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Relocation of residents on the banks of the pluit reservoir and its impact on the level of community vulnerability

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ABSTRACT

Background: Flooding, particularly tidal flooding, has become a major environmental threat to coastal cities around the world, including Jakarta, Indonesia. North Jakarta, which directly borders the Java Sea, is one of the most flood-prone areas, with high vulnerability due to climate change, land subsidence, and unplanned urban settlement. This study focuses on the Pluit area, historically a water retention zone, which has undergone significant transformation in its spatial and social structure. **Methods**: This study employs a qualitative approach based on a literature review and secondary data analysis. It investigates the dynamics of community vulnerability in North Jakarta, with a special focus on the impact of relocation from the banks of the Pluit Reservoir to Rusunawa Muara Baru. The research also compares social, economic, and environmental conditions before and after the relocation process to assess changes in flood risk and resilience. **Findings:** The relocation program around the Pluit Reservoir has contributed significantly to reducing community vulnerability to flood risk. Compared to previous major flood events in 2002 and 2015, the Pluit area experienced minimal flooding during the Jakarta flash flood in early 2020, despite the area being 4 meters below sea level. The restored function of Pluit as a "Ponder" area with reinforced embankments has proven effective in controlling water intrusion. However, projections indicate that sea-level rise will submerge large parts of North Jakarta by 2050. **Conclusion**: Integrating spatial planning, historical water infrastructure restoration, and social relocation strategies can effectively reduce urban flood risk. Nonetheless, long-term sustainability is threatened by climate change-driven sea-level rise. Multi-sectoral adaptation strategies are urgently needed to secure the future of low-lying urban coastal areas. **Novelty/Originality of this article:** This study highlights the effectiveness of combining historical water infrastructure concepts with modern relocation strategies in mitigating urban flood risk, offering a localized yet scalable model for other flood-prone coastal cities.

KEYWORDS: urban flood risk; pluit reservoir; community relocation; tidal flooding; coastal adaptation.

1. Introduction

Flooding has caused damage to the physical environment in several cities around the world that are located on the coast. These floods can be caused by sea water rising inland, called tidal flooding. Tidal flooding, also known as tidal flooding, occurs when the tide rises and inundates parts of the coastal land or in places lower than the high tide level (Amira et al, 2020). Tidal flooding occurs due to the rise in sea level caused by tides, as well as the push of water, wind, or swell (long distance waves).

Flooding is a dangerous disaster and a real threat, especially in Indonesia. Data from the National Disaster Management Agency/*Badan Nasional Penanggulangan Bencana*

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(BNPB) recorded 679 cases of flood disasters out of a total of 2,574 disaster cases in Indonesia. At the beginning of 2019, there were 83 flood cases nationwide, with a total of 82 fatalities. Flooding has also become an annual disaster that has always occurred in the DKI Jakarta area in the last decade (dibi.bnpb.go.id). Urban areas such as DKI Jakarta face the threat of flooding triggered by climate change, land subsidence, and socioeconomic changes. The Jakarta area of 664.01 km^2 is inhabited by 11.13 million people, making the city vulnerable to natural disasters (Wicaksono & Herdiansyah, 2019).

Jakarta's status as the center of government and economy is the main driving factor for people in other regions to choose to live and work in Jakarta. However, not all residents who choose to move to Jakarta have a high level of education or have specialized skills. The demand for housing that is not matched by the ability to fulfill it causes many people to live homeless, or choose to build housing in inappropriate locations, such as under bridges/toll roads, near railroad tracks, or on the banks of reservoirs. Based on data from the Central Bureau of Statistics/*Badan Pusat Statistik* (BPS), in 2021 only 40% of DKI Jakarta residents have access to decent housing. Among the Jakarta areas, only South Jakarta has 50% of its citizens with access to decent housing.

