *i* is influenced barrier *j*
c) Symbol "±" means that barrier *i* and barrier *j* influence each other
d) Symbol "0" means that barrier *i* and barrier *j* are independent of each other.

The questionnaire were given to 5 practitioners and experts who are working closely with the Department of Public Works and Highways (DPWH) on flood control projects in MM. The nationwide flood control management in the Philippines is under the mandate of DPWH along with other national infrastructure projects. DPWH is the sole responsible on the flood control and management in the Philippines, except in MM. The flood control functions, responsibilities, assets and liabilities of DPWH for MM was transferred to Metro Manila Development Authority (MMDA) starting 2002. This was an urgent executive order to improve flood control efficiency and to reduce inundation within the metro. However, many were critical about this

transfer of role because MMDA does not have the expertise to fulfill the newly given directive since flood control has been with DPWH from time immemorial. Despite the transfer of role, DPWH has still been supporting MMDA on the flood control in MM on the contemporary. The authors of this study have engaged experts and practitioners from DPWH because of their overarching facts, information and skills on flood management in Metro Manila which was proven over the years. Also, it was DPWH who initiated the Integrated FRM masterplan for Metro Manila after the onslaught of typhoon Ondoy.

There are various government agencies and non-government agencies which are involved with disaster risk reduction, which includes flooding. These include the Office of Civil Defense (OCD), the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA), the National Disaster Risk Reduction and Management Council (NDRRMC), etc. However, these government agencies lack experience and comprehensive knowledge on the flood situation, management, and needs in Metro Manila. For example, the OCD's role on flood management is more active on the response after any flood-related disaster occurrences. OCD's role is to provide only further funding, based on DPWH's program of urgent rehabilitation to damaged areas after flood occurrences. On the other hand, PAGASA's role on flood forecasting is also limited only to 4 major river basins in Luzon which do not include Metro Manila, and they are limited only to prediction of storm's intensity i.e. wind speed, gustiness, etc.[5] Engaging and finding experts on flooding with these agencies is almost impossible due to the lack of experts within their organization.

Only 5 experts and practitioners are engaged to this study since Philippines is crucially lacking of experts especially on flood management. Even more so, there are very limited academic papers regarding flood management since many studies focus more on the hydrological processes. This study is the first to pursue flood management problems in Metro Manila with the participation of experts and practitioners. The authors have a strong connection to DPWH particularly at the Unified Project Management Office – Flood Control Management Cluster and the experts and practitioners engaged in this study are the foremost authority on the department who have adequate experience and overarching knowledge with the former and current flood related issues in Metro Manila. The inputs from these experts and practitioners hold notable information that realistically represent the contemporary flood management conditions in Metro Manila. This study's intention is to acquire only inputs from experts and practitioners which does not encompass lower-level managers, and rank and file employees. Moreover, statistical analysis among a large number of people, with lesser confidence on their experience on flood management and control, is not desired in this study to inhibit large variation on their perception.

3. RESULTS AND DISCUSSION

(1) FRM Barriers

Table 1 presents the summary of the barriers and the respective definition are also presented. These barriers are found to be related to three aspects: governance (A_1), social (A_2) and scientific resources (A_3). There are a total of 12 identified barriers wherein 4, 3 and 5 are related to the governance, social and scientific resources aspects, respectively.

Barriers related to governance pertains to those structural context in which the Philippine government develop policies for FRM and implement projects for flood control. Four barriers were identified related to governance: Lack of sole organizing body (B_{11}), lack of communication among agencies and to the communities (B_{12}), lack of prioritization (B_{13}) and lack of flood control infrastructure (B_{14}). Before MM was devastated by Typhoon Ondoy, there were no comprehensive implementation program for flood control projects in MM. Roles and functions among government agencies are not clearly defined and coordination among them are not established by a clear policy which inevitably led to ineffective and delayed implementation of flood control projects. The disastrous flooding by Typhoon Ondoy magnified the lack of governance to flooding in the region.

FRM barriers associated with the social aspect which relates to urban development and society's values, attitudes and morals towards its surroundings. Three barriers are identified related to this: poor urban planning (B_{21}), excessive encroachment (B_{22}) and poor solid waste management (B_{23} Urban planning involves integrating flood risks in an area however it is not normally considered to be an essential of planning as evidently experienced by MM.

Table 1 Barriers to FRM in MM.

