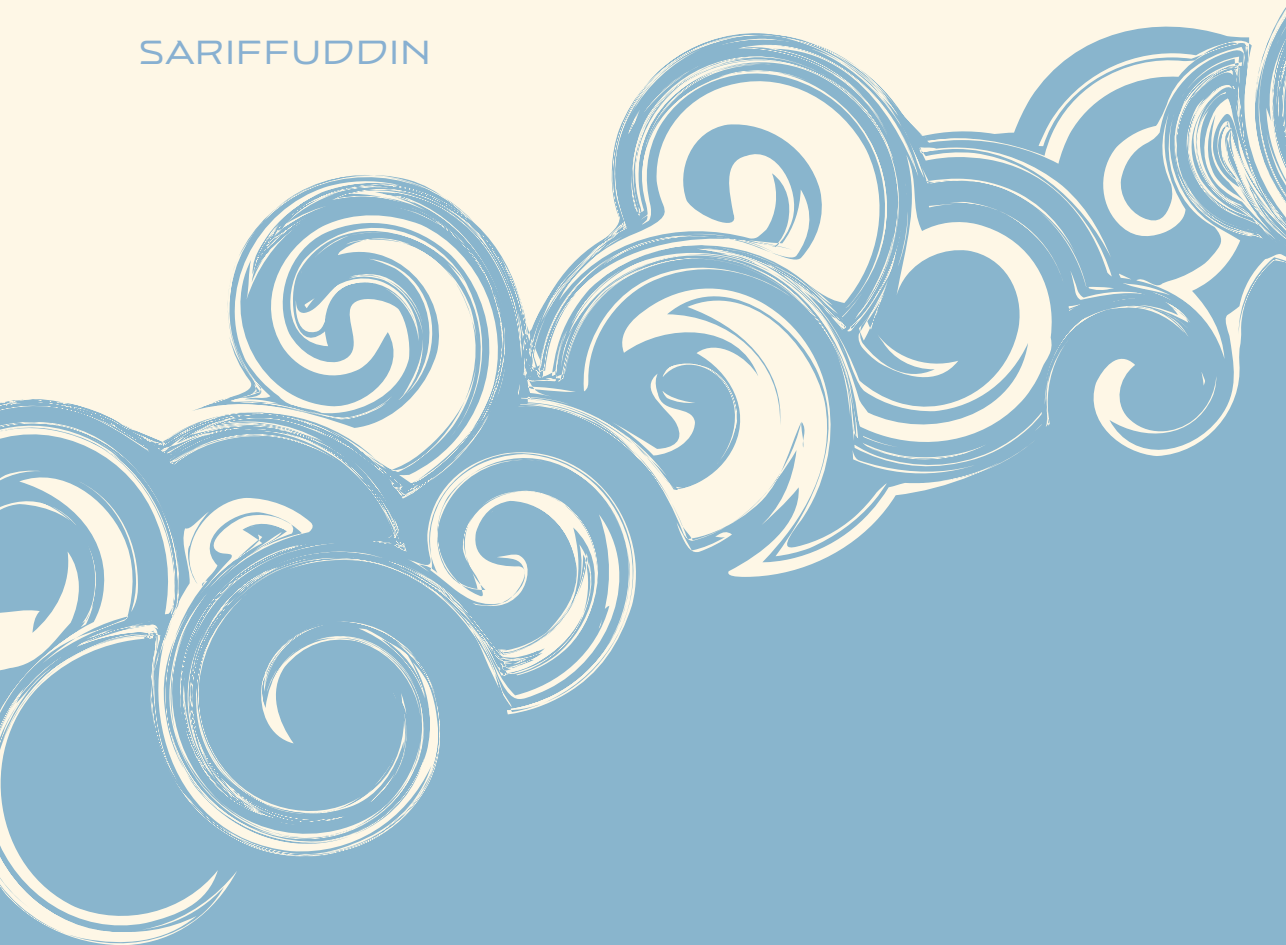


COASTAL NEIGHBOURHOOD IN DECLINE:

PROPERTY MARKET RESPONSE
IN INDONESIA'S COASTAL
FLOOD-PRONE AREAS

SARIFFUDDIN



Institute for
Management Research

**RADBOD
UNIVERSITY
PRESS**

Radboud
Dissertation
Series

**Coastal Neighbourhood in Decline:
Property Market Response in Indonesia's Coastal
Flood-Prone Areas**

Sariffuddin

This publication has been made possible by Universitas Diponegoro, and Ministry of Education, Culture, Research and Technology.



