PART FOUR:
MACRO ANALYSIS ON GIS

Geographical maps provided by Indonesian National Coordinating Agency for Surveys and Mapping (BAKOSURTANAL), with scale of 1:25,000 for Jawa Island and 1:50,000 for other islands, were scanned and saved in GIS system, based on the UTM coordinates noted on these maps.

Throughout 3 years, several kinds of satellite images available, including LANDSAT7, SPOT and IKONOS were monitored and compared, from viewpoint of quality (mainly rate of clouds), resolution for identifying building/district type and land use, etc. The original satellite images were converted to orthogonal images, through several obvious objects whose locations are identified on geographical maps. Finally, those images are stored into GIS system and the following analysis was carried out:

(1) Boundaries among different land-use, building typology were identified. Each area of land-use/building type was stored in the form of polygon, so that the total area of each land-use could be summed up.

(2) Altitude zones were identified, based on singular points on geographical maps noted with altitude (1m, 2m etc.). Coast lines are also referred for this identification.

(3) Cross-tabulation between land use zones and altitude zones was executed on GIS in order to know the configuration of land-use in the area where the land will be submerged after SLR.

(4) Each segment of land-use was multiplied by the index, that show the basic unit per hectare, in order to calculate the total loss caused by SLR as for whole city.

In this part, a prediction with GIS on future inundated areas, accompanied with estimation of building loss illustration on typical adaptations.

4.1. Method and Data available

In order to evaluate the total amount of assets within a city which might be damaged/lost after Sea Level Rise, identification of land-use area and contour zone is inevitable.

Usually, basic geographical map available is provided by National Institute for Geography and Mapping (BAKOSURTANAL) with scale of 1:25,000 (cities in Jawa Island) and 1:50,000 (other cities). This map follows UTM co-ordinate system and major streets, built-up area, coastal line etc. are identified. Contour lines are given with pitch of 12.5m. However, as for land use, it provides only the built-up area. Identification of detailed land-use or building typology is impossible by this.

Satellite images are recently available, and its resolution is getting higher to identify than. We tested LANDSAT7, SPOT and IKONOS for identifying land use. It came clear that the latest IKONOS, with highest resolution let us identify individual buildings and detailed land use. However, the service of IKONOS was started since 2000 and it did not cover all the cities to be surveyed, with enough low rate of clouds.

Table 4.1. Specification of available satellite images

	LANDSAT7	SPOT	IKONOS
START SINCE	1979-	1988-	1999-
RESOLUTION	28.5m	10m (monochrome)	1m

Table 4.2. Analyzed cities and data utilized/obtained

Site \ The done	Satellite Image Analysis	Fact-finding Survey	Building Measurement Survey	Adaptation Study
Jakarta	IKONOS	O	O	
Semarang	IKONOS	O	O	O
Surabaya	(IKONOS)	O	O	
Makassar	LANDSAT7	O	O	O
Banjarmasin	SPOT	O	O	
Palembang	*	O	**	
Denpasar	*		O	
Mataram	*		O	

* Satellite images were not available/ in good quality
**Abandoned, because geographical map was not available

The Satellite images were, by referring to several identical objects on geographical map, calibrated/converted to the orthogonal (orthographic) image and saved into GIS system, on which scanned image of geographical map is also kept.

As for some cities, more precise maps with special purpose were available. For example, in Makassar, detailed map with scale 1:10,000 was provided for planning urban sewage network. In this map, detailed contour is noted and rough building typology could be identified.

4.2. Identification of current area zone on GIS

After preparing image data with calibration, area zoning of land use and contour are identified. After that we prepared the format of polygon to specific layer, in order that they can be cross tabulations.

As for Makassar, satellite image of LANDSAT7 could give only rough land use identification, although the geographical map (1:50,000) provides little information about land use and contour. However, the special map for urban plant planning was available.

As for Semarang and Jakarta (Northern "Penjaringan" district), high-resolution satellite image of IKONOS was available and geographical map of 1:25,000 was also avalable. IKONOS images (pan chrome) were enough for identifying land-use area/zone.

4.2.1. Land-use identification through satellite image

In cases of Semarang and Jakarta, IKONOS with high resolution (1m/dot) was available and direct images, border lines between different land-use /building types were identified (Fig.4-1) and, these images were converted to such as the form of polygon data in GIS system(Fig. 4-2)

