TC-H1-1

CLIMATE CHANGE ADAPTATION IN URBAN FLOODS -CASE STUDY IN SUBURB OF METRO MANILA-

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ABSTRACT

Japan International Cooperation Agency (JICA) started climate change adaptation (CCA) projects in the Philippines, and assisted planning for urban flood mitigation considering climate change impacts in a Metro Manila suburb area where rapid urbanizations have adversely affected flood disasters. By using a statistical down scaling methodology, the targeted design scale of 10-year return period is predicted to decline to 3-6 year return period in 2050 because of climate change. The JICA study found that the flood peak volume increase by 25 – 50% in 2050 because of impacts of both climate change and urbanization. The number of houses inundated would increase to two to three times. To mitigate these flood damages, an integrated CCA approach is proposed. Conventional structural measures and non-structural measures are jointly required. Land use management and retarding structures in river basins are useful counter measures.

Keywords: urbanization, climate change adaptation, flood disaster management

1 INTORDUCTION

Japan International Cooperation Agency (JICA), the world's largest bilateral development assistance agency with a size of estimated $10.3 billion dollars, is providing technical assistance, concessionary ODA loans, and grant aid to developing countries. JICA started climate change adaptation (CCA) projects in the Philippines. However, planning methodologies for CCA have not been established. JICA attempted to plan CCA of urban floods in a Metro Manila suburb area.

2 PROEJCT AREA

The project area is located in the eastern part of the Cavite Province in the Philippines, and close to the border of Metro Manila covering an area of about 400 km^2 (Fig. 1 and Table 1). A considerable part (about 900ha) of the area along the coast has the low ground elevation below EL. 1m, only 20cm higher than the present mean monthly highest sea level. This area is vulnerable to flood overflow from rivers, inundation by stagnant of storm rainfall and tidal floods. Intensive residential development is being induced. Natural flood-retarding basins are being reclaimed, and a considerable part of the ground is being covered with pavement. These have decreased flood detention capacities, and increased flood discharges. During the recent nine years, serious floods have occurred four times causing death of people and damages of many houses as shown in Table 2 and Photo 1.

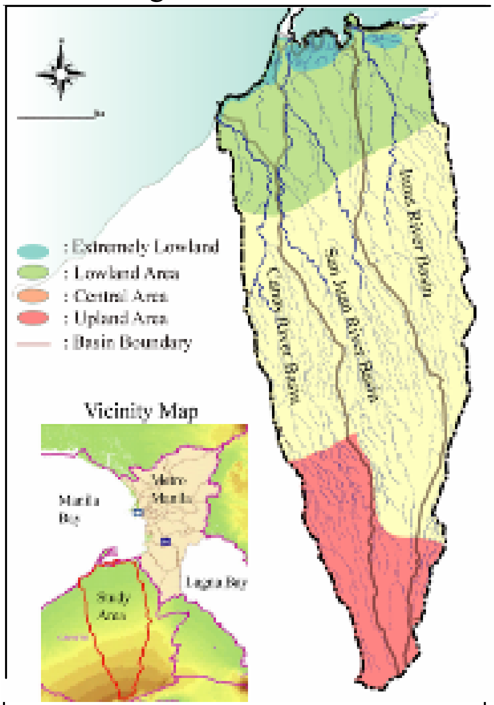


Fig. 1 Project Area

Table 1 Major Rivers

River Basin	Catchment Area (km2)	River Length (km)
Imus	115.5	45.0
San Juan	147.76	43.4
Canas	112.32	42.0
Residual	32.84	-
Total	407.4	

3 AGGRAVATION OF FLOOD BY URBANIZATION AND CLIMATE CHANGE

A built-up area as of 2003 covers about 26% of the entire area. The Provincial government projected that the build-up area will be increased to 65% in 2020 (Fig. 2). According to flood runoff simulation, the probable peak runoff discharge of 10-year return period under the present ratio of built-up area is estimated at 910 m^3/s, and 640 m^3/s at the downstream end of Imus River and San Juan River, respectively. These volumes would increase to 1,500 m^3/s for Imus River, and 870 m^3/s for San Juan River, because of rapid urbanization projected by the provincial government (Table 3).

