REPUBLIC OF THE PHILIPPINES

DATA COLLECTION SURVEY
ON
URBAN INFRASTRUCTURE DEVELOPMENT IN GREATER COTABATO CITY

FINAL REPORT

ANNEXES

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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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ANNEX OF CHAPTER 4

Annex 4.1 – Land Demand and Supply Analysis for Cotabato City

ANNEX OF CHAPTER 5

Annex 5.1 - Transportation Surveys
Annex 5.2 - Road Condition Survey Sheet with Photographs
Annex 5.3 - Drainage Condition Survey Sheet with Photographs
Annex 5.4 - Straight Line Diagram of Surveyed Roads

ANNEX OF CHAPTER 7

Annex 7.1 – 1st Stake Holders Meeting
Annex 7.2 – 2nd Stake Holders Meeting

ANNEX OF CHAPTER 23

Annex 23.1- Traffic Demand Forecast Condition

DRAWINGS

Part1-West Diversion Road
Part2-Mindanao River South Side Road

Annex 4.1

Land Demand and Supply Analysis for Cotabato City

ANNEX 4.1
LAND DEMAND AND SUPPLY ANALYSIS FOR COTABATO CITY

1.1 Land Supply and Demand for Cotabato City

1.1.1 Inhabitable Land Analysis (Supply Side)

Natural hazards that frequently occurred in the city and its surrounding areas have become essential constraints on existing living and working environment and toward future socio-economic development for Cotabato City. Environmental vulnerability analysis aims to identify inhabitable lands where living and working activities are secured against natural hazards.

(1) Methodology

Cotabato City has various types of natural hazards to threaten living and working environment in the city such as flood, storm surge, tsunami, earthquake in association with liquefaction and landslide. The following methodology within limited conditions for the analysis is taken.

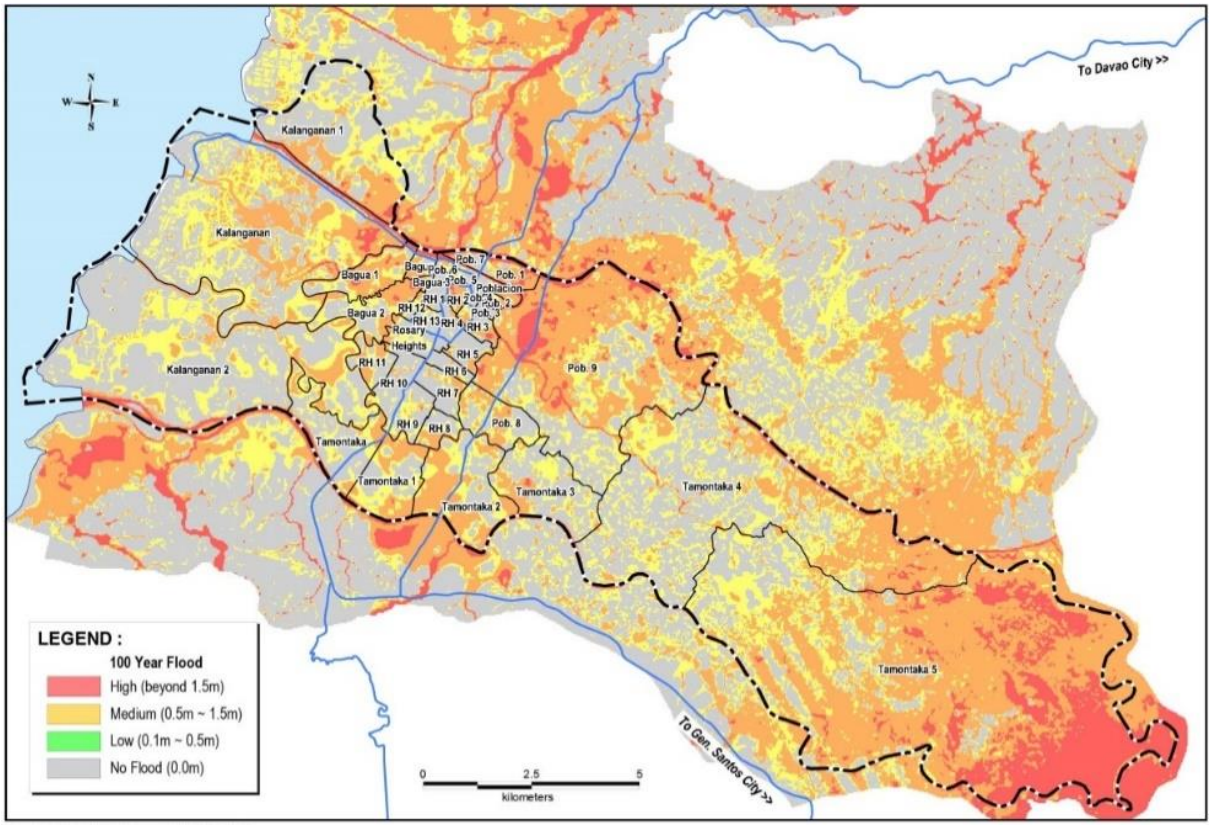
- **Flood risk factor identifying inhabitable lands:** The flood factor is one of the most essential negative factors to identify uninhabitable lands to be excluded. The flood hazard geo-data of LiDAR Portal (National Engineering Center of the University of the Philippines) for Archiving and Distribution (100 years flood probability) covering the city and surrounding areas publicized on the website as the available data is utilized. The criteria for inhabitable lands apply to the land with flood risk by the flood water depth under 0.5 m.