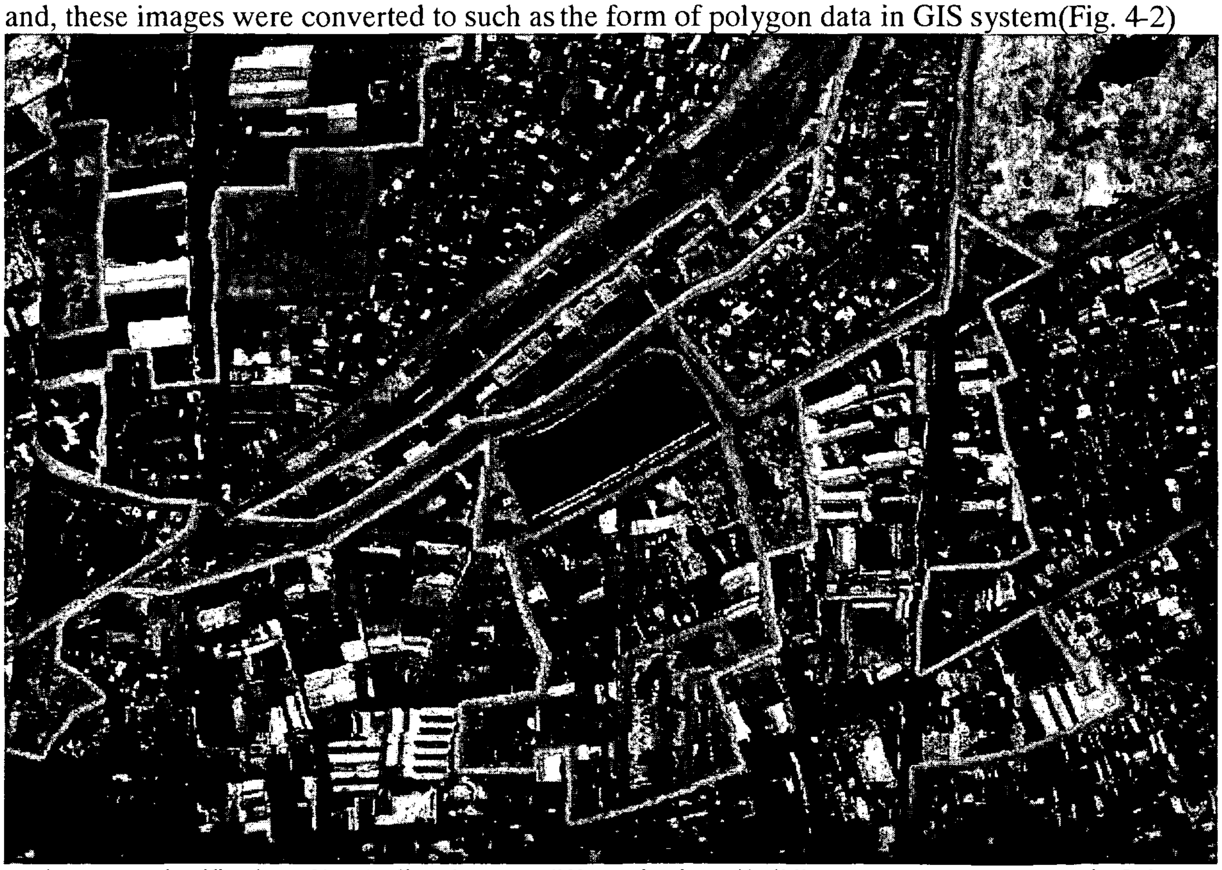


Figure 4.1. Identification of border lines between different land use / building types on satellite image in GIS

At least, 7 types of land use were identified: (1)un-planned housing, (2) planned housing, (3) public buildings, (4) factories and storages, (5) commercial, (6) pond, and (7) open space.

In case of cities where satellite image with high-resolution (IKONOS) is available, number of buildings can be counted to get the building density. For example, in "Tanjung-Mas" district, which is categorized as "un-planned housing area" can be measured as 843,938 m2 (including road), where 5,296 buildings are counted. Therefore, the building density is calculated as 62.75 units/ha.

On the contrary, in case of Makassar, resolution of LANDSAT7 images (Fig.4-4a,b) is not enough for directly identifying detailed land use pattern. However, a special map with 1:10,000 scale was available (Fig.4-5), from which rough land use pattern of (1) unplanned housing area (2) planned housing area (3) public building were identified. That is; we suppose; Unplanned housing area is mainly consist of traditional timber houses with raised floor (platform type) in low-wet area, and planned area housing area is consist of masonry houses. And public buildings area drawn separately, surrounded by garden or open space in the map, some of which are large residential houses, factories, offices etc, which could not be identified separately.

Figure4.2. Zones of specific land-use/building types, on GIS] the categories are : (1)un-planned housing, (2) planned housing, (3) public buildings, (4) factories and storages, (5) commercial,(6) pond, and (7) open space

As for Jakarta, several land use categories are added, including (8) wide road (fly-over), (9) High-rise flat houses, (10) Area hidden by clouds, etc due to the more complex urban space.