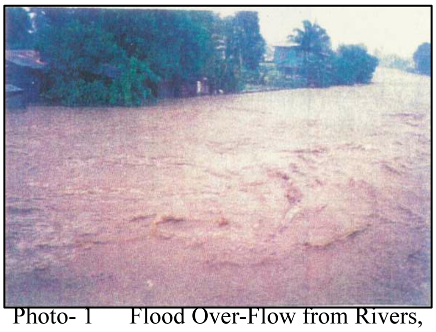


Photo- 1 Flood Over-Flow from Rivers, Oct. 2000 (Source: IDI-Japan)

Table 2 Recent flood Damage

Date	Typhoon	Damages
Oct. '00	Reming	Death: 10 Affected population: 380,616
Jul. '02	Gloria	Death: 0 Affected population: 173,075
Jul. '02	Inday	Death: 1 Affected population: 168,025
Sep. '06	Milenyo	Death: 28, Missing: 18, Injured: 61, Evacuated: 28,322, Affected 196,904

The Intergovernmental Panel on Climate Change (IPCC) has warned the climate changes associated with global warning. IPCC estimated the change of global temperature based several scenarios on future global emission volumes. The present global average temperature would most likely rise by 1.8 to 4.0°C at the end of the 21st Century (IPCC 2007). The largest rise of the temperature would break out in the A1F1 scenario, and the smallest would be in the B1 scenario.

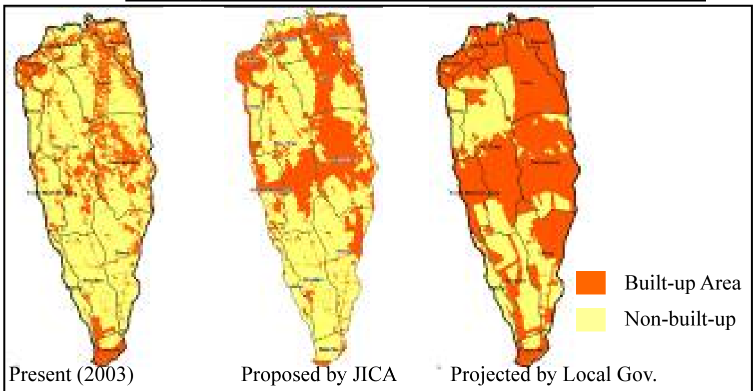


Fig. 2 Present and Proposed Land Zoning

The Transdisciplinary Initiative for Global Sustainability and Center for Climate System Research, the University of Tokyo simulated relations between the global average temperature rise and a local temperature rise in the Philippines based on a subset of models used for the Forth Assessment Report of IPCC as shown in Fig. 3. The local average temperature would rise by 1.1 to 2.3℃ in 2050 and further 1.5 to 3.5℃ in 2010 as shown in Table 4. The Transdisciplinary Initiative for Global Sustainability and Center for Climate System Research, the University of Tokyo simulated the relation between the local average temperature rise and the local incremental rate of storm rainfall in the Philippines as shown in Fig. 4 (Sugiyama 2007). This simulation is based on the Model for Interdisciplinary Model and assumption of the factors of precipitable water as boundary conditions for the model. The storm rainfall intensity would increase by 11 to 20% in 2050 and 14 to 29% in 2100 as shown in Table 5. The present rainfall intensity of 10-year return period is estimated at 295mm, while the intensities of same return period in 2050 would increase to 327mm under the B1 scenario and 354mm under the A1FI scenario, which are almost equivalent to the present rainfall intensities of 20 and 50-year return period, respectively (Table 6). The present peak runoff discharge of 10-year return period at the downstream end of Imus River would increase from 900m^3/s to 1,100m^3/s (24% increment) in 2050 under B1 Scenario or 1,300m^3/s (48% increment) under the A1FI Scenario as shown in Fig.5.