Table 1.1-1 Type and Criteria utilizing Flood Risk Data

Segment	Depth of Flood / Inundation	Criteria for Inhabitable Land
SEG-1	0 m	Applicable
SEG-2	0.1 - 0.5 m	Applicable with condition (by counter measures)
SEG-3	0.6 - 1.5 m	Not applicable by life-threatening and considerable physical damages as uninhabitable land
SEG-4	Over 1.5 m	

Source: JICA Study Team based on Flood hazard geo-data (2017) distributed by LiDAR Portal for Archiving and Distribution

- **Conditions for inhabitable lands:** Inhabitable lands could apply to land use types not only for settlement (residential, commercial, industry, institutions, etc) as low-risk areas against river flood or stormwater inundation but also favorable other uses of land use comparatively by agriculture land with less negative impacts in terms of economical damage on agricultural products under condition of a well-organized drainage system to shorten the time by submergence for agricultural products.



Source: Flood hazard geo-data (2017) distributed by LiDAR Portal for Archiving and Distribution

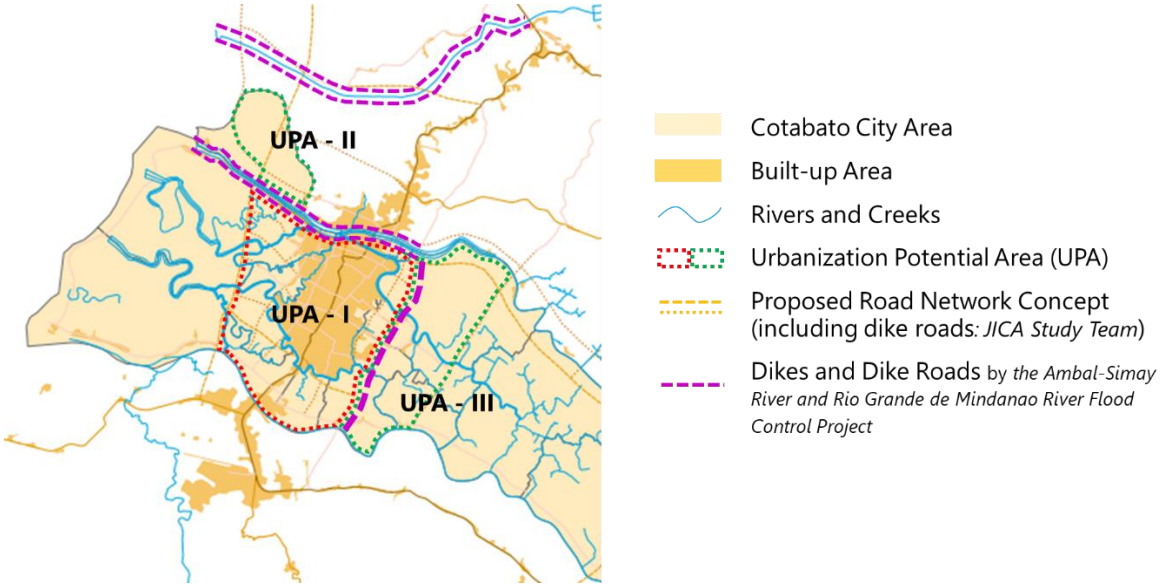
Figure 1.1-1 Flood Risk Hazard Map (100 years probability)

- **Another consideration for inhabitable land:** According to the Ambal-Simuay River and the Rio Grande de Mindanao Flood Control Projects by the Philippines government financed by the Chinese government, the construction of river dikes for Ambal-Simuay River and the Rio Grande de Mindanao River including river dike roads is expected to give positive impacts greatly on the secured urban areas as inhabitable lands in Cotabato City and its surroundings. Therefore this project should be considered as one of the factors to improve land conditions to analyze potentials for inhabitable land in the city.
- **Assessment by options including dike road concept:** The inhabitable lands are assessed by three options in cases of 1) the case-1 without of dikes and dike roads, 2) the case-2 with dikes and dike roads for the Urbanization Potential Area I (UPA-I) involving the existing urban area and surroundings enclosed by the dike road projects on the Cotabato East Diversion Road and a proposed dike road (JICA Study Team) as one of the west diversion roads, and 3) the case-3 adding other UPAs (UPA-II and UPA-III) with dikes and dike roads for the area of PUAs, where these two areas could be candidates for future expansion beyond 2040 unless UPA-I has enough land supply capacity against future population increase up to 2040. The following Table 1.1-2 and Figure 1.1-2 illustrating the status of Urbanization Potential Areas (I, II, III) with proposed road network (JICA Study Team) are conditions of land demand and supply analysis for inhabitable land.

Table 1.1-2 Three Urbanization Potential Areas (PUAs) as Supply-side Condition

Candidate of Urban Area	Inhabitable Land (ha)	Existing Land Use	Status and Potentials
UPA-I	1,692	• The existing key urban area including the city center • Agricultural land and vacant lands	• The highest urbanization potential area because of proximity to existing urban areas • The western side of the area is characterized as low-lying lands with high dense rivers and creeks
	2,565		
UPA-II	310	• Agricultural land with dispersed settlements • Some fishery ponds	• Second potential for urbanization with the advantage of the flood control project in Ambal-Simuay River and Rio Grande de Mindanao River • Comparative fewer rivers and creeks
	425		
UPA-III	648	• Agricultural land with dispersed settlements • Waste disposal site • Vacant lands	• The third potential for urbanization, if a dyke and dyke roads are provided with advantage proximity to an urban area (PUA-II)
	1,349		
Total	2,649	Inhabitable land excludes rivers and creeks, and land without severe flood (water depth over 0.5 m)	
	4,338	Inhabitable land excludes rivers and creeks and flood risk-free by dikes and dike roads	

Source: JICA Study Team



Source: JICA Study Team

Figure 1.1-2 Urbanization Potential Areas (UPA) in consideration with Dikes and Dike Roads Concept including the Flood Control Project for Inhabitable Land Analysis Assessment

2) Case-1 without any dike and dike road for all UPAs

- As the first step of the assessment, the land (C) in Table 1.1-3 with developable lands for urbanization potential area and agriculture land are identified as 15,185 ha deducted by the areas of (B) rivers and creeks (2,414 ha: 14%) from the administrative areas (A). Secondarily uninhabitable lands (D: flood risk areas over 0.5m water depth) defined in Table 1.1-1 are identified as 8,371 ha to be deducted for inhabitable lands.
- Finally, the inhabitable lands in the city are estimated by 6,814 ha (E: 39% out of the total city area), where all UPA-I (1,692 ha) covers 25% out of the total inhabitable area, and 958 ha by

the other candidate urban areas of UPA-II and UPA-III are estimated for future urban development if dikes and dike roads are developed for the UPAs.