Coastal Neighbourhood in Decline: Property Market Response in Indonesia's Coastal Flood-Prone Areas

Sariffuddin

Radboud Dissertation Series

ISSN: 2950-2772 (Online); 2950-2780 (Print)

Published by RADBOUD UNIVERSITY PRESS

Postbus 9100, 6500 HA Nijmegen, The Netherlands

www.radbouduniversitypress.nl

Design: Proefschrift AIO | Guus Gijben

Cover: Proefschrift AIO | Guntra Laivacuma

Printing: DPN Rikken/Pumbo

ISBN: 9789465150536

DOI: 10.54195/9789465150536

Free download at: <https://doi.org/10.54195/9789465150536>

© 2025 Sariffuddin

**RADBOUD
UNIVERSITY
PRESS**

This is an Open Access book published under the terms of Creative Commons Attribution-Noncommercial-NoDerivatives International license (CC BY-NC-ND 4.0). This license allows reusers to copy and distribute the material in any medium or format in unadapted form only, for noncommercial purposes only, and only so long as attribution is given to the creator, see <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

Coastal Neighbourhood in Decline: Property Market Response in Indonesia's Coastal Flood-Prone Areas

Proefschrift ter verkrijging van de graad van doctor
aan de Radboud Universiteit Nijmegen
op gezag van de rector magnificus prof. dr. J.M. Sanders,
volgens besluit van het college voor promoties
in het openbaar te verdedigen op

dinsdag 8 april 2025
om 10.30 uur precies

door

Sariffuddin geboren op 1 mei 1983
te Magelang (Indonesië)

Promotoren:

Prof. dr. E. van der Krabben

Prof. B. Setiyono (Universitas Diponegoro, Indonesië)

Copromotor:

Dr. ir. D.A.A. Samsura

Manuscriptcommissie:

Prof. dr. S.V. Meijerink

Prof. dr. T. Filatova (Technische Universiteit Delft)

Prof. dr. T. Hartmann (Technische Universität Dortmund, Duitsland)

Coastal Neighbourhood in Decline: Property Market Response in Indonesia's Coastal Flood-Prone Areas

Dissertation to obtain the degree of doctor
from Radboud University Nijmegen
on the authority of the Rector Magnificus prof. dr. J.M. Sanders,
according to the decision of the Doctorate Board
to be defended in public on
Tuesday, April 8, 2025
at 10:30 AM

by

Sariffuddin born on May 1, 1983
in Magelang (Indonesia)

PhD supervisors:

Prof. dr. E. van der Krabben

Prof. B. Setiyono (Universitas Diponegoro, Indonesia)

PhD co-supervisor:

Dr. ir. D.A.A. Samsura

Manuscript Committee:

Prof. dr. S.V. Meijerink

Prof. dr. T. Filatova (Delft University of Technology)

Prof. dr. T. Hartmann (Technische Universität Dortmund, Germany)

Table of contents

Summary	I
Samenvatting	VI
 Chapter 1 General Introduction	 13
 Chapter 2 Toward Obsolete Housing: A Complementary Explanation of Increasing Coastal Vulnerability	 33
 Chapter 3 Distressed Property and Spillover Effect: A Study of Property Price Response to Coastal Flood Risk	 55
 Chapter 4 Declining Coastal Neighborhoods and Anti-Gentrification: Understanding the Heterogeneity Response of Property Buyers	 75
 Chapter 5 Housing displacement and replacement in coastal flood-prone areas: evidence from a land and building tax-based study in Indonesia	 95
 Chapter 6 Conclusion	 111
 References	 131
 Appendix	 147