Table 3 Increase of Probable Flood Runoff Discharge

River	flood runoff discharge (m^3/s)		
	Present Urbanized Ratio	Urbanized Ratio in 2020 proposed by JICA	Urbanized Ratio in 2020 proposed by LGUs
Imus	910	1,200	1,500
San Juan	640	680	870

Instead of the projected ratio of 65% prepared by the provincial government, the JICA study proposed a new zoning plan to control the urbanized ration of 43% as shown in Fig. 2. This alternative zoning plan contributes to substantial reduction of the basin flood runoff discharge.

The new zoning plan proposed by JICA can substantially reduce flood damages compared with the current provincial government plan. The probable flood inundation area and number of buildings under the status quo of climate and urbanized ratio of 43% as proposed by JICA are about 37 km^2 and 34 thousands, respectively as shown in Table 7 and Fig. 6. The probable flood inundation area would increase to about 48km^2 in 2050 under the A1FI scenario, even if the urbanized ration were maintained at 43% of the new zoning plan (see Case 4 in Table 7). It would further increase to 51km^2, if the urbanized ration expands to 65% as the current zoning plan projected by the provincial government (see Case 7 in Table 7). The number of buildings to be inundated would increase from 22 thousands under the status quo of climate to 44 thousands and 74 thousands for the said two cases, respectively.

4 PLAN FOR FLOOD MITITGATION MEASURES

The JICA study prepared a structural flood mitigation plan, which includes: (a) offsite flood-retarding basins, (b) partial river channel improvements, and (c) onsite flood regulation ponds at new housing development sites. Since the area along the downstream river stretches is densely packed with houses, it is difficult to implement conventional structural measures, such as high and long dykes, due to extremely large number of house resettlement required. Instead, the offsite flood retarding basins together with the minimum partial river channel improvement are proposed (Fig. 7). The proposed design level is set to cope with the probable flood of 10-year return period taking the financial affordability and the economic viability into account.

The offsite flood-retarding basins could be constructed in the less populated agricultural land and grassland in middle reaches. The flood peak discharge could be reduced by retarding the flood runoff discharge in the retarding basins. Ten flood-retarding basins covering an area of about 200ha in total are proposed.

Enforcement of a provincial government ordinance is proposed to obligate land developers to construct onsite flood regulation ponds at new subdivisions, housing development sites, more than five hectors to offset the increment of the flood runoff discharge. The onsite flood regulation ponds are designed to occupy 3% of the entire extent of subdivisions, and to offset the peak flood runoff discharge of 20-year return period. These onsite flood regulation ponds can be used as amenity space such as sports grounds during a non-flood time (Photo-2).

5 CLIMATE CHANGE ADAPTATION

5.1 STRCTURAL MEASURES

The design scales of the proposed flood mitigation structures are set at 10-year return period against floods. This design scale would decline to 6-year return period in 2050 under the B1 scenario or 3-yaer return period under the A1FI scenario as shown in Fig. 8. Since the climate change will gradually take place for during several decades and the precise degrees of the change would be hardly predicted due to uncertainties, the following practical methodologies are proposed:

- ✓ The stage-wise expansion of the flood mitigation capacities of the structures in accordance with the aggravation of flood inflicted by the climate change, and

Table 4 Future Local Average Temperature Rise in Philippines

Scenario	Year	Global Average Temperature Rise (℃)	Local Average Temperature Rise in Philippines (℃)*
B1	2050	1.2	1.1
	2100	1.8	1.5
A1FI	2050	2.6	2.3
	2100	4.0	3.5

Table 5 Relation between Local Average Temperature Rise and Incremental Rate of Storm Rainfall in Philippines

Scenario	Year	Temperature Rise (℃)	Increase Rate of Storm Rainfall Intensity (%)
B1	2050	1.1	11
	2100	1.5	14
A1FI	2050	2.3	20
	2100	3.5	29

