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COASTAL COMMUNITIES' ADAPTATION TO DOMESTIC WATER NEEDS DUE TO TIDAL FLOODS IN TAMBAK LOROK AND KEMIJEN

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ABSTRACT

Tambak Lorok and Kemijen in Semarang face chronic tidal flooding, land subsidence, and seawater intrusion that degrade groundwater, the leading domestic water source. Limited piped-water supply forces households to combine unsafe wells with bottled water to meet daily needs. Scientific gaps persist regarding integrated analyses of groundwater quality, household-level adaptation, and stakeholder roles at the village scale. This study aimed to analyse the quality of water used by communities affected by tidal flooding and to examine how coastal households adapt to fulfil domestic water needs in Tambak Lorok and Kemijen. A mixed quantitative–qualitative approach was applied through groundwater sampling and semi-structured interviews with 114 household respondents. The results show that 2 of 7 artesian well samples fall into the brackish category, with Electrical Conductivity values of 1,045 µmhos/cm in Tambak Lorok and 1,165 µmhos/cm in Kemijen. Other samples indicate fresh water transitioning to brackish, with EC values ranging from 663–937 µmhos/cm in Tambak Lorok and 912 µmhos/cm in Kemijen. Community adaptations include reliance on artesian wells (90.4%), universal use of gallon water for drinking and cooking (100%), and limited use of PDAM services (9.6%). In conclusion, degraded groundwater conditions directly shape household adaptation strategies and demonstrate uneven vulnerability across neighbourhoods. The findings imply the urgency of improving piped-water access, strengthening stakeholder coordination, and designing targeted interventions for chronically affected communities. Scientifically, this study contributes a novel village-scale integration of water-quality assessment, adaptation behaviour, and governance analysis, offering a comprehensive framework for coastal water management under tidal-flood pressures.

Keywords: *coastal adaptation; groundwater quality; tidal flooding*

INTRODUCTION

Coastal areas in Semarang City are increasingly exposed to environmental pressures resulting from tidal flooding, land subsidence, and seawater intrusion, which directly affect domestic water security. Among the most vulnerable locations are Kampung Tambak Lorok in North Semarang and Kampung Kemijen in East Semarang, both situated in low-lying coastal and estuarine zones. These settlements experience recurrent tidal inundation that disrupts daily activities and degrades groundwater quality, which remains a primary water source for many households. The specific geographic position of these two villages at the downstream convergence of major drainage and river systems intensifies their exposure to saline intrusion and prolonged flooding.

In Kampung Tambak Lorok, tidal flooding has increasingly compromised artesian groundwater through salinisation, turbidity, and unpleasant odour. Historically, artesian wells functioned as a reliable domestic water source, distributed through community-based piping systems. However, frequent tidal flooding combined with long-term groundwater extraction has accelerated land subsidence and seawater intrusion, resulting in declining water quality that is no longer suitable for consumption. As a consequence, households are forced to rely on bottled water for drinking while continuing to use poor-quality groundwater for hygiene and other domestic purposes, creating both economic and health vulnerabilities, particularly for low-income fishing households.

Similar challenges are observed in Kampung Kemijen, especially in RW V, where access to piped water remains uneven despite its urban setting. Although PDAM Tirta Moedal provides municipal water services in Semarang, coverage in Kemijen is limited by technical constraints, infrastructure gaps, and high connection costs. As a result, nearly ninety per cent of households in RW V depend on privately owned deep wells, even though groundwater quality has deteriorated due to tidal flooding and land subsidence. This reliance perpetuates a cycle of groundwater overexploitation, further aggravating environmental degradation and reducing the sustainability of domestic water provision.

In response to these constraints, communities in both Kampung Tambak Lorok and Kampung Kemijen have developed adaptive strategies to secure domestic water supplies. These strategies include combining multiple water sources, such as bottled water, artesian wells, and limited PDAM connections, alongside physical adaptations like elevating houses and installing pumps.

However, these adaptations are largely autonomous and household-based, with limited coordination among stakeholders. Government agencies, local organisations, utility providers, and informal water suppliers all play roles in water provision, yet their efforts are often fragmented, leading to inefficiencies and unequal access.

Kampung Tambak Lorok and Kampung Kemijen represent two distinct yet interconnected coastal settings within Semarang City, making them scientifically significant case studies. Dense fishing settlements with strong social networks and long-standing dependence on communal artesian water systems characterise Tambak Lorok. In contrast, Kemijen reflects a peri-urban neighbourhood where formal infrastructure coexists with persistent reliance on private groundwater extraction. This contrast highlights how differences in socio-economic structure, settlement history, and infrastructural access shape community responses to tidal flooding and domestic water insecurity, offering comparative insights that are rarely captured in existing coastal adaptation studies.

Water quality in coastal areas is deteriorating due to pollution from industrial and household waste, as well as seawater intrusion. In a study by Saputra, E. et al. (2021), the results of their research show that slow disasters such as land subsidence and tidal floods do not always reduce land values in coastal areas. Unlike sudden disasters that can immediately reduce land prices drastically, the impact of slow disasters is more complex because economic and social factors influence it. Land subsidence causes tidal flooding. The occurrence of tidal floods causes water pollution (Sitaningrum and Widjajanti, 2024). When tidal flooding occurs, seawater contaminates freshwater sources, making them unfit for use. This adds to the burden on communities already trapped in difficult environmental conditions, where access to clean water becomes increasingly limited. Despite the polluted water quality and the constant threat of tidal flooding, many people choose to remain in Tambak Lorok and Kemijen villages.

Based on previous research, this decision is not only driven by limited resources but also by various social and emotional factors. Place attachment, such as childhood memories, length of stay, and a sense of comfort with the neighbourhood, is one of the main reasons. In addition, family ties and close social ties, such as support from neighbours and relatives, also hold people back from migrating. Economic ties (occupational ties), especially employment in the marine sector and access to local markets, also play an important role (Amin, C., Sukamdi, & Rijanta, 2021). Despite facing health risks from pollution and flooding, many people in Tambak Lorok and Kemijen villages choose to stay. Their main reasons are emotional and social attachments, such as childhood memories, family relationships, and support from neighbours. Interestingly, among the other constructs, the place valuation construct is the dimension that most influences the decision to stay.

This shows that the decision to live in disaster-prone areas is largely determined by valuations about the condition of the living area. Tambak Lorok residents are reluctant to move from their current residence because they do not want to lose their existing social environment. If they move to another place, then they will lose the social environment that they value the most. This proves that while migration can make a significant contribution to future household welfare and security, it comes at a high social cost. In addition, migration increases the risk to the nuclear family, resulting in increased psychosocial stress and social disconnection from the migrant's place of origin (Amin, Sukamdi, & Rijanta, 2019).