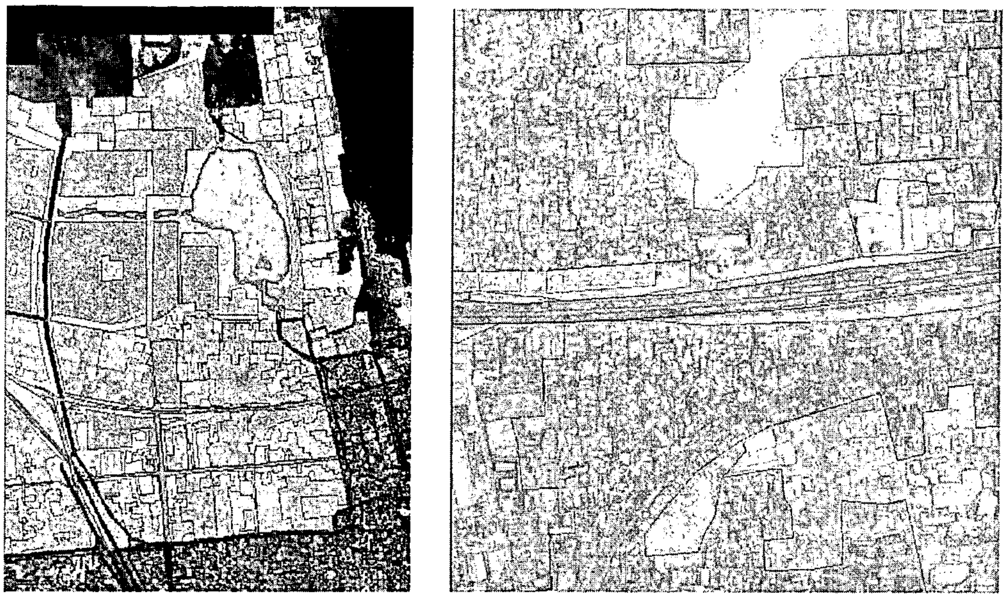


Figure4.3. Jakarta: Land use zone

Figure4.4a. Makassar LANDSAT7 image: urban area

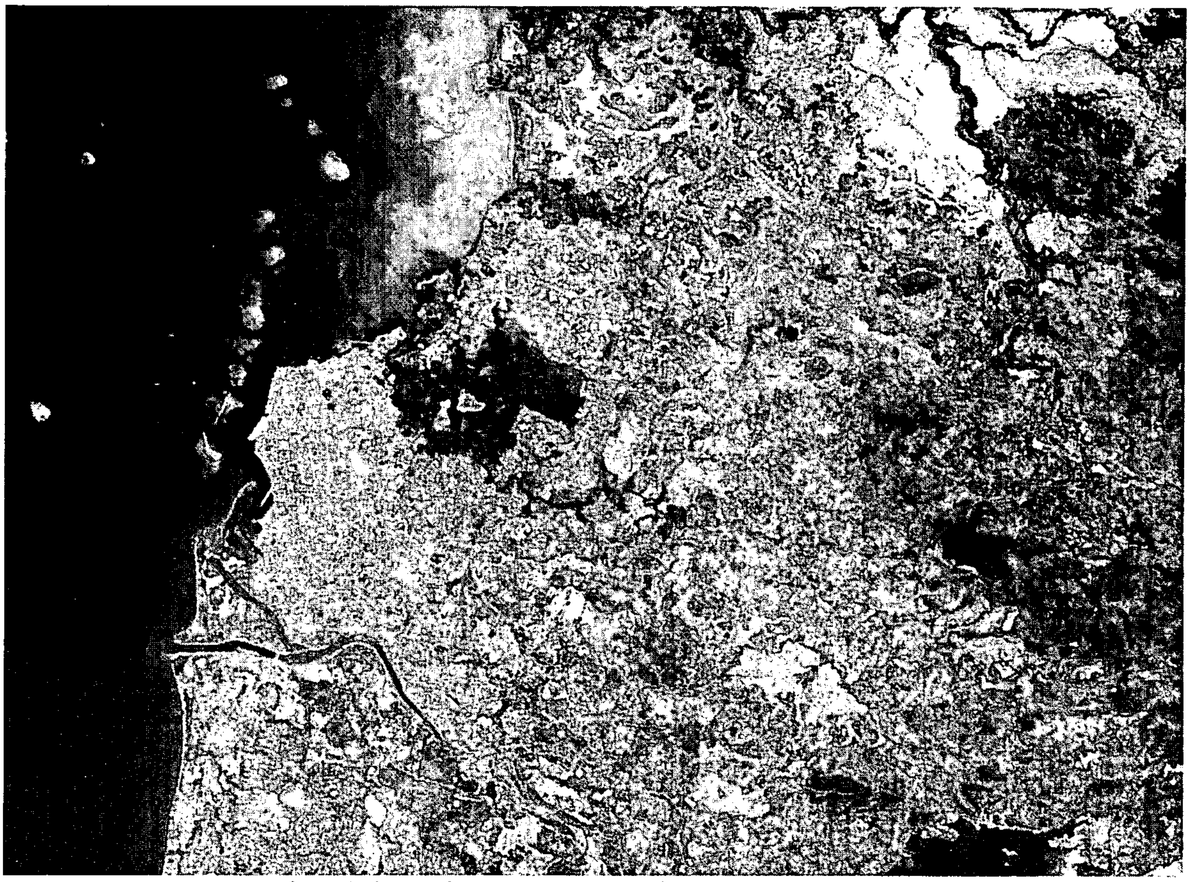


Figure4.4b. Makassar LANDSAT7 image, surrounding area

Figure4.5. Makassar, special map for planning urban plant, 1:10,000

4.2.2. Contour zone identification from geographical map data

It is possible to identify contours from satellite images, if a slant view is also available. In some cases, precise map provided for specific purpose is useful (e.g. Map for flood control in Makassar, 1:10,000) to pick-up contour lines (Fig.4-7). In other cases, a best way was to pick up singular height points from the standard map (1:25,000 or 1:50,000) provided by the national mapping authority. The contour zones (0-1m, 1-2m, etc.) are also described as polygon data in GIS.