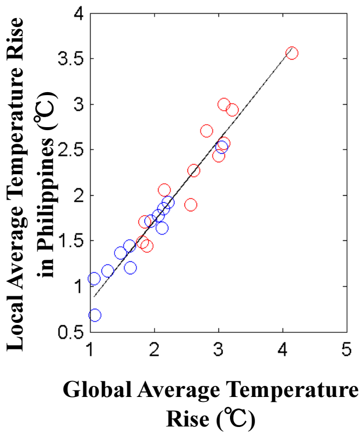


Fig. 3 Relation between Global Average Temperature Rise and Local Temperature Rise in the Philippines

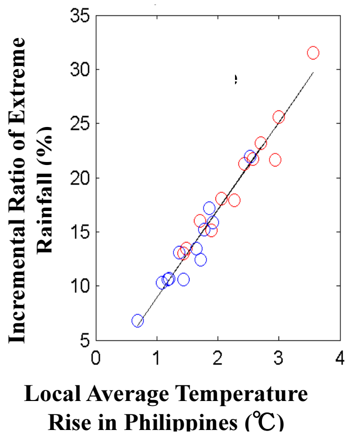


Fig.4 Relation between Local Average Temperature Rise and Incremental Rate of Storm Rainfall in Philippines

Photo-2 Onsite Flood Regulation Pond in Japan

Table 6 Future Increment of Probable Two-day Storm Rainfall

Scenario	Year	Increase Rate of Storm Rainfall (%)	Probable 2-day Storm Rainfall (mm)					
			2-year	5-year	10-year	20-year	50-year	100-year
Status Quo	2003	-	191	258	295	326	360	383
B1 Scenario	2050	11	212	286	327	362	400	425
	2100	14	218	294	336	372	411	437
A1FI Scenario	2050	20	229	310	354	391	432	460
	2100	29	246	333	380	421	465	494

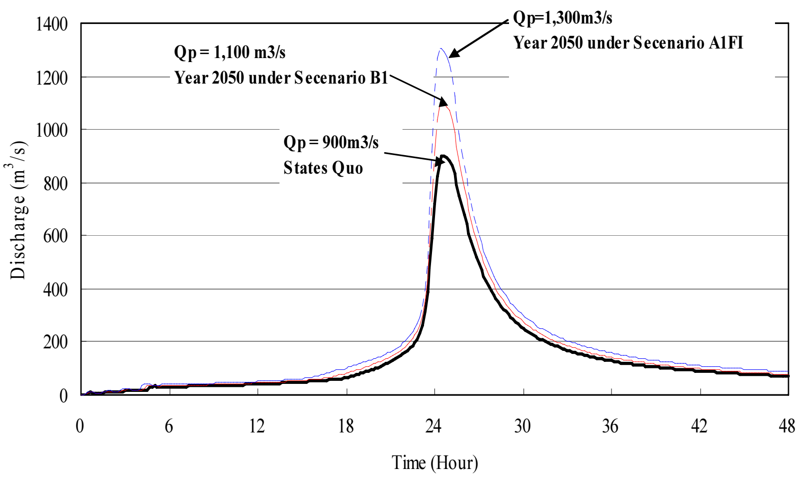
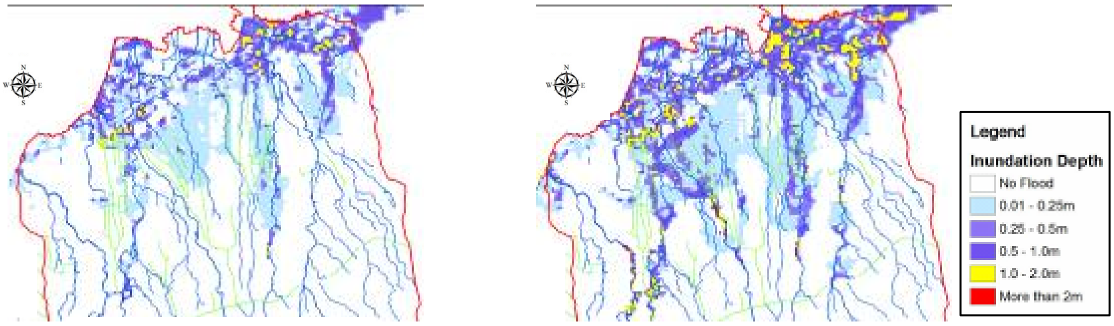