Aspects	Barriers		Definition
Governance A_1	B_{11}	Lack of sole organizing body	Two government agencies manage flood control in MM, however, the delineation of work is unclear. There is a lack of existence of a government agency that is solely responsible for flood management that supports planning, implementation and maintenance must be established[20), 21), 22)].
	B_{12}	Lack of communication among agencies and to the community	Insufficient communication system with the current diverse and separate agencies that manage flood related concerns requires constant tedious parallel coordination, and information exchange[7), 20)]. There are no established policy on information exchange and communication between agencies that manage flooding in MM.
	B_{13}	Lack of prioritization	Flood has yet perceived as a national problem. Flood control projects receive least attention compared to other less expensive and revenue-generating urban infrastructure[21)]. Primal focus of the government is disbursement allocation for infrastructure, agriculture and peace and order[20), 21)].
	B_{14}	Lack of flood control infrastructure	Importance of flood control projects is not well recognized by the government, resulting to lack of infrastructure for flooding[20), 23)]. Also, there is an ineffective implementation of non-structural measures during flood occurences[5)].
Social A_2	B_{21}	Excessive encroachment	Massive encroachment of poor informal settlers in drainage ways resulting to inaccessible maintenance and dredging activities at the river waterways[21), 24)].
	B_{22}	Poor solid waste management	Tons of solid wastes being disposed by poor urban settlers and residential areas clogs the drainage ways and increases the likelihood of flooding. Lack of available spaces for waste disposal such as sanitary landfills etc. led to an ineffective solid waste management system in MM[21)].
	B_{23}	Poor urban planning	Obsolete urban planning in MM resulted to an overwhelming crowding of people including those who thrive for a better living from the rural areas. The exponential increase in land prices led to encroachment of the poor to many areas within the city[21)]
Scientific Resources A_3	B_{31}	Lack of technological capabilities	There are no real-time forecast and updates on the water level and rainfall depths. Flood forecasting system from agencies does not include floods estimations in Metro Manila and they solely rely on storm intensity as a warning system[5)]. R&D budgets allocation are inefficient[24)] and most government agencies are still used to the manual way, manual tabulation and data processing[7)].
	B_{32}	Lack of data and access	Access to these rainfall data, river flow data and other variables are not continuously measured and the smallest time interval is daily. These data are also restricted if not, it is open for purchase and very costly. There is limited and sparse hydro-meteorological information and flood data results to high uncertainty on flood estimates and forecasts[5), 7), 20)]
	B_{33}	Lack of experts	Lack of experts and capabilities among the agencies related to flood control management[22), 24)]. Engineers of local consultants are also less experienced with studies for flood control plans[20)].
	B_{34}	Lack of funding and data processing systems	Metro Manila Development Authority (MMDA) - Effective Flood Control Operation and Warning System (EFCOS) is established to reduce the flood in MM but due to lack of funding and data processing systems only water levels and rainfall depths have been monitored and they have not been analyzed for any real-time flood forecasting or research[5), 7)].
	B_{35}	Modernization of flood control structures	Almost 25 to 35 years have been passed since the construction of flood control structures and remarkable problems were identified[7)]. Also, operation and maintenance were not fully undertaken[20)].

Table 2 Results of the pairwise assessment from the experts and practitioners.

Aspect			A_1				A_2			A_3				
	Barriers		*j*											
			B_{11}	B_{12}	B_{13}	B_{14}	B_{21}	B_{22}	B_{23}	B_{31}	B_{32}	B_{33}	B_{34}	B_{35}
A_1	*i*	B_{11}		+++ +-	+++ ++	+++ +0	+00 00	++0 00	++0 00	+++ 00	+++ ++	+++ +0	+++ +±	+++ +±
		B_{12}	- - - -+		+++ +±	++0 00	+++ +0	++0 0±	+++ 0±	+00 0±	+-0 ±±	-00 00	-00 00	+00 00
		B_{13}	- - - - -	--- -±		+++ -±	-00 0±	000 ±±	+-0 0±	+++ -±	++- 0±	++- 0±	+++ ± ±	+++ +±
		B_{14}	- - - -0	--0 00	--- +±		+00 0±	+00 00	++- 00	+++ +±	+++ +±	++0 ±±	+0± ±±	+++ ++
A_2		B_{21}	-00 00	--- -0	+00 0±	-00 0±		+++ +±	+-- ±±	000 00	000 00	000 00	000 00	000 0±
		B_{22}	--0 00	--0 0±	000 ±±	-00 00	--- -±		--0 0±	-00 00	000 00	-00 00	000 00	000 0±
		B_{23}	--0 00	--- 0±	-+0 0±	--+ 00	-++ ± ±	++0 0±		-00 00	-00 0±	--- 00	000 ±±	000 0±
A_3		B_{31}	--- 00	-00 0±	--- +±	--- -±	000 00	+00 00	+00 00		+++ +±	++- --	+±± ±±	+++ 0±
		B_{32}	--- --	-+0 ±±	--+ 0±	--- -±	000 00	000 00	+00 0±	--- -±		+-- --	+-- -±	+00 0±
		B_{33}	--- -0	+00 00	--+ 0±	--0 ±±	000 00	+00 00	+++ 00	--+ ++	-++ ++		++- 00	++0 0±
		B_{34}	--- -±	+00 00	--- ±±	-0± ±±	000 00	000 00	000 ± ±	-±± ± ±	-++ +±	--+ 00		+00 ±±
		B_{35}	--- -±	-00 00	--- -±	--- --	000 0±	000 0±	000 0±	--- 0±	-00 0±	--0 0±	-00 ± ±	

