



# MITIGASI LAND SUBSIDENCE MELALUI PENERAPAN RAIN WATER HARVESTING DAN PENGUATAN PERAN ANTAR AKTOR

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**01**

## **INTRODUKSI**

Definisi *Land Subsidence*  
Faktor Pemicu

**02**

## **JAKARTA LAND SUBSIDENCE**

Pengantar  
Karakteristik Wilayah Jakarta Utara  
Land Subsidence dan Sejarah Kebijakan Pembangunan  
Dampak Land Subsidence di Jakarta Utara  
Respon terhadap Land Subsidence dan Dampaknya

**03**

## **MITIGASI LAND SUBSIDENCE MELALUI RWH**

Tantangan Pemenuhan Air Bersih  
Faktor Pemicu Penggunaan Teknologi RWH  
Karakteristik Pengguna Teknologi RWH  
Kualitas Air RWH  
Potensi Kuantitas Air RWH terhadap Penurunan Penggunaan Air Tanah  
Rekomendasi Kebijakan Penerapan RWH untuk Mitigasi *Land Subsidence*





# INTRODUKSI

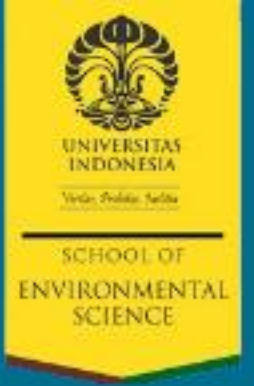
## Definisi *Land Subsidence*

Proses deformasi yang terjadi secara relatif, bertahap, atau tiba-tiba pada setiap lapisan tanah lunak, seperti lapisan geoid dan elipsoid , yang umumnya dibentuk oleh lapisan tanah liat atau lanau dengan tingkat permeabilitas rendah dan kedap air

(Ishii *et al.*, 1970; *The United State Geological Survey*, 2019)

# FAKTOR PEMICU





# **JAKARTA *LAND SUBSIDENCE***

# Pengantar

1982



Pertama Kali disorot

1993



Pertama Kali diteliti  
Penurunan 1-9 cm/tahun

1997



Penurunan Meningkat  
1-25 cm/tahun

2011



Penurunan Meningkat Kembali  
1-28 cm/tahun (total 116 cm)



JAKARTA UTARA

SEBAGAI WILAYAH  
DENGAN PENURUNAN  
TERTINGGI



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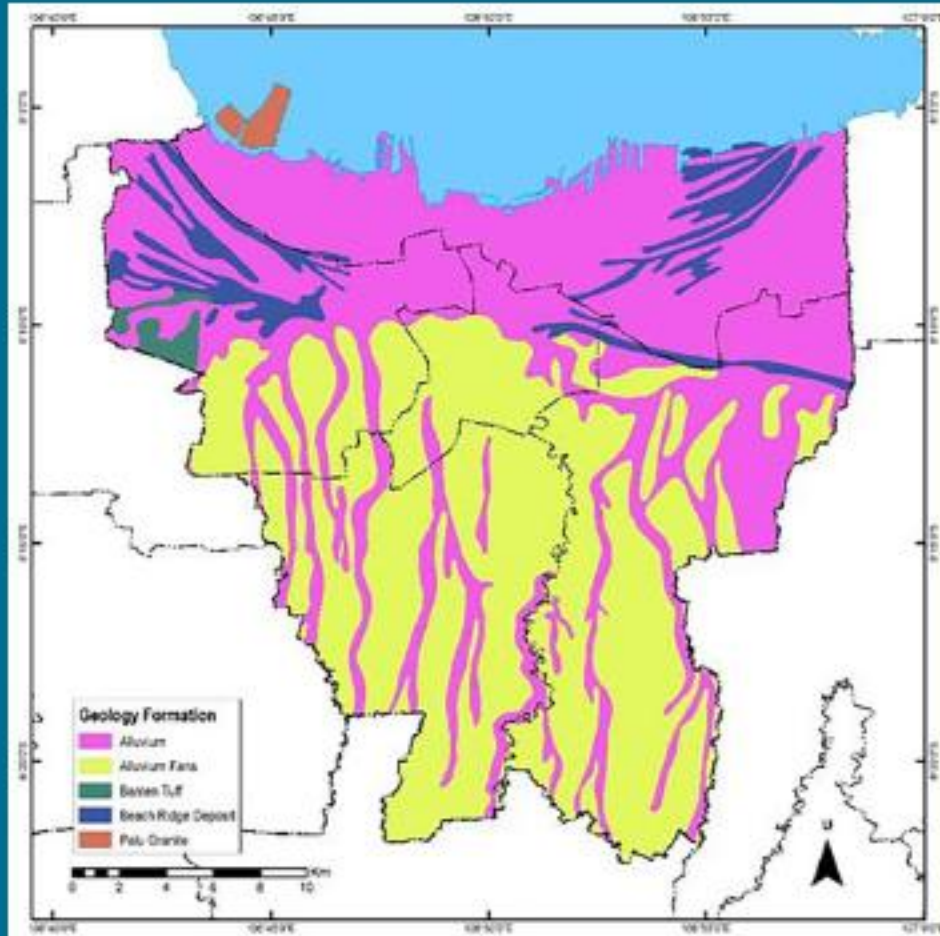