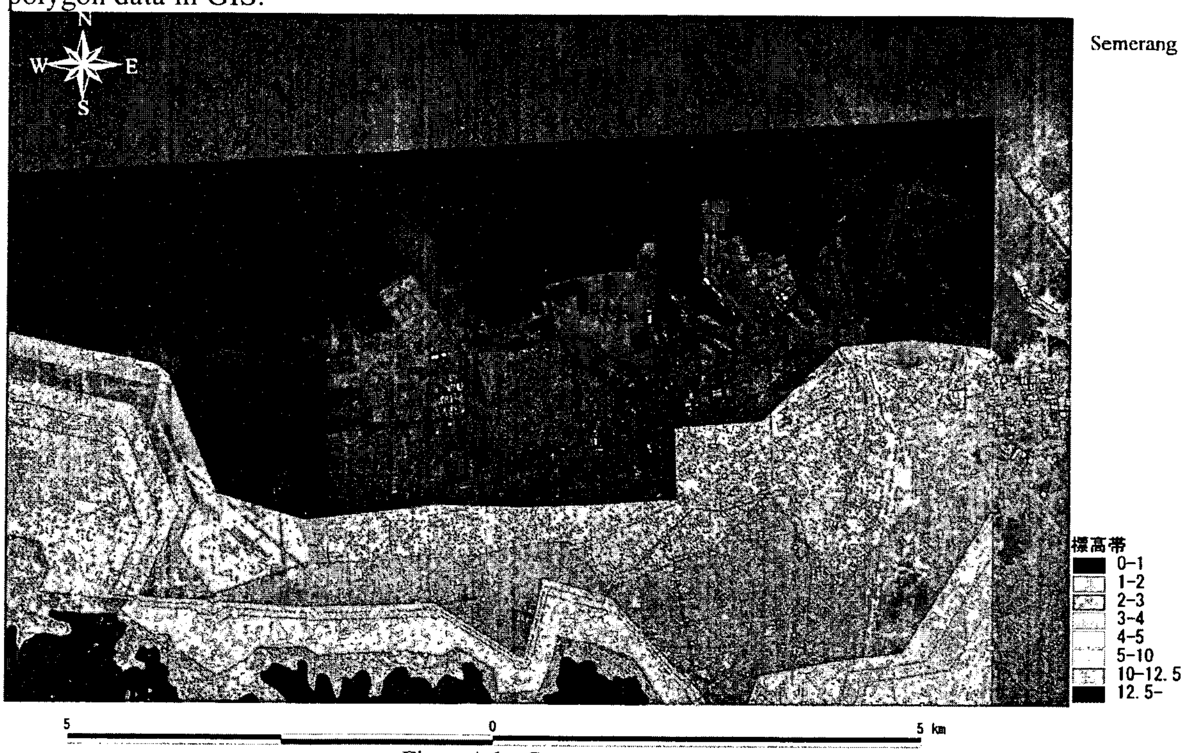


Figure4.6. Semarang, contour zone

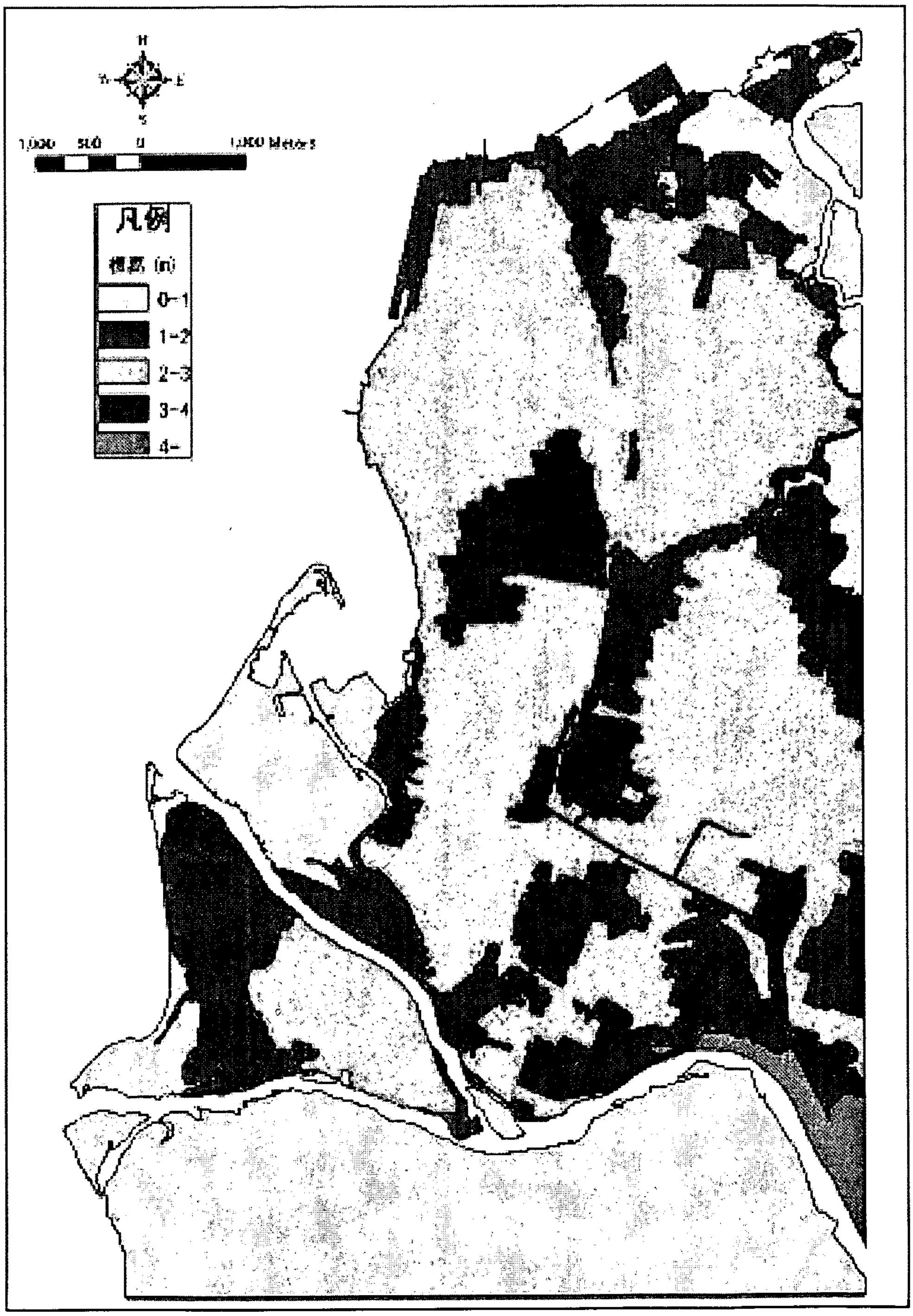
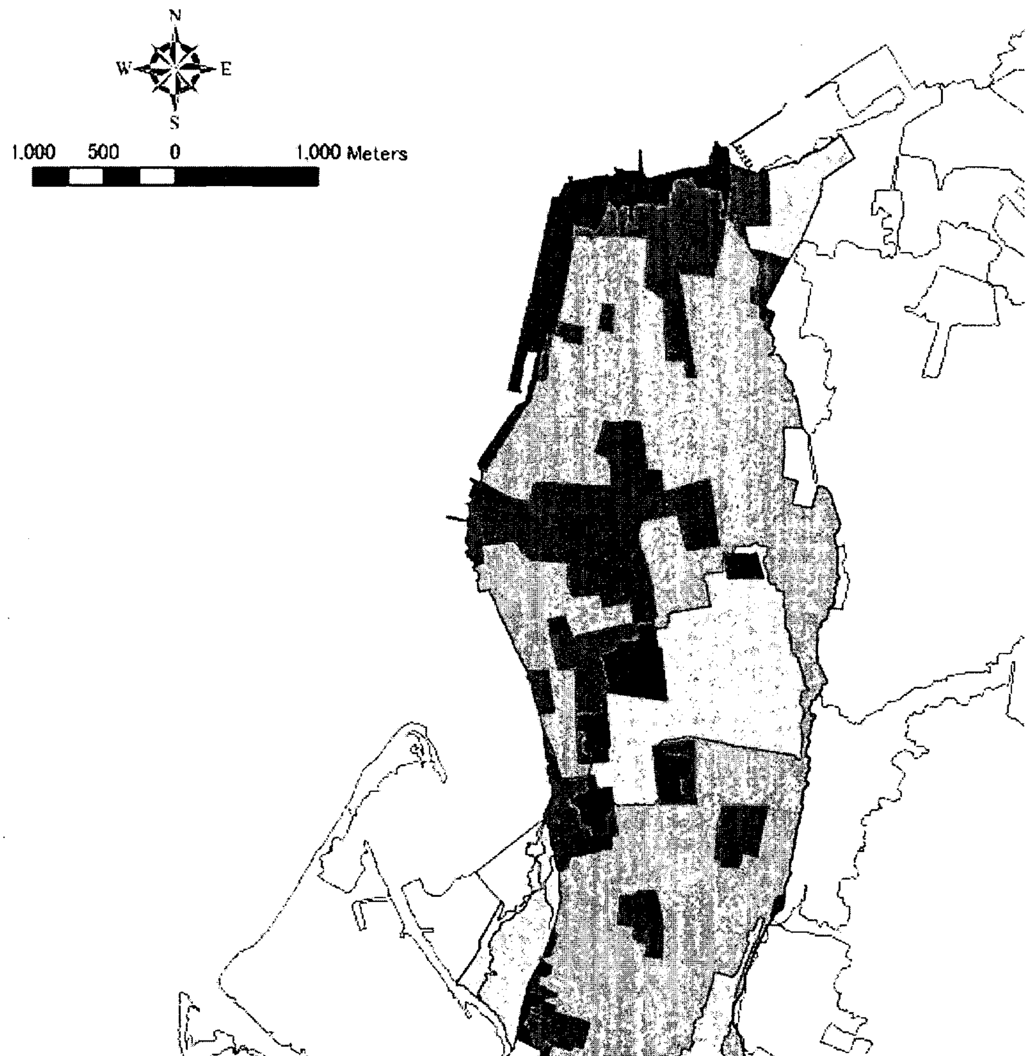