Handling flood problems in Jakarta generally focuses on technical protection mechanisms to reduce the possibility of flood hazards by building flood control facilities (Texier, 2008). With the widespread impact of flooding in Jakarta, there has been a shift to a flood risk-based management approach in recent years (Ward, et al., 2013). One framework that is often used as a guideline in disaster management is the Disaster Management Cycle, which divides disaster management into four phases; mitigation, preparedness, emergency response, and recovery. The disaster risk mitigation phase is an important phase to reduce the risk of disaster occurrence, as well as efforts to increase community preparedness.

North Jakarta Municipality, which is directly adjacent to the Java Sea, is an area most vulnerable to flooding. Some areas in North Jakarta that are prone to flooding are Pluit, Ancol, Kamal, Marunda, Cilincing, Penjaringan, Kapuk Muara and Kalibaru. Of all these areas, Pluit, which was once a swampy water catchment area, and has now developed into an elite residential area, power plant industry and business center, has an interesting flood-related history to explore. The name Pluit comes from the Dutch word fluitschip, which means long sailing ship. The name was given because the Dutch put a fluitschip that was no longer seaworthy on the east coast of the Angke River estuary, so this area was then named Pluit.

After the Dutch East Indies took over Banten and most of Batavia, the government at the time deliberately made Pluit into a swamp. This was due to the fact that, after the great Batavia flood of 1918, Pluit was considered an ideal swampy area for natural infiltration. Geologically, the Pluit plain consists of Pleistocene deposits that are more or less 50 meters below ground level and below sea level. In addition, thirteen rivers and two canals that flow through Jakarta empty into Pluit.

In 1923, the creator of the West Flood Canal, Herman Van Breen, defined Pluit as a polder area, which is an area designed in such a way and bounded by embankments that water runoff from outside the area cannot enter. This meant that the water that fell in Pluit had to be pumped regularly. Via Decree No. 387/1960, this area was originally intended as the Pluit polder. The Pluit Reservoir was built later to control Jakarta's flooding. The Pluit Reservoir project began in 1960, designating Pluit as a closed area. With an area of 80 hectares and a capacity of 2.5 million cubic meters, the Pluit reservoir was completed in 1981. There are four pumping stations and a polder system to control inundation from Krukut and Cideng to Jatibaru, Taman Sari, Mangga Besar, Kali Beton, and beyond. However, in 1960, the government also made a Detailed Plan to build Gelora Senayan, which was approved by the DPRD at that time. Among these was Kampung Gusti/Pluit, which had an area of 1415.6 ha. The Pluit Authority was developing Pluit Baru for housing, industry, and a reservoir, power plant, and fishing village.

Despite the shortage of land, the Pluit Project went ahead in 1971. After that, it expanded to Jelambar and Pejagalan. The Pluit area developed even faster in 1976. Even

now, Pluit is no longer a swampy area. Instead, it has turned into an elite residential area full of recreational areas and industrial facilities.

In 2002, floods inundated some areas of Pluit. During the rainy season, the area relies on water pumps. At the start of the 2015 rainy season, the peak occurred when the Pluit reservoir pumps malfunctioned. The water level quickly rose from 100 cm to 180 cm. The overflowing water from the Pluit Reservoir caused several surrounding areas to be flooded. In addition, at present, Pluit Reservoir is getting shallower and narrower as it is filled with slums. Of its 80 hectares, 20 percent are slum locations. Silting causes the water storage capacity during the rainy season to decrease. In 2012, the reservoir water was only 2 meters deep from its previous depth of 10 meters.

To date, the land in the Pluit area is still falling. By 2030, the surface of Pluit will be in the range of 5-10 meters below sea level, according to calculations by the JCDS team based on data from the Jabodetabek Water Resources Management Study. This study discusses the socio-economic factors of people living in the Pluit area of North Jakarta that influence their vulnerability to the ever-present danger of flooding.