In addition, limited resources and employment opportunities elsewhere are also factors that encourage them to stay, even though environmental conditions are not ideal. In a study by Saputra, E., Spit, T., & Zoomers, A. (2019), the results found that land subsidence resulted in large economic costs for households. On average, they spent 28% of their total annual expenditure on repairs and 32% on adaptation. In addition, households that depended on the fisheries and agriculture sectors experienced an average income decline of 5.3% due to the destruction of ponds and agricultural land. Various decisions determine the likelihood of communities moving forward in achieving higher adaptation measures. When communities decide to stop their dependence on government support, for example, they look for other possibilities to survive on their own and address all available capabilities and resources. They also start renting or selling their assets, or try to access viable or flexible loans from relatives. These resources are used for housing modifications and improvements to reduce some of the risks of coastal flooding (Artiningsih et al., 2016).

The Semarang City government needs to adopt policies that support environmental sustainability and clean water access. The state of water supply in Semarang City, including water loss rates, household access to PDAM services, and primary raw water sources. Groundwater conservation is the responsibility of both the government and citizens, especially those with groundwater management licences (Kristiany, Hardjanto, & Prihatin, 2016; Derana, 2020). This is done to prevent overexploitation of groundwater. Based on the data, 57.07% of water is lost in the PDAM piping system, indicating leakage or inefficiency in clean water distribution. In addition, around 62.4% of households are connected to PDAM piped water services, meaning that there are still some people who do not have access to it. On the other hand, as many as 64.03% of households still rely on groundwater as a source of clean water, signalling a high dependence on groundwater that could lead to problems such as land subsidence (Pemerintah Kota Semarang, 2019).

Adaptive capacity is influenced by economic resources, infrastructure, institutions, and access to information and skills (Lindenmann et al., 2022). Despite numerous studies on tidal flooding and physical adaptation in Semarang, limited research has specifically examined domestic water adaptation through an integrated analysis of groundwater quality, community practices, and stakeholder roles at the village scale. This study addresses that gap by focusing explicitly on Kampung Tambak Lorok and Kampung Kemijen, where tidal flooding directly intersects with water governance challenges. By combining water quality analysis, community adaptation assessment, and stakeholder mapping, this research contributes to a more nuanced understanding of how coastal communities manage domestic water needs under chronic environmental stress, providing evidence to support more inclusive and coordinated coastal water management policies.

MATERIALS AND METHODS

This research is divided into three stages that are interrelated with each other, namely pre-field activities (preparation), field, and post-field (data analysis and conclusion). In the initial stage, the research began with the collection of secondary data relevant to the research location. Sources of data included the Indonesia Earth Map to understand the geographical conditions of the area, as well as the monographs of Tanjung Mas and Kemijen villages to obtain an overview of the social and environmental conditions of the communities affected by tidal flooding. In addition, government documents containing policies related to water resources management and adaptation to tidal flooding were collected for further analysis. The map of the research area is presented in **Figure 1**, which illustrates the geographical context and spatial boundaries of Tambak Lorok and Kemijen as the focus of this study.

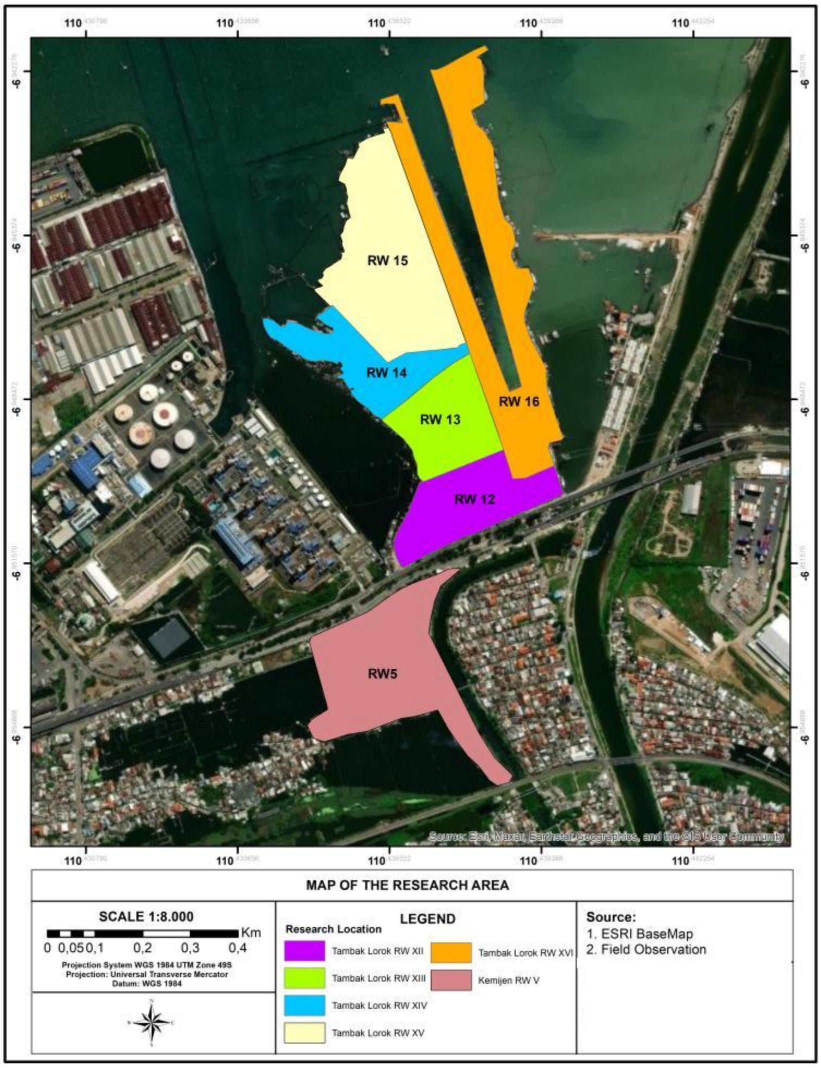

Figure 1. Map of The Research Area

Source: ESRI BaseMap & Field Observation, 2025

After the preparatory stage was completed, the research proceeded to the fieldwork stage, which included several data collection methods. Firstly, groundwater sampling. Researchers determined the coordinates of groundwater samples in the affected area. The water samples taken were then classified based on the Electrical Conductivity (EC) value to assess the quality of groundwater used by the community. Water quality assessment in this study was conducted by measuring Electrical Conductivity (EC) using a portable EC meter (handheld conductivity meter) commonly applied in field-based measurements. The measurements were carried out in situ as a preliminary indicator of water quality, particularly to identify electrical conductivity levels associated with potential seawater intrusion, without involving further laboratory analysis.

Water samples were collected from 12 household wells distributed across the two research locations. In Tambak Lorok, sampling points were located in RW XII, RW XIII, RW XIV, RW XV, and RW XVI, while in Kemijen, sampling was conducted in RW V. The selection of sampling points was based on the spatial distribution of settlements and the availability of actively used wells serving as domestic water sources. The sampled wells had depths ranging from 90 to 110 meters, representing the characteristics of deep bore wells commonly utilised by coastal communities in the study areas. Laboratory testing was not conducted, as the water quality measurement served as supporting data for analysing community adaptation in meeting domestic water needs in response to tidal flooding impacts, rather than for a comprehensive chemical or biological water quality assessment.