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# Karakteristik Jakarta Utara



Memiliki 4 jenis bentang alam:

*Marine-Origin* (Utara)

*Beach-Ridge* (Barat & Timur Laut)

*Rawa & Rawa Bakau* (Pinggiran Pantai)

*Former River Channel* (Garis Pantai)

## No. Regional Characteristics

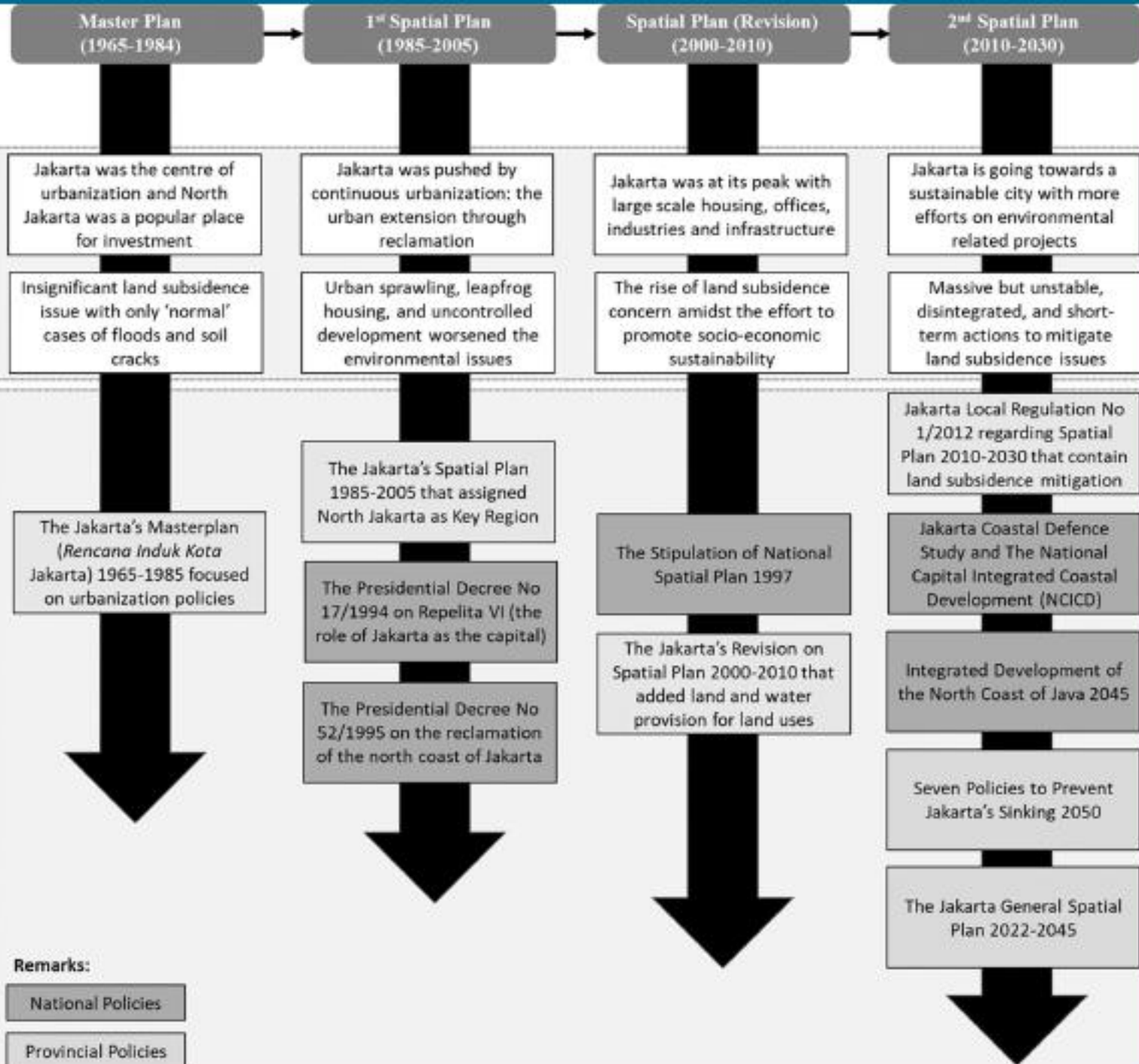
1. Unit Area 1 This area features coastal bunds with a typology landscape in the form of embankments that are parallel to the shoreline and have relatively flat surface contours. It is formed by fine- and coarse-grained sand deposits and sandy silt with a groundwater depth of 0.5–1.5 m from the surrounding ground surface. It is also a center of sedimentation and erosion, which occurs around the Pantai Kapuk and Citarum Estuary on the east side.
2. Unit Area 2 This area is formed by the distribution of river deposits of loose sand and gravel. Shallow groundwater in this area is found at a depth of 2–5 m from the ground surface, while compressed groundwater is found at a depth of 60–120 m. These characteristics have the potential to cause flooding.
3. Unit Area 3 This area is coastal lowland with an altitude of 0–2 m above sea level. It is formed by flood and swamp deposits in the form of soft sandy loam and gray–black in color. Shallow groundwater is generally brackish, whereas deep groundwater is found in the middle and deep aquifers.