2. Methods

The method used in this study uses literature review by prioritizing analysis of research or writings related to aspects of flood disasters in the North Jakarta area, community vulnerability to flood disasters, as well as comparison of environmental, social and economic aspects of the community around the Pluit Reservoir banks that were relocated to Rusunawa Muara Baru, before and after the relocation process. This study uses a qualitative approach by analyzing secondary data.

3. Results and Discussion

3.1 Research location

DKI Jakarta Province administratively has an area of about 664 km^2 and is located in the delta area, which is a sedimentary area at the mouth of the river bordering the sea, the river flow always passes through this delta when the water goes to the sea. The area of Jakarta Province is categorized as flat or sloping based on its topographic conditions. Land elevation from the coast to the flood canal ranges from 0-10 meters above sea level, measured from zero point at Tanjung Priok. Whereas from the flood canal to the southernmost boundary of Jakarta Province ranges from 5 to 50 meters above sea level. Coastal areas that are swamps are always flooded during the rainy season. Based on the LIDAR elevation data with a DEM size of about 2 x 2 m, we found that the area is below sea level with an elevation of +1.2 m PP, as shown in Figure 1.

Jakarta, as the nation's capital, serves as the main center of government and economy in Indonesia. This makes Jakarta a significant attraction. Economic factors act as the main driver for people in other cities to choose to live and work in Jakarta. Not all people who choose to move to Jakarta have a high level of education or specialized skills. The pressure for housing needs that is not matched by the ability to fulfill it causes people to choose to build housing in locations that should not be, such as on the banks of reservoirs (Agyaputeri & Rahayu, 2017). This is also the case in Pluit Reservoir, North Jakarta. The community built houses and settled around the Pluit Reservoir. However, this will have an impact on reducing the area and capacity of water reservoirs. The area around the reservoir should be allocated for green land and border zones. There are about 5,000 families living on the eastern side of the Pluit Reservoir (Belarminus, 2014). Settlement conditions in Pluit Reservoir are characterized by high density and unsanitary environment. In addition, floods often hit the area, resulting in an increasingly noticeable increase in squalor. Poor environmental quality issues have resulted in the area being classified as uninhabitable.

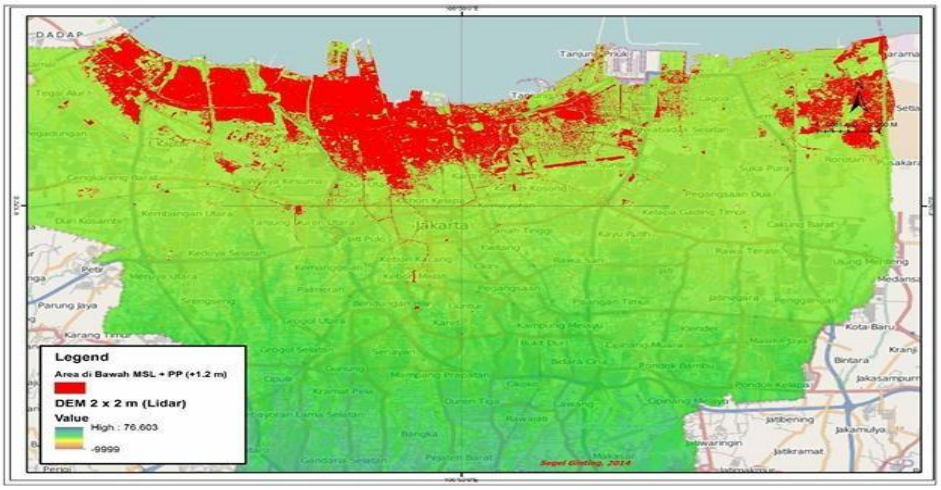

Fig. 1 Areas of Jakarta that are below sea level

3.2 Challenges and opportunities

Community Pluit is one of the urban villages located in Penjaringan sub-district, North Jakarta city, and has an area of 7.71 km^2. In 2020, the population of Pluit urban village was 56,572 people, consisting of 27,828 men and 28,744 women, and a population density of 7,337 people/km^2. Like other areas of North Jakarta, Pluit urban village residents come from various ethnicities, religions, races and customs. Based on data from the 2010 population census, North Jakarta residents are predominantly Chinese, Javanese, Betawi, Batak, and Sundanese, and some are Minangkabau, Bugis, and other tribes (id.wikipedia.org/wiki/Pluit).