Summary

Coastal neighborhoods in the Global South are now experiencing severe challenges due to climate change, land subsidence, and uncontrolled land use change. IPCC (2012) even argues that vulnerability in developing countries increases more quickly than its hazard. This argumentation is consistent with Wolff et al.'s (2020) finding that uncontrolled land use change in coastal areas could be the next exposure in coastal studies. These issues are allegedly associated with a lack of adaptation from the property market. Although voluntary housing displacement away from at-risk areas in the Global South has also been identified, the property market has not abandoned these areas. This situation could be explained by the decreasing property prices in at-risk areas, which have emboldened lower-income people to purchase and live in flood-prone areas. Speculation on and the exchange of property in slum areas suffering from flooding have been identified in several regions in the Global South, such as India (Desai, 2021), Bangladesh (Braun & Aßheuer, 2011), and Indonesia (Buchori et al., 2018). These property markets tend to form new housing submarkets for distressed properties that suffer from flooding. Because these new submarkets are inhabited by low-income residents with limited financial capabilities to conduct self-maintenance, these areas transform from decent to slum housing. In short, the decline of coastal neighborhoods occurs due to not only coastal hazards but also the lack of adaption from the property market.

Urban planners and policymakers must thus conceptually and practically understand how to prevent the decline of coastal neighborhoods. On the one hand, Grigsby et al. (1987) introduce the concept of neighborhood succession to explain the dynamics of neighborhood change and decline. Their seminal work, still relevant today, has conceptual implications for us, which is evidenced by Bates (2006), He and Zhang (2023), Mordechay and Terbeck (2023), and Terbeck (2023). These authors have concluded that the dynamics of the property market could represent neighborhood transformation through changes in inhabitants and housing quality. On the other hand, Lee (2017) explains that property price adjustment, either increasing or decreasing, also represents neighborhood change as the practical consequence of property price transactions via agreements between suppliers and buyers. The hedonic price model explains this phenomenon as the spatial equilibrium issue: the meeting point between the production and consumption curves (Rosen, (1974). Because property price defines the bundle of property vectors, including building structure, locational service, and environmental quality, the changes represent neighborhood service changes. Hence, property price adjustment also defines neighborhood change.

However, although the idea of property-based neighborhood change and decline is conceptually well established, it remains unclear how the property market demonstrates the process of neighborhood decline in practice. Thus, this study aims to answer the following research question: *To what extent do property markets demonstrate a process of decline in coastal neighborhoods?* By employing hedonic property variables, this study illustrates how these property markets demonstrate neighborhood decline in practice. Based on that, this study argues that the property market's response to coastal flood risk could be used to explain the process of coastal neighborhood decline. To answer the main research question, four research sub-questions are investigated: (i) To what extent do housing submarkets react to coastal flood risk? (ii) To what extent do property prices adjust and spill over to nearby houses? (iii) To what extent does neighborhood succession affect the heterogeneity of property price decline? and (iv) To what extent does coastal flooding affect residential mobility? Before answering these questions, we build a conceptual framework of coastal neighborhood decline combining two theories: the dynamics of neighborhood change and decline from Grigsby et al. (1987) and hedonic property modeling from Rosen (1974).

The conceptual framework of coastal neighborhood decline is addressed in Chapter 1. Rooted on Grigsby et al. (1987), we argue that coastal flood risk as an exogenous shock enters the property market, thus affecting property damage/decay and consumer preference changes. On the one hand, coastal flooding damages property, leading to abandoned neighborhoods and blight in nearby areas, resulting in neighborhood decay. This property market forms a new housing submarket that suffers from coastal flood risk: a housing submarket for distressed properties. This process may be illustrated by the dynamic of the housing submarket for distressed properties, supported by the answers to Research Sub-questions 1 and 2. The spatial dynamics of the housing submarket and property price spillover effects may illustrate housing submarket change. On the other hand, coastal flood risk entering the property market also influences the preference of property buyers to “consume” houses in at-risk areas. Higher-income residents may leave the at-risk area and be replaced by lower-income households who benefit from decreasing property prices. This process may be demonstrated by the heterogeneity response of property buyers and housing displacement for adaptation, supported by the answers to Research Sub-questions 3 and 4. In turn, this process may illustrate the anti-gentrification phenomenon in the at-risk areas.

