Land subsidence and Climate Change Adaptation in Jakarta Bay, Indonesia

Case study on Yeosu Project - 3D Topographic Survey Using LIDAR on Vulnerable Areas and Establishment of Coastal Management Plan in Jakarta Bay

EAS Congress 2015

18th November 2015
Furama Resort, Da Nanag, Viet Nam

Dr. Park, Han san
KIOST

Contents

YEOSU PROJECT

Outline of Project

YEOSU PROJECT

Project Title

- STUDY ON ESTABLISHMENT OF INTEGRATED COASTAL MANAGEMNT PROGRAM IN JAKARTA BAY AREA, INDONESIA
- Sub Title : *3D Topographic Survey Using LIDAR on Vulnerable Areas and Establishment of Coastal Management Plan in Jakarta Bay*

Project Period

- Phase I : October 2010 ~ April 2012 (18 month)
- Phase II : October 2012 ~ December 2013 (14 month)

Project implementation:

- Korea Institute of Ocean Science and Technology (KIOST)
- Bandung Institute of Technology (ITB)

Funding Resources

- The Organizing Committee for **EXPO 2012 Yeosu Korea**

Outline of Project - Background

- Coastal flooding
  - Higher sea surface than land

Outline of Project - Background

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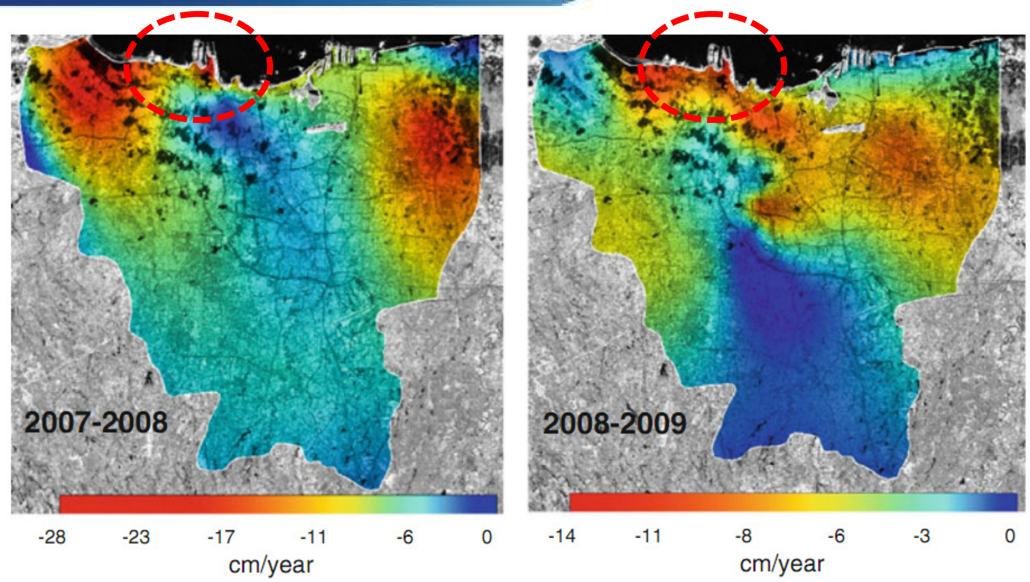
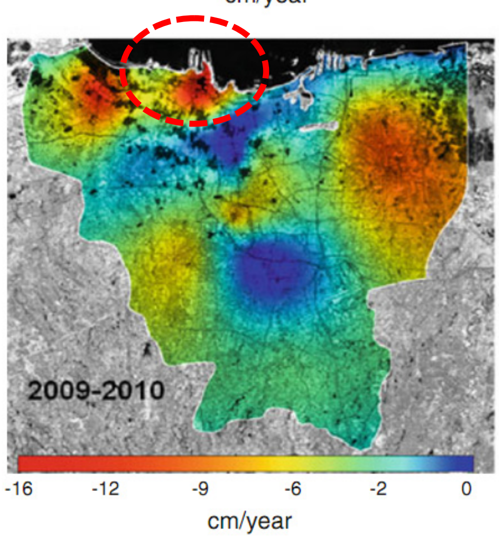




- Level of Land subsidence derived from GPS in Jakarta

* Hasanuddin Z. Abidin, Heri Andreas, Irwan Gumilar, Yoichi Fukuda, Yusuf E. Pohan, T. Deguchi, 2011, Land subsidence of Jakarta (Indonesia) and its relation with urban development, *Nat Hazards*, DOI : 10.1007/s11069-011-9866-9

Outline of Project

YEOSU PROJECT

Objective

- To obtain and analyze scientific data of Land subsidence,
- To set up criteria based scientific analysis for decision maker about land subsidence
- To provide capacity building program and equipment for Indonesia experts

CONTENTS OF PROJECT

Project Contents – Survey and Research

YEOSU PROJECT

- Literature review on land subsidence in Jakarta bay
- 3D Topographical survey and analysis
  - 3D topographical survey on Pantai mutiara
  - Topography and structure data processing and analyzing
  - Costal flooding vulnerability analysis
- Policy recommendations for coastal zone management
  - Benefit / cost analysis
  - Practical recommendations based scientific survey and analysis for by land subsidence

Project Contents – Capacity Building

- Training for Survey data processing and analyzing
  - Field survey training using Terrestrial LIDAR, Total-station and GPS
  - Data processing software training
- Training for Coastal zone management and policy
  - Data analyzing training using surveyed data in GIS
  - Introducing CZM in Korea – at IPB
- Total trainee : 240persons (15p x 4day x 4times)

Project Contents – Provision of Equipment

- Provision Survey equipment and computer for monitoring and data processing by Indonesia

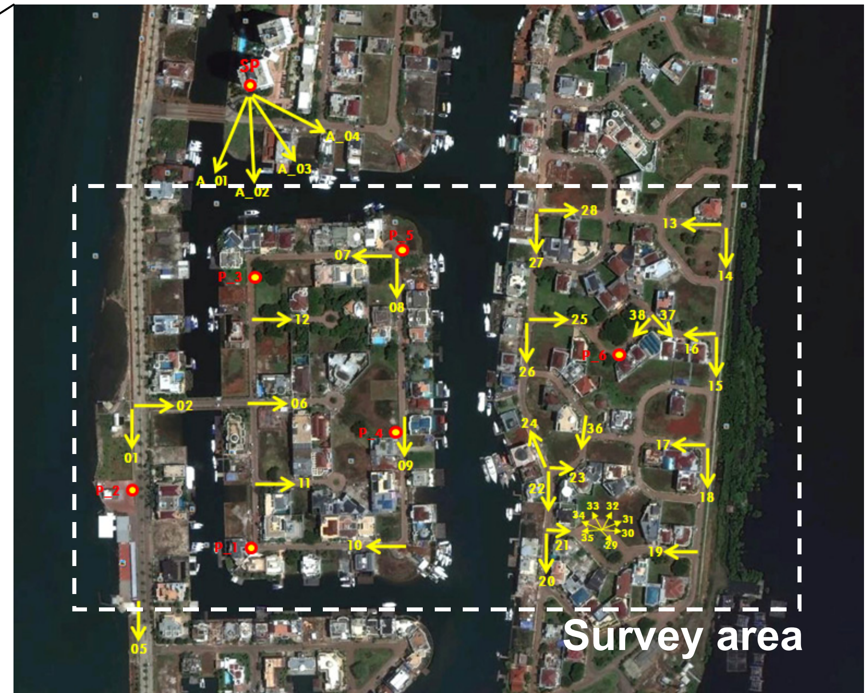
Item	Specification	Quantity
Total-station	- Angle accuracy 2" - Reflectorless measuring range 1200m	1
Surveying instrument accessory	- Single Prism, 2m Pole, Mini-Tripod	3
Laptop computer	- Intel-i7 CPU, 8G RAM, 500G HDD - Full-HD 17” LCD	8