This data will be visualised in a water quality distribution map. Second, household interviews. To understand the condition of community adaptation, this study sampled households affected by tidal flooding. Data collection was conducted through questionnaires and semi-structured interviews, which aimed to identify the types of water sources used by the community in fulfilling domestic needs. After the field data was collected, the researcher entered the data analysis and interpretation stage. Firstly, water quality was analysed. Data from EC measurements on water samples were used to construct a water quality distribution map, which shows the variation in water quality at the study site. Secondly, community adaptation was analysed. The results of questionnaires and household interviews were analysed to identify the adaptation strategies adopted by the community in meeting domestic water needs due to tidal flooding.

The primary instruments used to identify forms of community adaptation in this research were questionnaires and semi-structured interviews. The questionnaire contained questions related to the water sources utilised by households, changes in water-use patterns following tidal flooding, physical and non-physical measures taken to meet domestic water needs, and respondents' experiences in dealing with limited access to clean water. The questionnaire included both closed- and open-ended questions, enabling the researcher to obtain quantitative insights into adaptation choices while also capturing qualitative information regarding the reasons and experiences underlying those choices. Semi-structured interviews were conducted to deepen and clarify the questionnaire findings, especially for aspects of adaptation that could not be fully explained through closed questions, such as communal strategies, social dynamics, and the roles of local actors in water provision.

The theoretical framework guiding the adaptation analysis explicitly refers to Smit & Pilifosova (2003), who conceptualise adaptation as a process of adjustment to environmental change supported by technology, human capacity, and institutional structures. This framework is further enriched by the IPCC (2007), which interprets adaptation as a response to climate-related risks such as flooding, saltwater intrusion, and coastal erosion, as well as by the work of Yohe & Tol (2002) and Williamson et al. (2010), who emphasise the importance of human capital, institutional readiness, and social adaptive capacity. In addition, contributions from Folke, Hahn, Olsson, and Norberg (2005) strengthen the understanding of the role of social capital and community networks in supporting local-level adaptation strategies. Together, these theoretical perspectives form the basis for examining how coastal communities in Tambak Lorok and Kemijen adapt, both individually and collectively, to the impacts of tidal flooding.

The analysis of community adaptation was conducted by processing data from the questionnaires and interviews, which were then reduced, grouped, and categorised into themes emerging from the field. This process involved identifying dominant adaptation patterns within each neighbourhood (RW), such as shifts in primary water sources, the use of artesian water, purchasing bottled or refilled water, implementing simple filtration methods, and undertaking physical measures such as raising floor elevations or improving drainage systems. The questionnaire data allowed the researcher to observe quantitative trends in adaptation choices. At the same time, the interview narratives provided more profound insights into the motivations, constraints, and local knowledge underlying those actions. Adaptation was evaluated descriptively rather than through numerical scoring by examining the relationships between water quality, environmental conditions, stakeholder interventions, and community responses. **Table 1** presents the groundwater classification based on Electrical Conductivity values, providing the criteria used to distinguish fresh water, brackish water, saline water, and hypersaline conditions in the study area.

Table 1. Groundwater Classification Based on Electrical Conductivity

Water Type	EC (µmhos/cm)
Fresh Water	0-1.000
Brackwish Water	1.000-2.000
Saline Water	2.000-10.000
Hypersaline	> 10.000

Source: Saeni, 1989

Based on data on the number of households obtained from the Tanjung Mas Village Monograph, in Tambak Lorok Village, there are 1,964 households, and in Kemijen Village, there are 3,179 households. Based on this population, the number of samples taken is 114 households or approximately 10% of the population. The method used to determine the sample population of households is the proportional random sampling method. This means that each population has an equal chance of being selected as a research sample. The reason is that the characteristics of the population in the study area are homogeneous, i.e. they both experience the impact of tidal flooding due to land subsidence and sea level rise.

The proportion of the distribution of respondents is based on the calculation of the sample population by considering the error and estimation of the proportion. The formula for calculating the proportion of sample size (Prakoso, 2009) is shown in **equation 1**:

$$n = \frac{\mathrm{N \times P\,(1-P)}}{\mathrm{(N-1) \times D + P \times (1-P)}} \quad (1)$$

N : Population
P : Estimation of proportion (0.5)
D : Bound of error (0.0025)
n : Number of samples
D : B2/4, error = 10% → $0{,}1^2/4 = 0{,}0025$
Based on the total number of households in the five RW in Tambak Lorok Village, which is 1,964 households, the calculation of the number of samples taken is as follows:

$$n = \frac{1.964 \times 0{,}5\,(1-0{,}5)}{(1.964-1) \times 0{,}0025 + 0{,}5 \times (1-0{,}5)}$$

$$n = \frac{491}{5{,}1575}$$

$$n = 95$$

The distribution of the number of samples in each RW (**Table 2**) was calculated based on the proportion of households in each RW, with the following calculation:

a. RW XII

$$n = \frac{334}{1.964}\, x\ 95 = 17\ Sample$$

b. RW XIII

$$n = \frac{328}{1.964}\, x\ 95 = 16\ Sample$$

c. RW XIV

$$n = \frac{564}{1.964}\, x\ 95 = 28\ Sample$$

d. RW XV

$$n = \frac{531}{1.964}\, x\ 95 = 26\ Sample$$

e. RW XVI

$$n = \frac{207}{1.964}\, x\ 95 = 11\ Sample$$

As for the total number of households in RW V Kemijen Village, which is 3,179 households, the calculation of the number of samples taken is as follows:

$$n = \frac{3.179 \times 0{,}5\,(1-0{,}5)}{(3.179-1) \times 0{,}0025 + 0{,}5 \times (1-0{,}5)}$$

$$n = \frac{794{,}75}{8{,}195}$$

$$n = 97$$

a. RW V

$$n = \frac{498}{3.179}\, x\ 97 = 16\ Sample$$

Table 2. Sample Size Distribution

No.	Region	RW	Household	Number of samples
1.	Tambak	RW XII	334	17
2.	Lorok	RW XIII	328	16
3.		RW XIV	564	28
4.		RW XV	531	26
5.		RW XVI	207	11
6.	Kemijen	RW V	498	16
Total			**2.462**	**114**

Source: Monographs of Tanjung Mas and Kemijen

RESULTS AND DISCUSSION

Based on the results of the research found through direct observation in the field and semi-structured interviews conducted, among others, as follows:

1. Spatial Distribution of Groundwater Quality Based on Electrical Conductivity Value

The very high salt content in seawater undergoes ionisation, which causes the water to have conductive properties and can conduct an electric current. Electrical Conductivity (EC) is a numerical representation of the ability of water to transmit electricity in units of µmhos/cm. The more dissolved salts that can be ionised, the higher the value of Electrical Conductivity (EC). The maximum level allowed is a maximum of 1,000 µmhos/cm. The source of water used by the community to fulfil domestic water needs in the study area is deep groundwater from depressed aquifers or so-called artesian wells. In some coastal areas, most well water tastes brackish to salty, due to the influence of seawater.