Table 3 Summary of the results in the pairwise assessment.

Aspects			A_1				A_2			A_3				
	Barriers		*j*											
			B_{11}	B_{12}	B_{13}	B_{14}	B_{21}	B_{22}	B_{23}	B_{31}	B_{32}	B_{33}	B_{34}	B_{35}
A_1	*i*	B_{11}		+	+	+	0	0	0	+	+	+	+	+
		B_{12}	-		+	0	+	+\0	+	0	±	0	0	0
		B_{13}	-	-		+	0	0	0	+	+	+	+	+
		B_{14}	-	0	-		0	0	+\0	+	+	+\±	±	+
A_2		B_{21}	0	-	0	0		+	-\±	0	0	0	0	0
		B_{22}	0	-\0	0	0	-		-\0	0	0	0	0	0
		B_{23}	0	-	0	-\0	+\±	+\0		0	0	-	0	0
A_3		B_{31}	-	0	-	-	0	0	0		+	-	±	+
		B_{32}	-	±	-	-	0	0	0	-		-	-	0
		B_{33}	-	0	-	-\±	0	0	+	+	+		+\0	+\0
		B_{34}	-	0	-	±	0	0	0	±	+	-\0		0\±
		B_{35}	-	0	-	-	0	0	0	-	0	-\0	0\±	

Barriers that are related on the scientific resource were also identified. The barriers related to this aspect are those that support decision making based from scientific insights and evidences. There are five barriers related to this: lack of technological capabilities (B_{31}), lack of data and access (B_{32}), lack of experts (B_{33}), lack of funding and data processing systems (B_{34}) and modernization of flood control structures (B_{35}). Generally, flood modeling and managing uncertainty are essential for FRM yet the Philippines lack in various ways to accomplish this as manifested from the barriers in this aspect.

(1) Interrelationships of Barriers FRM

This study presents an approach to which FRM barriers can be analyzed by assessing the pairwise relationship among the identified barriers to FRM. The most crucial tasks on this analysis are the inputs from the experts and practitioners in flood control practice.

Table 2 shows the results of the pairwise assessment conducted by the experts and practitioners. These results are then summarized in **Table 3** showing the most prevailing evaluation. It can be seen in the summary that the lack of sole organizing body, B_{11}, have the strongest influence to all other barriers especially to those in the governance, A_1, and scientific resources, A_3, aspect. This is an indicative that establishment or at least assigning a lead agency in FRM that supports planning, implementation, operations and maintenance has to be carried out Meanwhile, B_{11} have less influence to barriers in the social aspect, A_2, although some experts perceived that B_{11} influences barriers A_2 on some degree as show in **Table 2**. The second most influential barrier is found to be the lack prioritization, B_{13}, followed by the lack of flood control infrastructure, B_{14}. These barriers also shows strong influence to barriers in A_3 aspect and weak influence on barriers in A_2. Lack of communication among agencies and to the community, B_{12}, on the other hand, also strongly influences B_{13} and weak influence on B_{14}. Moreover, the results show that barriers on A_2 aspect do not influence any other barriers while barriers on A_3 are interrelated to each other while also being strongly influenced by A_1 according to the expert assessment. For instance, the lack of technological capabilities, B_{31}, and lack of funding and data processing systems, B_{34}, are influenced by barriers in A_1 and at the same time, these two barriers influence each other. Three barrier interrelationships in the A_2 and A_3 are not clearly defined by the experts and practitioners as shown in **Table 2**. This may be attributed to the lack of perception on matters of the social and scientific context.

Generally, the findings show that barriers in A_1 aspect are strong influencers to all other barriers to FRM especially to barriers in A_3 aspect. Barriers in A_2 on the other hand do not strongly influence all other barriers indicating that barriers in this aspect are highly dependent on others and overcoming them would depend to the barriers in A_1.