Fig. 5 Hydrograph of Probable Flood Runoff Discharge at Downstream End of Imus River Basin

Table 7 Increase of Flooding Area and Number of Houses and Buildings Flooded due to Effects of Urbanization and Climate Change (Probable Flood of 10-year Return Period)

Case No.	Scenario of Climate Change	Urbanized Ratio	Probable Flood Inundation Area (km^2)			Number of Houses/Buildings Inundated (thousand houses)		
			Flood Depth below 1m	Flood Depth above 1m	Total	Flood Depth below 1m	Flood Depth above 1m	Total
1	Status Quo	26%*	31.51	1.05	32.56	20.1	1.7	21.8
2	States Quo	43%**	35.82	1.50	37.32	31.4	2.9	34.4
3	In 2050 under B1 Scenario		41.10	2.52	43.62	35.5	4.4	39.9
4	In 2050 under A1FI Scenario		44.64	3.54	48.18	38.4	5.9	44.3
5	States Quo	65%***	41.05	2.45	43.50	56.4	7.2	63.6
6	In 2050 under B1 Scenario		43.92	2.97	46.89	60.1	8.5	68.6
7	In 2050 under A1FI Scenario		47.27	3.98	51.25	63.0	11.2	74.2

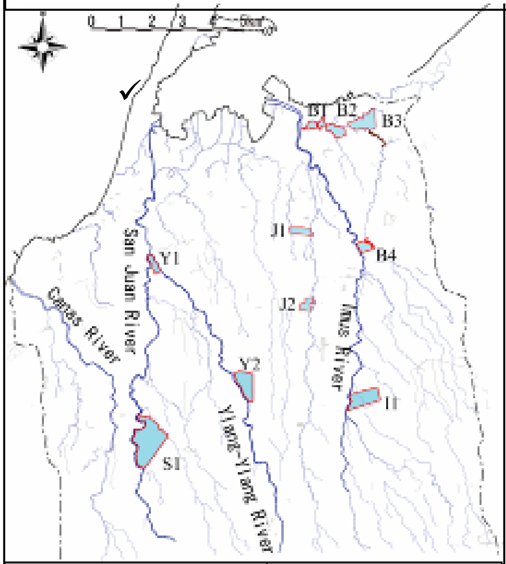
Note :* :present urbanized ratio as of 2003
** :urbanized ratio in 2020 proposed by JICA
*** : urbanized ratio in 2020 projected by local governments



Present (Case 1 in Table 7)

In 2050 under A1FI Scenario (Case 7 in Table 7)

Fig. 6 Probable Inundation Area by the Flood of 10-year Return Period



Description	Quantity
Design Scale	10-year return Period
Offsite Retarding Basin	10 basins with 203ha
River Improvement	14.7km

