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Flood Vulnerability Assessment of Public School Buildings in Metro Manila, Philippines

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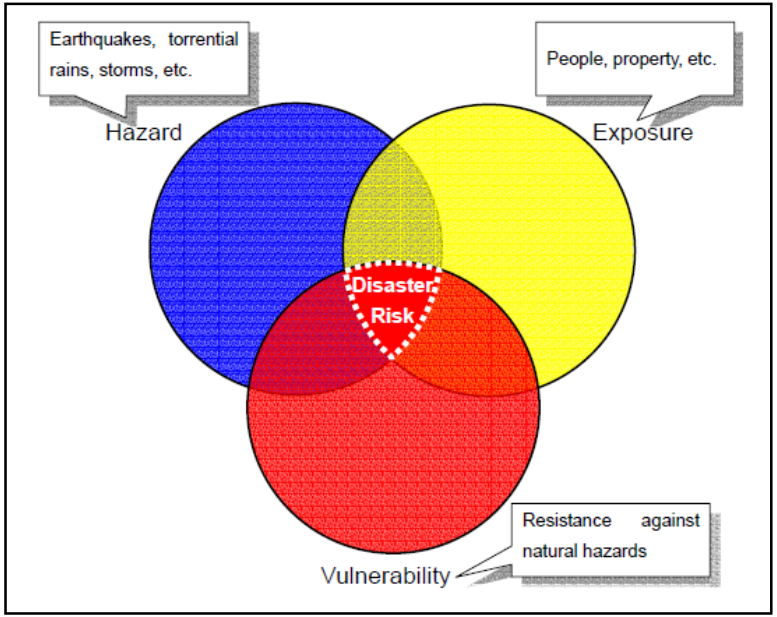
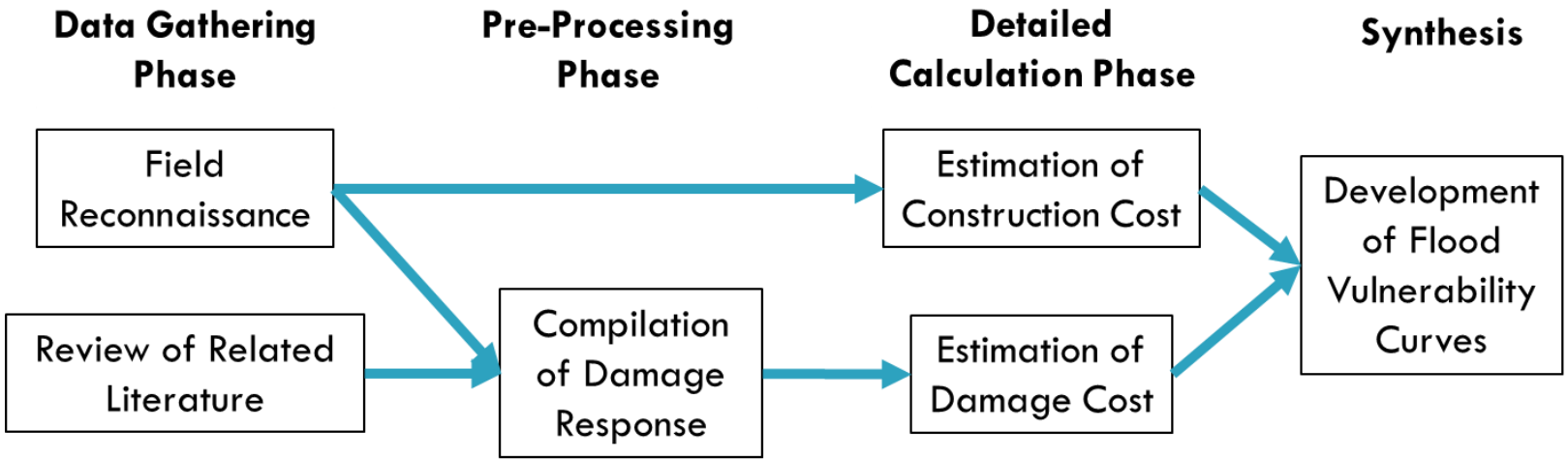
There is a need to assess the **vulnerability** of public infrastructures as one of the pre-requisites to having a **national flood risk management strategy**