The first research sub-question (*To what extent do housing submarkets react to coastal flood risk?*) is addressed in Chapter 2. This chapter builds a theoretical framework of obsolete housing based on the hedonic property model to understand housing

submarkets' reactions to coastal flood risk. This chapter, which contributes to the ongoing debate on coastal vulnerability, complements the explanation of how property purchasers also play a central role in increasing spatial vulnerability. Using spatial cluster analysis with k-means, we observed 1,440 property sale transactions and concluded that coastal flood risk increased due to the formation of new housing submarkets in the at-risk areas. Because this new housing submarket experiences flooding, we define it as a housing submarket for distressed properties. Moreover, we also compare the spatial dynamics of the housing submarket with the surface water body. This chapter finds that the spatial delineation of the housing submarket for distressed properties spreads and grows more quickly than the surface water body. Based on that, we argue that property market reaction via the formation of a submarket for distressed properties contributes to exposure, resulting in coastal vulnerability greater than coastal hazard. In short, this chapter reveals that flood risk influences the formation of housing submarkets and their spatial dynamics.

The second research sub-question (*To what extent do property prices adjust and spill over to nearby houses?*) is addressed in Chapter 3. This chapter develops a theoretical framework for distressed property and the spillover effect of blighted neighborhoods (Grigsby et al., (1987). Inspired by Chapter 2, regarding the spread of housing submarkets for distressed properties, we then observe property price behavior in response to coastal flooding. We build the framework based on the understanding of risk capitalization from Tobin and Newton (1986), echoed by Pryce et al. (2011), that property price also represents flood risk. Based on this, the negative spillover of property price may also represent the blighted neighborhood and the spatial growth of slum living in at-risk areas. This chapter examines property price transactions ($n = 1,029$) with a spatial autoregressive model to reveal property price spillover in at-risk areas. Thus, this chapter argues that property prices respond to the risk by reducing the price and spilling over to nearby areas. Based on this, the property price spillover effect also negatively represents the spatial dynamics of the housing submarket for distressed properties, which can offer practical insights for urban planners and policymakers.

The third research sub-question, a pivotal aspect of our study (*To what extent does neighborhood succession affect the heterogeneity of property price decline?*), is addressed in Chapter 4. In this chapter, we build a theoretical framework for declining coastal neighborhoods and anti-gentrification. This chapter observes residential mobility in correlation with the housing submarket and the heterogeneity of property price decline. We are inspired by Meen (1999), who explains that property price spillover effects are often induced by migration in association with housing consumption.

Hence, we screen over 1.9 billion property tax datapoints to illustrate residential mobility based on changes in property ownership. Based on this, we then define neighborhood succession. This chapter reveals that internal residential mobility occurs in the cross-housing submarket. Residents migrate from risky areas to safer ones and are then replaced by lower-income residents. Moreover, we employ a dataset containing 1,761 property sale transactions with geographically weighted regression (GWR) to observe the heterogeneity in property price decline. The results show that various decreasing property prices are associated with internal cross-submarket residential mobility within Pekalongan, which represents a novel perspective on housing dynamics and neighborhood change.

The fourth research sub-question (*To what extent does coastal flooding affect residential mobility?*) is addressed in Chapter 5. This chapter aims to observe residential mobility within the city in association with coastal flood risk variables and, at minimum, answer the question of whether residential displacement correlates with the risk regarding housing consumption. We consider private adaptation from Mendelsohn (2000) to build the theoretical framework of the influence of private adaptation in housing consumption on residential mobility. Based on this, housing displacement may be understood as location-based decisions in housing consumption to balance household expenses. Because coastal flooding damages property, it exerts consequences on the ability of each household to perform maintenance. Thus, self-repair is part of marginal cost (MC), which influences the balance of marginal benefit (MB) and marginal externalities (ME). According to Mendelsohn (2000), effective adaptation could be achieved when MB is greater than, or at least equal to, MC and ME ($MB \geq MC + ME$). We observe their mobility based on the results from Chapter 4 and investigate its causality with flood risk variables. Using multinomial logistic regression, we identify that mobility away from coastal flood-risk areas is strongly associated with flood risk. The significance value of the statistical model determines this association.