- It should be noted that the inhabitable lands and uninhabitable flood risk areas are treated as an aggregated land volume area as a whole to verify the demand and supply totally, where actual land areas are necessary to secure a package of lands due to its dispersed distribution.

Table 1.1-3 Case-1 without Any Dike and Dyke Road for Inhabitable Lands of All UPAs

Type of Barangay	Settlement Area	Administrative Area (ha) (A)	Rivers & Creek (ha) (B)	Developable Land (ha) (C) (C= A-B)	Uninhabitable Flood Risk Area (ha) (D)	Inhabitable Land (ha) (E) (E=C-D)	Share (E)
Urban Barangay	UPA-I	2,738	293	2,445	814	1,631	23.9%
	UPA-II	515	90	425	115	310	4.5%
	UPA-III	1,072	87	985	556	429	6.3%
	Others	4,913	611	4,302	2,606	1,695	24.9%
	sub-total	**9,237**	**1,081**	**8,156**	**4,091**	**4,065**	**59.7%**
Rural Barangay	UPA-I	149	30	120	59	61	0.9%
	UPA-II	0	0	0	0	0	0.0%
	UPA-III	512	148	364	145	218	3.2%
	Others	7,701	1,155	6,546	4,076	2,470	36.2%
	sub-total	**8,363**	**1,333**	**7,029**	**4,280**	**2,749**	**40.3%**
Total	UPA-I	2,887	323	2,565	873	1,692	24.8%
	UPA-II	515	90	425	115	310	4.5%
	UPA-III	1,584	235	1,349	701	648	9.5%
	Others	12,613	1,766	10,847	6,682	4,165	61.1%
	Total	**17,599**	**2,414**	**15,185**	**8,371**	**6,814**	**100.0%**

Note: UPA = Urbanization Potential Area
Source: JICA Study Team based on the data of flood hazard geo-data (2017) of LiDAR Portal

3) Case-2 with dikes and dike roads formulating UPA-I

- Based on the assumption of dikes and dike roads formulating safe lands without floods as UPA-1, the inhabitable land (E) is estimated by 2,565 ha increasing 873 ha (51% increase of the case-1 without any dike and dike road). Therefore, expected dike and dike roads could contribute greatly to the capacity of land supply for UPA-1, although dikes and dike roads are required to add the proposed west diversion road (JICA Study Team) on the flood project as the secured urban area of UPA-I.
- Although UPA-II could provide a potential urbanization area taking account of the expected flood project with dikes and dike roads, there is another constraint close to the coastal area where risks by a storm surge or tsunami could affect negatively the UPA-II rather than PUA-I far from the coast. Therefore, UPA-II needs further improvement of another dike roads preventing storm surge or tsunami.
- Other potential urban lands by UPA-II and UPA-III enable to provide a certain scale of potential lands (958 ha), although this case is based on no dikes and dike roads to address larger land demand by future population beyond the capacity of this UPA-I.

Table 1.1-4 Case-2 with Dikes and Dike Roads formulating UPA-I

Type of Barangay	Settlement Area	Administrative Area (ha) (A)	Rivers & Creek (ha) (B)	Developable Land (ha) (C) (C= A-B)	Uninhabitable Flood Risk Area (ha) (D)	Inhabitable Land (ha) (E) (E=C-D)	Share (E)
Urban Barangay	UPA-I	2,738	293	2,445	0	2,445	31.8%
	UPA-II	515	90	425	115	310	4.0%
	UPA-III	1,072	87	985	556	429	5.6%
	Others	4,913	611	4,302	2,606	1,695	22.1%
	sub-total	**9,237**	**1,081**	**8,156**	**3,277**	**4,879**	**63.5%**
Rural Barangay	UPA-I	149	30	120	0	120	1.6%
	UPA-II	0	0	0	0	0	0.0%
	UPA-III	512	148	364	145	218	2.8%
	Others	7,701	1,155	6,546	4,076	2,470	32.1%
	sub-total	**8,363**	**1,333**	**7,029**	**4,221**	**2,808**	**36.5%**
Total	UPA-I	2,887	323	2,565	0	2,565	33.4%
	UPA-II	515	90	425	115	310	4.0%
	UPA-III	1,584	235	1,349	701	648	8.4%
	Others	12,613	1,766	10,847	6,682	4,165	54.2%
	Total	**17,599**	**2,414**	**15,185**	**7,498**	**7,687**	**100.0%**

Note: UPA = Urbanization Potential Area
Source: JICA Study Team based on the data of flood hazard geo-data (2017) of LiDAR Portal

4) Case-3 with dikes and dike roads formulating all UPAs as the maximum land supply capacity condition

- The inhabitable lands in Case-3 give the maximum land availability (8,503 ha) by all UPA-1, UPA-II, and UPA-III with dikes and dike roads network in every UPA to prevent river floods. The figures in detail are shown in Table 1.1-5.