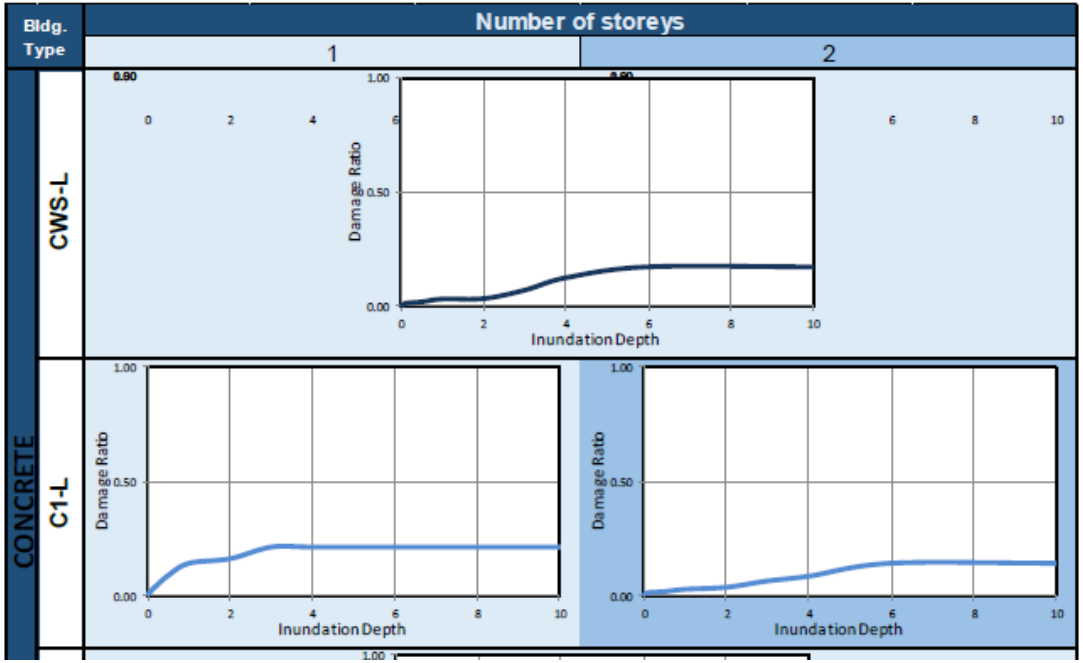
Vulnerability of Public Schools

Characterize **building damages** as a function of **inundation depth**



Flood Vulnerability Curve

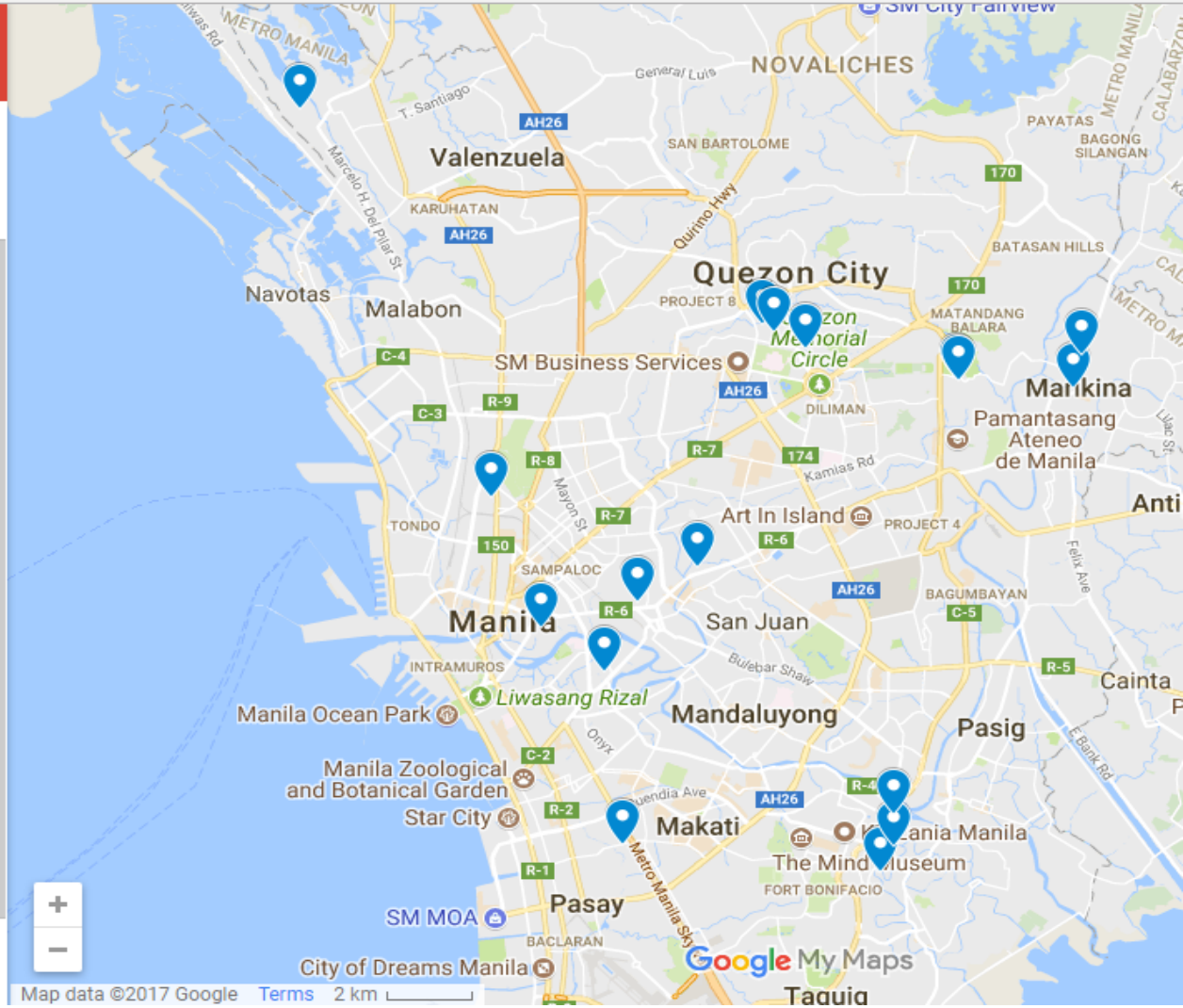
- a graph that correlates inundation depth and damage ratio (i.e., damage cost vs. construction cost of building)



Building Damage includes load and non-load-bearing components, building finishes, fixtures, and fixed equipment.

Site Visit

- Balara Elementary School
- Balara High School
- Concepcion Integrated School
- Ernesto Rondon High School
- H. Bautista Elementary School
- Mines Elementary School
- Project 6 Elementary School
- Mayor Simplicio Manalo National High S...
- Hen. Pio Del Pilar Elementary School
- BENIGNO AQUINO HIGH SCHOOL
- Tibagan High School, 7th Avenue, East R...
- Salapan Elementary School
- Antonio A Maceda Integrated School
- Bagong Diwa Elementary School
- Antonio Luna Elementary School
- Victorino Mapa High School
- A Deato Elementary School



Field Reconnaissance

Building Models (DPWH Standard)