After addressing the four research sub-questions, we focus on answering the primary research question: *To what extent do property markets demonstrate a declining process in coastal neighborhoods?* This study argues that the property market's response to coastal flood risk can reflect the process of declining coastal neighborhoods in practice. This study also introduces two new terms to demonstrate coastal neighborhood decline: the spatial dynamics of housing submarkets and cross-submarket replacement. Evidence from Chapters 2 and 3 illustrates the dynamics of housing submarkets in response to coastal flooding. The spatial dynamics of housing submarkets thus reflect in practice the dynamics of housing neighborhood change and decline, as proposed

by Grigsby et al. (1987). Moreover, evidence from Chapters 4 and 5 demonstrates how property buyers react to coastal flooding in their decisions to purchase houses. The residential mobility that displaces cross-submarkets within the city demonstrates the changes in inhabitants. Hence, cross-submarket replacement may demonstrate neighborhood succession in practice.

Moreover, the hedonic property model, an approach for risk capitalization into property price, conceptually and practically illustrates the reactions of property buyers. Based on the hedonic property model, rooted in Lancaster's demand theory, we can understand the decline of coastal neighborhoods as simply the link between goods (houses) and consumers (people). Of course, this linkage relates to the basic assumption of neighborhood change: changes of places and people. Finally, this thesis offers a new perspective to explain the process of the coastal neighborhoods in decline. Coastal hazards enter property markets and influence property buyers' preferences in housing consumption.

This thesis extends Grigsby et al.'s (1987) theory, which attributes neighborhood change to housing disinvestment due to financial constraints and property ownership changes, by considering property market behavior based on the hedonic property model initiated by Rosen (1974). Flood hazards, a pressing concern in many coastal areas, significantly affect how inhabitants consume housing, which influences the housing submarket's spatial dynamics. The transformative impact of flood hazards is evident in the self-adaptation strategies of residents, who elevate their houses or foundations, leading to a burden on each household. This drives residents to move to safer areas, decreasing property prices and emboldening lower-income people to purchase houses in flood-prone areas, which results in neighborhood succession. As a result, property in flood-prone areas experiences price decreases and transforms from decent housing to distressed properties.

By extending Grigsby's theory (1987), this thesis reflects at least three theoretical frameworks. First, it demonstrates how exogenous shocks influence neighborhood change and decline in practice (Lee, 2017). Second, this thesis provides evidence of and theoretical explanations for why market memory, returning property values after flooding, is not observed in the Global South. The transformation from decent to slum housing is arguably the explanation for this phenomenon (Fletcher, Ganegodage, Hildenbrand, & Rambaldi, 2022; Ortega & Taşpınar, 2018). Third, this study may also contribute to the ongoing debate on spatial adaptation policy. Market-based instruments initiated by Filatova (2014) may need to be considered for flood risk management and to prevent coastal neighborhoods from declining.

Samenvatting

Kustwijken in het zuiden van de wereld worden nu geconfronteerd met ernstige uitdagingen als gevolg van klimaatverandering, bodemdaling en ongecontroleerd landgebruik. Het IPCC (2012) stelt zelfs dat de kwetsbaarheid in ontwikkelingslanden sneller toeneemt dan de blootstelling. Deze redenering komt overeen met de bevinding van Wolff et al. (2020) dat ongecontroleerde veranderingen in het landgebruik in kustgebieden de volgende blootstelling in kuststudies zou kunnen zijn. Deze problemen worden naar verluidt in verband gebracht met een gebrek aan aanpassing van de vastgoedmarkt. Hoewel er in het zuiden ook sprake is van vrijwillige verplaatsing van woningen uit de risicogebieden, heeft de vastgoedmarkt deze gebieden niet opgegeven. Deze situatie kan worden verklaard door de dalende vastgoedprijzen in de risicogebieden, die mensen met lagere inkomens hebben aangemoedigd om in overstromingsgevoelige gebieden te gaan wonen en kopen. De speculatie met onroerend goed en de transactie van onroerend goed in sloppenwijken die te lijden hebben onder overstromingen worden vastgesteld in verschillende regio's in het zuiden, zoals India (Desai, 2021), Bangladesh (Braun & Aßheuer, 2011), en Indonesië (Buchori et al., 2018). Deze onroerendgoedmarkt heeft de neiging om een nieuwe submarkt voor huisvesting te vormen voor noodlijdende eigendommen die te lijden hebben onder overstromingen. Omdat deze nieuwe submarkt wordt bewoond door bewoners met lage inkomens die weinig financiële middelen hebben om zelf onderhoud te plegen, transformeert deze nieuwe submarkt van fatsoenlijke huisvesting naar krottenwijk. Kortom, de achteruitgang van kustwijken is niet alleen te wijten aan kustgevaaren, maar wordt ook veroorzaakt door het gebrek aan aanpassing van de vastgoedmarkt.