## *Three Types of North Jakarta Environmental Geological Unit Areas*

*(The 1965 DKI Jakarta Regional Environmental Geological Investigation Report).*

Development

Policy Chronology



Remarks:

- National Policies
- Provincial Policies

**LAND SUBSIDENCE & SEJARAH KEBIJAKAN PEMBANGUNAN**





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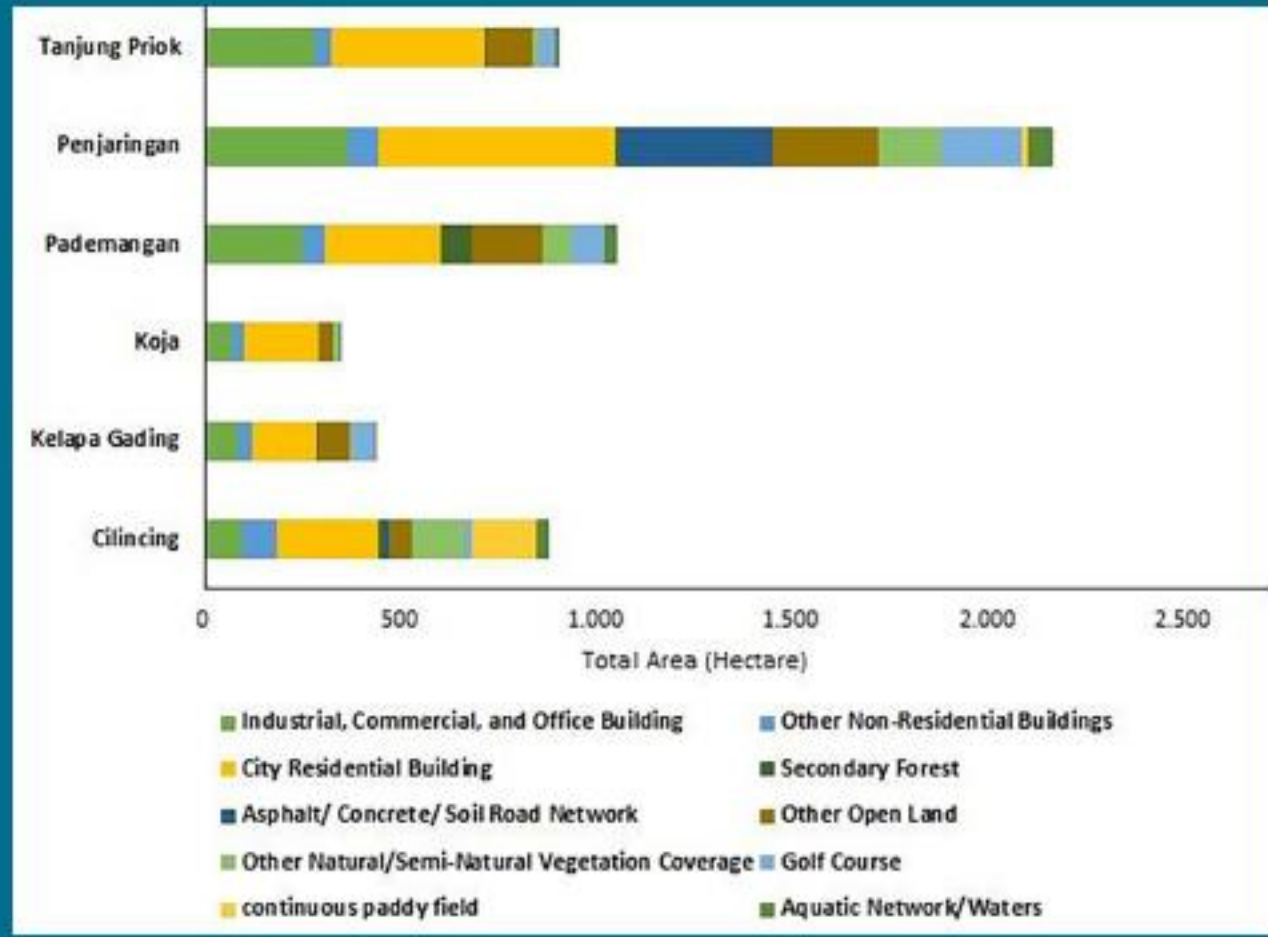
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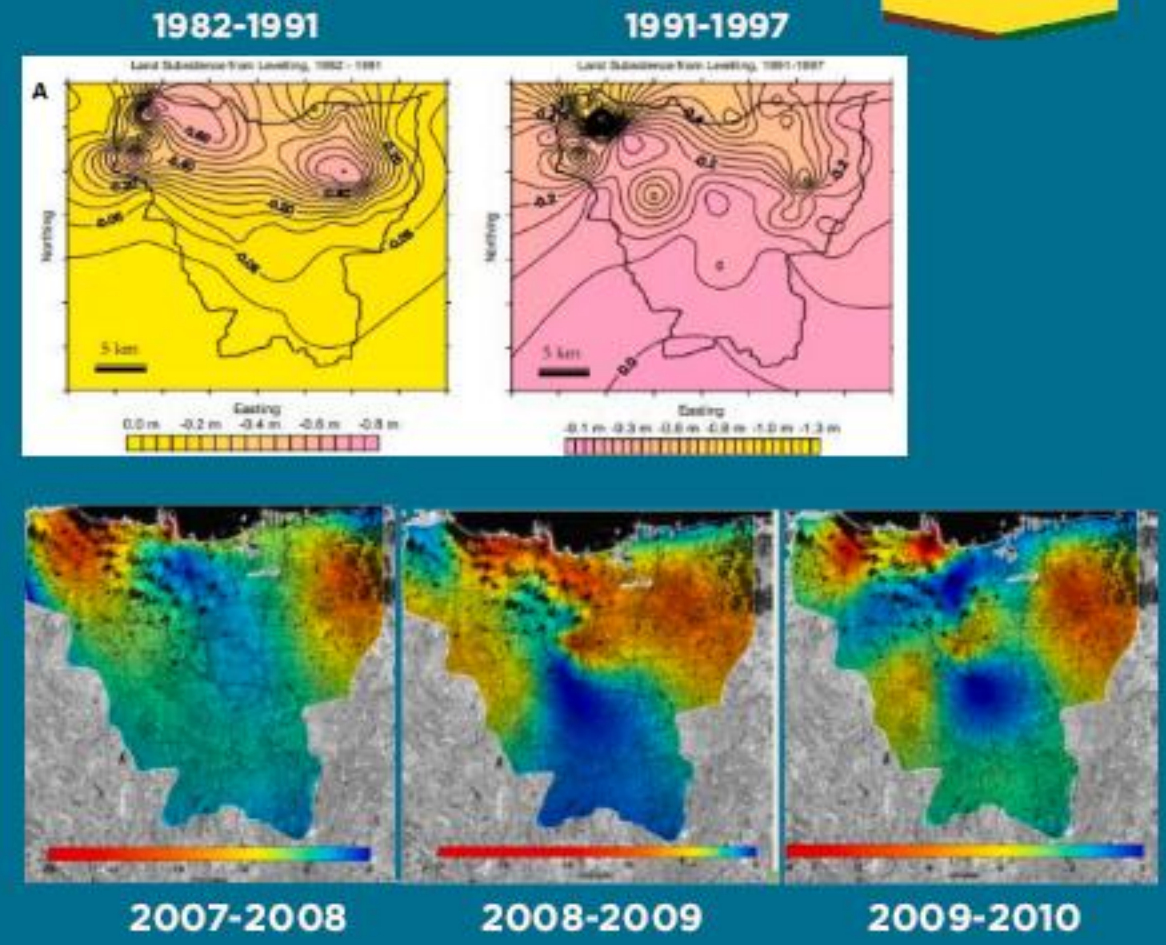
1.	Infrastructure	Cracking of permanent constructions and roads Tilting of houses and buildings Sinking of houses and buildings Breaking of underground pipelines and utilities	Malfunction of the sewerage and drainage system
2.	Economic	-	Increase in the maintenance cost of infrastructure Decrease in land and property values Abandoned buildings and facilities Disruption of economic activities
3.	Environment	-	Changes in river, canal, and drain flow systems Frequent coastal flooding Wider expansion of flooding areas Inundated areas and infrastructure Increase in inland seawater intrusion Deterioration in the quality of environmental conditions