Table 1.1-5 Case-3 with Dikes and Dike Roads formulating Area-A and Area-B for Inhabitable Lands by Settlement Area

Type of Barangay	Settlement Area	Administrative Area (ha) (A)	Rivers & Creek (ha) (B)	Developable Land (ha) (C) (C= A-B)	Uninhabitable Flood Risk Area (ha) (D)	Inhabitable Land (ha) (E) (E=C-D)	Share (E)
Urban Barangay	UPA-I	2,738	293	2,445	0	2,445	28.8%
	UPA-II	515	90	425	0	425	5.0%
	UPA-III	1,072	87	985	0	985	11.6%
	Others	4,913	611	4,302	2,606	1,695	19.9%
	sub-total	**9,237**	**1,081**	**8,156**	**2,606**	**5,550**	**65.3%**
Rural Barangay	UPA-I	149	30	120	0	120	1.4%
	UPA-II	0	0	0	0	0	0.0%
	UPA-III	512	148	364	0	364	4.3%
	Others	7,701	1,155	6,546	4,076	2,470	29.0%
	sub-total	**8,363**	**1,333**	**7,029**	**4,076**	**2,953**	**34.7%**
Total	UPA-I	2,887	323	2,565	0	2,565	30.2%
	UPA-II	515	90	425	0	425	5.0%
	UPA-III	1,584	235	1,349	0	1,349	15.9%
	Others	12,613	1,766	10,847	6,682	4,165	49.0%
	Total	**17,599**	**2,414**	**15,185**	**6,682**	**8,503**	**100.0%**

Note: UPA = Urbanization Potential Area
Source: JICA Study Team based on the data of flood hazard geo-data (2017) of LiDAR Portal

1.1.2 Land Demand Analysis

This analysis aims at examining conditions of future land demand by preliminary future population framework and land capacity (supply) by the inhabitable lands identified in the previous section to validate the population framework just as a total volume of population. Therefore, the purpose of this examination is not to validate population distributions into areas of the city. The examination proceeds under the following methodology including several hypothetical conditions.

(1) Methodology

- **Condition of the preliminary future population:** The preliminary future population is set out by two possible cases of lower growth case (Annual Average Growth Ratio: AAGR 1.86% as the current policy of Cotabato City) and higher growth case (2.93% as potential growth) with mid-term target 2028 and 2040 as a long-term frame. Two cases apply to the land demand estimation based on a density set taking account of the existing density of the city referring to the Philippines standards or norms. Regarding the distribution of the total population framework into barangays, it is also set by temporal figures for distribution taking account of existing distribution by Barangays (2015). The final densities will be set by the land use plan in the next stage.
- **Density standards:** Population density is one of the fundamental factors to examine and set out a future population in consideration with an appropriate living environment and sustainable settlement formulation. Although no close-fitting standards are defining gradual density (low-mid-high) in urban planning of the Philippines, several standards for housing projects of authorities of the government can be referred to, of which the standards, in general, indicate very high-density standards in comparison with the developed countries.
- **Compatible density standards:** The most familiar density term in general planning is used by "gross density" as people per area (a square kilometer or hectare) estimated by a total population and an administrative area. However, "semi-gross density" as a compatible term with the density standards in the Philippines is required for this examination, of which density is estimated by narrowing down to urban areas excluding conditional areas such as water bodies, natural environment as unsuitable lands for settlement.
- **UPA-I treated as a critical area for estimation:** UPA-I with existing urban settlement including candidate areas for future expansion will be the key supply-side areas addressing future population demands. This analysis considers critically the land supply capacity in consideration with a smaller amount of areas, of which land areas are estimated by GIS rather than the official land areas at the barangay level. Although it is observed that there are gaps between the official administrative areas and GIS estimations (15,086 ha), the total administrative area (17,599 ha) is managed by controlled total focusing on rural area barangays or large barangays.

Table 1.1-6 Referable Standards by Authorities in the Philippines for Semi-gross Population Density

Semi-gross (A)	
Density Type for Social Housing (IRR-RB220)	
Lot-unit / ha	Max Pop
a < 150	Under 660
151 < a < 160	704
151 < a < 175	770
151 < a < 200	880
151 < a < 225	990
225 < a	Over 990

Net-density (C)	
CLUP Residential Density (example)	
Type	Pop/ha
Low	Under 150
Medium	151 - 250
High	Over 250

Semi-gross (B)		
NHA Site Planning Guide Max Pop (NHA-MC-2015)		
Housing	Lot /ha	Max Pop
1 story	150	660
2 story	192	845
3 story	252	1,109
4 story	336	1,478
5 story	420	1,848

Typical Newtown Density (Japan)	
Pop Density / ha	
Semi	Net
Large	Large
300	650
Small	Small
60	250

Note: Number of persons is assumed by an average household (4.4 persons as Philippines average) per a lot/unit.
Source: Each regulative document (A, B, C) by the authorities of A: Housing and Land Use Regulation Board (HLURB) (Implementing Rules and Regulations for BP 220, C: National Housing Authority (NHA-MC-2015-0015 Guidelines for Site Selection, Site Suitability and Site Planning of NHA Housing Development Projects) and only reference by because of just samples in the document of HLURB CLUP Guidebook Volume 2. Densities in Japan based on URA data

(2) Existing density condition (semi-gross)

- Existing semi-gross densities by settlement areas of UPA-I, UPA-II, UPA-III, and others in urban and rural barangays are identified by the population in 2015 of the census of population (PSA) and built-up area by the geo-data (open-source map) updated by the satellite imagery of 2015 data (google earth).
- The average density of the whole built-up areas is 314 people per hectare (p/ha), while UPAs indicates the highest average density (775 p/ha, UPA-III in urban barangay) and the lowest (104 p/ha by Others in rural barangays). The maximum density is shown by 931 p/ha in UPA-III in rural barangay while the minimum density is 64 p/ha in Others in rural barangay and the median value of density is indicated by 244 p/ha in urban barangays and 250 p/ha as a whole.