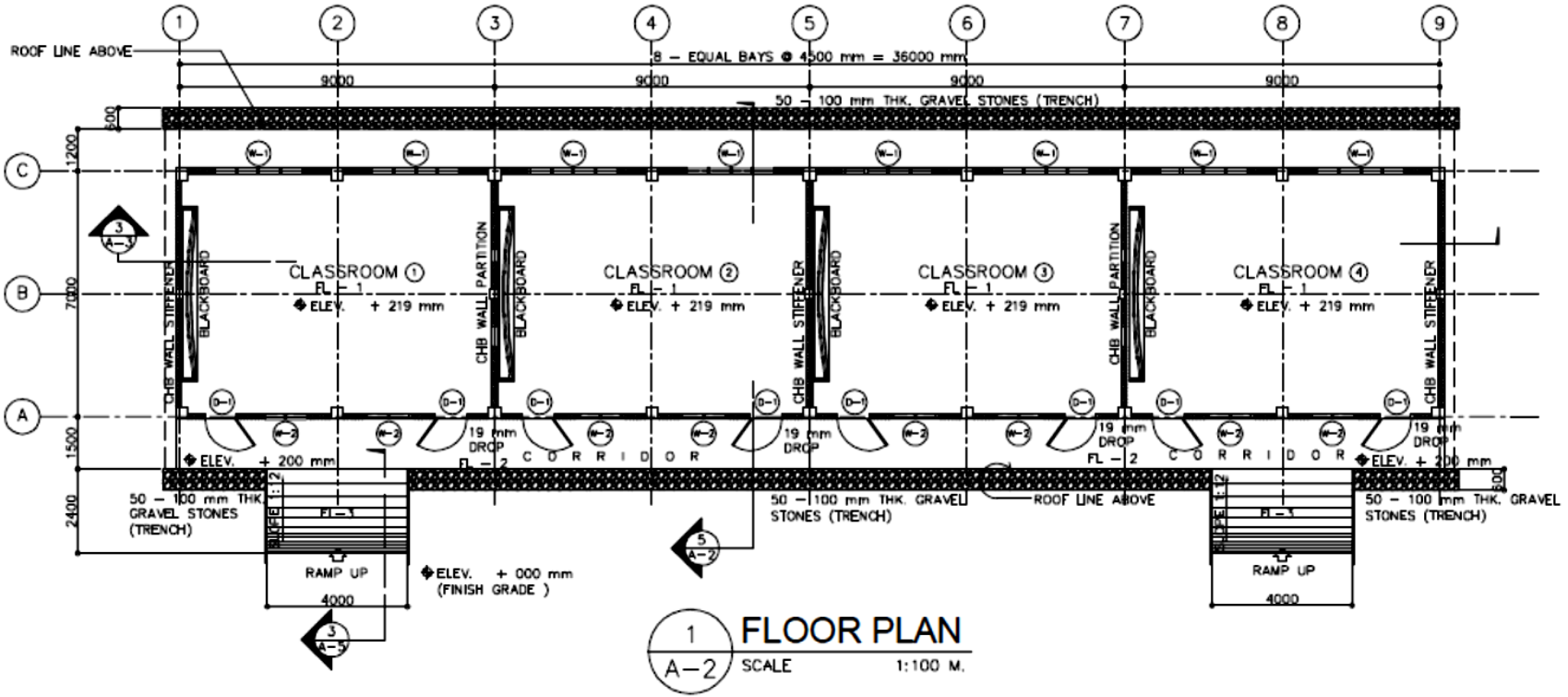
1-storey 4-classroom Building

2-storey 12-classroom Building

3-storey 15-classroom Building

4-storey 20-classroom Building

Sample Architectural Plan



Damage Response Summary

Attribute	Damage Response
Floor	Clean
Interior Wall	Clean (d=0.1) / Repaint (d≥0.5)
Exterior Wall	Clean (d=0.1) / Repaint (d≥0.5)
Door	Clean (d=0.1) / Repair (d=0.5) / Replace (d≥1)
Window	Clean and Repair
Blackboard	Replace
Ceiling	Replace (Wood) / Clean&Repaint (Concrete)

Attribute	Damage Response
Electrical Outlets	Replace
Electrical Switch	Replace
Other Electrical Fixtures	Replace
Lighting Fixtures	Replace
Fire Alarm System	Repair
Septic Tank	Maintenance
Roof	Clean