## **DAMPAK** ***LAND SUBSIDENCE*** **PADA PEMABNGUNAN** **DI JAKARTA UTARA**

(Hasibuan *et al.*, 2023)



(Hasibuan *et al.*, 2023)



(Abidin *et al.*, 2001; 2005; 2008; 2008b)

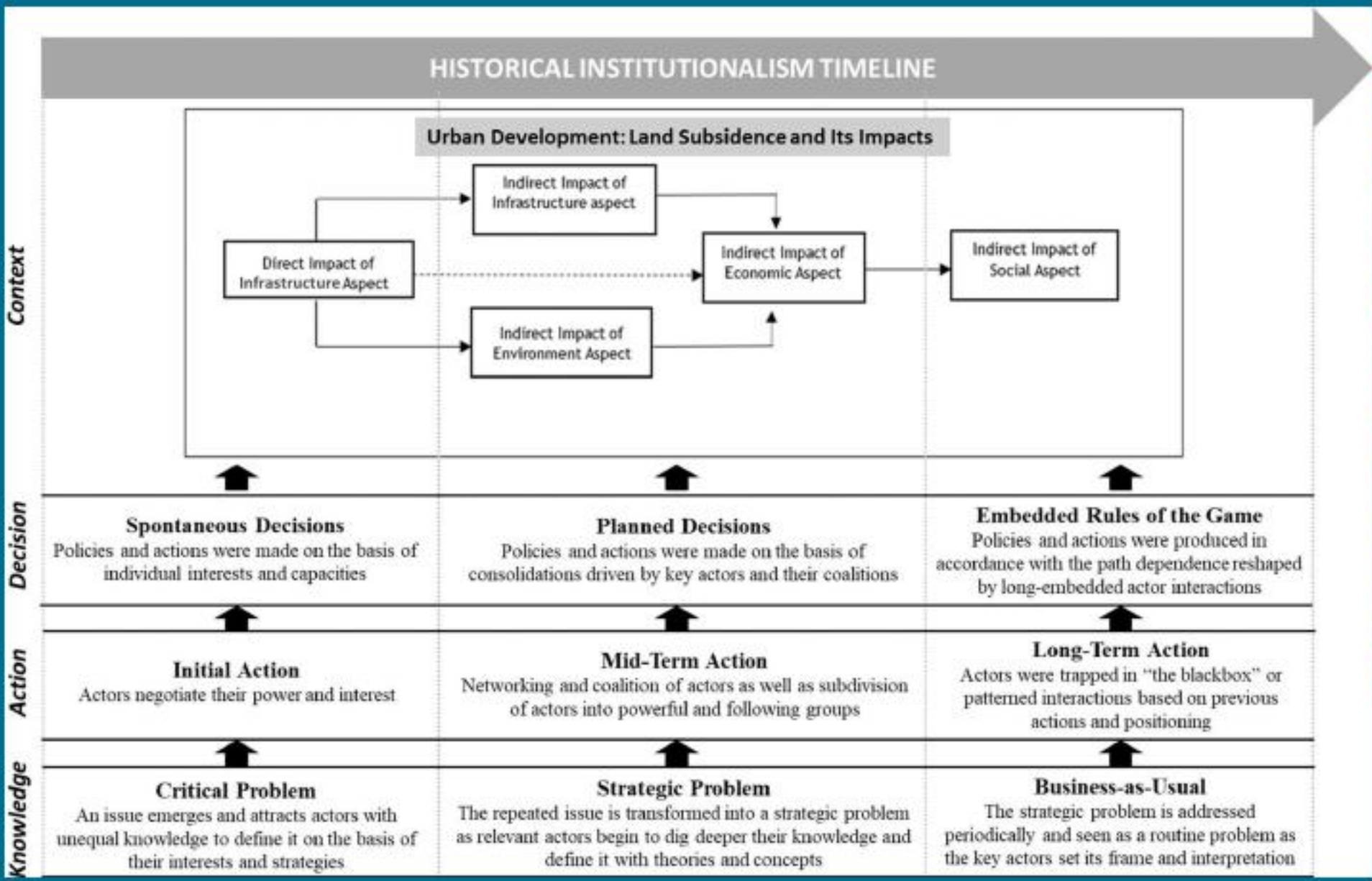


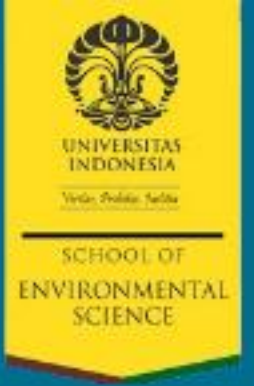
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# LAND SUBSIDENCE RESPONSE





# MITIGASI *LAND SUBSIDENCE* MELALUI RWH

## Tantangan Pemenuhan Air Bersih

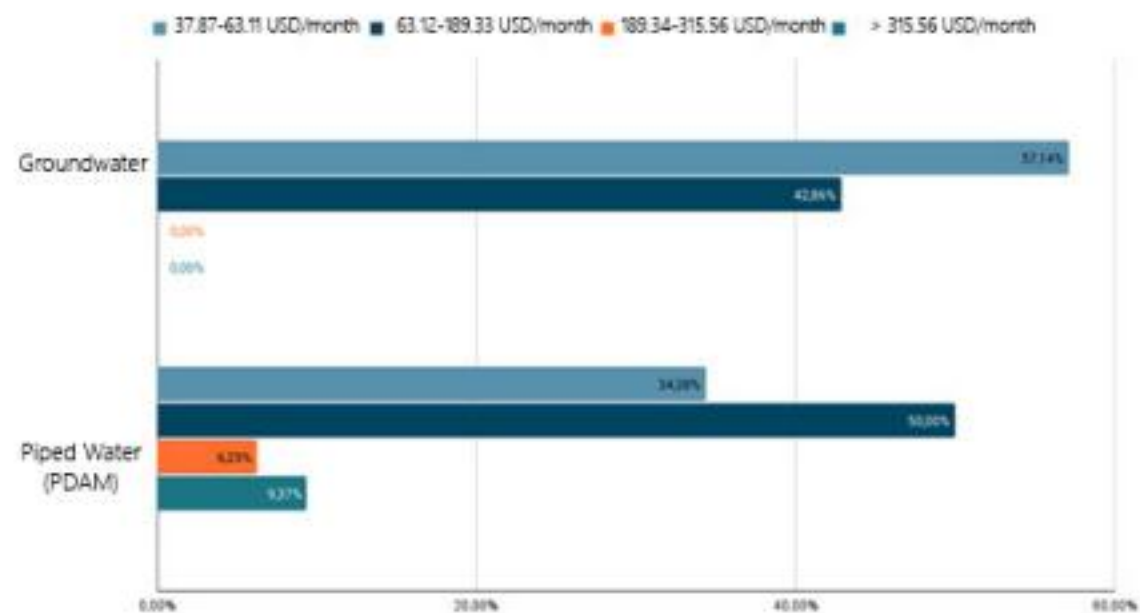
Fulfillment challenges	The main water sources			
	Pipe Water		Groundwater	
	n	%	n	%
Quantity limitation	30	93.75	8	57.14
Low quality	0	0	5	35.71
Expensive cost	2	6.25	1	7.15