Table 1.1-7 Existing Population Density by Built-up Areas (2015)

Type of Barangay	Settlement Area	Administration Area (ha)	Existing Built-up Area (ha)	Existing Population 2015	Existing Semi-gross Density Indices (Barangay Base) (person/ha)			
					Average	Maximum	Median	Minimum
Urban Barangay	UPA-I	2,738	1,152	263,391	287	739	239	91
	UPA-II	515	7	3,789	--	559	--	559
	UPA-III	1,072	21	3,690	245	316	--	174
	Others	4,913	79	16,736	293	559	238	135
	sub-total	**9,237**	**1,259**	**287,606**	**292**	**739**	**244**	**91**
Rural Barangay	UPA-I	149	3	1,769	--	619	--	619
	UPA-II	0	0	0	--	--	--	--
	UPA-III	512	7	5,145	775	931	--	619
	Others	7,701	44	4,918	104	145	--	64
	sub-total	**8,363**	**54**	**11,832**	**475**	**931**	**619**	**64**
Total	UPA-I	2,887	1,155	265,160	297	739	244	91
	UPA-II	515	7	3,789	--	559	--	559
	UPA-III	1,584	28	8,835	510	931	467	174
	Others	12,613	123	21,654	241	559	145	64
	Total	**17,599**	**1,313**	**299,438**	**314**	**931**	**250**	**64**

Note: UPA = Urbanization Potential Area
Source: JICA Study Team based on open-source geo-data updated by Google Earth and 2015 Census of Population (PSA)

(3) Preliminary population growth by two growth cases (AAGR: 1.86% and 2.93%)

- Based on the two growth cases by AAGR 1.86% and 2.93%, the preliminary population growth for the target year 2028 and long-term population 2040 are set out by the settlement areas as shown in Table 1.1-8.
- The majority of the population (over 80%) is distributed into the area of UPA-I in every phase from 2015 to 2040 followed by the existing distribution trend.

Table 1.1-8 Preliminary Population Growth Case in 2028 and 2040 (AAGR: 1.86%)

Type of Barangay	Settlement Area	Population in 2015	Share	Population in 2028	Share	Population in 2040	Share
Urban Barangay	UPA-I	263,391	88.0%	334,695	88.0%	417,555	88.0%
	UPA-II	3,789	1.3%	4,815	1.3%	6,007	1.3%
	UPA-III	3,690	1.2%	4,689	1.2%	5,850	1.2%
	Others	16,736	5.6%	21,267	5.6%	26,532	5.6%
	sub-total	**287,606**	**96.0%**	**365,465**	**96.0%**	**455,943**	**96.0%**
Rural Barangay	UPA-I	1,769	0.6%	2,248	0.6%	2,805	0.6%
	UPA-II	0	0.0%	0	0.0%	0	0.0%
	UPA-III	5,145	1.7%	6,538	1.7%	8,156	1.7%
	Others	4,918	1.6%	6,249	1.6%	7,797	1.6%
	sub-total	**11,832**	**4.0%**	**15,035**	**4.0%**	**18,757**	**4.0%**
Total	UPA-I	265,160	88.6%	336,943	88.6%	420,359	88.6%
	UPA-II	3,789	1.3%	4,815	1.3%	6,007	1.3%
	UPA-III	8,835	3.0%	11,226	3.0%	14,006	3.0%
	Others	21,654	7.2%	27,516	7.2%	34,328	7.2%
	Total	**299,438**	**100.0%**	**380,500**	**100.0%**	**474,700**	**100.0%**

Note: UPA = Urbanization Potential Area

Source: JICA Study Team

Table 1.1-9 Preliminary Population Growth Case in 2028 and 2040 (AAGR: 2.93%)

Type of Barangay	Settlement Area	Population in 2015	Share	Population in 2028	Share	Population in 2040	Share
Urban Barangay	UPA-I	263,391	88.0%	383,250	88.0%	541,757	88.0%
	UPA-II	3,789	1.3%	5,513	1.3%	7,794	1.3%
	UPA-III	3,690	1.2%	5,369	1.2%	7,590	1.2%
	Others	16,736	5.6%	24,352	5.6%	34,423	5.6%
	sub-total	**287,606**	**96.0%**	**418,484**	**96.0%**	**591,563**	**96.0%**
Rural Barangay	UPA-I	1,769	0.6%	2,574	0.6%	3,639	0.6%
	UPA-II	0	0.0%	0	0.0%	0	0.0%
	UPA-III	5,145	1.7%	7,486	1.7%	10,582	1.7%
	Others	4,918	1.6%	7,156	1.6%	10,116	1.6%
	sub-total	**11,832**	**4.0%**	**17,216**	**4.0%**	**24,337**	**4.0%**
Total	UPA-I	265,160	88.6%	385,824	88.6%	545,396	88.6%
	UPA-II	3,789	1.3%	5,513	1.3%	7,794	1.3%
	UPA-III	8,835	3.0%	12,855	3.0%	18,172	3.0%
	Others	21,654	7.2%	31,508	7.2%	44,539	7.2%
	Total	**299,438**	**100.0%**	**435,700**	**100.0%**	**615,900**	**100.0%**