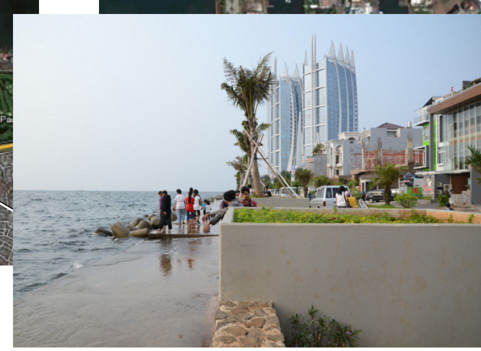



RESULTS OF SURVEY AND ANALYSIS

Site Selection

- Survey site : Pantai Mutiara





Installation and survey Reference Points

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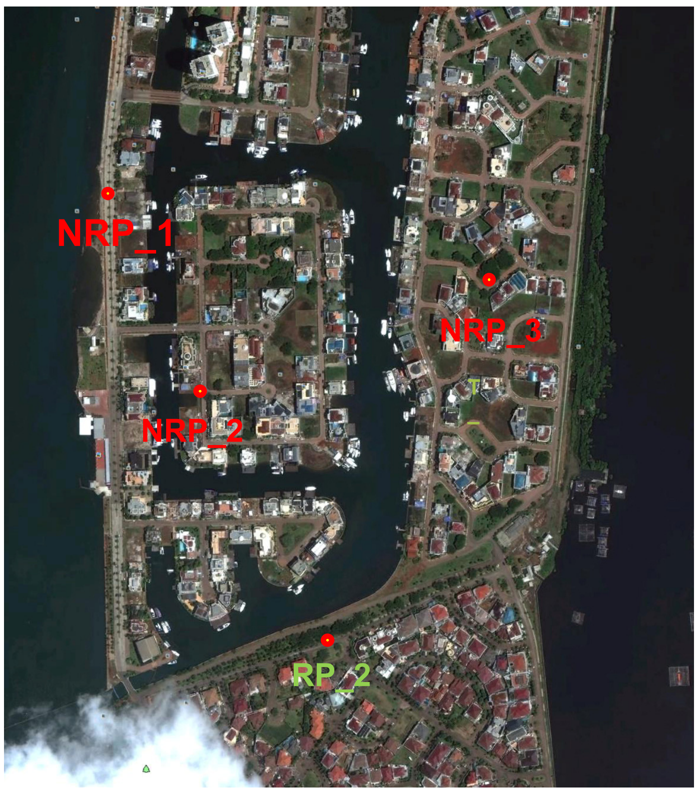
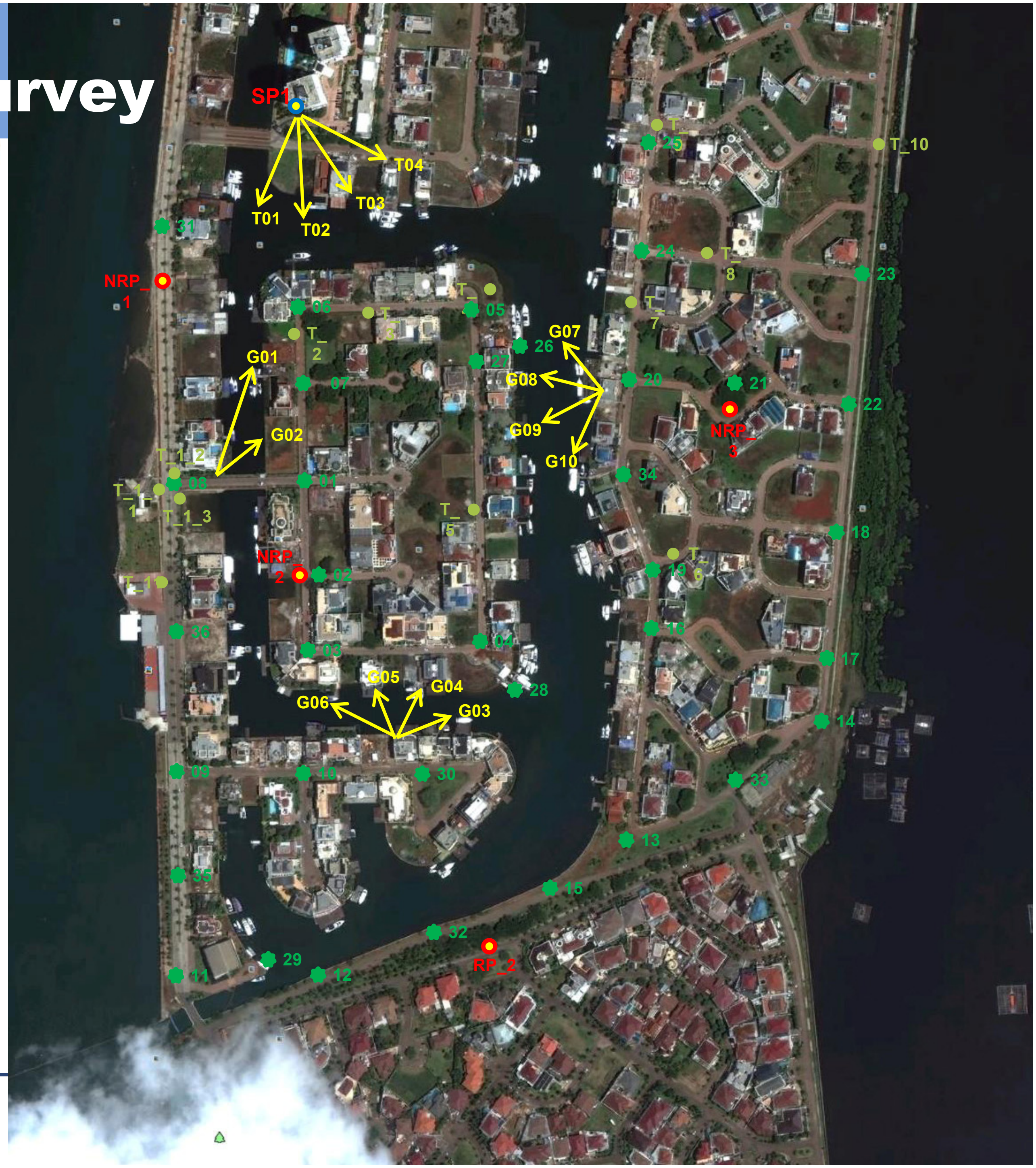
- Install 3 new reference points
- Survey by dual-frequency GPS
  - Total 4 points, processed by ITB



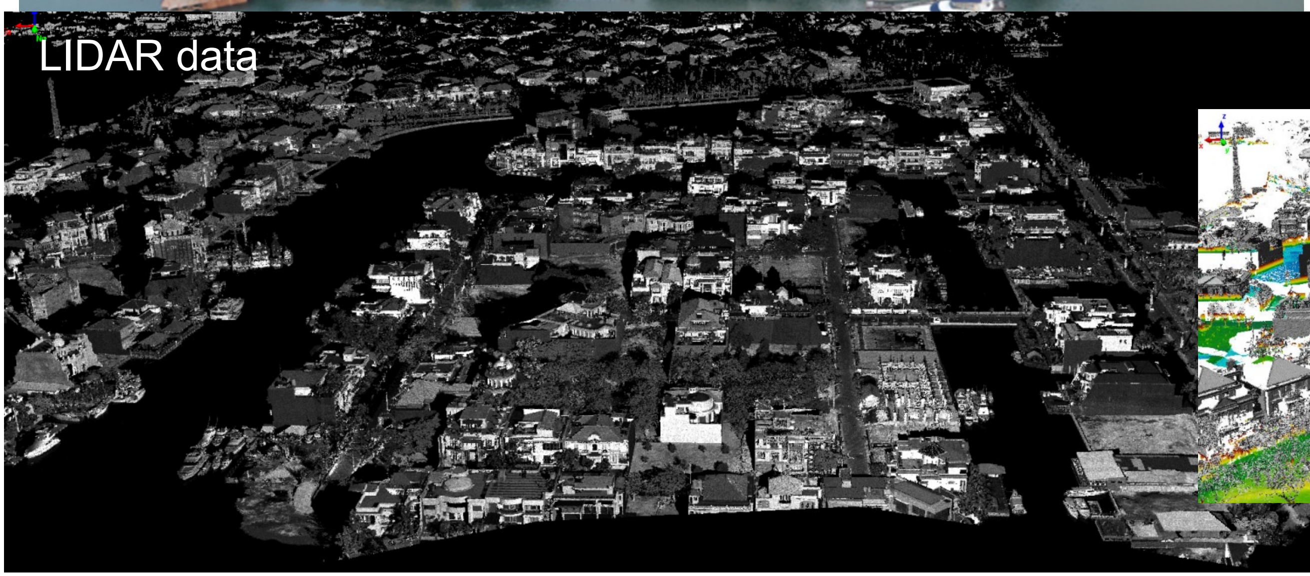
3D Topographic Survey

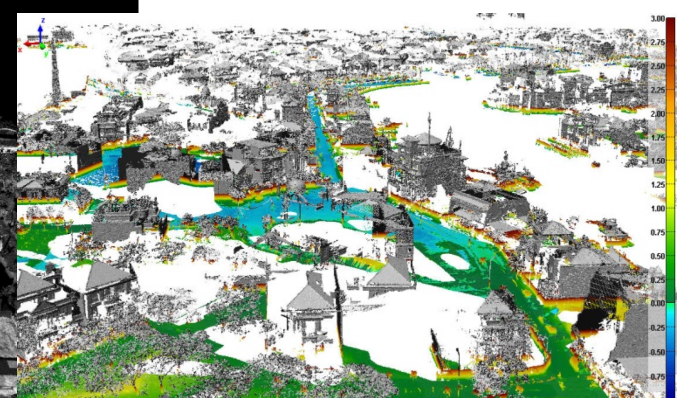
- Using Terrestrial LIDAR
  - On the roof of building
    - 4 scans
  - On the ground
    - 40 positions
  - 460 billion data points