Sample Damage Cost Estimate

Inundation Depth (m)	Component with Damage	Damage Response	Unit	Quantity	Unit Cost	Damage Cost
0.0	None	None	N/A	N/A		-
0.1	Floor	Clean	sq.M	565	32.83	18,550.08
	Interior Wall	Clean	sq.M	25.71	42.68	1,097.34
	Exterior Wall	Clean	sq.M	50.785	42.68	2,167.59
	Door	Clean	sets	18	79.38	1,428.84
	Subtotal				-	**23,243.85**
0.5	Floor	Clean	sq.M	565	32.83	18,550.08
	Interior Wall	Repaint	sq.M	822.72	362.88	298,548.63
	Exterior Wall	Repaint	sq.M	464.32	362.88	168,492.44
	Door	Repair	sets	18	648.00	11,664.00
	Electrical Outlet	Replace	lot	1	17,551.99	17,551.99
	Septic Tank	Maintenance	lot	1	10,800.00	10,800.00
	Subtotal				-	**525,607.14**
1.0	Floor	Clean	sq.M	565	32.83	18,550.08
	Interior Wall	Repaint	sq.M	822.72	362.88	298,548.63
	Exterior Wall	Repaint	sq.M	464.32	362.88	168,492.44
	Door	Replace	lot	1	610,829.10	610,829.10
	Electrical Outlet	Replace	lot	1	17,551.99	17,551.99
	Blackboard	Replace	sets	6	10,461.15	62,766.90

Sample Construction Cost Estimate

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
A.	TWELVE CLASSROOMS				
I.	Mobilization/ Demobilization	lot	1.00	81,270.0	81,270.00
	Subtotal				**81,270.00**
II.	Temporary Facilities and Billboard	lot	1.00	103,950.0	103,950.00
				-	**103,950.00**
III.	Safety and Health			-	-
	Item SPL-1 Personal Protective Equipment	md	1920.00	22.8	43,835.90
	Item SPL-2 Safety and Health Personnel	md	16.00	2,800.0	44,800.00
	ITEM SPL-3 Signages and Barricades	sets	7.00	1,606.5	11,245.50
	Subtotal				**99,881.40**
IV.	Earthworks			-	-
	Item 803 Excavation of Column Footing, WF and SW Footing	m^3	283.98	420.0	119,271.60
	Item 804(a) Backfilling of Excavated Materials	m^3	175.37	350.0	61,379.50

Results

MODEL: 1-Storey 4-Classroom Building	
Construction Cost (Php)	**5,560,000.00**
Construction Cost (USD)	111,200.00

Inundation Depth (m)	**Damage Cost (Php)**	**Damage Index (%)**
0.0	0.00	0.00
0.1	12,000.00	0.21
0.5	230,000.00	4.14
1.0	380,000.00	6.74
2.0	430,000.00	7.58
3.0	1,280,000.00	23.0
4.6	1,300,000.00	23.4
6.0	1,300,000.00	23.4
10.0	1,300,000.00	23.4

Results

MODEL: 2-Storey 12-Classroom Building	
Construction Cost (Php)	**22,610,000.00**
Construction Cost (USD)	452,200.00

Inundation Depth (m)	Damage Cost (Php)	Damage Index (%)
0.0	0.00	0.00
0.1	24,000.00	0.10
0.5	530,000.00	2.32
1.0	1,450,000.00	6.40
2.0	1,530,000.00	6.74
3.0	1,920,000.00	8.45
4.0	3,330,000.00	14.7
6.0	4,880,000.00	21.6
8.9	5,230,000.00	23.1
10.0	5,230,000.00	23.1

Results

MODEL: 3-Storey 15-Classroom Building	
Construction Cost (Php)	**29,780,000.00**
Construction Cost (USD)	595,600.00