This is because the clay material formed in the marine environment still binds salt, which then reacts with groundwater, making the groundwater brackish or salty. In addition to these material factors, the influence of freshwater on land is also due to seawater intrusion. Seawater intrusion in coastal Semarang is caused by tidal floods that cause seawater intrusion to be very far away, a very flat topography, a very small river slope (intrusion through the river), overflow from ponds during tidal floods, and shoreline retreat.

Figure 2 presents the distribution map of artesian wells in Tambak Lorok and Kemijen, illustrating the spatial locations of groundwater sources used by households in the study area.

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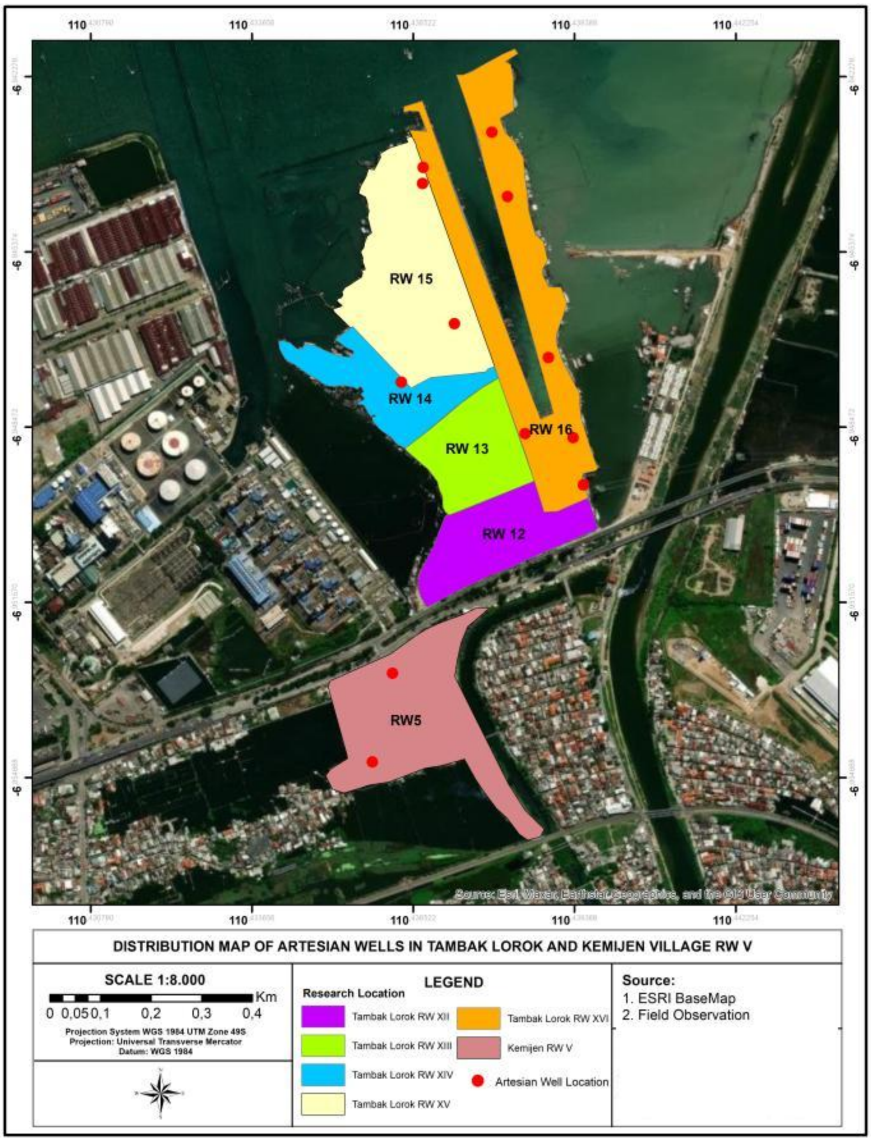

Figure 2. Distribution Map of Artesian Wells in Tambak Lorok and Kemijen
Source: ESRI BaseMap & Field Observation, 2025

A notable feature of the results in Table 5.1 is the very significant variation in groundwater quality between neighbourhoods that are geographically close to each other, but show extreme differences in EC values. For example, RW XV in the centre of the area has very low EC values of 663 and 664 µmhos/cm, reflecting good freshwater quality. Meanwhile, RW XVI, which is directly adjacent to the coastal area and canals, shows a variety of values, including the highest of 1,045 µmhos/cm and even RW V (Kemijen), which is still located on the same stretch as RW XV, has a EC value of 1,165 µmhos/cm, indicating that the water has entered the brackish category. This difference is unique because it proves that within a small area, groundwater quality is uneven and highly influenced by local factors, such as well depth, location relative to the coastline, human activities, and potential seawater intrusion.

Furthermore, it was unique that physical parameters such as colour, taste and odour in water classified as brackish (EC above 1,000 μmhos/cm) were still recorded as 'clear', 'tasteless' and 'odourless'. This highlights an important finding that elevated dissolved mineral content in groundwater is not always detectable to the naked eye or senses, so water users may continue to use water of degraded quality without realising it. This finding is important as it points to a gap between perceived and actual water conditions that, if not intervened with laboratory testing or education, could potentially lead to health risks or damage to household appliances due to the use of highly saline water.

Another uniqueness lies in the distribution pattern of the artesian wells themselves. RW XII and XIII do not have artesian wells, so they depend on distribution from neighbouring RWs. This creates a unique social condition, namely the emergence of a subscription-based water fee system between residents. This pattern indirectly shows the inequality of clean water infrastructure within the community. It opens up space for discussion about regional independence and structural dependence in accessing vital resources such as water. In the context of coastal development that is vulnerable to environmental change and saline intrusion, the findings show that the presence of artesian wells does not necessarily guarantee water quality security, and conversely, not having a well also creates challenges of access and water security.

The statement that variations in groundwater quality within a small area are influenced by local factors such as well depth, proximity to the coastline, human activity and potential seawater intrusion can be closely linked to the Theory of Environmental Determinism. This theory posits that physical environmental conditions have a dominant influence on human behaviour patterns, community development, and the quality of resources available in an area. Mujabuddawat (2015) explains that environmental determinism is the belief that the environment, especially physical factors such as landscape or climate, determines patterns of human culture and community development. At the social level, value systems, politics and governance are consistently shaped by the geography and climate in which people live (Malihu, L., 2023). In the context of this study, the differences in groundwater EC values between RWs despite their spatial proximity reflect the strong influence of the local environment in shaping the quality of resources used by the community. Neighbourhoods closer to the coastline or canals, for example, tend to have higher EC values due to more intensive seawater intrusion, while neighbourhoods further away and perhaps at a slightly higher elevation tend to have better water quality.