Fig. 7 Proposed Offsite Flood Retarding Basin and Partial River Improvement

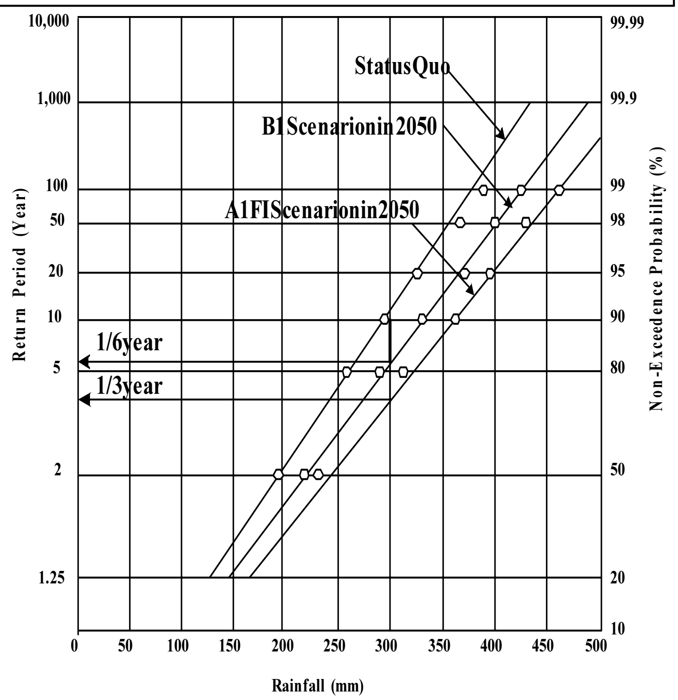


Fig. 8 Relationship between 2-day Storm Rainfalls and Recurrence Probabilities

✓ The minimum flood damage in the event of the flood scale, which exceeds the design level of the flood mitigation structures.

(1) Minimization of River Channel Improvement

The proposed plan minimizes river channel improvements. The design high water level needs to be about 3 to 4m higher than the hinterland ground level without basin flood retention structures (Fig. 9). Destruction of such high river dike could possibly leads to rushing out of river discharges within a short period, and disastrous damages including a large number of death calamities, once the river water level exceeds the dike crown level.

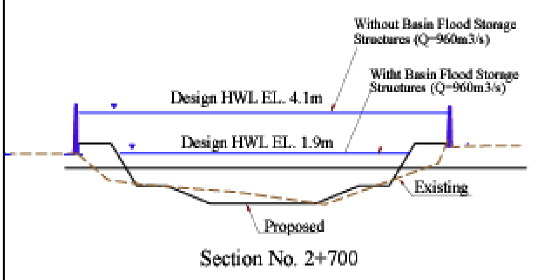


Fig. 9 Standard Cross-sections with and without Basin Flood Retention Structure (Case for Elevating of River Dike)

Widening of the river channel could be considered as another option. The downstream of river channel needs widening by about 30 to 40m as shown in Fig. 10. Due to the dense houses along the downstream river stretches, the channel widening would require a large number of house relocations, 1,960 houses.

The both options of further higher river dike and channel widening to adapt the climate change are evaluated to be not feasible.

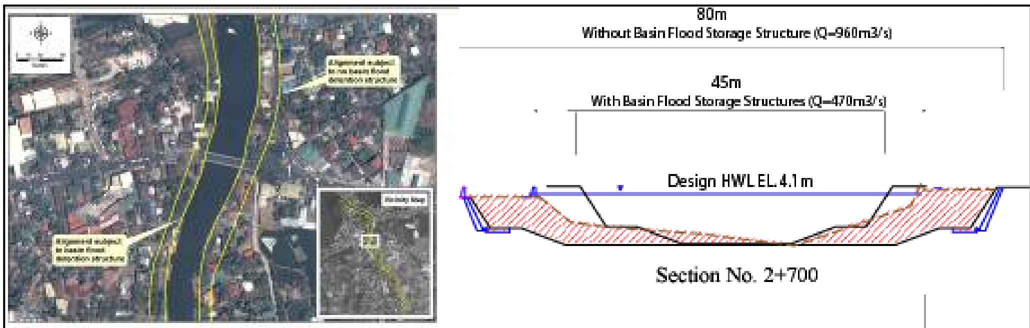


Fig. 10 Alignment and Standard Cross-Sections with and without Basin Flood Detention Structure (Case for Channel Widening)