Figure4.7. Makassar, contour zone

4.3. Identification of damaged area after SLR



TYPE OF BUILDING/AREA	0m	0-1m	-2m	-3m	-4m
Unplanned housing area					-
Planned housing area	-	-			
Public buildings	-	-			

Figure4.8. Makassar, Land use * contour

After identifying 2 zones; area of each land-use zone and contour zone was measured. Table 4-3 shows an example for Semarang city.

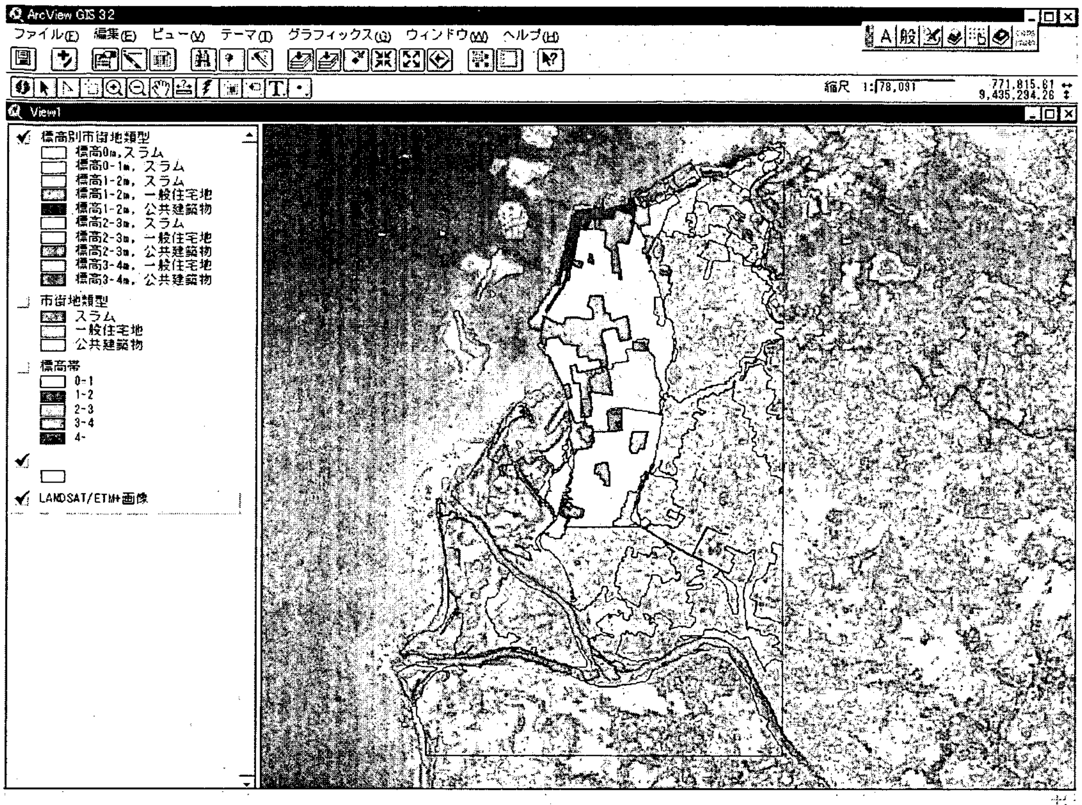


Figure4.9. Makassar, Land use * contour zone, overlapped with satellite image

Table4.3. Table of area (hectars) of each land use * contour zone (Semarang)

Height / Urban classification	0-1m	1-2m	2-3m	3-4m	4-5m	5-10m	10-12.5m	12.5m -	total
Un-planned residential area	171.37	128.06	69.94	11.07	8.93	22.07	26.04	11.88	
Planned residential area	314.40	316.79	436.64	68.59	39.76	140.43	118.91	128.46	
Public buildings	69.80	216.76	133.52	21.14	14.95	70.79	47.52	25.92	
Factory/warehouse	150.62	56.42	17.53	1.04	2.01	16.94	9.01	20.04	
Commercial area	0.00	3.41	13.83	0.00	0.00	0.00	0.00	0.00	
Pond	607.89	114.64	64.70	66.54	69.55	217.87	5.37	0.00	
Open space	584.80	199.39	315.36	73.39	53.00	115.65	72.22	95.42	

Table4.4. Table of area (hectars) of each land use * contour zone (Makassar)