Environmental determinism can be interpreted as an understanding that provides an explanation that humans and their culture are determined by nature. Cultural forms formed by humans, including efforts to fulfil basic needs such as water, occur as a result of environmental forces that include many things, such as climatic conditions (Hidayat and Priambodo, 2023). This theory helps explain that groundwater quality is not only determined by human treatment or technical efforts alone, but is also highly dependent on the characteristics of the natural environment inherent to the location. For example, underground geological layers, aquifer structure or the direction of groundwater flow determine how much saltwater from the sea can seep in and contaminate freshwater that could otherwise be consumed. Even human activities such as development, excessive drilling, or surface pollution amplify the process of water quality degradation. This means that the difference in water quality between RWs is not a coincidence or just a result of social inequality, but a manifestation of how the physical environment works deterministically on the availability and quality of groundwater resources. By using the framework of environmental determinism, the analysis of this local phenomenon becomes sharper. It can explain why community adaptation must also consider ecological conditions that cannot be changed casually. According to Rachmad (2019), in his study, he views culture as an adaptive system of behavioural beliefs whose primary function is to adapt to the physical and social environment.

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In addition, the gap between community perceptions and actual conditions of water quality can also be linked to Social Capital Theory, especially in the context of how information about risks and scientific knowledge is or is not disseminated within the community's social network. Social capital is the potential within a community that can be utilised to connect, strengthen and even enhance other potential assets. In essence, social capital refers to the ability of members in a community to pool their resources to solve problems (Saheb et al., 2013). Social capital not only includes trust and solidarity, but also relates to the flow of information that occurs within a society. When communities rely on everyday perceptions, such as clarity or absence of odour, in assessing water quality, it shows that access to scientific information or laboratory test results is limited or not considered important in the existing social network. This could be due to low involvement of outsiders (such as health or education institutions), or because social relations within the community favour shared experience and trust information over technical knowledge.

In the context of Social Capital Theory, trust between residents, for example, towards artesian well owners or local figures, can strengthen the water distribution system, but also has the potential to hinder awareness of risk if information about water quality is not properly disseminated. According to Abdullah (2013), social capital can function as a lubricant, encouraging interaction and collaboration to meet individual goals quickly and effectively. To achieve the goal of improving the quality of life, the dimensions of social capital emphasise community togetherness; therefore, it is important to build values that must be accepted by its members, such as participatory attitudes, caring for each other, giving and receiving, and trusting each other (Cahyono, 2014). When people trust each other that the water they consume is "fine" based on experience, this collective perception will be stronger than scientific data that may not have touched the discussion spaces between them. Therefore, the lack of inclusion of scientific information into local social networks is a form of void in social capital that could actually be filled to strengthen community resilience. This means that if social capital is managed more openly and collaboratively, for example, through community activities involving environmental education or socialisation of water quality test results, then the gap between perception and reality can be narrowed and health risks and technical damage due to the use of water with high salinity can be prevented more effectively.

This condition also illustrates the form of "horizontal dependency" in the community, where the gap between small areas that are administratively equal creates a relationship system that resembles a centre-periphery structure on a micro scale. RWs that have artesian wells act as distribution centres, while other RWs become dependent consumers. This inequality becomes more complex when associated with the development of coastal areas that are vulnerable to environmental changes and ecological pressures, such as seawater intrusion. Although artesian wells are considered a technological solution, the reality shows that their existence does not necessarily guarantee safe water quality due to the high levels of EC in some locations.

In the framework of sustainable development, these findings highlight the importance of building clean water systems that do not rely solely on individual or small group initiatives, but are also designed to reduce structural inequalities and strengthen the independence of the region as a whole. Such dependence risks widening the resilience gap if not accompanied by equitable policy interventions and equitable distribution of technology across regions within a community.

Social Capital Theory is very relevant when associated with findings regarding the unequal distribution pattern of artesian wells and the emergence of a subscription-based water contribution system between residents. This theory emphasises social networks, reciprocal trust, and norms as forces that enable communities to act together effectively in facing everyday challenges. Theoretically, social capital leads to social interaction. To gain economic and social benefits, individuals or organisations can use social ties such as values, social networks, and trust (Fathy, 2019). In this context, although RW XII and XIII do not have their own water infrastructure, they are not entirely isolated or vulnerable because social relations with neighbouring RWs that have artesian wells are a bridge to accessing clean water. The informal water contribution system managed by the residents themselves shows that social capital in the form of trust and agreements between residents is able to create adaptive mechanisms amidst structural limitations.

This uniqueness shows that social capital functions as a social glue that allows the redistribution of resources beyond the administrative boundaries of the RW. The owners of artesian wells do not monopolise water as a private commodity, but rather open up space for residents from other areas to access water with a socially agreed subscription system. This reflects the values of solidarity, reciprocity, and informal norms that function as social institutions in the local context. In conditions of infrastructure inequality, social capital becomes the main capital that allows people to continue to gain access to basic needs, not through the state or the market, but through community-based collective mechanisms. **Table 3** and **Figure 3** present the artesian well quality and its spatial distribution in the study area.

Table 3. Artesian Well Quality at Research Location Based on EC Value

No.	RW	Coordinate Points	EC (µmhos/cm)	Physical parameters			Category
				Color	Taste	Smell	
1.	XII	-	-	-	-	-	-
2.	XIII	-	-	-	-	-	-
3.	XIV	-6.947677, 110.436313 (Location 1)	920	Clear	No taste	Odorless	Fresh
4.	XV	-6.944165, 110.436691 (Location 1)	663	Clear	No taste	Odorless	Fresh
		-6.943880, 110.436701 (Location 2)	664	Clear	No taste	Odorless	Fresh
		-6.946645, 110.437257 (Location 3)	839	Clear	No taste	Odorless	Fresh
5.	XVI	-6.9433260, 110.437922 (Location 1)	937	Clear	No taste	Odorless	Fresh
		-6.944398, 110.438200 (Location 2)	920	Cloudy	No taste	Odorless	Fresh
		-6.947242, 110.438925 (Location 3)	1.045	Clear	No taste	Odorless	Brackish
		-6.948657, 110.439363 (Location 4)	822	Clear	No taste	Odorless	Fresh
		-6.949496, 110.439546 (Location 5)	826	Clear	No taste	Odorless	Fresh
		-6.948587, 110.438513 (Location 6)	693	Clear	No taste	Odorless	Fresh
6.	V (Kemijen)	-6.954391, 110.435796 (Location 1)	1.165	Clear	No taste	Odorless	Brackish
		-6.952825, 110.436157 (Location 2)	912	Clear	No taste	Odorless	Fresh