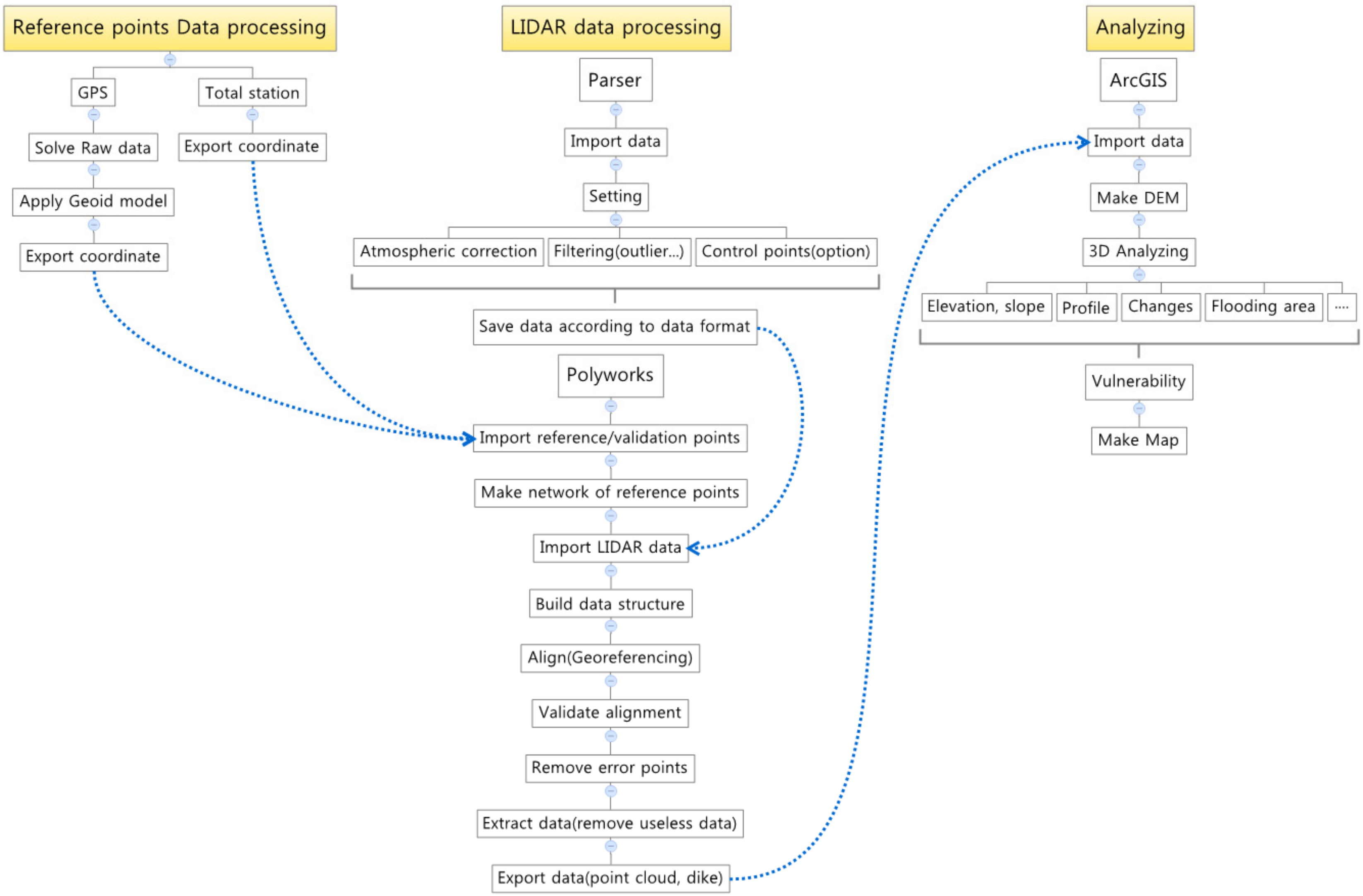
3D Topographic Survey

YEOSU PROJECT





Data processing



Characteristics of Topography

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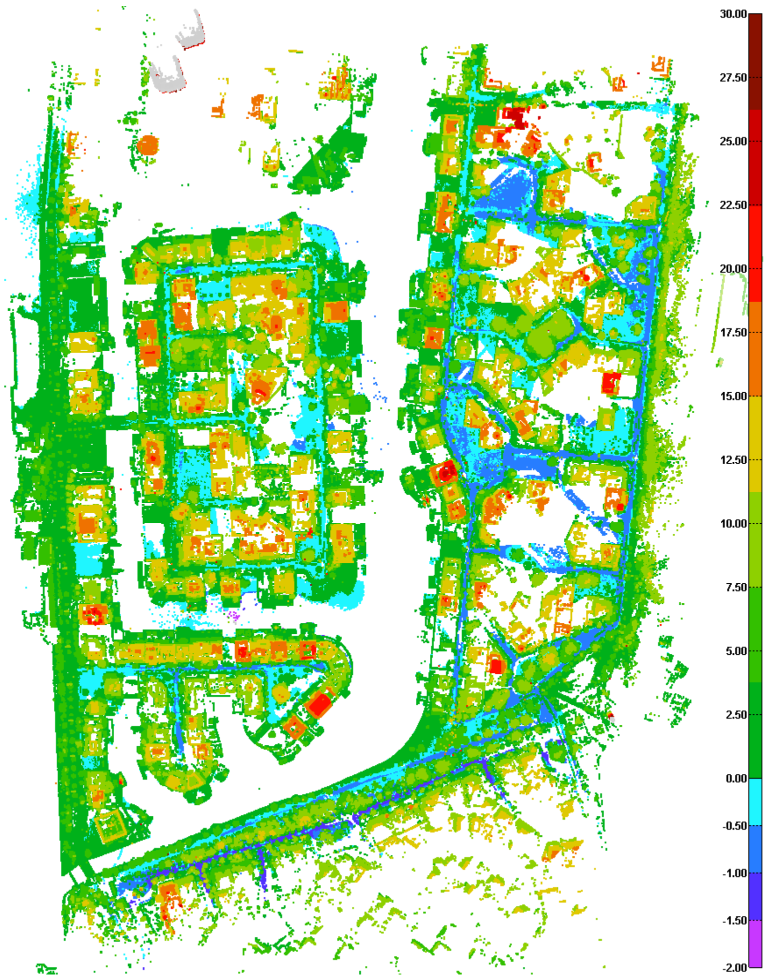
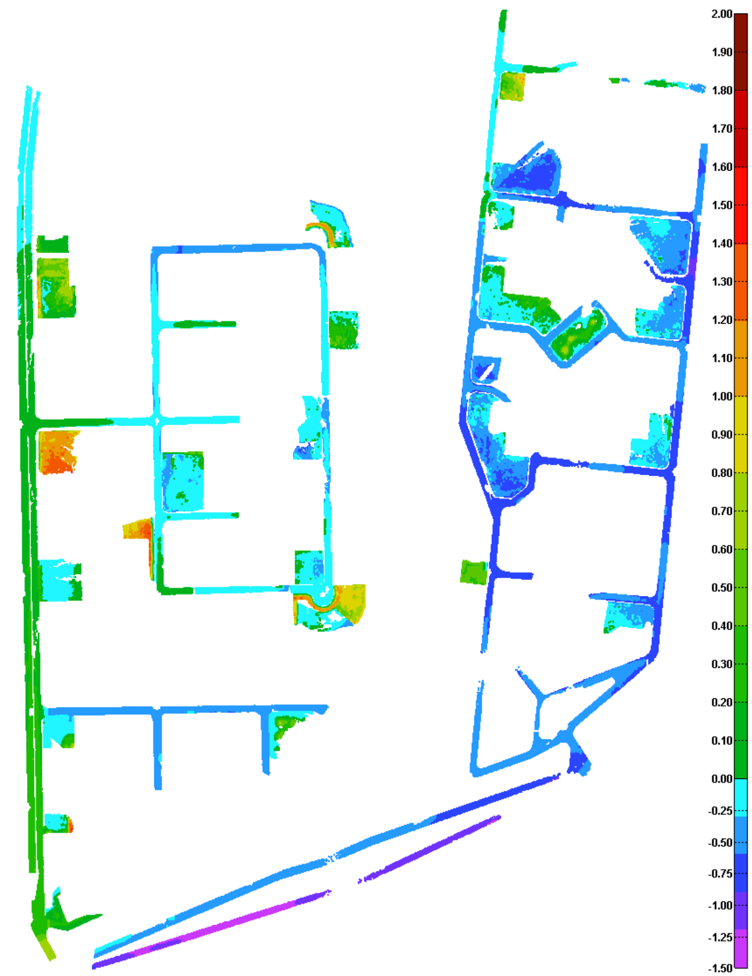


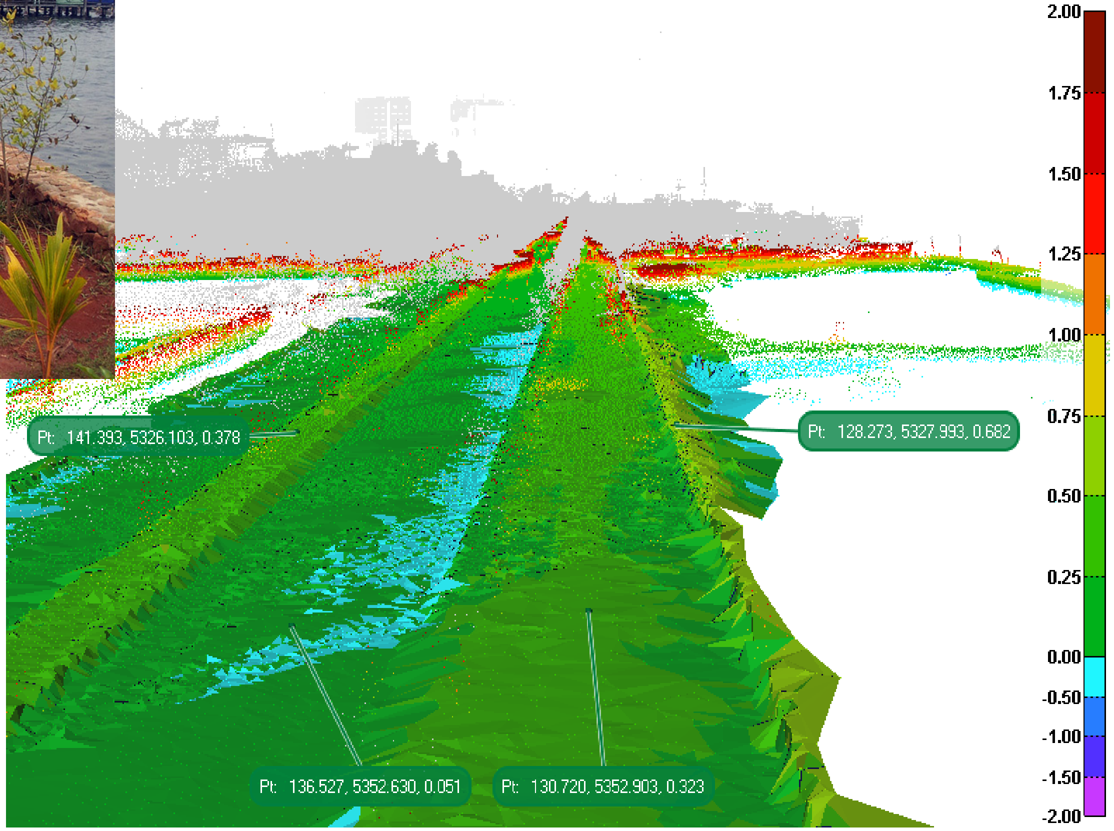
All data (include house and tree)



Only road and ground

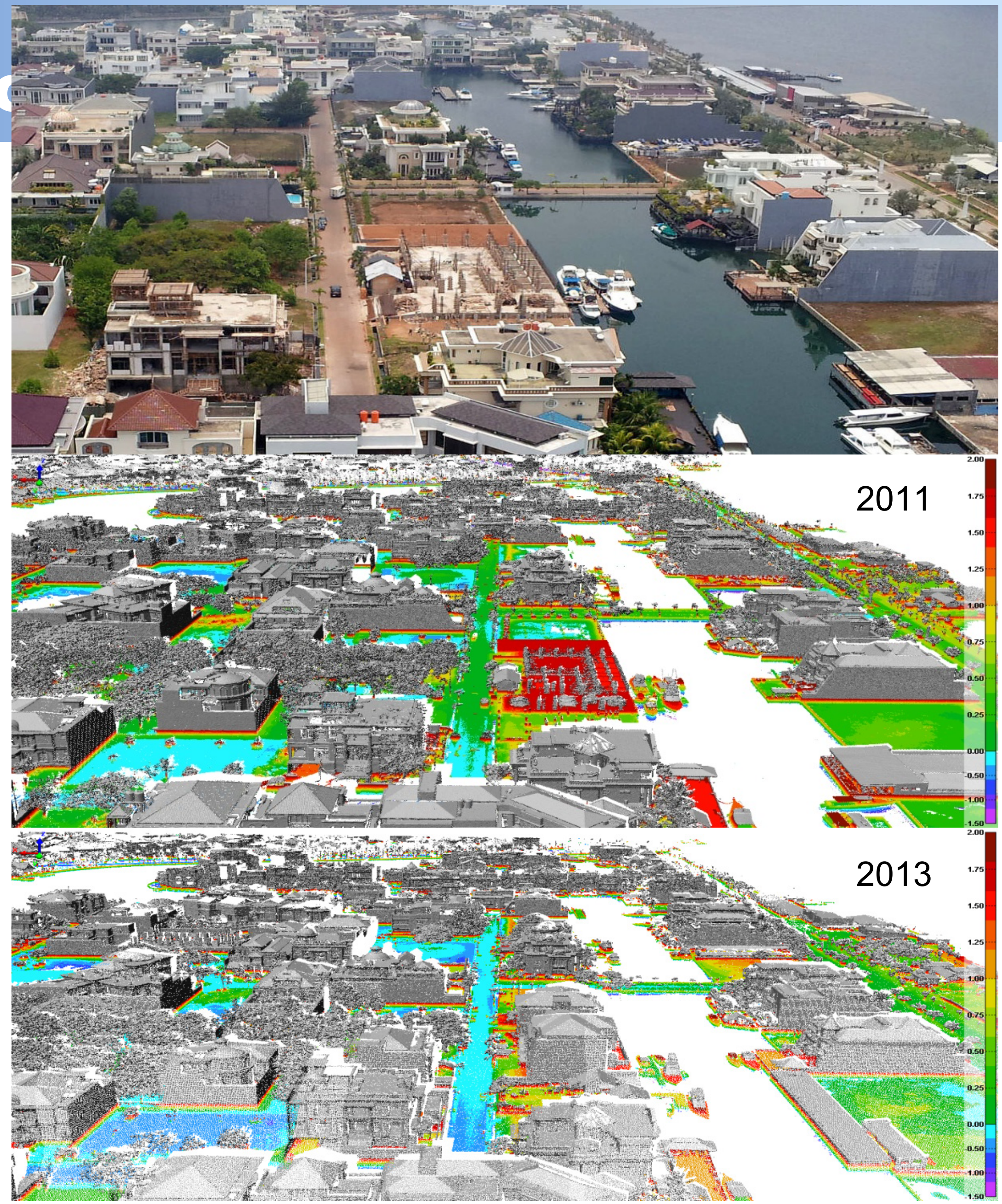
Distribution of elevation in Pantai mutiara