TYPE OF BUILDING/AREA	HEIGHT					total
	0m	0-1m	1-2m	2-3m	3-4m	
Unplanned housing area	12.7765	10.1163	57.4270	3.2051	0.0000	
Planned housing area	0.0000	0.0000	27.8788	652.1688	1.8206	
Public Building	0.0000	0.0000	56.2596	235.7445	42.1709	
total						

Table4.5. Average features of sampled houses

city→	Jakarta	Semarang	Surabaya	Denpasar	Mataram	Makassar	Banjarmasin
Age(years)	27.2	22.6	27.4	14.1	9.8	22.3	36.7
1st fl. area(m^3)	51.2	74.2	78.2	89.0	44.7	47.7	89.3
2nd fl. area(m^2)	38.3	0.0	3.8	0.0	0.0	27.3	5.9
Foundation(m^3)	24.2	24.1	32.2	89.0	7.4	46.1	3.1
Wall of 1st fl.(m^2)	122.1	120.3	166.3	225.7	123.9	120.3	172.6
Wall of 2nd fl.(m^2)	90.3	0.0	11.4	0.0	0.0	73.3	20.4
Door & window (m^2)	12.1	14.5	15.4	13.9	12.4	10.1	26.7
Sash (m^2)	7.7	3.5	8.2	10.4	5.3	5.5	8.9
Ceiling (m^2)	84.5	30.2	39.0	89.0	13.7	44.15	75.3
Roof area(m^2)	89.5	107.9	103.8	108.9	82.1	75.0	unknown

In order to multiply total unit loss and area as for each urban area, simply, the area of each land-use zone lower than the forecasted sea level are multiplied by each basic unit of damage of respective land-use, and summed up.

Usually, the area below 1m contour is taken for rough calculation. Strictly speaking, we are trying to assume the future coast line might not agree with 1 m contour, but with the contour of current highest tide line (=coast line) plus 1 m, so we calculate the impact through proportional distribution from the table data.

(Table 4-6) shows the result of Makassar city, which shows the area below the height of SLR is classified as "un-planned housing area".

Table4.6. summary of Makassar

DENSITY
BUILDING DENSITY : 182 units/ha HOUSEHOLD DENSITY : 255 household/ha
PER BUILDING UNIT
MATERIAL USE / UNIT : - timber 4.5 m3 / unit - brick 4,000 pieces / unit - cement 1,000 kg / unit MANPOWER INVESTED / UNIT : 4 man-month (carpenter & assistant)
PER HECTAR
MATERIAL USE / HA - timber 819 m3 / ha - brick 728,000 pieces / ha - cement 182 tons / ha MANPOWER INVESTED / HA : 728 man-month
FOR TOTAL AREA BELOW 1 M CONTOUR : 22.9 ha, all un-planned housing area
LOST LAND : 22.9 HA Submerged BUILDING : 4,168 UNITS Submerged HOUSEHOLDS AFFECTED : 5,840 households Submerged MATERIAL USE - timber : 18755 m3 - brick : 16,672,000 pieces - cement : 4167.8 tons MANPOWER INVESTED for restorations or repairs : 16,671 man-month

This roughcalculation is only summing up the total of assets existing on the land below 1m of contour. This assumes that total loss of the area will occur only 1 time in 100 years. And if the abandoned house will be just ending the life time (less than 100 years) at the time point of re-settlement, the total loss might be almost negligible.

On the contrary, when we examine the heavy extra payments of dwellers of the area where high-water/flood frequently attacks, then the total loss could be far higher. The total extra cost for inevitable adaptation will including more frequent re-building in 100 years. Therefore, in further discussions, we have to calculate the additional damage costs appended by SLR. This kind of extra cost for adaptation will continually occur in every year, and will be summed up for 100 years. Many of the poor families even so in such a risky zone seem unlike to choose the way to re-settle for the time being.

4.3.1. Future coastline

Height of coastline corresponds to the normal highest sea level above average sea level. Tidal movement is described by major 4 harmonics constants of M2, S2, K1 and O1, and the highest sea level are hydrographically supposed to be equal to the sum of these 4 constants. According to the data from Japan Hydrographic Association(http://www.jha.jp/index_e.html), the available data relevant for the cities being investigated area shown in table 4-7).

Table4.7. Tidal data

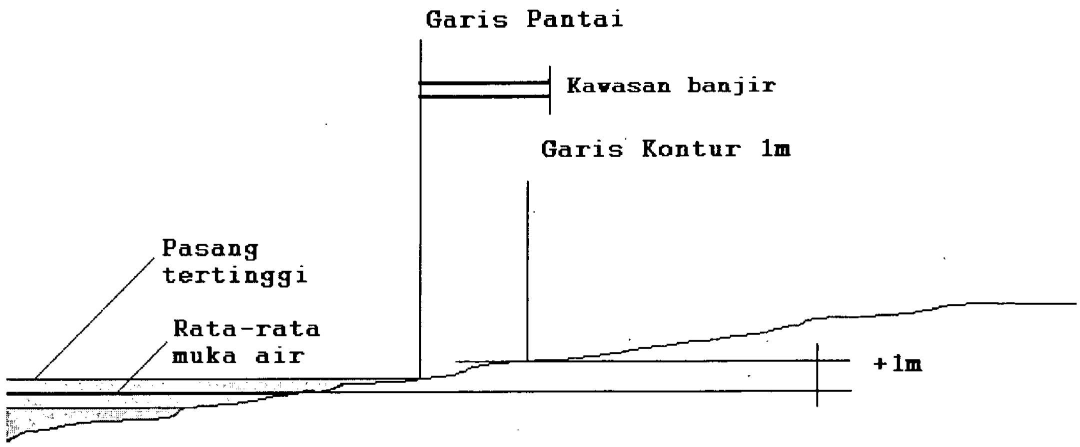
	M2	S2	K1	O1	TOTAL
Jakarta	0.05	0.05	0.21	0.13	0.44 m
Semarang	0.10	0.08	0.22	0.08	0.48
Surabaya	0.35	0.21	0.47	0.26	1.29
Banjarmasin	0.31	0.05	0.59	0.32	1.27
Makassar	0.08	0.11	0.28	0.17	0.64
Denpasar	0.57	0.14	0.38	0.20	1.29
Mataram	0.57	0.14	0.38	0.20	1.29

These values are relatively small, because the geographical conditions along the Javanese sea, causes tidal movement relatively small. (c.f. Along East China Sea, it can reach to 4m).