Note: UPA = Urbanization Potential Area

Source: JICA Study Team

1.1.3 Demand and supply assessment

(1) Assumption of assessment

- The supply-side is examined through the capacity of the future population by the inhabitable lands by three cases of Case-1 (without dikes and dike roads), Case-2 (with dikes and dike roads for UPA-I), and Case-3 (with dikes and dike roads for all UPAs) under the following assumptions taking account of sustainable urban development with natural environment protection and/or agricultural use in the habitable lands.
  - ✓ New lands for urban settlement within the inhabitable lands can be developed by decent population density with the assumption of settlement density (240 p/ha: referring to the median value of the all "average density" values) without drastic change or increase of density formulation except lower density areas to be fitted with this value.
  - ✓ As the inhabitable land including lowland suitable for agriculture lands and/or natural environment for biodiversity can be developed by agriculture development area or other recreational open spaces with an assumption basis.
  - ✓ The inhabitable lands identified in the previous analyses are considered by the urban land use occupancy whether the lands dedicated to "urban area including settlement, commercial-business and industries, public facilities, infrastructure and park and open spaces" or "other agriculture land use or other green areas". Therefore, the assumptions are set by "urban land use occupancy rate" for the area of urban settlement in the inhabitable lands. The existing proportion between the urban area and other lands (e.g. agriculture, etc) in each PUA is referred to as a decent ratio to the analyses.
  - ✓ Supply-side capacity is also examined by two cases of the preliminary future population growth (AAGR: 1.86% growth and 2.93% growth) except cases to be apparent by expected or presumed results without estimation.

(2) Assessment in Case-1 (without dikes and dike roads)

- In Case-1 without dikes and dike roads based on both demands for future population growth (AAGR: 1.86% and 2.93%), the land supply is apparently insufficient in 2040 as a whole capacity, although the land demand by both population growth cases (380,500 by 1.86% and 435,700 by 2.93%) in 2028 could be secured by the total land supply. As a result, the total land capacity of UPAs and Other areas without dikes would not be capable to absorb the total future population demand of 2040 even if the lower growth (1.86%) case as shown in Table 1.1-10. Otherwise high-density settlement (e.g. over 340 p/ha as average) is required for UPAs to accommodate the future population as this assumption applies the density by 240 p/ha to land supply condition.

Table 1.1-10 Demand and Supply Assessment in Case-1 (without Dikes and Dike Roads) by the case of AAGR 1.86%

Type of Barangay	Settlement Area	Inhabitable Land (ha) (A)	Urban Land Use Occupancy (%)	Urban Land Use Area (ha)	Population Capacity by Applied Average Density (240p/ha)	A balance between Preliminary Population Growth (1.86%)	
						2028	2040
Urban Barangay	UPA-I	1,631	100.0%	1,631	391,385	56,690	-26,170
	UPA-II	310	2.0%	6	1,487	-3,327	-4,519
	UPA-III	429	5.0%	21	5,151	462	-698
	Others	1,695	5.0%	85	20,341	-925	-6,190
	sub-total	**4,065**	**42.9%**	**1,743**	**418,365**	**52,900**	**-37,578**
Rural Barangay	UPA-I	61	100.0%	61	14,658	12,410	11,853
	UPA-II	0	0.0%	0	0	0	0
	UPA-III	218	3.0%	7	1,572	-4,966	-6,584
	Others	2,470	2.0%	49	11,855	5,606	4,059
	sub-total	**2,749**	**4.3%**	**117**	**28,085**	**13,050**	**9,328**
Total	UPA-I	1,692	100.0%	1,692	406,042	69,100	-14,317
	UPA-II	310	2.0%	6	1,487	-3,327	-4,519
	UPA-III	648	4.3%	28	6,723	-4,503	-7,282
	Others	4,165	3.2%	134	32,197	4,681	-2,131
	Total	**6,814**	**27.3%**	**1,860**	**446,450**	**65,950**	**-28,250**

Note: UPA = Urbanization Potential Area
Source: JICA Study Team

Table 1.1-11 Demand and Supply Assessment in Case-1 (without Dikes and Dike Roads) by the case of AAGR 2.93%

Type of Barangay	Settlement Area	Inhabitable Land (ha) (A)	Urban Land Use Occupancy (%)	Urban Land Use Area (ha)	Population Capacity by Applied Average Density (240p/ha)	A balance between Preliminary Population Growth (2.93%)	
						2028	2040
Urban Barangay	UPA-I	1,631	100.0%	1,631	391,385	8,135	-150,372
	UPA-II	310	2.0%	6	1,487	-4,026	-6,306
	UPA-III	429	5.0%	21	5,151	-218	-2,438
	Others	1,695	5.0%	85	20,341	-4,010	-14,082
	sub-total	**4,065**	**42.9%**	**1,743**	**418,365**	**52,900**	**-37,578**
Rural Barangay	UPA-I	61	100.0%	61	14,658	12,084	11,019
	UPA-II	0	0.0%	0	0	0	0
	UPA-III	218	3.0%	7	1,572	-5,914	-9,010
	Others	2,470	2.0%	49	11,855	4,699	1,740
	sub-total	**2,749**	**4.3%**	**117**	**28,085**	13,050	9,328
Total	UPA-I	1,692	100.0%	1,692	406,042	20,219	-139,353
	UPA-II	310	2.0%	6	1,487	-4,026	-6,306
	UPA-III	648	4.3%	28	6,723	-6,132	-11,448
	Others	4,165	3.2%	134	32,197	689	-12,342
	Total	**6,814**	**27.3%**	**1,860**	**446,450**	**10,750**	**-169,450**

Note: UPA = Urbanization Potential Area
Source: JICA Study Team

(3) Assessment in Case-2 (with dikes and dike roads for UPA-I)

- Case-2 with dikes and dike roads for PUA-I could solve the insufficient land capacity against the future population demand both in 2028 and 2040 as a whole capacity as shown in Table 1.1-12 (AAGR-1.86%) and Table 1.1-13 (AAGR-2.93%).
- Taking account of sufficient capacity of the secured land supply from flood risk in Case-2 with dikes and dike roads, lower density could be applied to Case-2 by the density of 180 p/ha in the case of population growth (1.86%), while Case-2 by population growth (2.93%) requires a little bit lower density (230 p/ha) than the applied density (240 p/ha).