Source: Research Analysis, 2025

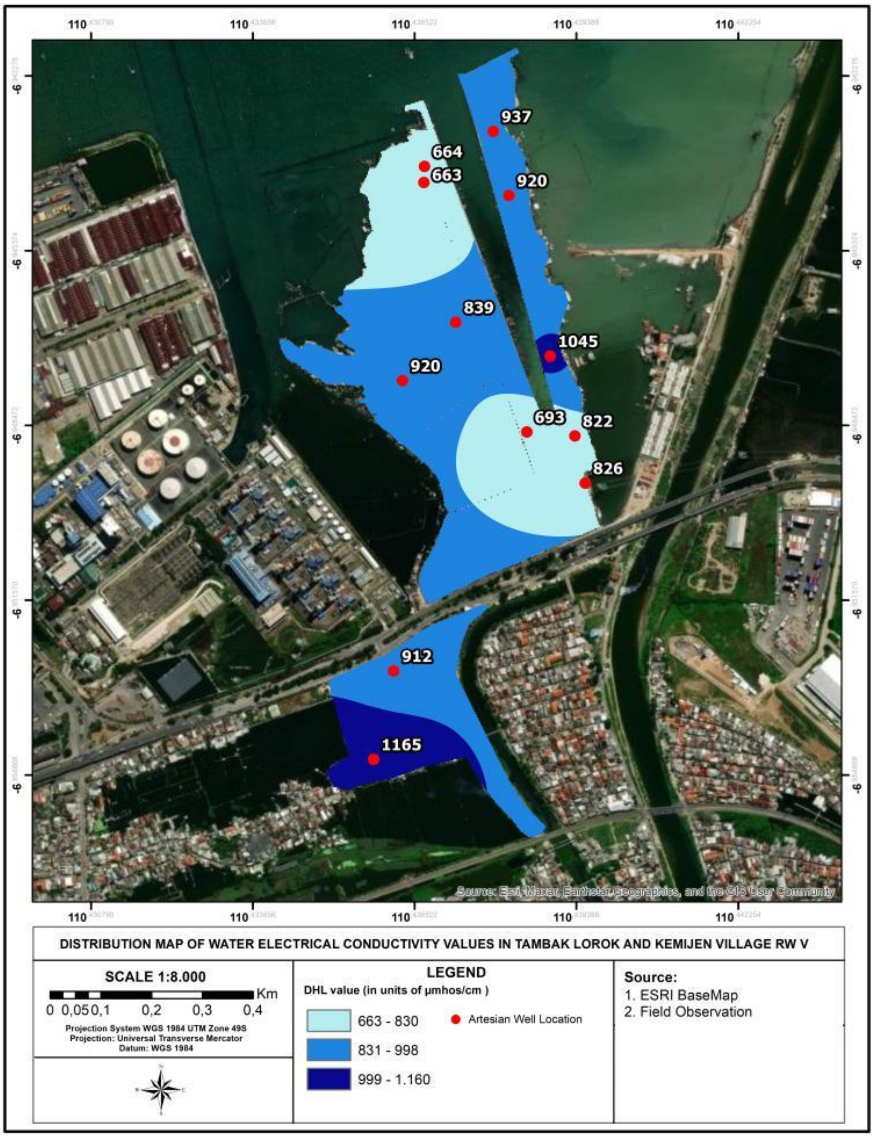

Figure 3. Distribution Map of Water Electrical Conductivity Values in Tambak Lorok and Kemijen Village RW V
Source: ESRI BaseMap & Field Observation, 2025

2. Community Adaptation in Meeting Domestic Water Needs

The problem of declining groundwater quality, which is a source of clean water to meet domestic water needs, requires the community to take action or make efforts to overcome this problem. In the context of the relationship between humans and the environment, there is a debate between environmental determinism and possibilism. Environmental determinism assumes that the environment entirely influences humans, while possibilism recognises that humans can choose actions on various opportunities offered by the environment. These two concepts form the understanding that humans are not only the result of the environment, but also have an active role in influencing their environment (Ratnasari, A., & Basuki Dwisusanto, Y., 2024).

The water needed to meet domestic water needs is clean water according to quality standards, so even though the quantity of water in coastal areas meets the needs, if the quality does not meet the standards, the water cannot be consumed. Communities living in areas vulnerable to the threat of tidal flooding have the capacity to adapt and use their abilities to minimise the effects of the disaster. The distance between the area and the sea is related to the water sources used by the community. This is because the reach of the tide has a different effect on water sources. The following is the distribution and proportion of overall domestic water sources from the research respondents.

Table 4 and **Figure 4** present the distribution and proportion of domestic water sources used by the research respondents, illustrating household reliance on artesian wells, bottled water, and limited piped-water services in the study area.

Table 4. Distribution and Proportion of Domestic Water Sources of Research Respondents

Region	RW	Number of Respondents	Artesian	%	Gallon Water	%	PDAM	%
Tambak Lorok	RW XII	17	15	88.2%	17	100.0%	2	11.8%
	RW XIII	16	16	100.0%	16	100.0%	0	0.0%
	RW XIV	28	28	100.0%	28	100.0%	0	0.0%
	RW XV	26	21	80.8%	26	100.0%	5	19.2%
	RW XVI	11	7	63.6%	11	100.0%	4	36.4%
Kemijen	RW V	16	16	100.0%	16	100.0%	0	0.0%
Total		114	103	90.4%	114	100.0%	11	9.6%

Source: Research Analysis, 2025

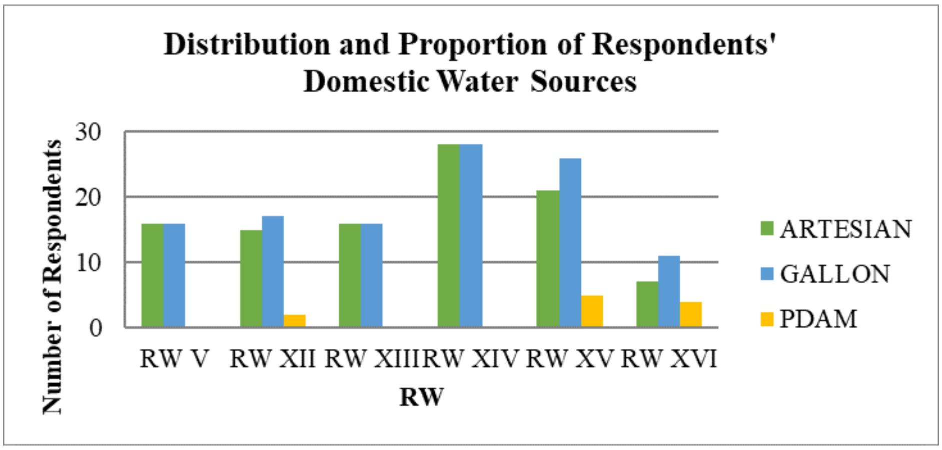

Figure 4. Distribution and Proportion of Respondents' Domestic Water Sources

Source: Field Observation, 2025

Based on the research results, in the Kemijen area, RW V is one of the areas with 16 households as respondents. Interestingly, all respondents in this RW use two main types of water, namely artesian and gallons. None of them is recorded as using PDAM. The use of gallon water is comprehensive because the need for clean water that is safe for consumption has become a general awareness among residents. Gallons are used for drinking and cooking, while artesian water is still the mainstay for bathing, washing clothes, and other daily needs. The absence of PDAM in this RW is due to the lack of pipe network infrastructure. In addition, residents already feel satisfied with the available groundwater and do not see the urgency to switch to PDAM. Economic factors and ease of access make artesian still the main choice in RW V.