Stedenbouwkundigen en beleidsmakers moeten daarom conceptueel en praktisch begrijpen hoe de achteruitgang van kustbuurten kan worden voorkomen. Aan de ene kant introduceren Grigsby et al. (1987) het idee van buurtopvolging om de dynamiek van buurtverandering en -afname te verklaren. Hun baanbrekende werk, dat vandaag de dag nog steeds relevant is, heeft conceptuele implicaties voor ons, zoals blijkt uit Bates (2006), He en Zhang (2023), Mordechay en Terbeck (2023) en Terbeck (2023). Zij concludeerden dat de dynamiek van de vastgoedmarkt de veranderingen in de buurt kan weergeven door de veranderingen in hun bewoners en de kwaliteit van de woningen. Aan de andere kant legt Lee (2017) ook uit dat een aanpassing van de vastgoedprijs, stijgend of dalend, ook veranderingen in de buurt vertegenwoordigt als het praktische gevolg van de vastgoedprijstransactie als de overeenkomst tussen leveranciers en kopers. Het hedonische prijsmodel legt het uit als het ruimtelijke evenwicht: het ontmoetingspunt tussen de productie- en consumptiecurve, volgens

Rosen (1974). Aangezien de onroerendgoedprijs de bundel van onroerendgoedvectoren definieert, met inbegrip van de structuur van het gebouw, de locatiegebonden dienstverlening en de omgevingskwaliteit, vertegenwoordigen de veranderingen, de veranderingen in de dienstverlening van de buurt. Daarom definiëren aanpassingen van de vastgoedprijs ook veranderingen in de buurt.

Hoewel het idee van op eigendom gebaseerde buurtverandering en -achteruitgang conceptueel goed is onderbouwd, blijft het onduidelijk hoe de vastgoedmarkt het proces van buurtachteruitgang in de praktijk aantoon. Daarom heeft deze studie tot doel om de volgende onderzoeksvraag te beantwoorden: 'In hoeverre laten de vastgoedmarkten een neergaand proces zien in kustbuurten?' Door hedonische vastgoedvariabelen te gebruiken, illustreert deze studie het praktische niveau van hoe de vastgoedmarkt het verval van een buurt laat zien. Op basis daarvan stelt dit onderzoek dat de onroerendgoedmarkt in reactie op het overstromingsrisico aan de kust gebruikt kan worden om het proces van verval van kustbuurten te verklaren. Om de hoofdonderzoeksvraag te beantwoorden, worden vier deelonderzoeksvragen onderzocht: (i) 'In welke mate reageren submarkten voor huisvesting op het overstromingsrisico aan de kust?' (ii) 'In welke mate passen vastgoedprijzen zich aan en spillen ze naar nabijgelegen huizen?' (iii) 'In welke mate beïnvloedt de opeenvolging van buurten de heterogeniteit van de daling van de vastgoedprijzen?' en (iv) 'In welke mate beïnvloedt de kustoverstroming de residentiële mobiliteit?' Voordat elke vraag kan worden beantwoord, wordt in deze studie een conceptueel raamwerk gebouwd van de achteruitgang van kustbuurten door twee theorieën te combineren: de dynamiek van buurtverandering en -daling van Grigsby et al., (1987) en de hedonische vastgoedmodellering van Rosen (1974).

Het conceptuele kader van het verval van kustwijken wordt behandeld in hoofdstuk 1. Gebaseerd op Grigsby et al. (1987) is gesteld dat het risico op kustoverstromingen als exogene schok de vastgoedmarkt binnendringt en de schade aan eigendommen/het verval en de veranderingen in consumentenvoorkeur beïnvloedt. Aan de ene kant beschadigen kustoverstromingen het eigendom, wat leidt tot verlaten buurten en verwoesting in nabijgelegen gebieden, wat weer resulteert in buurtverval. Deze eigendomsmarkt vormt een nieuwe submarkt voor huisvesting die te lijden heeft onder het risico van een kustoverstroming. Dit wordt een submarkt voor woningen in nood genoemd. Dit proces kan worden geïllustreerd aan de hand van de dynamiek van de submarkt voor woningen in nood, ondersteund door het antwoord op deelonderzoeksvragen 1 en 2 van dit onderzoek. De ruimtelijke dynamiek van de submarkt voor woningen en de overloopeffecten van de vastgoedprijs kunnen de verandering van de submarkt voor woningen illustreren. Aan de andere kant