In terms of religion, the population is also quite diverse, and tends to be almost balanced between Islam, Christianity and Buddhism. Based on data from the North Jakarta Central Bureau of Statistics in 2020, the number of religious adherents in this kelurahan was recorded, where Islam was 34.62%, then Christianity 34.29% (Protestantism 21.15% and Catholicism 13.14%), Buddhism 31.00%, a small proportion of Hindus 0.06% and others 0.03% (Confucianism and beliefs). The Jakarta Coastal Defense Strategy (JCDS) analyzed the population and future projections for the provinces of DKI Jakarta, Banten and West Java, as shown in Table 1 below.

Table 1. Population projections (2000–2030)

Region	2000	2010	2020	2030
BANTEN	466,699.7	1,570,780.6	2,615,777.3	4,391,794.4
Tangerang Regency	74,463.5	90,834.9	161,691.2	287,819.2
Tangerang City	392,236.2	575,268.9	843,711.6	1,382,707.2
South Tangerang	-	904,676.8	1,610,374.5	2,721,268.0
DKI JAKARTA	7,798,679.0	9,567,127.0	11,284,161.0	12,665,252.0
West Jakarta	1,531,636.0	2,278,825.0	2,807,023.0	3,103,000.0
Central Jakarta	1,051,630.0	898,883.0	1,101,686.0	1,263,890.0
South Jakarta	1,589,895.0	2,001,907.0	2,325,482.0	2,493,000.0
East Jakarta	2,451,943.0	2,449,645.z	2,774,537.0	3,144,000.0
North Jakarta	1,173,463.0	1,937,867.0	2,275,433.0	2,360,362.0
WEST JAVA	2,222,405.4	3,773,637.9	6,473,707.2	11,205,380.6
Bekasi Regency	27,250.9	73,627.4	145,526.7	287,637.5
Bogor Regency	318,192.9	495,373.7	771,215.0	1,600,654.0
Cianjur	-	-	-	-
Bekasi City	557,825.2	1,007,026.5	1,817,958.2	3,281,914.0
Bogor City	378,898.7	520,988.1	832,459.7	1,579,929.6
Depok City	930,237.7	1,677,521.3	2,906,547.6	4,455,247.6
Jabodetabekpunjur	10,487,784.1	14,911,545.5	20,373,645.9	28,262,460.3

3.3 Land subsidence

Land subsidence in Jakarta occurs at varying rates. In general, the north side is faster than the south side. In the north side (Ancol area), the ground level drops to about 7 cm/year based on the data of the groundwater damage zone map of the Jakarta Groundwater Basin (CAT) in 2013 and in 2018 from the Geological Agency survey (Badan Geologi, n.d).

The results show that the accumulation of the four factors causing land subsidence in Jakarta, namely subsidence due to geological structures, natural consolidation, building loads, and due to groundwater extraction, has caused significant land subsidence. Groundwater extraction is the main cause of land subsidence in Jakarta.

The land surface in DKI Jakarta experiences continuous subsidence every year, varying from 1 to 20 centimeters per year. The condition of the land surface in Pluit Village, North Jakarta, with the highest rate of land subsidence is 20 centimeters, in the last 10 years the land subsidence has reached 2 meters (Andreas, 2018). In the Pluit area, the land surface is currently around 2 to 4 meters below sea level. Muara Karang, Muara Baru, Muara Angke, Pantai Indah Kapuk, to Kamal Muara, some areas are already below sea level, some up to 1 meter as well. Data from the Jakarta Coastal Defense Strategy (JCDS) starting from 1974 to 2010 there is land subsidence that reaches 4 meters.