So future coastline might reasonably correspond to the current contour line of these values of height above current average sea level in this study.

4.3.2. Future inundated area

The Sea-level rise will cause advance of coastline, and that is; available land will decrease. It means the low-wet area, which is now frequently inundated, will also be either submerged area or easily flood area, and other areas free from inundation now will become easily suffered from flood. In order to analyze SLR precisely, detailed flood simulation is needed. However, simply moving contour lines of inundated area by assumed degree of SLR could show the future area of inundated area.



[Fig.4-10 : Location of Seacoast line and 1m Contour line]

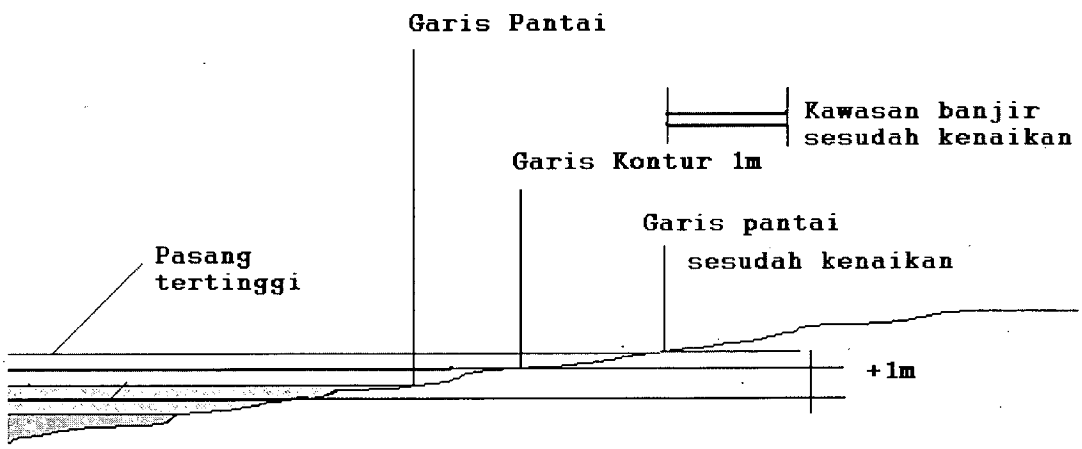


Figure4.11. Advance of Seacoast line and with drawal ofinundated area after SLR

4.4. Total Loss of living areas in terms of damaged houses

Total loss caused by SLR will be the amount of land and building which are totally lost and the repeated partial loss ob building caused by inundation which will occur more frequently than before SLR.

Table 4-8 shows the partial loss of buildings caused by one time inundation, reported through questioner answered by the inhabitants who live in the low-wet area. It depends on the type of building (platformed type /landed type) and height of highwater, however this shows the profile of damages. Besides this, time losses (time spent for rehabilitation, time for activities stop, etc) occurring are reported in previous chapters.

Table4.8. Partial loss caused by one time inundation

Cities→	Jakarta	Semarang	Surabaya	Makassar	Denpasar	Mataram	Banjarmasin

Stone(m3)	1.6	0.3		11.0			
Brick(m3)	27.9	7.9	9.8	26.9	8.7	0.8	
Plaster(m2)	68.4	61.6	34.7	28.0	0.5	31.8	
Timber(m3)	2.3	0.8	0.5	3.3	0.0	0.3	7.4
Plywood(m2)	24.1	9.2	2.7	9.2		0.5	1.1
Roof tile(m2)	16.1	16.5	38.7			1.6	
Asbestos(m2)	14.8	5.5	2.1			1.4	
Zinc plate(m2)	2.1	4.1	0.1	29.7		7.5	
RC(m3)							
Floor tile(m2)	1.7	1.1	2.7	3.0			
Wall tile(m2)		1.9	2.7			1.5	
Bamboo mat(m2)		1.7	4.8			2.2	
Bamboo(m)		4.6		15.0		1.2	

4.5. Typical Adaptations

Adaptation is already undertaken in several cities where land subsidence has caused impacts which are deemed as similar to what will happen after SLR. Following types of adaptation could be listed up.

(1) Provision of Bank/Dike and Pumping

Provision of bank/dike and pumping might to be effective to give least change to the existing land use pattern. However, the cost for initial investment and operation will be heavy to the developing area. Also, if the 'rob' phenomena (ground water leakage from the soil) occurs, then the function of Bank/Dike will be limited.

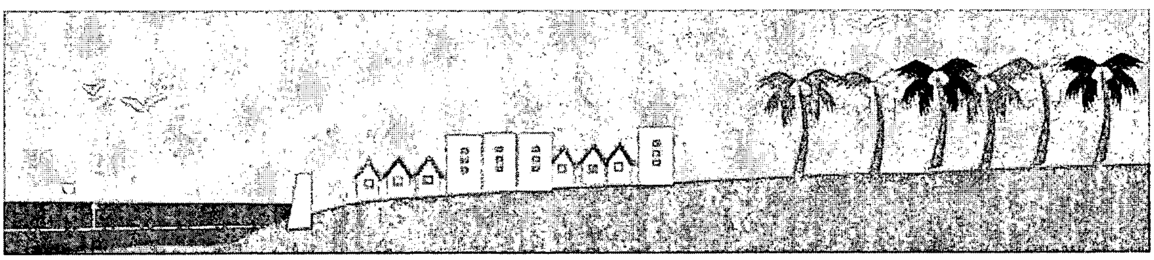


Figure4.12. Provision of Bank & Pump

(2) Reclamation

This approach is already taken in individual/family scale in damaged areas. Also urban scale reclamation is undertaken by public/private sectors in coastal areas(Photo4-1~3). Garbage disposal/treatment would also be useful materials for reclamation (Photo4-4~5). In Japan, sometimes new town development, which needs place to dispose a huge amount of soil, is accompanied with another reclamation project.