beïnvloedt de intrede van het kustoverstromingsrisico op de huizenmarkt ook de voorkeur van kopers van onroerend goed om een huis in de risicogebieden te ‘consumeren’. De mensen met een hoger inkomen verlaten mogelijk het risico en worden vervangen door huishoudens met een lager inkomen die de daling van de vastgoedprijzen veiligstellen. Dit proces kan worden aangetoond door de heterogene respons van kopers van onroerend goed en verdringing van woningen met het oog op aanpassing, ondersteund door het antwoord op deelonderzoeksvragen 3 en 4. Dit proces kan het antiglobalisering-sfenomeen in de risicogebieden illustreren.

De eerste deelonderzoeksvraag, ‘In welke mate reageren submarkten voor huisvesting op het overstromingsrisico aan de kust?’, wordt behandeld in hoofdstuk 2. In dit hoofdstuk is een theoretisch kader voor verouderde huisvesting ontwikkeld op basis van het hedonische onroerendgoedmodel. Dit hoofdstuk bouwde een theoretisch kader van verouderde woningen gebaseerd op het hedonische eigendomsmodel om de reactie van de submarkten op het overstromingsrisico aan de kust te begrijpen. Dit hoofdstuk, dat bijdraagt aan het lopende debat over kwetsbaarheid aan de kust, vult de informatie aan over hoe kopers van onroerend goed ook een centrale rol spelen in het vergroten van de ruimtelijke kwetsbaarheid. Met behulp van ruimtelijke clusteranalyse met k-means zijn 1.440 vastgoedtransacties geobserveerd en er is geconcludeerd dat het kustoverstromingsrisico de nieuwe submarkten voor woningen in de risicogebieden vormde. Omdat deze nieuwe submarkt voor woningen te maken kreeg met overstromingen, is deze gedefinieerd als een submarkt voor woningen in nood. Bovendien is ook de ruimtelijke dynamiek van de submarkt voor woningen vergeleken met het oppervlaktewaterlichaam. Uit dit hoofdstuk bleek dat de ruimtelijke afbakening van de submarkt voor huizen met problemen zich sneller verspreidde en groeide dan het oppervlaktewaterlichaam. Op basis daarvan kan worden gesteld dat de reactie van de woningmarkt met de vorming van een submarkt voor noodlijdende woningen bijdraagt aan de blootstelling, wat resulteert in een kwetsbaarheid van de kust die groter is dan het kustgevaar. Kortom, deze studie onthulde dat overstromingsrisico's van invloed zijn op de zich vormende submarkt voor woningen en de ruimtelijke dynamiek ervan.

De tweede deelonderzoeksvraag, ‘In welke mate passen vastgoedprijzen zich aan en spillen ze naar nabijgelegen huizen?’, wordt behandeld in hoofdstuk 3. Dit hoofdstuk ontwikkelde een theoretisch kader voor noodlijdend vastgoed en het overloopeffect van verwoeste buurten. In dit hoofdstuk ontwikkelden Grigsby et al. (1987) een theoretisch kader voor noodlijdend vastgoed en het overloopeffect van verwoeste buurten. Geïnspireerd door hoofdstuk 2 met betrekking tot de verspreiding van submarkten voor noodlijdend onroerend goed, is vervolgens het

prijsgedrag van onroerend goed in reactie op kustoverstromingen geobserveerd. Hierbij is het raamwerk gebouwd op basis van het begrip risicokapitalisatie van Tobin en Newton (1986), met als echo door Pryce et al. (2011) dat de vastgoedprijs ook het overstromingsrisico vertegenwoordigt. Op basis hiervan kan een negatief overloopeffect van de onroerendgoedprijs ook de verwoeste buurt en de ruimtelijke groei van sloppenwijken in de risicogebieden weergeven. Dit hoofdstuk gebruikte onroerendgoedprijstransacties ($n=1.029$) met een ruimtelijk autoregressief model om de overloopeffecten van onroerendgoedprijzen in de risicogebieden te laten zien. Dit hoofdstuk stelt dus dat onroerendgoedprijzen reageren op het risico door de prijs te verlagen en door te slaan naar de nabijgelegen gebieden. Op basis hiervan vertegenwoordigt het negatieve overloopeffect van de vastgoedprijs ook de ruimtelijke dynamiek van de submarkt voor woningen in nood, wat praktische inzichten biedt voor stedelijke planners en beleidsmakers.