3.4 Pluit Reservoir Normalization

The Most of the land on the edge of Pluit Reservoir was occupied by illegal housing, which caused siltation and diversion of the function of most of the 80 hectares of land that should be used as a water storage reservoir. Residents began taking land on the edge of the Pluit Reservoir that was supposed to be free from development since the 1990s. Initially, the structure was built semi-permanently using the reservoir wall as a barrier. Garbage and silt from upstream, along with household waste from nearby residents, caused siltation to worsen, causing Pluit Reservoir to lose its function. Silting causes the water storage capacity during the rainy season to decrease. In 2012, the reservoir was only 2 meters deep from its previous depth of 10 meters.

Learning from the case of the Pluit flood in 2015, where there was damage to the water pump in the Pluit area which was unable to cope with the water discharge due to the overflow of the Pluit Reservoir, the Provincial Government of DKI Jakarta conducted Pluit Reservoir Normalization (Ginting, 2015). Therefore, the local community must be relocated to a place that has been prepared, one of which is to Rusunawa Muara Baru. In addition, the relocation is one form of the DKI Jakarta government's strategic plan to curb slums and illegal settlements and improve the quality of life of the local community (Khalil, 2012) because where they live is a residential area of houses and with unfit environmental conditions. Muara Baru Flat is a flat located directly opposite the previous residential area. The Head of Housing and Government Buildings Agency of DKI Jakarta, Jonathan Pasodung (Yuliansari, 2013) said that Muara Baru Flat is planned to consist of 12 towers so that it can accommodate around 1,200 FAMILIES. To accommodate other residents, several flats have been provided, but their locations are far from the location of the previous settlements.

According to a study from Agyaputeri & Rahayu (2017), there were changes in the physical aspects of the environment after the relocation of residents on the banks of the Pluit Reservoir. There is an improvement in environmental conditions that can affect changes in other aspects, namely social aspects and economic aspects of the community. For more details, it can be seen in Table 2 below.

3. 4. 1 Aspects of the physical environment

From table 1, it can be seen the total score obtained by each of the variables that make up the physical aspect of the environment and the distribution of scores. From the total score of each variable, it can be seen that all variables in the physical aspects of the

environment have increased, both in terms of the availability of supporting facilities and environmental conditions. This can be seen from the increase in the total score owned by each constituent variable. The biggest score change occurred in the variable availability of supporting facilities. The largest change in score indicates a significant change related to the provision of supporting facilities in the community settlement environment. The availability of supporting facilities then has implications for the ease with which people can obtain basic services. Improving the condition of the residential environment will have an impact on improving the conditions of cleanliness, environmental health, comfort, and safety in living. Meanwhile, improvements in accessibility conditions and ease of transportation will have an impact on the ease of community mobility.

Table 2 Distribution of scoring results of Physical Environmental aspects

Variabel	Pluit Reservoir (4)	3	2	1	Muara Baru Public Housing (4)	3	2	1
Housing Environment Conditions								
Housing Characteristics and Conditions	16	64	13	7	74	13	2	0
Cleanliness	0	0	16	67	0	0	100	0
Environmental Sanitation System	0	17	58	25	0	52	36	12
Disasters	0	69	0	0	100	0	0	0
Availability of Supporting Facilities								
Educational Facilities	29	36	23	12	65	33	2	0
Play and Entertainment Facilities	3	19	30	48	19	52	23	6
Health Facilities	7	36	52	5	3	36	44	17
Trade Facilities	26	47	27	0	55	33	11	2
Worship Facilities	22	64	10	4	58	0	0	42
Accessibility and Ease of Transportation								
Road Conditions & Ease of Access to Public Transportation	19	55	25	1	56	16	0	0
Availability of Parking Spaces	0	3	0	97	25	11	64	0

(Agyaputeri & Rahayu, 2017)