Characteristics of Topography



Characteristics of Topo

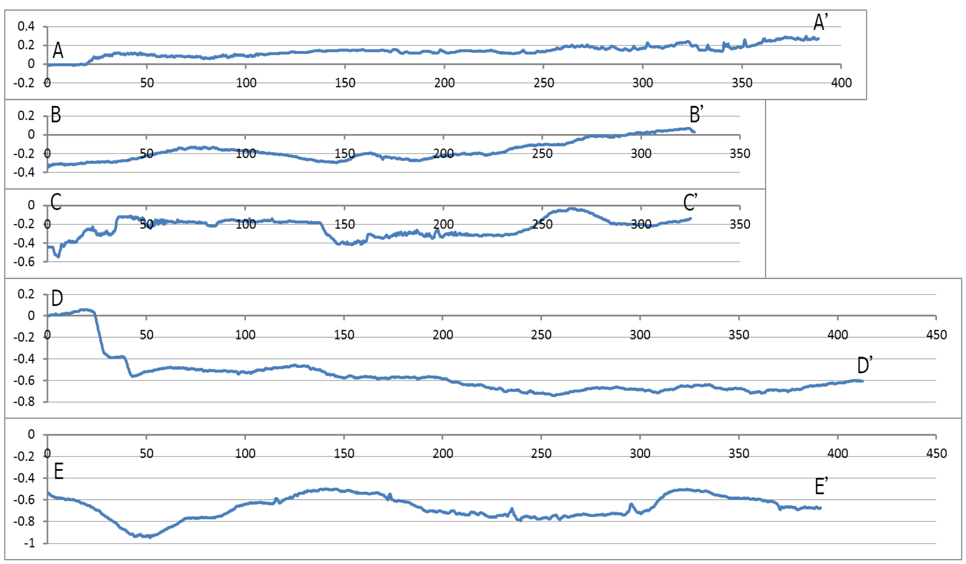
- Open space had been disturbed by estate owner



Characteristics of Topography

Elevation Statistics by section

	West	Middle	East	Overall
Mean	0.08	-0.21	-0.62	**-0.31**
Highest	0.31	0.17	0.15	**0.31**
Lowest	-0.12	-0.70	-0.99	**-0.99**
Standard Deviation	0.06	0.14	0.14	**0.31**



Profiles of roads

Characteristics of Dike

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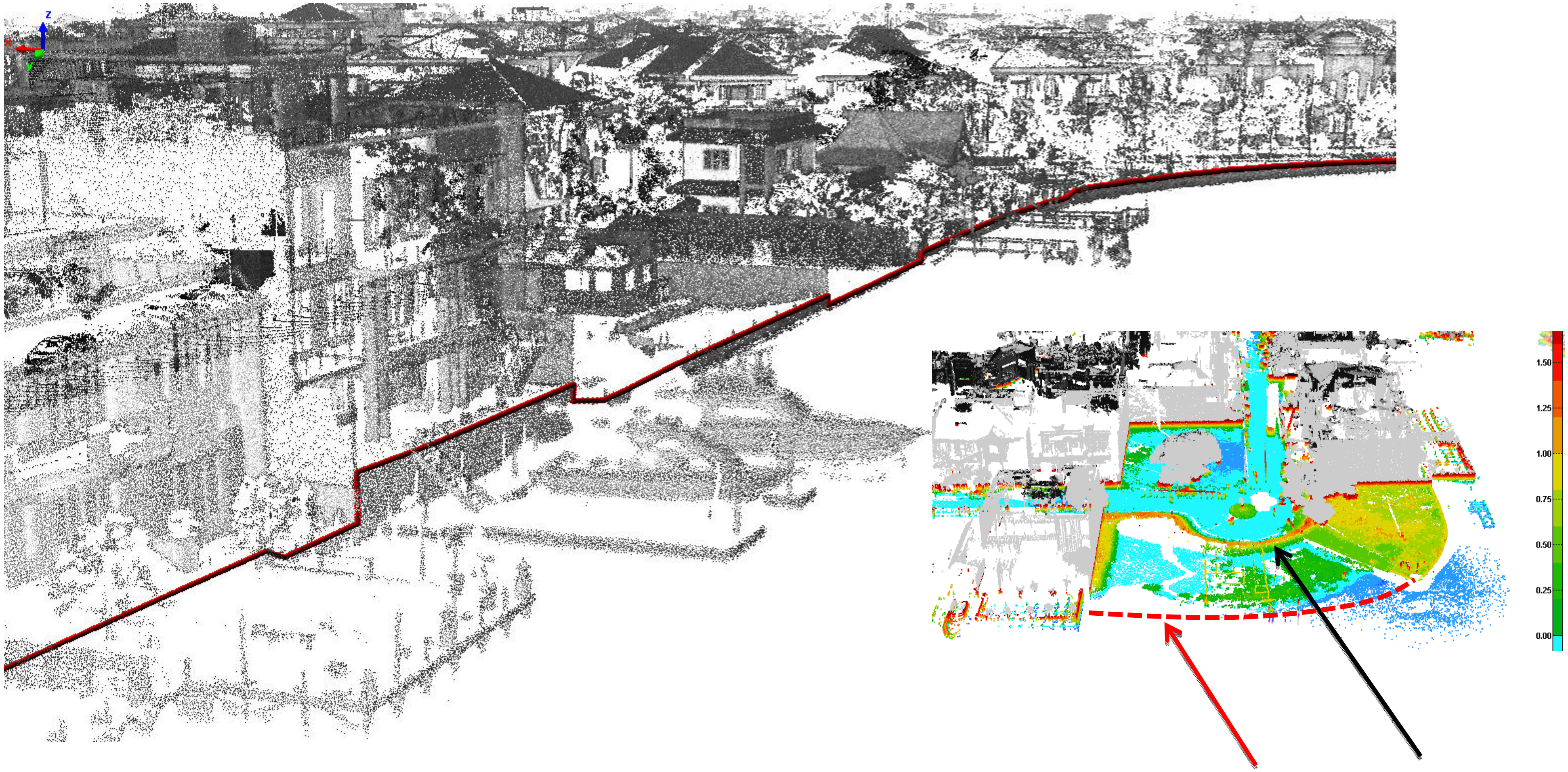

Extracting dike from Lidar data

Characteristics of Dike

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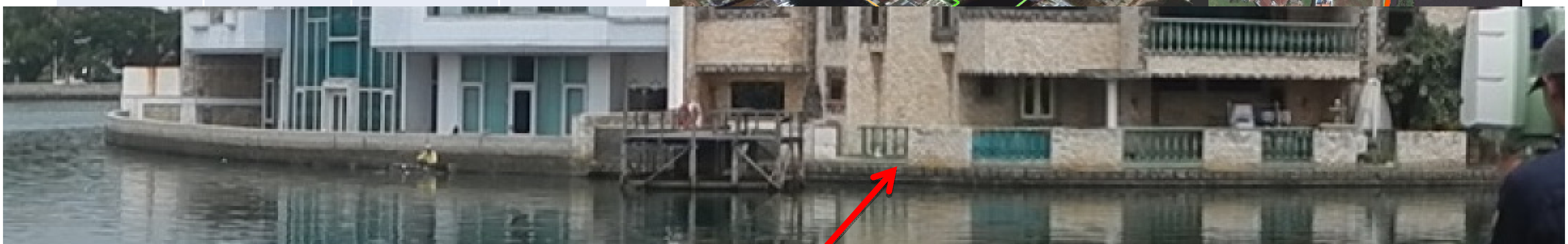
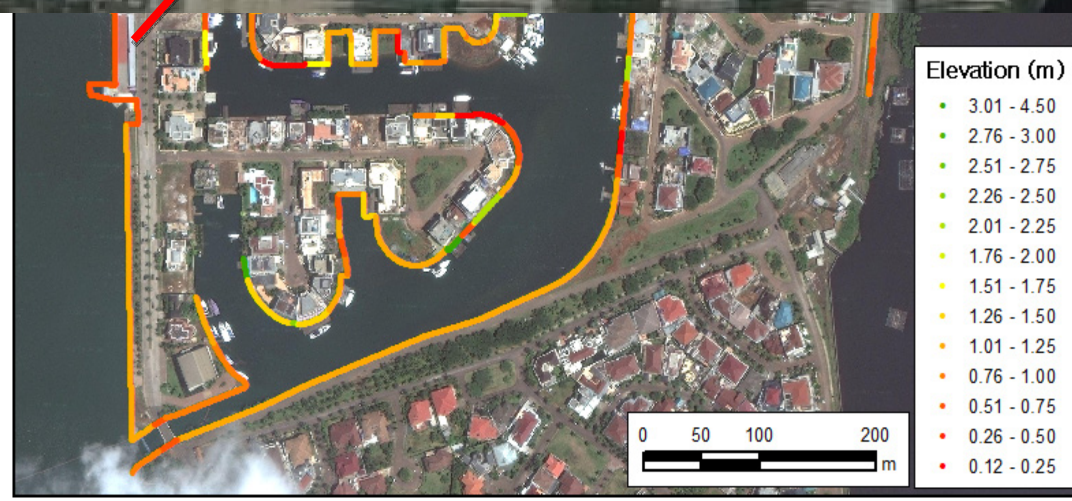
Dike height (m)	length (m)	Coverage (%)	Accumulative coverage (%)
0.00 - 0.25	146.2	2.7	2.7
0.25 - 0.50	0	0	2.7
1.75 - 2.00	256.6	4.8	88.8
2.00 - 2.25	235.7	4.4	93.1
2.25 - 2.50	127.3	2.4	95.5
2.50 - 2.75	65.6	1.2	96.7
2.75 - 3.00	1	0	96.7
3.00 - 3.25	176	3.3	100
Total	5,396.80	100	