In the Tambak Lorok RW XII area, 17 respondents had slightly more diverse types of water use compared to the previous RW. As many as 15 respondents used artesian water, 17 used gallon water, and two respondents were recorded as using PDAM. Gallons remain the main water for consumption, while artesian and PDAM are used in a mixture for other purposes. RW XII is one of the RWs that has begun to be touched by PDAM services, although still on a very small scale. The existence of PDAM has only reached a small part of the area. It is usually only used by families with more stable economic conditions who can afford subscription fees and pipe installation. Although PDAM has entered, artesian remains

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dominant because the public perception that groundwater is cheaper and easier to obtain is still quite strong in this area.

Meanwhile, RW XIII, with 16 respondents, all use artesian water and gallons, without a single one using PDAM. This situation is almost identical to RW V Kemijen, indicating that the absence of PDAM is not only due to community preference, but also to the unavailability of clean water pipe facilities in the area. The uniform use of gallons also strengthens the suspicion that artesian water is no longer suitable for consumption. Most residents have realised changes in the quality of their groundwater, both in terms of taste, colour, and even smell, so they choose to switch to gallon water for consumption needs. However, artesian is still considered sufficient for daily needs such as washing and bathing. This RW reflects the condition of coastal communities that still rely on groundwater, but are slowly switching to more hygienic sources for consumption.

RW XIV has the largest number of respondents in this study, namely 28 households. All respondents in this RW were recorded as using artesian water and gallons, while PDAM has not been used by any respondents. This condition shows that although there is a high awareness of the importance of clean water for consumption, as evidenced by the uniform use of gallons, the alternative of piped water from PDAM has not been an option in this area. This is because the PDAM network has not yet entered the RW XIV area, and there are technical and cost obstacles that prevent people from being able to access these services. The reliability of artesian water as a source of household water is still quite high, even though it is not used for drinking. This tendency reflects a combination of infrastructure limitations and the type of water consumption that is gradually changing.

In RW XV, there were 26 respondents who showed more complex variations in water use patterns. A total of 21 households used artesian water, 26 households used gallon water, and five households started using PDAM. Although some have used PDAM, the majority of respondents still rely on artesian, especially for household activities that are not directly related to consumption. Even so, the existence of PDAM shows that there are changes that are starting to occur in the clean water supply system in RW XV, especially for residents who have more ability to subscribe.

RW XVI is the area with the fewest respondents, namely 11 households. However, this area has the highest proportion of PDAM usage in percentage compared to other RWs. Based on a total of 11 respondents, seven use artesian water, 11 use gallons, and four have used PDAM. Interestingly, this data is in line with information from the local RW Head, who stated that there are actually 97 families in RW XVI who have used PDAM services because they live in the Huntara area, a housing complex built by the Semarang City Government as part of the Tambak Lorok coastal residents relocation program. The area has been equipped with basic infrastructure, including PDAM connections from the start, so access to clean water in this area is relatively better. Although only a small portion of respondents came from this area, the existing data still reflects the dominant trend of PDAM utilisation in RW XVI as a whole.

Huntara is an abbreviation of temporary housing. This is a residential area built by the Semarang City Government as part of the relocation and settlement arrangement program, especially for residents who previously lived in coastal areas prone to tidal flooding, such as Tambak Lorok. The primary purpose of the construction of Huntara is to provide a more decent place to live, safe from disasters, and have better access to basic infrastructure such as clean water (PDAM), sanitation, electricity, and roads. The construction of Huntara is also part of an effort to eradicate slums and improve the quality of life of low-income people in Semarang. So, it is not only a matter of physical relocation, but also increasing access to basic services and a healthier residential environment.

Overall, it can be concluded that the use of gallon water in all RW is uniform and total, indicating a high level of public awareness of the importance of clean water for consumption. Meanwhile, artesian water continues to dominate as a source of water for household needs because it is considered easily accessible and does not require routine costs like PDAM. The limited use of PDAM occurs due to several factors, including the uneven distribution of pipe networks, high initial installation costs, and negative perceptions of the quality and reliability of PDAM water.

Low PDAM usage can also be associated with other technical aspects, such as unstable water pressure or the unavailability of main pipelines in densely populated surface areas. In some areas, residents stated that the application for PDAM installation took a long time, and the administrative process was confusing for some people, so they preferred to continue using artesian wells even though the water quality was declining. This is a challenge for local governments and clean water service providers. The use of artesian wells is still very high (90.4% of total respondents), even dominating in almost all RW. This indicates that artesian wells are still the primary source for domestic needs due to cost, availability, or tradition of use. However, in terms of quality and sustainability, dependence on groundwater can pose risks, primarily if not appropriately managed in the long term.

The condition of the coastal environment, which is experiencing degradation of groundwater quality, especially with indications of seawater intrusion, also encourages the community to be more selective. In many cases, artesian water can no longer be consumed directly because it contains a salty taste, odour, or cloudy colour. As a result, people choose to rely on gallon water for drinking and cooking needs. This finding shows that people are adapting independently to changes in water quality. This adaptation, although practical, actually creates a new burden in the form of additional expenses to buy gallon water. On the other hand, the choice to continue using artesian water shows that not all needs can be met by bottled water, especially large-scale needs such as bathing and washing.

Contextually, the differences in the types of water use between RW can also be explained from the perspective of accessibility and socio-economic characteristics of each region. RWs that are closer to the PDAM network or have more organised settlements tend to access piped water services more quickly. Conversely, RWs located in dense and narrow areas or in the outermost coastal areas tend to stick with artesian water due to limited space and pipe networks.

Thus, the analysis of each RW shows that although the use of gallon water is evenly distributed and shows the level of public awareness of the quality of drinking water, the choice between artesian and PDAM is greatly influenced by technical, economic, and geographical factors. This is an early indicator that the quality of groundwater in the research area is indeed under pressure, and the community is in the process of transitioning to a more appropriate clean water system. This study underlines the importance of integrated policies in managing clean water in coastal areas. The government and water service institutions must use these findings as a basis for increasing access, reducing barriers to installation costs, and improving public perception of PDAM services. At the same time, monitoring of groundwater conditions must also be improved so that seawater intrusion does not continue to worsen.

CONCLUSIONS

This study offers a unique contribution by integrating groundwater quality analysis with community-level adaptation strategies and multi-stakeholder governance dynamics within two adjacent yet hydrologically contrasting coastal settlements in Semarang. The findings reveal highly localised variations in water quality even between RW units that are geographically close, which demonstrates that environmental stressors such as seawater intrusion and land subsidence affect communities unevenly. By combining mixed-method household data with stakeholder mapping, the research provides a comprehensive understanding of how domestic water management is shaped not only by physical environmental conditions but also by institutional coordination and socio-economic constraints.