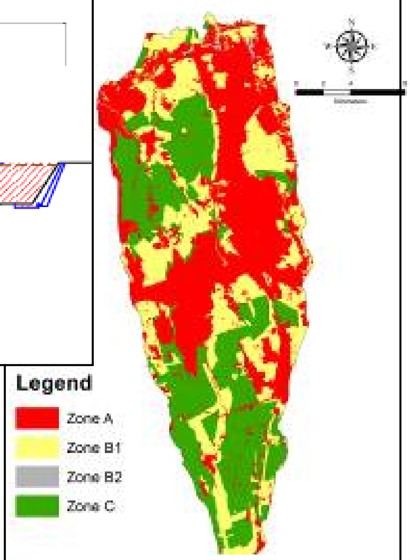
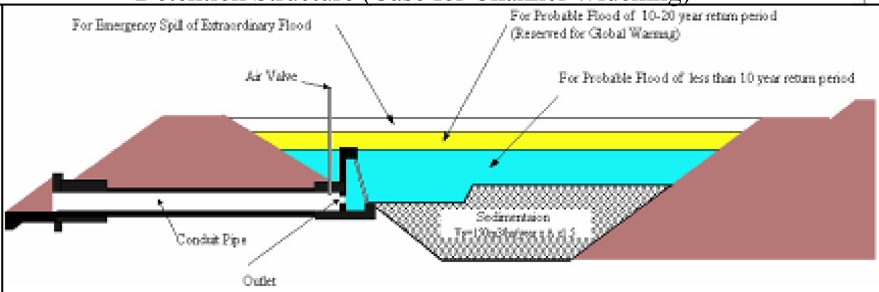


Fig. 12 Zoning Plan



Fig, 11 Conceptual Longitudinal Section of Onsite Flood Regulation Pond

(2) Reservation of Supplementary Flood Detention Capacity for Offsite Flood Retarding Basin and Onsite Flood Regulation Pond

To reserve lands for step-wise expansion of offsite flood-retarding basins, the Urban Growth Development Ordinance is proposed. About 23,000ha in total should be reserved as the non-built-up area, and could be used as the lands for step-wise expansion of the impounding areas of the retarding basins to cope with climate change impacts.

To maintain the flood control capacity even under the future conditions of the climate change, the onsite flood regulation pond is designed to complementarily possess the flood control capacity to offset the increment of the probable peak runoff discharge of 20-year return period as shown in Fig. 11.

5.2 Non-Structural Measures

The aggravation of flood intensified by the climate change is hardly resolved solely by the structural measures, and it is indispensable to adapt the non-structural measures such as proper land use control in river basins, establishment of flood warning and evacuation system (FWES).

Table 8 Zoning Plan by 2020

Zone	Land Use	Area (ha)	Share
A	Residential	14,561	35.7%
	Industrial	1,426	3.5%
	Institutional	407	1.0%
	Commercial	1,019	2.5%
	Sub-total	**17,413**	**42.7%**
B	Agricultural	2,462	6.0%
	Grassland/Open Area	3,145	7.7%
	Tree Plantation	2,856	7.0%
	Water Bodies	665	1.6%
	Unclassified	20	0.0%
	Sub-total	**9,148**	**22.5%**
C	Agricultural	12,861	31.6%
	Grassland/Open Area	1,004	2.5%
	Tree Plantation	249	0.6%
	Water Bodies	68	0.2%
	Unclassified	1	0.0%
	Sub-total	**14,183**	**34.8%**
Total		**40,744**	**100.0%**

(1) Land Use Control

The zoning plan should be enforced by Urban Growth Management Ordinance of the provincial government to control the urbanization ratio at 43%. This Ordinance facilitates to control the ongoing excessive land development, and to reserve available lands for expansion of offsite flood retarding basins. Zoning is made taking the complex factors into account such as: (a) present land use states, (b) population growth by the year 2020, (c) existing urban development plan prepared by the local governments, (d) states of applications from land developers and (e) high flood risk area, as shown in Table 8 and Fig. 12. The sporadic land development would be strictly controlled in Zone B and any land development would be prohibited in Zone C until 2020. The zoning would be revised after 2020 in accordance with the socio-economic changes as well as the climate-changes.

- ✓ Zone A is designated as the Development Promotion Zone, which is either the existing built-up area or the future projected built-up area to be positively developed.
- ✓ Zone B is designated as the Development Control Zone, where the land development is not allowed before 2020 and is subject to monitor and control even after 2020. Zone B is further divided into Zone B1 and B2. Zone B1 is not preferable for urbanization, such as the existing agricultural land and grassland. Zone B2 is the present built-up area but lies over the flood hazard area.
- ✓ Zone C covers the priority agricultural conservation area, where any land development is legally prohibited, unless it promotes public interests. The steep slope area of more than 15% is further included into this zone as the environmentally critical area.