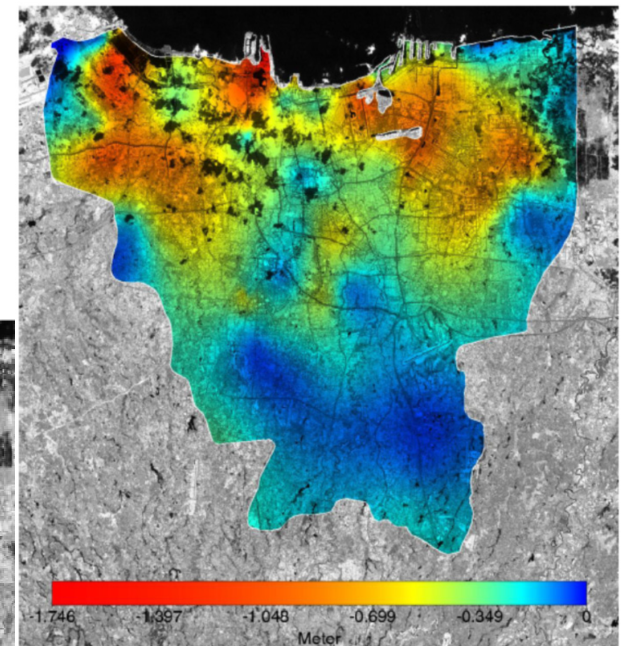




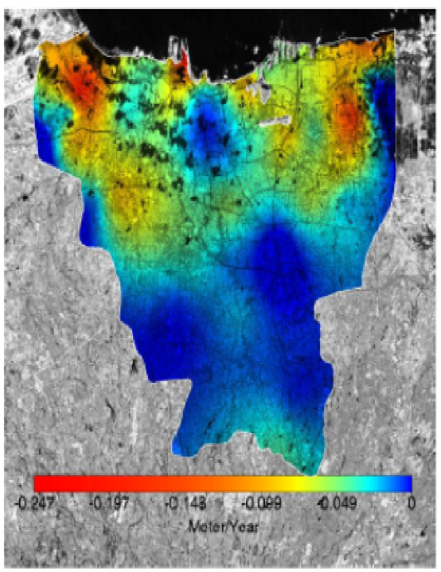
Level of land subsidence

- In previous survey by GPS
  - Subside max. 1.7m (2000-2010)
  - Subsidence rate : 1 – 15 cm/y
  - Max. Subsided area : Muara Baru

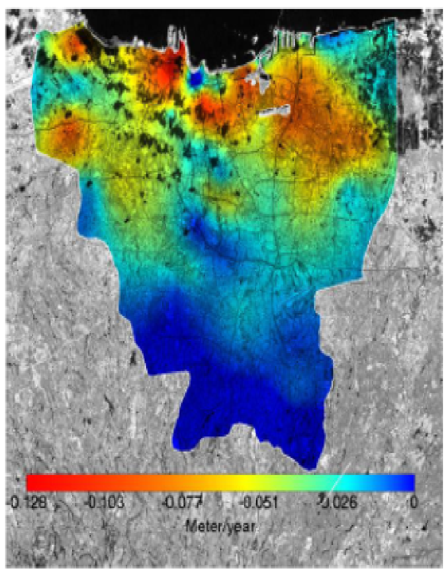
2000 - 2010



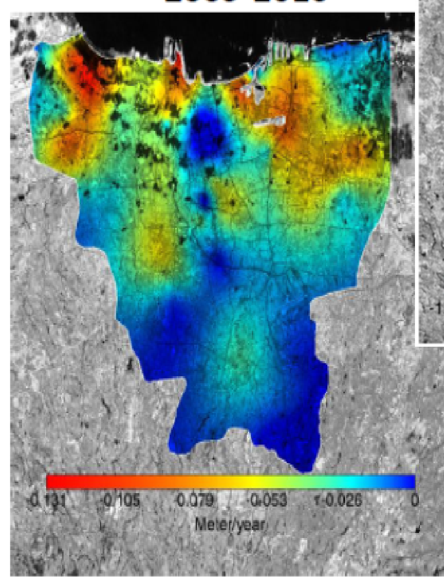
2007-2008



2008-2009



2009-2010



Level of land subsidence

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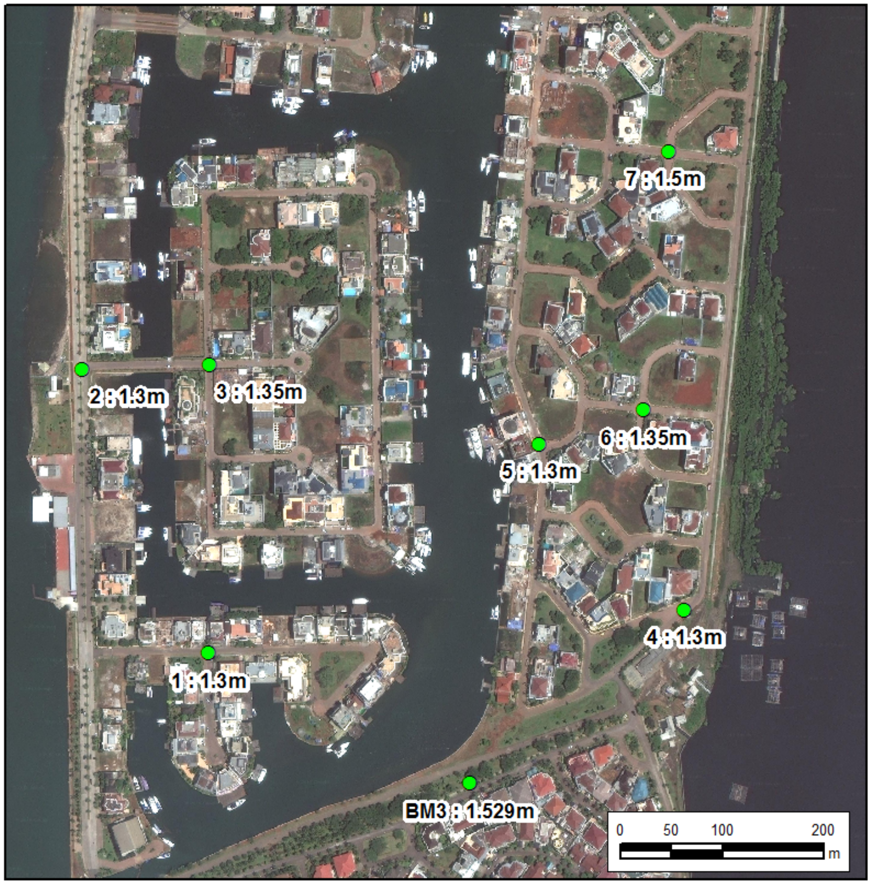

- After reclamation to present

No	1995A (m, MSL)	2013B (m, MSL)	deviation (m) (B-A)
BM3	1.529	-0.693	-2.222
1	1.30	-0.522	-1.822
2	1.30	0.166	-1.134
3	1.35	-0.195	-1.545
4	1.30	-0.594	-1.894
5	1.30	-0.673	-1.973
6	1.35	-0.567	-1.917
7	1.50	-0.516	-2.016
		average	-1.815 m
		rate	-0.095 m/y

Level of land subsidence

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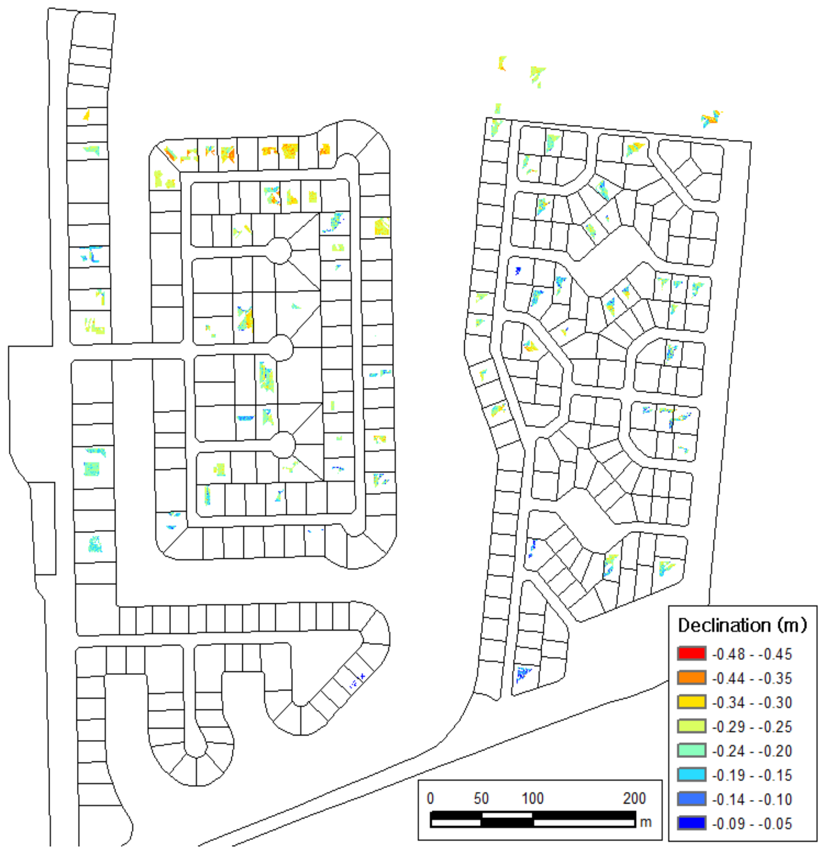
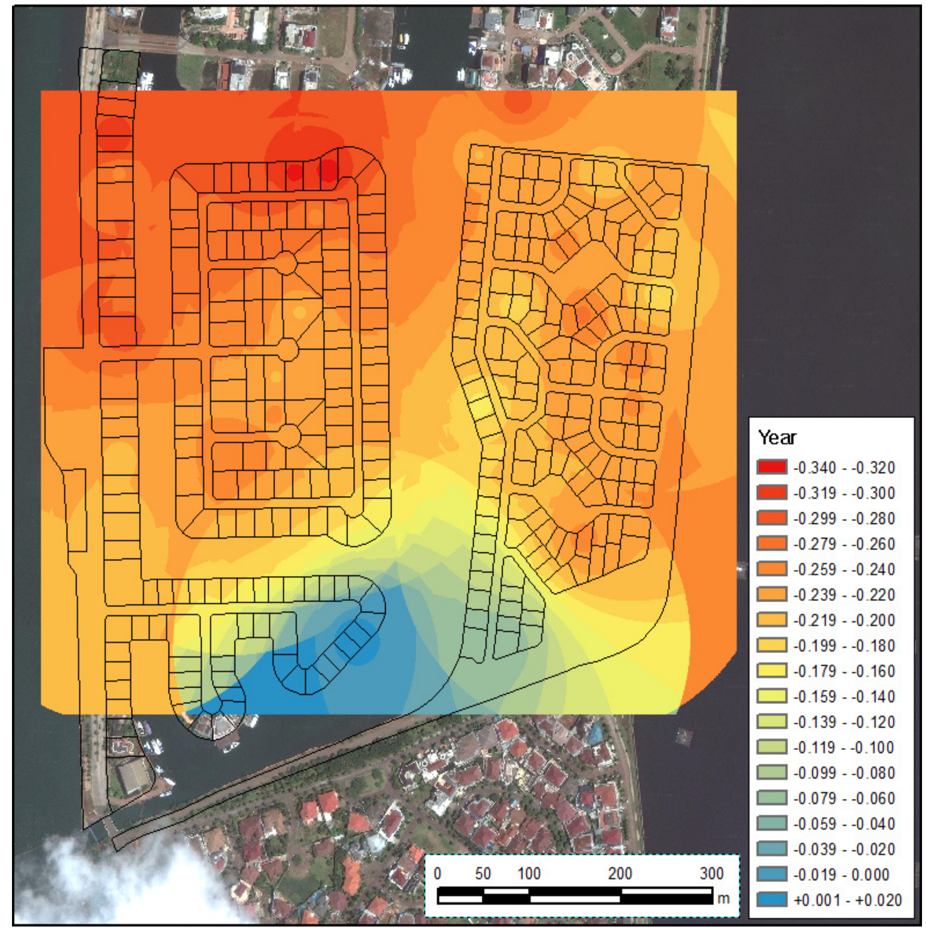
- LIDAR Surveyed data (2011 – 2013)