Table 1.1-12 Demand and Supply Assessment in Case-2 (with Dikes and Dike Roads) by the case of AAGR 1.86%

Type of Barangay	Settlement Area	Inhabitable Land (ha) (A)	Urban Land Use Occupancy (%)	Urban Land Use Area (ha)	Population Capacity by Applied Average Density (240p/ha)	A balance between Preliminary Population Growth (1.86%)	
						2028	2040
Urban Barangay	UPA-I	2,445	100.0%	2,445	586,788	252,094	169,234
	UPA-II	310	2.0%	6	1,487	-3,327	-4,519
	UPA-III	429	5.0%	21	5,151	462	-698
	Others	1,695	5.0%	85	20,341	-925	-6,190
	sub-total	**4,879**	**52.4%**	**2,557**	**613,769**	**248,304**	**157,826**
Rural Barangay	UPA-I	120	100.0%	120	28,710	26,462	25,905
	UPA-II	0	0.0%	0	0	0	0
	UPA-III	218	3.0%	7	1,572	-4,966	-6,584
	Others	2,470	2.0%	49	11,855	5,606	4,059
	sub-total	**2,808**	**6.3%**	**176**	**42,138**	**27,103**	**23,380**
Total	UPA-I	2,565	100.0%	2,565	615,499	278,556	195,139
	UPA-II	310	2.0%	6	1,487	-3,327	-4,519
	UPA-III	648	4.3%	28	6,723	-4,503	-7,282
	Others	4,165	3.2%	134	32,197	4,681	-2,131
	Total	**7,687**	**35.6%**	**2,733**	**655,906**	**275,406**	**181,206**

Note: UPA = Urbanization Potential Area
Source: JICA Study Team

Table 1.1-13 Demand and Supply Assessment in Case-2 (with Dikes and Dike Roads) by the case of AAGR 2.93%

Type of Barangay	Settlement Area	Inhabitable Land (ha) (A)	Urban Land Use Occupancy (%)	Urban Land Use Area (ha)	Population Capacity by Applied Average Density (240p/ha)	A balance between Preliminary Population Growth (2.93%)	
						2028	2040
Urban Barangay	UPA-I	2,445	100.0%	2,445	586,788	203,539	45,032
	UPA-II	310	2.0%	6	1,487	-4,026	-6,306
	UPA-III	429	5.0%	21	5,151	-218	-2,438
	Others	1,695	5.0%	85	20,341	-4,010	-14,082
	sub-total	**4,879**	**52.4%**	**2,557**	**613,769**	**195,285**	**22,205**
Rural Barangay	UPA-I	120	100.0%	120	28,710	26,136	25,071
	UPA-II	0	0.0%	0	0	0	0
	UPA-III	218	3.0%	7	1,572	-5,914	-9,010

	Others	2,470	2.0%	49	11,855	4,699	1,740
	sub-total	**2,808**	**6.3%**	**176**	**42,138**	**24,921**	**17,801**
Total	UPA-I	2,565	100.0%	2,565	615,499	229,675	70,103
	UPA-II	310	2.0%	6	1,487	-4,026	-6,306
	UPA-III	648	4.3%	28	6,723	-6,132	-11,448
	Others	4,165	3.2%	134	32,197	689	-12,342
	Total	**7,687**	**35.6%**	**2,733**	**655,906**	**220,206**	**40,006**

Note: UPA = Urbanization Potential Area
Source: JICA Study Team

(4) Assessment in Case-3 (with dikes and dike roads for all UPAs)

- **The assumption for Case-3 with dikes and dike roads for all UPAs:** As examined in Case-2, indicating sufficient supply capacity of Case-2 (only UPA-1), Case-3 with all UPAs with dikes and dike roads, the larger lands by all UPAs could allow applying lower density than Case-2. And the urban land use occupancy would not be necessary to utilize all of UPA-II and UPA-III. As the results, The lower density of Case-3 is applicable such as 140 p/ha in 1.86% population growth and 180 p/ha, under the condition of 50 % of the urban occupancy rate applied to UPA-II and UPA-III.
- As described in the above assumption for Case-3, the expected urban areas of all PUAs would be able to accommodate both future population growth (1.86% and 2.93%) in 2028 and 2040. However, it should be noted that UPA-I would not be able to accommodate population demand in case of the lower density in both cases of 1.86% and 2.93% population growth.

Table 1.1-14 Demand and Supply Assessment in Case-3 (with Dikes and Dike Roads for All UPAs) by the case of AAGR 1.86%

Type of Barangay	Settlement Area	Inhabitable Land (ha) (A)	Urban Land Use Occupancy (%)	Urban Land Use Area (ha)	Population Capacity by Applied Average Density (140p/ha)	A balance between Preliminary Population Growth (1.86%)	
						2028	2040
Urban Barangay	UPA-I	2,445	100.0%	2,445	342,293	7,599	-75,261
	UPA-II	425	50.0%	212	29,719	24,904	23,712
	UPA-III	985	50.0%	492	68,946	64,257	63,096
	Others	1,695	5.0%	85	11,866	-9,401	-14,666
	sub-total	**5,550**	**58.3%**	**3,234**	**452,824**	**87,359**	**-3,119**
Rural Barangay	UPA-I	120	100.0%	120	16,748	14,499	13,943
	UPA-II	0	0.0%	0	0	0	0
	UPA-III	364	50.0%	182	25,467	18,929	17,311
	Others	2,470	2.0%	49	6,916	666	-881
	sub-total	**2,953**	**11.9%**	**351**	**49,130**	**34,095**	**30,373**
Total	UPA-I	2,565	100.0%	2,565	359,041	22,098	-61,319
	UPA-II	425	50.0%	212	29,719	24,904	23,712
	UPA-III	1,349	50.0%	674	94,413	83,186	80,407
	Others	4,165	3.2%	134	18,782	-8,734	-15,547
	Total	**8,503**	**42.2%**	**3,585**	**501,954**	**121,454**	**27,254**