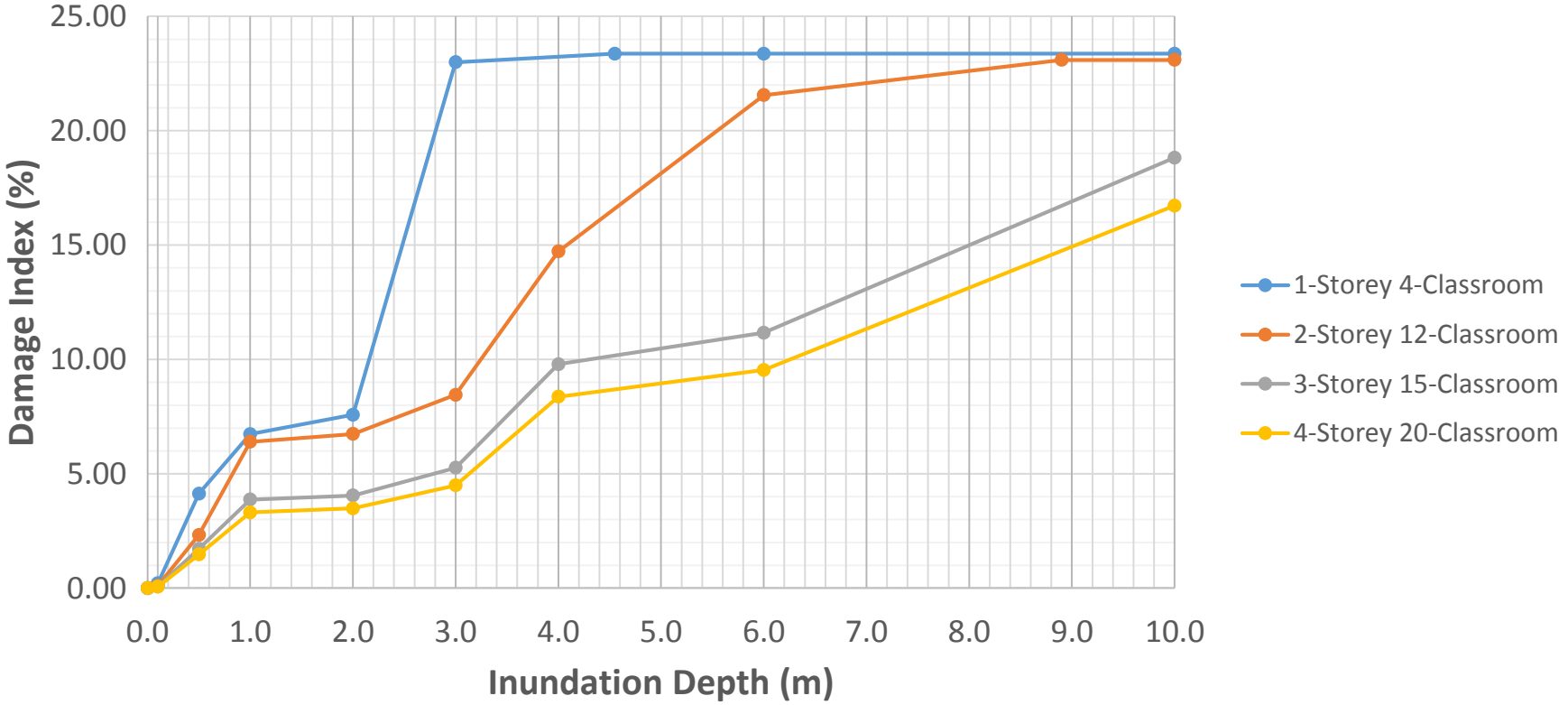
Inundation Depth (m)	**Damage Cost (Php)**	**Damage Index (%)**
0.0	0.00	0.00
0.1	22,000.00	0.07
0.5	520,000.00	1.72
1.0	1,160,000.00	3.87
2.0	1,210,000.00	4.05
3.0	1,570,000.00	5.26
4.0	2,920,000.00	9.79
6.0	3,330,000.00	11.2
10.0	5,610,000.00	18.8

Results

MODEL: 4-Storey 20-Classroom Building	
Construction Cost (Php)	**34,820,000.00**
Construction Cost (USD)	696,400.00

Inundation Depth (m)	**Damage Cost (Php)**	**Damage Index (%)**
0.0	0.00	0.00
0.1	22,000.00	0.06
0.5	520,000.00	1.47
1.0	1,160,000.00	3.31
2.0	1,220,000.00	3.49
3.0	1,570,000.00	4.49
4.0	2,920,000.00	8.37
6.0	3,330,000.00	9.54
10.0	5,830,000.00	16.7

Flood Vulnerability Curves



Summary

- There is a need to assess the vulnerability of public infrastructures against flooding.
- In general, public schools have poor flood coping mechanism, therefore detailed damage estimation must be done
- A starting point towards a comprehensive vulnerability assessment is the evaluation of building damages (scope of this study)
- The developed flood vulnerability curves fully describe building damages to public schools

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