Min : 0m, max : 0.34m

Level of land subsidence

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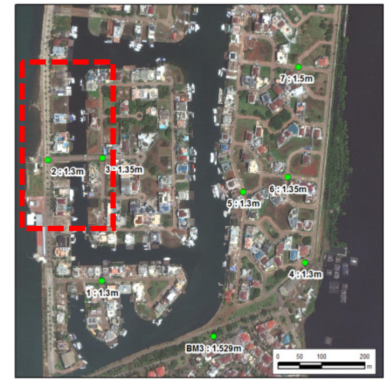
March 2004

February 2010



Vulnerability of coastal flooding

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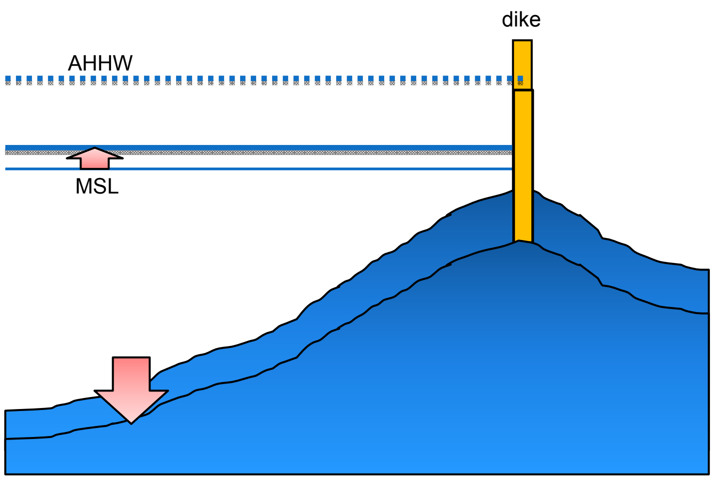
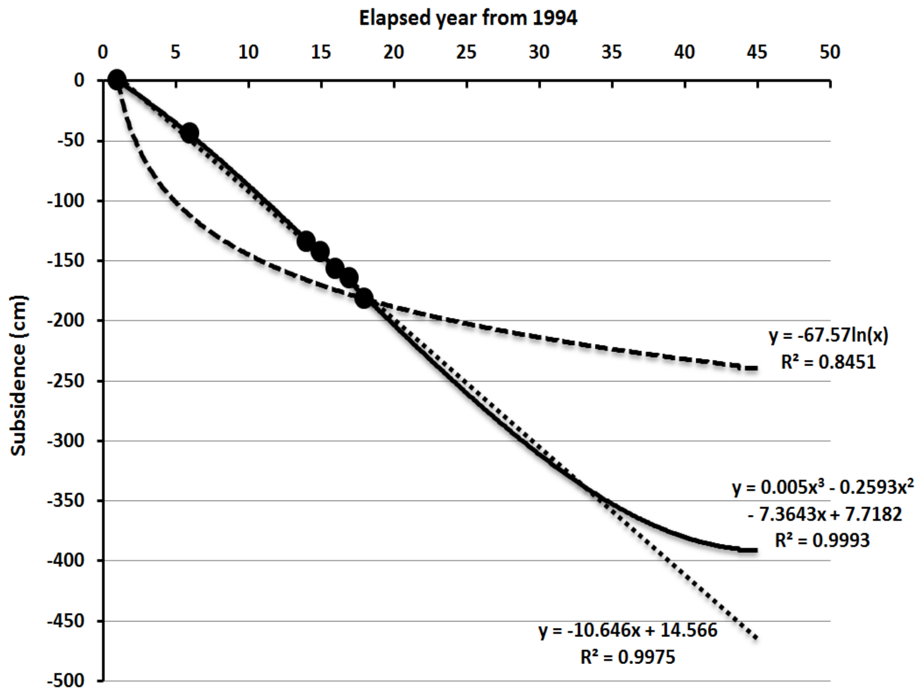
- Factors of Coastal Flooding

- Coastal flooding
  - Land subsidence
    10-cm/yr
    - Geologic
      - Tectonic movements
      - Isostasy
      - Faults
      - Holocene sediment compaction
    - Decreasing groundwater level
      - over use
    - Adding load
      - Development
    - Compacting reclamation soil
    - ....
  - Sea Level Rising
    3 - 7mm/yr
    - Climate change
    - ....
  - River Flood
    - Hydrological Characteristics
    - Insufficient channel capacity
    - ....
  - Storm Surge
    50cm
    (30cm+20cm)
  - Tsunami
  - ....
    3m (130years ago)

Vulnerability of coastal flooding

- Sea level of potential overtopping =
  (level of land subsidence)
  + 7mm/y (sea level raising)
  + 0.51 m (AHHW)
  + 0.3 m (height of storm surge)
  + 0.2 m (height of wave)





Period	level of Land subsidence (m)	Rate of Land subsidence (m/y)	Method
1994 - 2012	-1.815	-0.095	Literature, survey
2000 - 2010	-1.123	-0.112	GPS
2008 - 2009	-0.085	-0.085	GPS
2009 - 2010	-0.138	-0.138	GPS
2010 - 2011	-0.078	-0.078	GPS
2011 - 2012	-0.171	-0.171	survey
	mean	-0.113	

Vulnerability of coastal flooding

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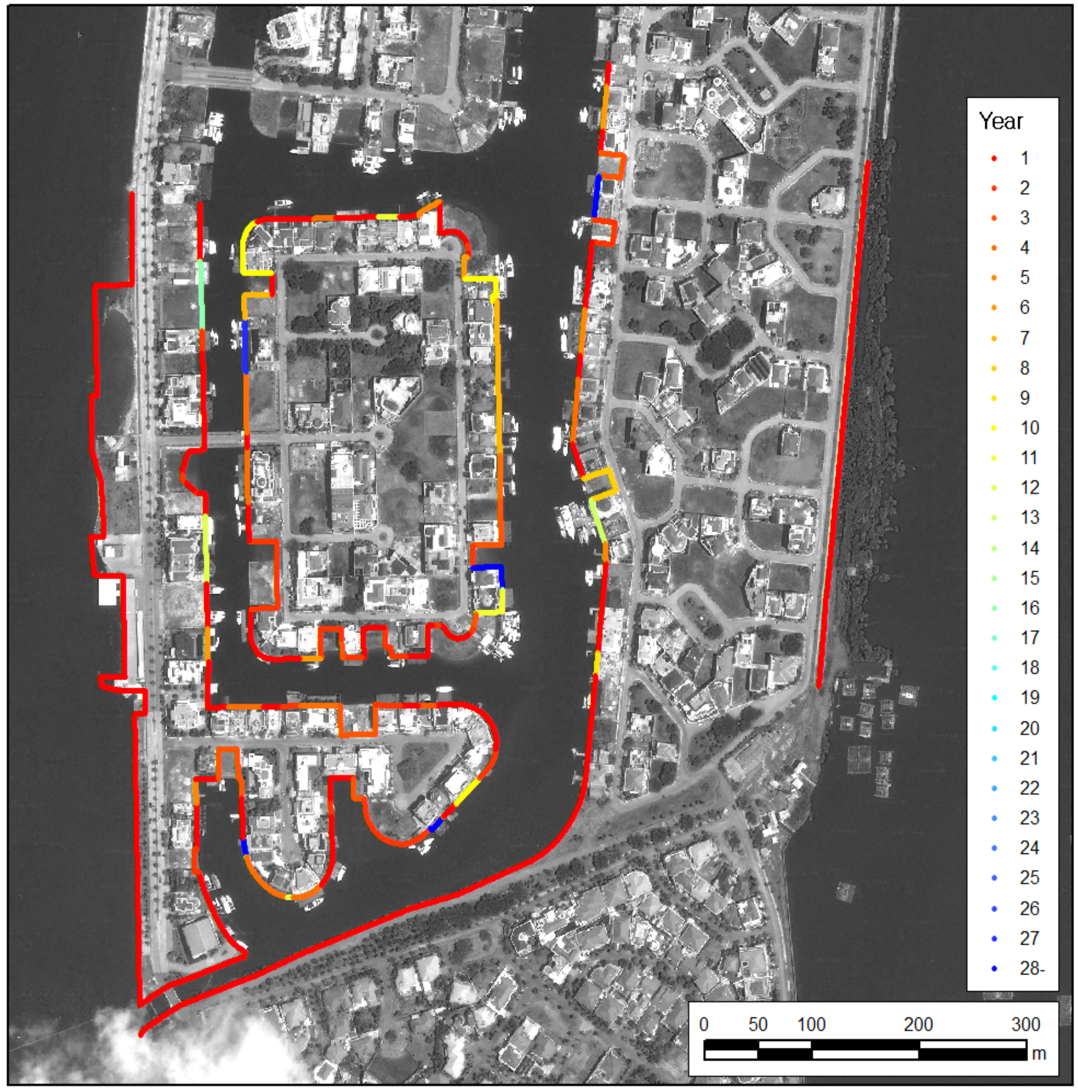
년	경과 연수	기준높이 (m)	침수 예상 제방 길이(m)	비율(%)	누적 비율 (%)
2013	1	1.13	3466	58.7	58.7
2014	2	1.26	573	9.7	68.4
2015	3	1.38	388	6.6	75.0
2016	4	1.51	385	6.5	81.5
2017	5	1.63	113	1.9	83.5
2018	6	1.75	116	2.0	85.4
2019	7	1.86	185	3.1	88.6
2020	8	1.98	70	1.2	89.7
2021	9	2.09	20	0.3	90.1
2022	10	2.20	169	2.9	93.0
2023	11	2.30	66	1.1	94.1
2024	12	2.41	65	1.1	95.2
2025	13	2.51	42	0.7	95.9
2026	14	2.60	4	0.1	95.9
2027	15	2.69	0	0.0	95.9
2028	16	2.77	62	1.1	97.0
2029	17	2.85	0	0.0	97.0
2030	18	2.93	0	0.0	97.0
2031	19	3.00	1	0.0	97.0
2032	20	3.06	0	0.0	97.0
2033	21	3.12	1	0.0	97.0
2034	22	3.17	0	0.0	97.0
2035	23	3.21	1	0.0	97.1
2036	24	3.25	0	0.0	97.1
2037	25	3.28	0	0.0	97.1
2038	26	3.30	0	0.0	97.1
2039	27	3.31	48	0.8	97.9
2040 이후	28 이상		126	2.1	100