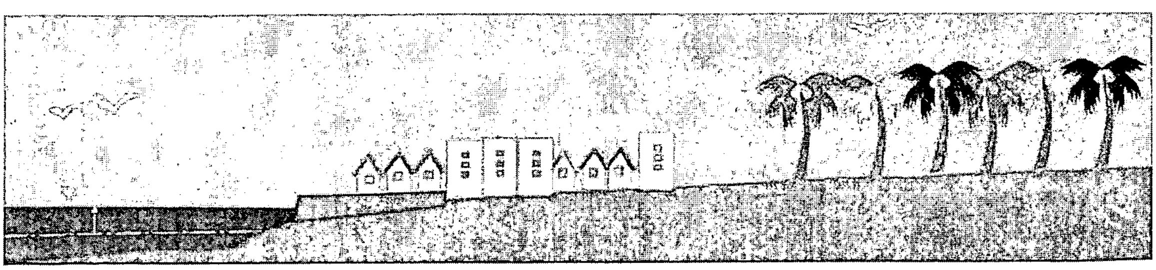


Figure4.13. Reclamation

(3) Relocation

If no considerable/careful approach is taken, inhabitants in coastal areas who are not capable to adapt by themselves will go out to find another place to live in. In that context, smooth provision of housing is a kind of solution. In Makassar, elder generation tends to remain in the traditional style houses in coastal zone, while younger generation tends to seek for find modern style houses in inner-land area.

If housing provision or planned relocation will not take place, deterioration of living condition through increasing population density, or unplanned land-use change (destruction) of forestry or agricultural land will occur.

As observed in fishery villages on coastal zone, re-location to the inner-land will cause change of then occupations and daily lives. This will need also social adaptation.

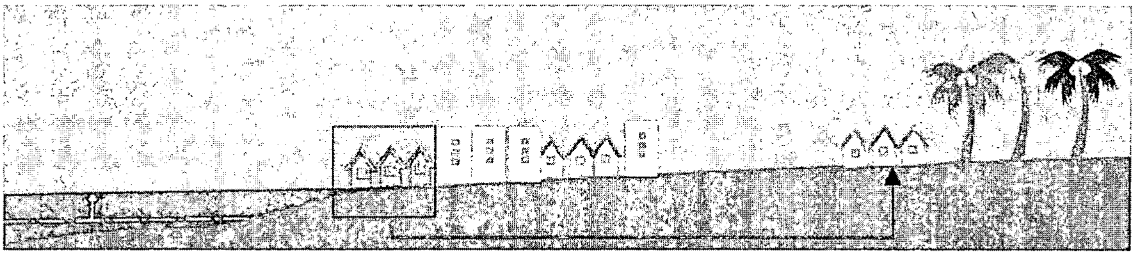


Figure4.14. Relocation

(4) High-rise buildings

This could be a solution to prevent horizontal urban extension. However, economical capacity is needed to afford this kind of solution.(Photo ...)

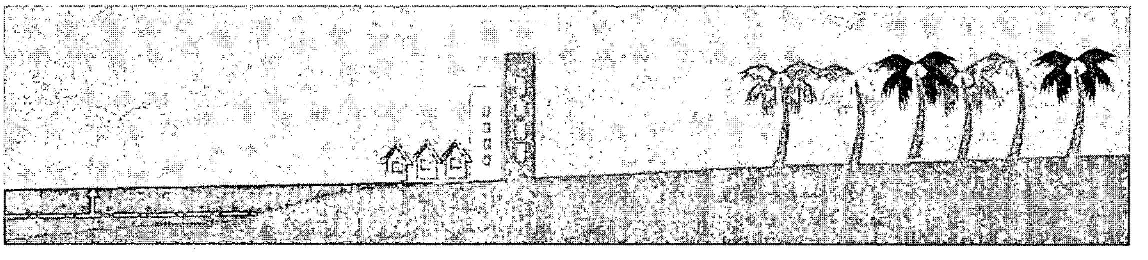


Figure4.15. High-rise buildings

Photo4.1~3. Urban scale reclamation, undertaken by private sector] (2002.01 Semarang, by H.K.)

For simulating the cost and benefit of these kinds of counter measures, each arrangement is described as change of contour zone (1, 2) and as change land use zone. Benefit factor is assessed through decrease of loss/damage, while cost factor is assessed through the achievement of past projects. Up to now, cost factor is still difficult to monitor accurately, because many projects were executed as model/pilot ones. This will be more precisely studied in the next studies. In short, slow relocation in parallel to the normal re-construction activities seems to be the effective choice. However, there is a strong will of inhabitants to continue to live in the same place, giving advantage to the income opportunity. Might it lead to a drastic collapse of a community which will occur when extraordinary weather attacks the community. Therefore, social approach is needed, that enables to choose better solution in the long run.


Photo 4.4~5. Reclamation through disposal of garbage, waste soil (2003/01 Semarang, by H.K.)

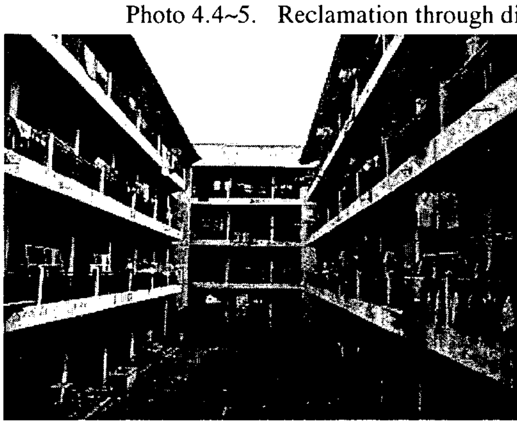



Photo 4.6~7. Example of flat house, Bandarhardjo, north Semarang, completed in 1998. subsidence in 4 years is observed at its foundation