(Hasibuan *et al.*, 2024)

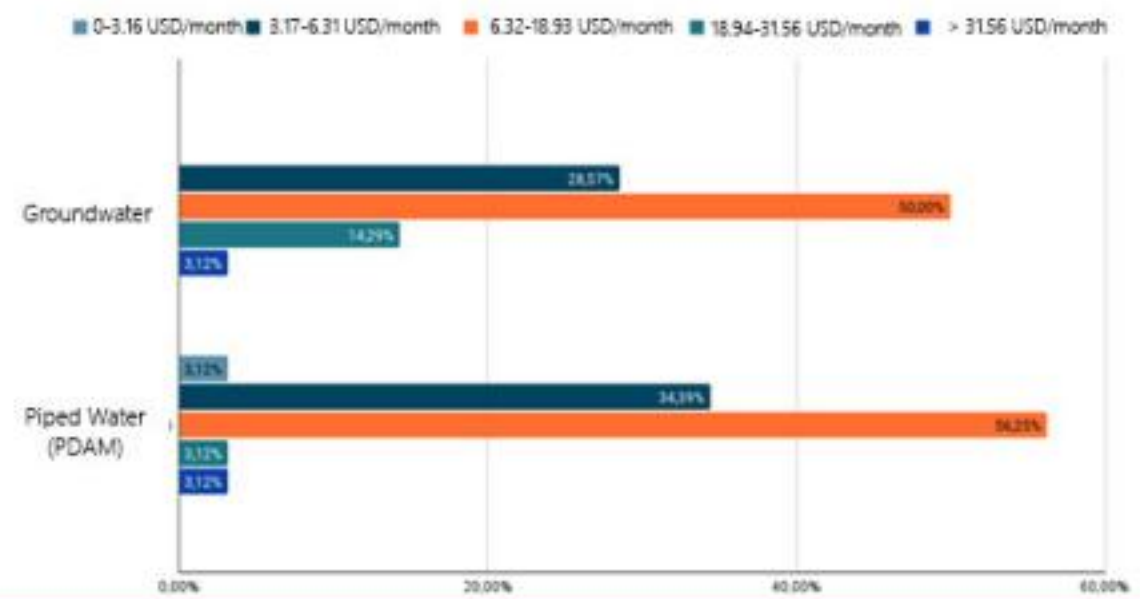
Difficulty factors	Total	
	n	%
Limited availability	17	77.27
1. Limited piped water	8	47.06
2. The lack operationalization of piped water	6	35.29
3. Dry wells	2	11.76
4. Unequal distribution of piped water	1	5.89
Unaffordable prices	3	13.64
1. Cost allocation 23% of monthly income	1	33.33
2. Cost allocation 10% of monthly income	2	66.67
Poor quality of main water source	2	9.09
1. Piped water	0	0
2. Ground water	2	100.00

(Hasibuan *et al.*, 2024)

### Income per Month



### Clean Water Expenses per Month



Pengguna pada kelompok ekonomi menengah bawah harus menyisihkan **23% pendapatan per bulan** untuk mengkases air bersih

(Hasibuan *et al.*, 2024)



**46, 62%**

Warga di sekitar wilayah penerapan teknologi memanfaatkan RWH sebagai sumber air bersih alternatif

*(Hasibuan et al., 2024)*

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## Faktor Pemicu

Variable	B	Standard error (SE)	Wald	Sig.	Exp(B)	Nagelkerke R square	-2 Log likelihood
Ability to meet the needs	1.323	0.581	5.177	0.023	3.754	0.223	37.489
Constant	-5.253	1.885	7.767	0.005	0.005		
The perceived benefits of RWH	1.281	0.920	1.939	0.164	3.600		
The ease of operating RWH	0.117	0.737	0.025	0.874	1.124		
The accessibility of RWH	0.369	0.538	0.470	0.493	1.446		

Individu yang mempersepsikan RWH mampu memenuhi kebutuhannya akan memiliki kecenderungan **3,754 kali lebih besar** untuk mengadopsi teknologi tersebut dibandingkan dengan mereka yang tidak mempersepsikan demikian