Basic Concept of B/C Analysis

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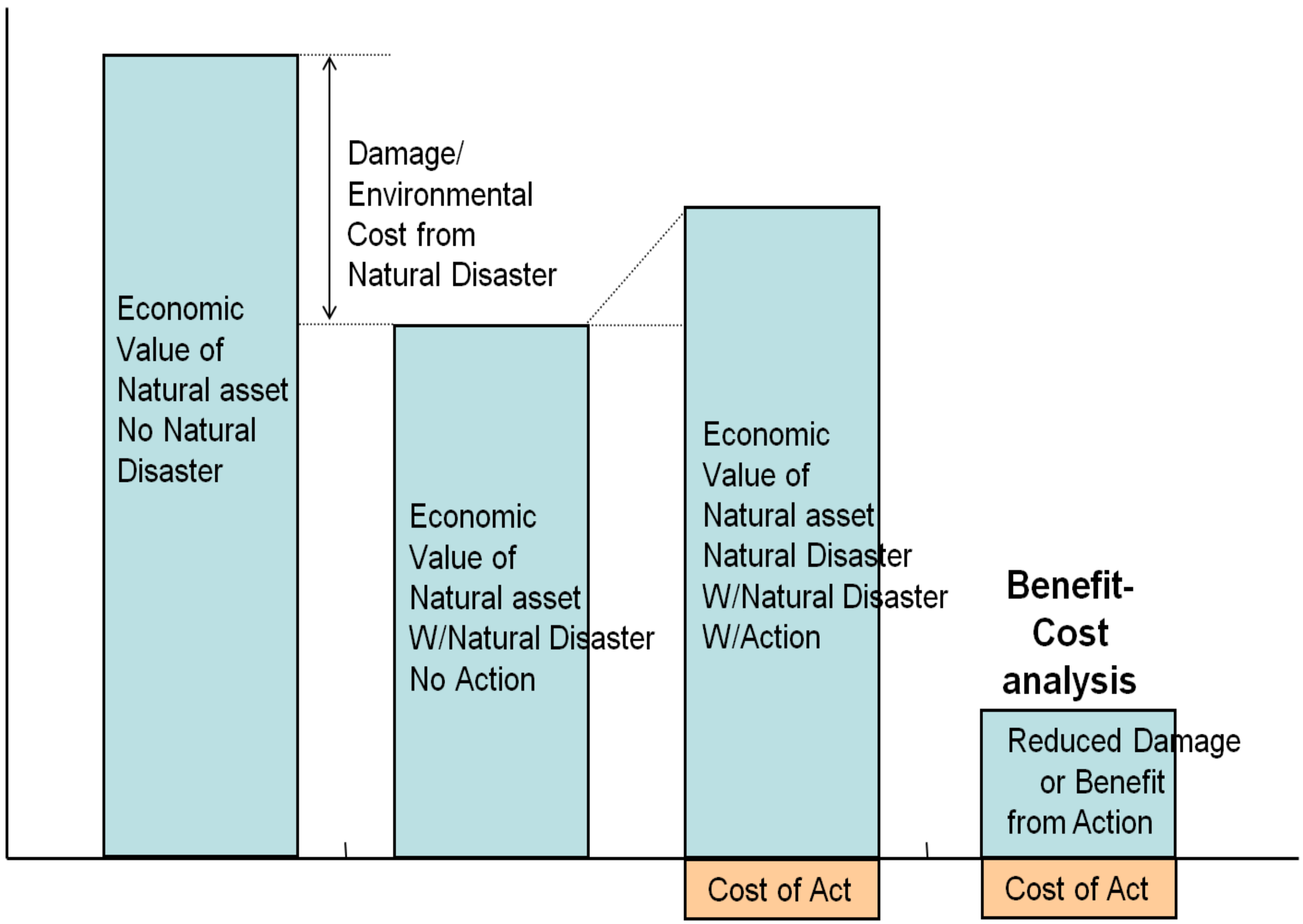

Survey for socio-economic data

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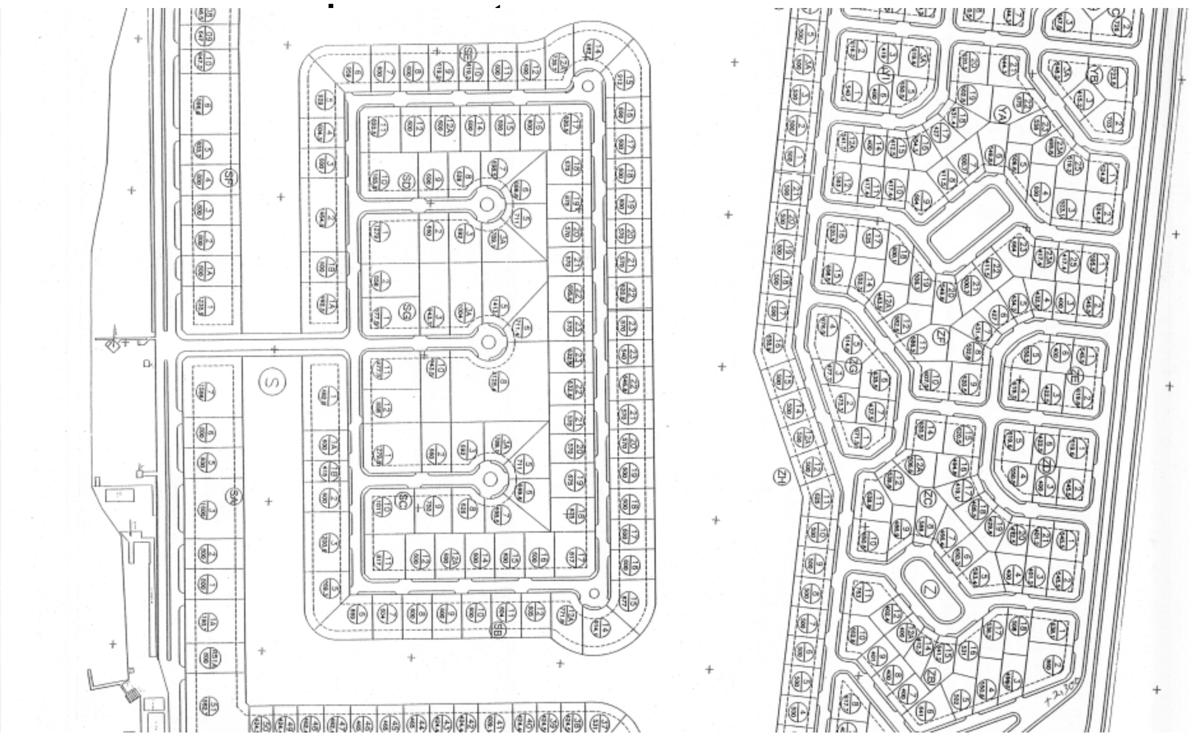
- Values of Pantai mutiara
  - Value of waterfront area, open space, houses, etc.
- Cost for actions
  - Building an higher dike, Pumping the water, Raising the ground



Benefit / Cost Analysis

YEOSU PROJECT

- Main Information for B/C Analysis
  - Based Year : 2014
  - Possible flooding level : 2033 (20years from 2013), 1.265m
  - Social Discount Rate : 10%
  - Damage by flooding due to land subsidence
    - Land price + house price
      - Land price : waterfront / non-waterfront price per unit area X area (GIS)
      - House price : number of floors (LIDAR) X area (GIS) X price per unit
      - Public and road area counted in non-waterfront area
  - Action Cost
    - Building an Higher Dike
      - Height, Length (GIS)

Benefit / Cost Analysis

YEOSU PROJECT

- Economic Value of Pantai Mutiara will disappear all, when the flooding (due to land subsidence) start. Therefore, the economic value of the area becomes a damage.
- That is, benefit from action implementation(or reduced damage) is to become whole economic value of the area. , the benefit from reduced damage
- Benefit from Action = 10.797 billion USD
- Action cost(building an higher dike) = 2.14 million USD

\- Raw data for calculation is given by private company, development of Pantai Mutiara

Recommendation

- Need the plan to build a higher dike
  - When, Where, How much(height)
  - Budget to raise dike
- Predict level of land subsidence
  - Intensive Monitoring
    - Ground Engineering survey
    - Topographical survey
- Volunteering Monitoring by residents
  - Reorganization of the issue by Residents
  - Reduction Monitoring costs
- Policy enforcement of monitoring

Recommendation

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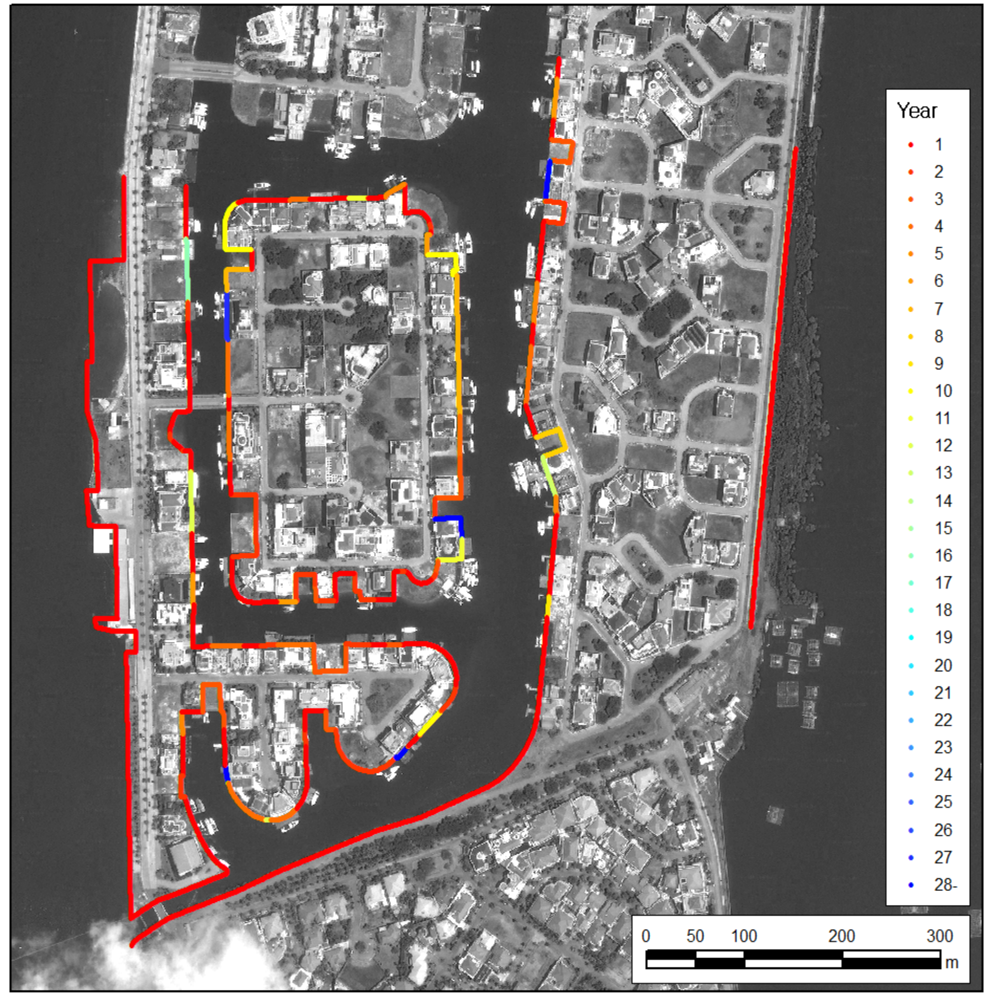