Aside from the pairwise assessment done by the experts and practitioners from DPWH, their collective perception on the FRM barriers were also assessed in this study. There are six levels of agreement used for this purpose which are as follows:

a) Level "A" signifies all 5 experts gave the same assessment
b) Level "B" signifies all 4 experts gave the same assessment while 1 differs from the others
c) Level "C" signifies that 2 possible answers were given by the experts wherein 3 experts gave the same assessment while the other 2 experts gave a different assessment but they have the same answer
d) Level "D" signifies 3 possible answers were given the experts wherein 3 assessments are the same while the other 2 differs from others

Table 4 Agreement levels between the experts and practitioners to the pairwise assessment.

Aspects			**A1**					**A2**			**A3**			
	Barriers		***j***											
			B11	**B12**	**B13**	**B14**	**B21**	**B22**	**B23**	**B31**	**B32**	**B33**	**B34**	**B35**
A1	***i***	**B11**		B	A	B	B	C	C	C	A	B	B	B
		B12			B	C	B	E	D	D	F	B	B	B
		B13				D	D	C	F	C	F	F	C	B
		B14					D	B	E	B	B	E	D	A
A2		**B21**						B	E	A	A	A	A	B
		B22							E	B	A	B	A	B
		B23								B	D	C	C	B
A3		**B31**									B	C	B	D
		B32										B	D	D
		B33											E	E
		B34												E
		B35												

e) Level "E" signifies 3 possible answers were given by the experts wherein 2 assessment are the same while the other 2 differs but are the same while the other 1 differs from others
f) Level "F" signifies all 4 possible answers were given by the experts and 2 experts gave the same assessment

Table 4 summarizes the collective perception of the experts and practitioners based on the agreement levels in the pairwise assessment on the FRM barriers. In the summary, levels A and B, C and D, and, E and F are grouped together to represent the strong agreement, slight agreement and slight disagreement among experts, respectively. This grouping is depicted in **Table 4** as the scale of shading. Results show that out of the 66 pairwise assessment, 9 is observed to be at level A, 25 at level B, 10 for level both C and D, 8 in level E and 4 in level F. Strong agreement in the collective perception of experts and practitioners are apparent in the pairwise assessment between the barriers in A_2 and A_3 aspect despite being independent of each other. Also, slight to strong agreement are found within the barriers in A_1 aspect. Evaluation of barriers between A_1 and A_2 aspect shows prevalent slight agreement to slight disagreement in the FRM barrier perception. This manifests a relatively poor understanding that flood problems are sometimes human-induced occurrences. Furthermore, this implies that the experts and practitioners have not yet considered flooding as a social problem that needs solutions from the society. This is clear indicative that when solving flood problems in MM, it should strengthen the involvement of the society. Likewise, collective perception on barriers within A_3 are not well established since MM gravely lack experts and scientists on flood problems. Nevertheless, the above findings suggests that the collective perception of the experts and practitioners from DPWH showed sufficient understanding on each of the barriers to FRM.

6. CONCLUSION

The main objective of this study is to identify barriers on FRM through an extensive review of literature and analyze its interrelationships based on experts' and practitioners' assessment. This study was able to engage only 5 practitioners and experts in MM because the Philippines is crucially lacking of experts with an overarching experience on the former and current flood conditions on the metro. The experts and practitioners engaged in this study are the foremost authority from DPWH. The information provided valuable realistic assessments that would represent the actual flood management conditions.

This study was able to identify three aspects that encompasses the FRM barriers in MM namely, governance, social and scientific resources aspects. A total of 12 barriers were identified in this study wherein 4, 3 and 5 are related to governance, social and scientific resources aspects, respectively. The interrelationships among these barriers shows that the most influential barrier is lack of sole organizing body. And generally, barriers in the governance aspect strongly influences other barriers within this aspect and in the scientific resources aspect. The collective perception of the experts and practitioners on these apparently shows strong agreement levels. On the contrary, perception on the social and governance aspect indicates the need for further inclusion of these aspects to the planning and implementation of FRM projects. Nonetheless, this study manifests sufficient understanding from engaged experts and practitioners on the barriers to FRM which would demonstrate a positive indication in overcoming all the barriers identified.

This study will aid and provide insights on decision making to the Philippine government, or any other developing countries that face the same dilemma on flooding. Understanding the context of the barriers to FRM especially from decision makers can lead to overcoming them and to an effective mitigation and control the flood problems in MM.

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