Persepsi terhadap RWH sebagai solusi pemenuhan sumber air bersih yang layak memegang peranan penting dalam proses pengambilan keputusan untuk menerapkan teknologi tersebut

(Hasibuan *et al.*, 2024)

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## Karakteristik Pengguna RWH

User characteristics	Utilization of RWH			
	Yes		No	
	n	%	n	%
<i>The main water sources</i>				
Piped water (PDAM)	51	73.91	54	68.35
Groundwater (Drill and dug wells)	18	26.09	25	31.65
<i>Family members</i>				
1-3 persons	20	28.99	18	22.78
4-6 persons	44	63.77	54	68.35
7-10 persons	4	5.80	7	8.87
> 10 persons	1	1.44	0	0
<i>Ease of access</i>				
Easy	23	33.33	39	49.37
Difficult	46	66.67	40	50.63

(Hasibuan *et al.*, 2024)

# Kualitas Air RWH

(Hasibuan *et al.*, 2024)

No.	Parameters	Unit	Result	Quality standard
<b>Physic criteria</b>				
<b>Groundwater</b>				
1.	Temperature	Degree Celsius (°C)	26.3	-
2.	TDS	mg/L	2829**	300
3.	Turbidity	Nephelometric turbidity unit (NTU)	1.99	3
4.	Color	True colour unit (TCU)	tt <0.70	10
5.	Odor	-	Odorless	Odorless
<b>Tap water</b>				
1.	Temperature	°C	26.0	-
2.	TDS	mg/L	133	300
3.	Turbidity	NTU	0.62	3
4.	Color	TCU	tt <0.70	10
5.	Odor	-	Odorless	Odorless
<b>Gallon water</b>				
1.	Temperature	°C	26.1	-
2.	TDS	mg/L	58	300
3.	Turbidity	NTU	0.5	3
4.	Color	TCU	tt <0.70	10
5.	Odor	-	Odorless	Odorless
<b>RWH</b>				
1.	Temperature	°C	26.0	-
2.	TDS	mg/L	20	300
3.	Turbidity	NTU	1.59	3
4.	Color	TCU	tt <0.70	10
5.	Odor	-	Odorless	Odorless
<b>Chemical criteria</b>				
<b>Groundwater</b>				
1.	pH	-	7.55	6.5-8.5
2.	Manganese	mg/L	0.1926*	0.1
<b>Tap water</b>				
1.	pH	-	7.78	6.5-8.5
2.	Manganese	mg/L	tt <0.0027	0.1
<b>Gallon water</b>				
1.	pH	-	7.71	6.5-8.5
2.	Manganese	mg/L	tt <0.01	0.1
<b>RWH</b>				
1.	pH	-	6.69	6.5-8.5
2.	Manganese	mg/L	tt <0.0027	0.1
<b>Microbiological criteria</b>				
<b>Groundwater</b>				
1.	Total coliforms	Colony/100 mL	> 1,000***	0
2.	E-coli	Colony/100 mL	> 1,000***	0
<b>Tap water</b>				
1.	Total coliforms	Colony/100 mL	1*	0
2.	E-coli	Colony/100 mL	0	0
<b>Gallon water</b>				
1.	Total coliforms	Colony/100 mL	<1.8*	0
2.	E-coli	Colony/100 mL	<1.8*	0
<b>RWH</b>				
1.	Total coliforms	Colony/100 mL	> 1,000***	0
2.	E-coli	Colony/100 mL	34.5**	0

\*\*\* parameters exceed quality standard, with the level represented by the number of symbol

## Potensi Kuantitas RWH pada Mitigasi *Land Subsidence*

### KEMAMPUAN MEMENUHI



Penerapan instalasi RWH eksisting dapat memenuhi **0,2%** sumber air bersih untuk kebutuhan **sanitasi**



Setiap instalasi RWH eksisting dapat memproduksi **20.010, 24 Liter/bulan** (**area tangkap: 80 m; Run-off koefisien: 0,9; intensitas curah hujan: 277,92 mm**)



Untuk **2.053 KK** dengan total kebutuhan **9.700,425 L** dan kebutuhan per KK adalah **4.725 Liter**

(Hasibuan *et al.*, 2024)

## Penggunaan Air Tanah & Mitigasi *Land Subsidence*

Well depth (m)	Total	
	n	%
0.15-1.00	18	33.96
1.01-3.00	26	49.07
3.01-5.00	7	13.21
5.01-10.00	3	5.74
>10.00	0	0

Setiap KK menggunakan **174,6 Liter** air tanah per hari.