Scientifically, the study contributes to adaptation scholarship by illustrating how community strategies reflect an interplay between environmental degradation, technological choices, and governance gaps. Practically, the research offers evidence-based insights for local governments and service providers to improve piped-water distribution, strengthen cross-stakeholder collaboration, and design targeted interventions for households facing chronic tidal flood impacts. Nonetheless, the study is limited to two coastal settlements and a fixed number of sampling points, meaning that broader regional variations could not be fully captured. However, the selected areas provide a representative picture of vulnerability in Semarang's tidal-flood-prone communities.

REFERENCES

Abdullah, S. (2013). Potensi dan Kekuatan Modal Sosial dalam Suatu Komunitas. *SOCIUS : Jurnal Sosiologi*, 12(2), 15–21.

Amin, C., Sukamdi, & Rijanta. (2019). Modeling (Im) mobility: the decision to stay in disaster prone area amongs fishermen community in Semarang. *E3S Web of Conferences* 76. https://doi.org/10.1051/e3sconf/20197603012

Amin, C., Sukamdi, & Rijanta. (2021). Exploring Migration Hold Factors in Climate Change Hazard-Prone Area Using Grounded Theory Study: Evidence from Coastal Semarang, Indonesia. *Sustainability*, 13, 4335, 1-18. https://doi.org/10.3390/su13084335

Artiningsih, et al. (2016). Enhancing Social-Ecological Resilience in Indonesia: A Case of North Pekalongan District, Central Java. *Jurnal Wilayah dan Lingkungan*, 4(3), 187-198. http://dx.doi.org/10.14710/jwl.4.3.187-198

Cahyono, B. (2014). Peran Modal Sosial dalam Peningkatan Kesejahteraan Masyarakat Petani Tembakau di Kabupaten Wonosobo. *Jurnal Ekobis,* Vol. 15(1), 1–16. https://doi.org/10.30659/ekobis.15.1.1-16

Fathy, R. (2019). Modal Sosial: Konsep, Inklusivitas dan Pemberdayaan Masyarakat. *Jurnal Pemikiran Sosiologi*, 6(1), 1. https://doi.org/10.22146/jps.v6i1.47463

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources*, 30, 441-473. https://doi.org/10.1146/annurev.energy.30.050504.144511

Hidayat, M. & Priambodo, T. K. (2023). Kajian Determinisme Lingkungan terhadap Budaya Pangan di Indonesia. *Jurnal Ekologi, Masyarakat, dan Sains*, 4(2), 94-103. https://doi.org/10.55448/xbag6t84

IPCC. (2007). "Climate change 2007: Impacts, adaptation and vulnerability." *A Special Report of Working Group II of the Inter-governmental Pannel on Climate Change.* Cambridge, UK: Cambridge University Press.

Kristiany, R. W., Hardjanto, U. S., & Prihatin, E. S. (2016). Pelaksanaan Peraturan Daerah Kota Semarang Nomor 2 Tahun 2013 Tentang Pengelolaan Air Tanah. *Diponegoro Law Review*, 5(3), 1-17. http://www.ejournal-s1.undip.ac.id/index.php/dlr/

Lindenmann, et al. (2022). Climate change and adaptation to coastal risks as perceived in two major coastal cities: An exploratory study in Marseilles and Nice (France). *Ocean and Coastal Management*, 225, 106209. https://doi.org/10.1016/j.ocecoaman.2022.106209

Malihu, L. (2023). Manusia, Lingkungan, dan Kebudayaan: Kajian Tentang Teori Adaptasi Manusia dan Lingkungan. *Jurnal Kajian Sosial dan Budaya: Tebar Science,* 7(2), 83-87. https://doi.org/10.36653/jksb.v7i2.162

https://doi.org/10.35568/earlychildhood.v4i2.860

Mujabuddawat, M. A. (2015). Kompleks Situs Ki Buyut Trusmi Cirebon: Tinjauan Bangunan Kuna. *Kapata Arkeologi*, 11(2), 139-154. https://doi.org/10.24832/kapata.v11i2.293

Pemerintah Kota Semarang. (2019). *Water for as Resilient Cities Leverage Asia: One Resilient Semarang (Volume II: Concept Design Proposals).* In Resilient Semarang (Issue April). Semarang City Government.

Prakoso, P. (2009). *Materi Kuliah Statistik Terapan.* Yogyakarta: Fakultas Geografi Universitas Gadjah Mada.

Rachmad, Y. (2019). Budaya Bahari Masyarakat Sriwijaya Pada Masa Pra-Modern. *JASMERAH: Journal of Education and Historical Studies*, 1(2), 23-30. http://jurnal.unimed.ac.id/2012/index.php/jasmerah

Ratnasari, A., & Basuki Dwisusanto, Y. (2024). Interaksi Manusia dan Lingkungan dalam Kajian Filosofis. *MARKA (Media Arsitektur dan Kota): Jurnal Ilmiah Penelitian*, 7(2), 195-208. https://doi.org/10.33510/marka.2024.7.2.195-208

Saeni, M. S. (1989). *Kimia Lingkungan*. Institut Pertanian Bogor. Bogor.

Saheb, Slamet, Y., & Zuber, A. (2013). Peranan Modal Sosial bagi Petani Miskin untuk Mempertahankan Kelangsungan Hidup Rumah Tangga di Pedesaan Ngawi (Studi Kasus di Desa Randusongo Kecamatan Gerih Kabupaten Ngawi Provinsi Jawa Timur. *Jurnal Analisa Sosiologi*, 2(1), 17-34.

Saputra, E., et al. (2021). Land Value in a Disaster-Prone Urbanized Coastal Area: A Case Study from Semarang City, Indonesia. *Land,* 10, 1187. https://doi.org/10.3390/land10111187

Saputra, E., Spit, T., & Zoomers, A. (2019). Living in a Bottomless Pit: Households' Responses to Land Subsidence, an Example from Indonesia. *Journal of Environmental Protection,* 10, 1-21. https://doi.org/10.4236/jep.2019.101001

Sitaningrum, A., & Widjajanti, N. (2024). Pergerakan Vertikal Titik GNSS CORS Pantai Utara Jawa Tengah dan Sekitarnya Tahun 2021-2023 Menggunakan Pengolahan Metode Precise Point Positioning (PPP). *Journal of Geospatial Information Science and Engineering,* 7(1), 44-52. https://doi.org/10.22146/jgise.95957

Smit, B., & Pilifosova, O. (2003). From adaptation to adaptive capacity and vulnerability reduction. In: J. B. Smith, R. J. T. Klein, & S. Huq (Eds.), *Climate Change, Adaptive Capacity and Development*. London: Imperial College Press, London.

Williamson, T., Hesseln, H., & Johnston, M. (2010). Adaptive capacity deficits and adaptive capacity of economic systems in climate change vulnerability 244 assessment. *Forest Policy and Economics*, 15, 160- 166. https://doi.org/10.1016/j.forpol.2010.04.003

Yohe, G., & Tol, R. S. J. (2002). Indicators for social and economic coping capacity-moving toward a working definition of adaptive capacity. *Global Environmental Change,* 12(1), 25-40. https://doi.org/10.1016/S0959-3780(01)00026-7