3.4.2 Social aspects of the community

Community social conditions are conditions that cannot be separated in community life that affect the comfort of residents in living in the environment. A comparison of community social conditions in the community's residential environment in reservoirs and flats is shown in Table 3. Based on the scoring results, it can be seen that the social conditions of the community in Muara Baru Flats tend to be better than the conditions at Pluit Reservoir. This improvement can be seen from the condition of environmental safety and health. As for the conditions of interaction between residents, the conditions at the Pluit Reservoir are still better than the current conditions in the Muara Baru Flat. The small difference in scores can indicate that the changes that have occurred are not too great with the previous conditions, despite the decline in conditions in community interaction. To further improve conditions in this social aspect, it is necessary to provide a better place to gather than at present. In addition, the management can also organize an activity that can strengthen social relations between communities. With the improvement of the community's social conditions, it is hoped that it will have an impact on the conditions of the residential environment that has a sense of family so that the environment becomes more comfortable to live in.

3.4.3 Economic aspects of the community

The economic aspect of the community is an important aspect that determines the level of community welfare. This aspect reflects the sustainability of the relocated community's livelihood.

Table 3.3 Distribution of scoring results of the economic aspect of the community

No	Variabel	Assessment							
		Pluit Reservoir				Muara Baru Public Housing			
		4	3	2	1	4	3	2	1
	Community Welfare	550				587			
1	Livelihood	-	-	-	-	-	-	-	-
2	Community Income	29	28	42	1	36	25	39	0
3	Regular Expenses	0	49	37	14	0	29	52	19

(Agyaputeri & Rahayu, 2017)

An increase in the total amount of community expenditure (flat rent, electricity, water) that is not matched by an increase in income causes the community's living conditions to become worse. The high cost required to fulfill the basic needs of the community leaves the community with no other choice but to try to get other income outside the basic income. This has led to an increase in the number of people who have additional income from the past at the reservoir to the current Muara Baru Flat. A total of 6 respondents said they currently had to have a side business to meet their needs so that the total number of respondents who had a side business at this time was 34 respondents. The effort to have a side business is good because the economic crush is able to increase community productivity. Based on the results of the questionnaire, people who have additional jobs while still living on the banks of the reservoir are 28 respondents with additional types of livelihoods as traders, laundry workers, shopkeepers, and laborers in fish processing factories or in apartments around Pluit. Meanwhile, after being moved to Muara Baru Flat, people who had additional income increased to 34 respondents. This increase is based on a lack of income so that it is unable to cover all existing needs. The type of livelihood chosen by the community is as a trader. Many people trade in front of their residence or in the corridor of the flat. There is no permission from the residents to the management to open a business in their flat unit. If this condition continues to occur, it will have an impact on the condition of the community who will continue to live in a high economic crush.

4. Conclusions

The relocation of residents on the banks of the Pluit Reservoir not only has an impact on improving their social, economic and environmental quality of life, but overall has an influence on reducing the level of vulnerability of the Pluit community to the threat of flood risk. Those who have legal residences, business premises, industrial and trade sectors in the Pluit area are now starting to feel the impact. If in 2002 and 2015 there were major floods that hit most of the Pluit area, in the case of the Jakarta flash floods in early 2020 the Pluit area was relatively safe and not flooded, even though the ground level was already 4 meters below sea level. Restoring the function of the Pluit area as a Ponder, which is an area designed in such a way and limited by embankments so that water runoff from outside the area cannot enter, as was done by the Dutch East Indies government in the early 20th century, reduces the level of community vulnerability to flooding, at least for the next 2 or 3 decades. However, the rapid rise of sea levels due to global warming is inevitable, and the coastal areas of the north coast of Jakarta with land levels lower than 4 meters above sea level will disappear (estimates are that by 2050 95% of North Jakarta will be submerged by sea water).

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Author Contribution
The author was responsible for the conceptualization, data collection, analysis, and manuscript writing. All aspects of the research, including the formulation of research questions, literature review, and interpretation of findings, were conducted independently. The author also reviewed and approved the final version of the manuscript.

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