Peningkatan kapasitas **produksi RWH** hingga **70%-80%** mampu **mereduksi** penggunaan air tanah secara signifikan

(Hasibuan *et al.*, 2024)

# Rekomendasi Kebijakan Penerapan RWH untuk Mitigasi *Land Subsidence*



(Hasibuan et al., 2024)

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Policy-making and the spatial characteristics of land subsidence in North Jakarta

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**ABSTRACT**

The incidence of "Jakarta is sinking" has grown faster following the recent flood events over the past few years. Many studies have been conducted to find the actual cause of land subsidence is growing faster by around 30 cm per year in the northern area, which is dominated by housing and industrial units like commercial buildings and industries. This study aims to provide an extensive explanation of the land subsidence phenomenon from the perspective of land use transformation. Applying spatial analysis and descriptive statistics to discuss the relationship between policy direction and land subsidence levels over decades. This paper found that spatial policy which has been pushed by urbanization in north Jakarta has contributed a more significant impact on land subsidence. The intensity of government policy to urbanize groundwater resources led from the urbanization and subsidence with the processing of access to job water, changed to one of the most significant factors regarding land subsidence.

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**Introduction**

The progressive expansion that Jakarta is sinking faster than other cities in the northern part of Java island has been more noticeable phenomenon. The North Jakarta area is the most affected area where the land subsidence rate is higher than the four other metropolitan in the province [1]. Indeed to find the development land-use/cover which is one of the most densely populated areas, has been experiencing a land subsidence rate of 1.9–4 m over the last three decades [2]. Jakarta's land subsidence is believed to be caused by groundwater depletion [3]. The geological and soil subsidence are the primary factors, while environmental groundwater use and land use development are the triggering factors [4,5,6]. However, it remains unclear whether the main influence during times of Jakarta's rise are natural and/or human-induced factors, economic and development issues, socio-cultural issues, or a combination of them.

Looking at the current status, North Jakarta has the strong urbanization of a coastal city where many parts of the area were lost by 1.3 times. This situation causes the urban control plan to be dominated by

affluent urbanization cell types [7]. This cell character demonstrates the composition of each composition on the ground, which is either dense central and, therefore, more vulnerable to land subsidence.

Although the area is vulnerable, both natural and societal perceptions are continuously changing. Development interventions like the north–south line expansion of the MRT, Jakarta's social spatial plan in 1994, etc. [8,9,10]. The area was designed to expand Jakarta to its east that is expected to be the best point of urban development because Jakarta needed the structural government's expansion to reorganize the area into a strategic growth pole, which is occupied by a mixture of dense housing, commercial, and industrial areas.

During the development process over the past 30 years, along with office and industrial zones, informal settlements and informal economic activities also emerged in the surrounding newly developed buildings. This situation caused massive and uncontrolled population growth over recent decades. From 1980 to 2020, for instance, the average rate of population growth reached 1.27%, and the population numbers increased from 10,500,000 to 10,441,771 inhabitants [11]. The overall increase in population has been made more by informal

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CASE STUDY

Potential application of rain water harvesting technology as an alternative clean water source to mitigate land subsidence

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**ABSTRACT**

**Background and Objective:** The limited supply of tap water has implications for the number usage of groundwater in North Jakarta coastal area, that suffer from land subsidence. As a result, it is crucial to provide alternative sources of sustainable clean water that can minimize groundwater consumption, calculating the sociological factors, rainwater harvesting technology provides remarkable potential and has been utilized in numerous countries. However, provided residential region near the coast, according to this, the study aims to analyze the viability of rainwater harvesting technology that is necessary to fulfill the water and sanitation needs to reduce groundwater use and meeting clean water needs for mitigating land subsidence in North Jakarta of North Java.

**Methods:** This study was conducted in North Jakarta coastal area within a radius of 0–2 kilometers, by conducting survey activities on 145 households who live near the border of the technology installation, as well as collecting the data on rainfall, and clean water charges. The purpose of this study activity is to assess the socio-economic and environmental related factor impact of rainwater harvesting technology on reducing land subsidence.

**Results:** based on its quality, rainwater harvesting has the potential to support the fulfillment of clean water needs in North Jakarta, especially for sanitation purposes. The quality test results indicate additional insight indicating that the clean water derived from the rainwater harvesting system is a better option for domestic than groundwater from either dug and drilled wells. The groundwater samples never showed extremely high levels of total dissolved solids (2571 mg/l) and nitrate, making it extremely dangerous to use for cooking and drinking, as well as sanitation, such as bathing and washing. In terms of quantity, environmental simulation indicates that the provision of rainwater harvesting technologies can support 0.2 percent of clean water for sanitation purposes in each implementation and this finding highlights that the adoption of rainwater harvesting is a viable solution for reducing water demand as a crucial factor influencing the decision to adopt such practices.

**Conclusion:** The existing rainwater harvesting is very critical to the mitigating the land subsidence, through the remaining depending on existing groundwater as their source of water supply. The society selected rainwater harvesting as a solution to the difficulty in getting clean water demands should be multiple factors, to encourage greater adoption of the technology, it is crucial to ensure the community's awareness of its effectiveness in addressing their water needs. Strategies such as awareness campaigns, demonstration, and providing technical assistance of rainwater harvesting technology could help drive community adoption, in contrast, while the focus on the benefits, operational ease, and availability of rainwater harvesting technology, they do not appear to have a direct and meaningful effect on the adoption of rainwater harvesting in this study.

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