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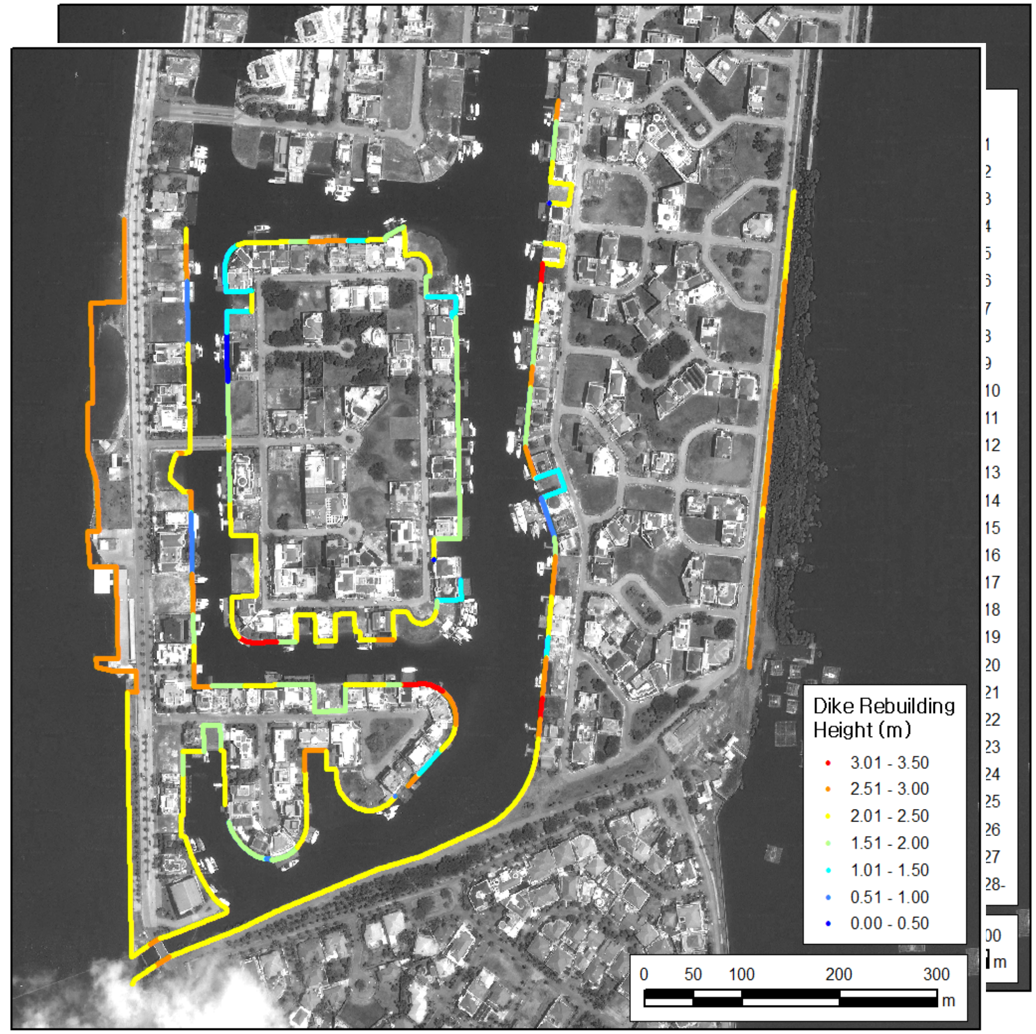

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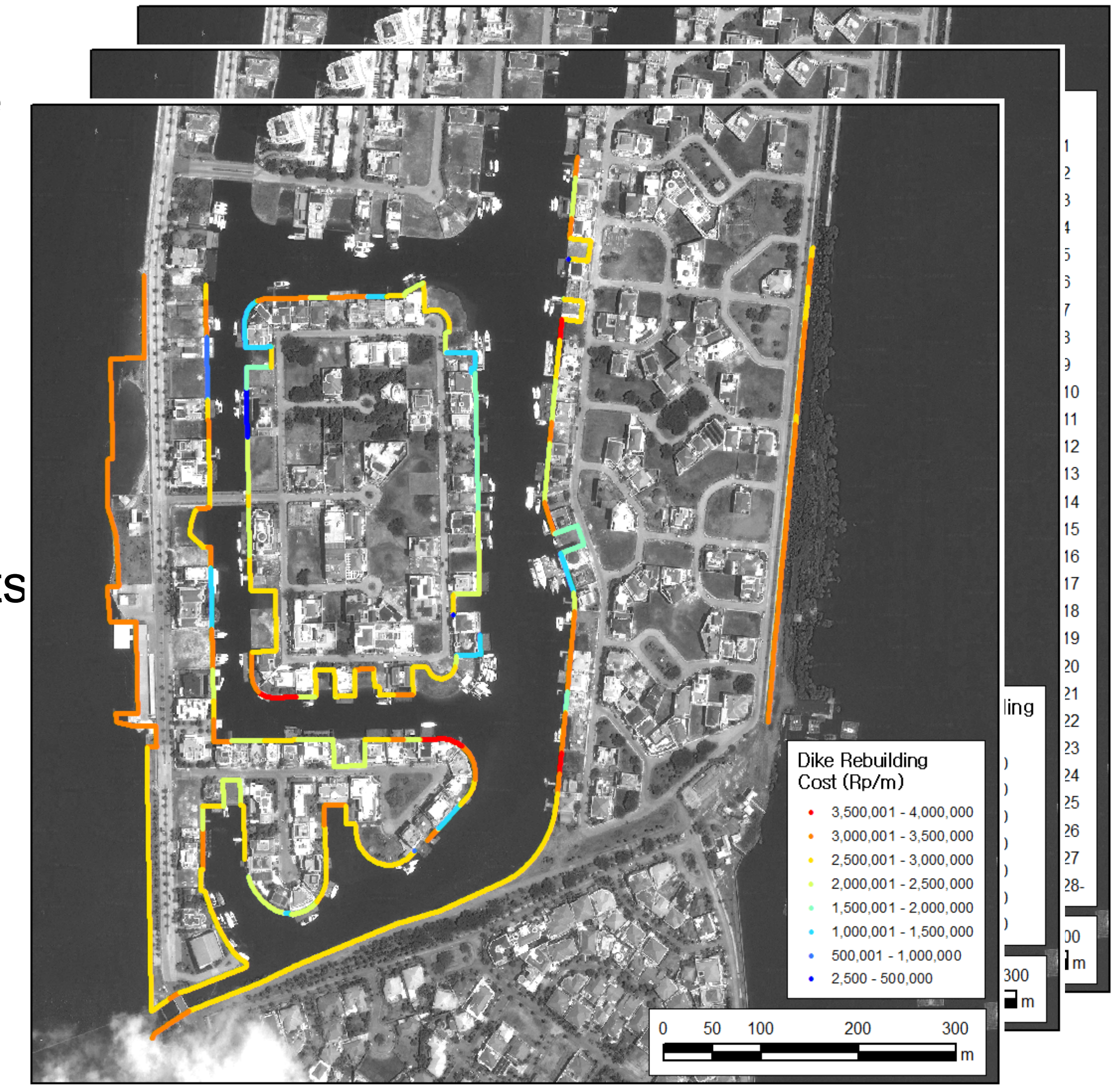

Outline of Project – Phase III

YEOSU PROJECT

- Project Title
  - STUDY ON ESTABLISHMENT OF INTEGRATED COASTAL MANAGEMNT PROGRAM IN JAKARTA BAY AREA, INDONESIA
  - Sub Title : ***Numerical Modeling and Policy Development for Preventing and Reducing Damage Caused by Coastal Inundation in Jakarta***
- Project Period
  - January 2015 ~ June 2016 (18 month)
- Project implementation:
  - Korea Institute of Ocean Science and Te
  - Bandung Institute of Technology (ITB)
- Funding Resources
  - **THE EXPO 2012 YEOYU KOREA FOUNDATION**

Sea level of potential overtopping =
(level of land subsidence)
+ 7mm/y (sea level raising)
+ 0.51 m (AHHW)
+ 0.3 m (height of storm surge)
+ 0.2 m (height of wave)

Q&A

Thank you!

What Change in Phase III

- Spatial Range : Coastal Area of Jakarta
- Contents Range :

Sea level of potential overtopping =
(level of land subsidence)
+ 7mm/y (sea level raising)
+ 0.51 m (AHHW)
+ 0.3 m (height of storm surge)
+ 0.2 m (height of wave)

Outline of Project

Objective

- To obtain and analyze scientific data of Land subsidence,
- To set up criteria based scientific analysis for decision maker about land subsidence
- To provide capacity building and equipment for Indonesia experts

Outline of Project

YEOSU PROJECT

■ Objective

- To obtain and analyze scientific data of **STORM SURGE AND WAVE** ,
- To set up criteria based scientific analysis for decision maker about **STORM SURGE AND WAVE**
- To provide capacity building and equipment for Indonesia experts

Contents of Project

YEOSU PROJECT

- Investigating the status of coastal management and coastal inundation in Jakarta
- Establishing the wave and storm surge prediction numerical models for Jakarta Bay
- Analyzing the damage by regional case study
- Developing the coastal action plan to reduce the damage by coastal inundation
- Reviewing Indonesian legal system and offering the improvement proposal
- Capacity building relating to the project for Indonesian expert