Note: UPA = Urbanization Potential Area
Source: JICA Study Team

Table 1.1-15 Demand and Supply Assessment in Case-3 (with Dikes and Dike Roads for All UPAs) by the case of AAGR 2.93%

Type of Barangay	Settlement Area	Inhabitable Land (ha) (A)	Urban Land Use Occupancy (%)	Urban Land Use Area (ha)	Population Capacity by Applied Average Density (180 p/ha)	A balance between Preliminary Population Growth (2.93%)	
						2028	2040
Urban Barangay	UPA-I	2,445	100.0%	2,445	440,091	56,842	-101,665
	UPA-II	425	50.0%	212	38,210	32,697	30,416
	UPA-III	985	50.0%	492	88,644	83,275	81,055
	Others	1,695	5.0%	85	15,256	-9,096	-19,167
	sub-total	**4,879**	**66.3%**	**3,234**	**582,202**	**163,718**	**-9,362**
Rural Barangay	UPA-I	120	100.0%	120	21,533	18,958	17,894
	UPA-II	0	0.0%	0	0	0	0
	UPA-III	364	50.0%	182	32,743	25,257	22,161
	Others	2,470	2.0%	49	8,892	1,736	-1,224
	sub-total	**2,808**	**12.5%**	**351**	**63,167**	**45,951**	**38,831**
Total	UPA-I	2,565	100.0%	2,565	461,624	75,800	-83,772
	UPA-II	425	50.0%	212	38,210	32,697	30,416
	UPA-III	1,349	50.0%	674	121,388	108,533	103,216
	Others	4,165	3.2%	134	24,148	-7,360	-20,391
	Total	**8,503**	**42.2%**	**3,585**	**645,369**	**209,669**	**29,469**

Note: UPA = Urbanization Potential Area
Source: JICA Study Team

1.1.4 Implication of Assessment

- The assessment results by these examinations imply that only PUA-1 in Case 2 could accommodate the population demand (both growth 1.86% and 2.93%) by the certain level of population density (240 p/ha) in 2028 and 2040, where flood control project with dikes and are inevitable to secure a safe settlement from flood risks. However, issues of appropriate population distribution and density formulation would remain to be resolved, especially in rural barangays settlement where there are flood risks without dikes and dike roads.
- In every case (1.2. and 3), inbalance distribution between surplus (sufficient capacity) and deficit (oversupply capacity) in each settlement becomes evident due to simple population projection following the current distribution pattern. Coping with these inappropriate distributions, higher density to absorb more population in each settlement would be required, as the settlement distributions in rural barangays are necessary to formulate appropriate scale with flood risks, agriculture development, and environmental conservation.
- Therefore, the distribution of the preliminary population growth with appropriate density for settlements, and relevant land uses of residential, agricultural land, and the natural environmental area should be scrutinized in the further detailed land use planning for the city.

1.1.5 Development considerations with dikes and dike roads network for UPAs

- **Inhabitable Land with Condition of Acceptable Water Depth (0.5m):** The water depth of inundation or flood by past flood events indicates its importance as a direct indicator for the degree of flood risks in general. The water depth of 0.5 m has been observed as a turning point toward difficult conditions of evacuation easiness, considerable building damage, and less asset damage. On the other hand, the countermeasures to eliminate flood and inundation conditions would require huge investment costs. Complete relocation of settlements located in a frequently flooded is also a difficult option. Therefore, inundation or flood water depth by 0.5 m is a criterion for the maximum allowable depth taking into account inhabitable lands under the condition that mitigation measures for flood and inundation are made.
- **Necessary Drainage System Improvement for Flood Mitigation in UPAs:** As the lands in UPAs are a pre-condition of Case-2 and 3 with dikes and dike roads, safe land from flood risks should be secured by certain measures including reclamation or drainage system improvement or provision of retention areas for river water, as the inhabitable areas include acceptable inundation areas (0.1 m to 0.5 m potential flood depth) and difficult areas with considerable flood water depth over 0.5 m. Table 1.1-16 suggests requirement areas for improvement by appropriate measures.

Table 1.1-16 Area to be Improved Coping with Acceptable Inundation Areas in Habitable Area in PUA and SUA

Type of Barangay	Settlement Area	Total Developable Land (ha) (A)	0.0 m depth Area Secured from Flood Risk	Area to be Improved		Share of Areas by Water Depth to be Improved		
				0.1~0.5m	Over 0.5m	0.0m	0.1~0.5 m	Over 0.5m
Urban Barangay	UPA-I	2,445	544	1,087	814	22%	44%	33%
	UPA-II	425	106	204	115	25%	48%	27%
	UPA-III	985	205	225	556	21%	23%	56%
	sub-total	**3,854**	**855**	**1,515**	**1,485**	**22%**	**39%**	**39%**
Rural Barangay	UPA-I	120	31	30	59	26%	25%	49%
	UPA-II	0	0	0	0	0	0	0
	UPA-III	364	97	122	145	27%	33%	40%
	sub-total	**483**	**128**	**152**	**204**	**26%**	**31%**	**42%**
Total	UPA-I	2,565	575	1,117	873	22%	44%	34%
	UPA-II	425	106	204	115	25%	48%	27%
	UPA-III	1,349	301	346	701	22%	26%	52%
	Total	**4,338**	**983**	**1,667**	**1,689**	**23%**	**38%**	**39%**

Note: UPA = Urbanization Potential Area
Source: JICA Study Team

- **Mitigation measures against flood risks for settlements outside of dike roads:** Unless settlements outside of the dike road for UPAs are relocated into inhabitable areas without flood risks, the settlements would face particular concern for the flood. Some measures by both of structure and non-structure such as building design control by compulsory multi-story building, evacuation training and measures and early warning for flood, etc.