(2) Flood Waning and Evacuation System

FWES is proposed with referring to the current activities and resources of the local government and communities. The Typhoon Milenyo in 2006 caused the maximum recoded flood with a recurrence probability of about 100-year return period. This extent of flooding area could be regarded as the present possible maximum flood risk area. The target areas of 1,283 ha for FWE are submerged with the depth of more than 50cm by the scale of Typhoon Milenyo as shown in Fig. 13. The eligible flood evacuation centers are proposed. The river water levels are to be monitored at the seven bridge sections and the critical river water levels are marked on the pier of the bridges as shown in Photo-3. The stage-wise release of flood warning and evacuation is proposed: stage 1: standby, stage 2: alert, stage 3: warning, and stage 4: evacuation.

The proposed FWES is executed by local disaster coordination councils (DCC) at provincial, city, municipality and barangay (the minimum government administrative unit in the Philippines) levels. The provincial DCC would undertake the monitoring on the flood conditions over the entire areas. The Provincial Governor as the chairperson of the provincial

DCC would issue the flood warning and direct evacuation. City and municipal as well as barangay DCC would stand for the frontline for the actual operation for dissemination of the messages for flood warning and evacuation among the residents.

Most of barangaysas as well as municipalities in the project area have not designated any definite flood evacuation center yet. Each municipality and barangay is required to determine the definite evacuation centers and evacuation routes, and disseminate them among the residents through the flood risk map. To defuse the methodologies and knowledge on the evacuation centers, evacuation routes, and flood hazard map, a pilot project was commenced in August 2008. The eligible evacuation centers and evacuation routes were clarified for the several pilot barangays.

Photo-3 Example of River Water Level Indicator for Flood Warning and Evacuation

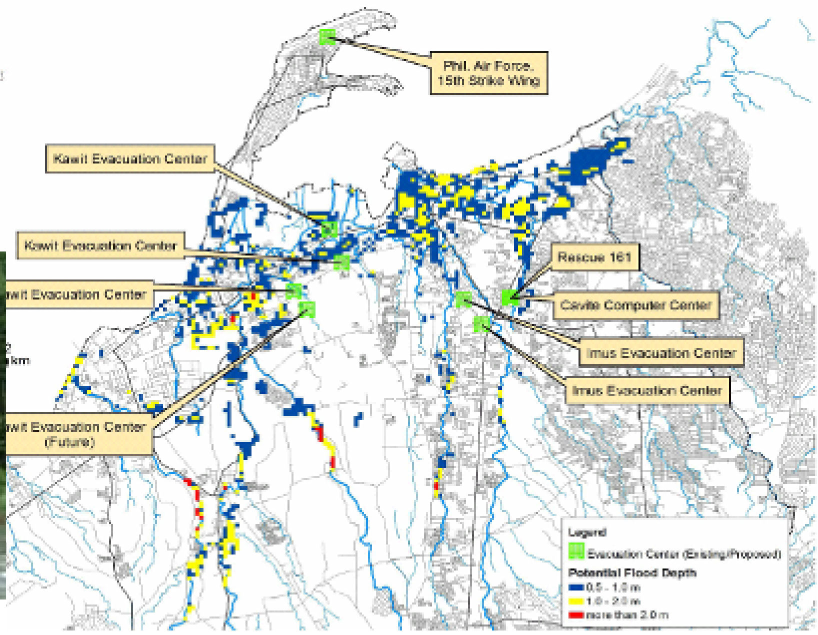


Fig. 13 Flood risk area and Evacuation Center

6 CONCLUSION

This case study shows that climate change and urbanization drastically deteriorate flood damages in areas under rapid urbanization in the suburb of Metro Manila. The number of houses inundated would be increased to two to three times. To mitigate these severe floods, an integrated CCA approach is proposed. Conventional structural measures and non-structural measures are jointly required. Land use management and retarding structures in river basins are useful counter measures.

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