De derde deelonderzoeksvraag, een centraal aspect van deze studie, ‘In welke mate beïnvloedt de opeenvolging van buurten de heterogeniteit van de daling van de vastgoedprijzen?’, wordt behandeld in hoofdstuk 4. In dit hoofdstuk is een theoretisch kader gebouwd voor krimpende kustbuurten en antigentrificatie. In dit hoofdstuk is de residentiële mobiliteit geobserveerd in correlatie met de submarkt voor huisvesting en de heterogeniteit van vastgoedprijzdaling. De onderzoekers zijn hierbij geïnspireerd door Meen (1999), die uitlegt dat overloopeffecten van onroerendgoedprijzen vaak werden veroorzaakt door migratie in combinatie met woningconsumptie. Daarom zijn meer dan 1,9 miljard datasets over de geschiedenis van de onroerendgoedbelasting gescreend om woonmobiliteit te illustreren op basis van veranderingen in eigendom van onroerend goed. Op basis hiervan is vervolgens de buurtopvolging gedefinieerd. Dit hoofdstuk onthulde dat interne woonmobiliteit optreedt in de submarkt die de woningmarkt doorkruist. Ze migreren van risicovolle gebieden naar veiligere gebieden en worden dan vervangen door mensen met een lager inkomen die naar risicovolle gebieden komen. Bovendien is een dataset gebruikt van 1.761 vastgoedtransacties met geografisch gewogen regressie (GWR) om de heterogeniteit van de vastgoedprijzdaling te observeren. Het resultaat toont aan dat verschillende dalende vastgoedprijzen geassocieerd worden met interne woonmobiliteit over de submarkt heen binnen Pekalongan, wat een nieuw perspectief biedt op woondynamiek en buurtverandering.

De vierde deelonderzoeksvraag, ‘In welke mate beïnvloedt de kustoverstroming de residentiële mobiliteit?’, wordt behandeld in hoofdstuk 5. Dit hoofdstuk trachtte de woonmobiliteit binnen de stad in verband te brengen met variabelen van het risico op kustoverstromingen. Dit hoofdstuk is gericht op het observeren van de

woonmobiliteit binnen de stad in relatie tot variabelen met betrekking tot het risico op kustoverstromingen. Dit hoofdstuk geeft in ieder geval antwoord op de vraag of hun verplaatsing correleert met het risico met betrekking tot woonconsumptie. Hierbij is rekening gehouden met de privéadaptatie van Mendelsohn (2000) om het theoretische kader op te bouwen van privéadaptatie in de woonconsumptie die de woonmobiliteit beïnvloedt. Op basis hiervan kan woonverplaatsing worden begrepen als de locatiegebonden beslissing in woonconsumptie om de uitgaven in evenwicht te brengen. Omdat kustoverstromingen het eigendom beschadigen, heeft dit gevolgen voor het vermogen van elk huishouden om onderhoud uit te voeren. Zelfherstel maakt dus deel uit van de marginale kosten (MC), die de balans tussen marginale baten (MB) en marginale externe effecten (ME) beïnvloeden. Volgens Mendelsohn (2000) kan effectieve aanpassing worden bereikt wanneer MB meer is dan of ten minste gelijk aan de MC en ME of $MB \geq MC + ME$. De mobiliteit op basis van het resultaat in hoofdstuk 4 is geobserveerd en de causaliteit met overstromingsrisicovariabelen is geobserveerd. Met behulp van multinomiale logistische regressie is vastgesteld dat de mobiliteit die kustgebieden met een overstromingsrisico verlaat, sterk samenhangt met het overstromingsrisico. De significantiewaarde van het statistische model bepaalt dit verband.

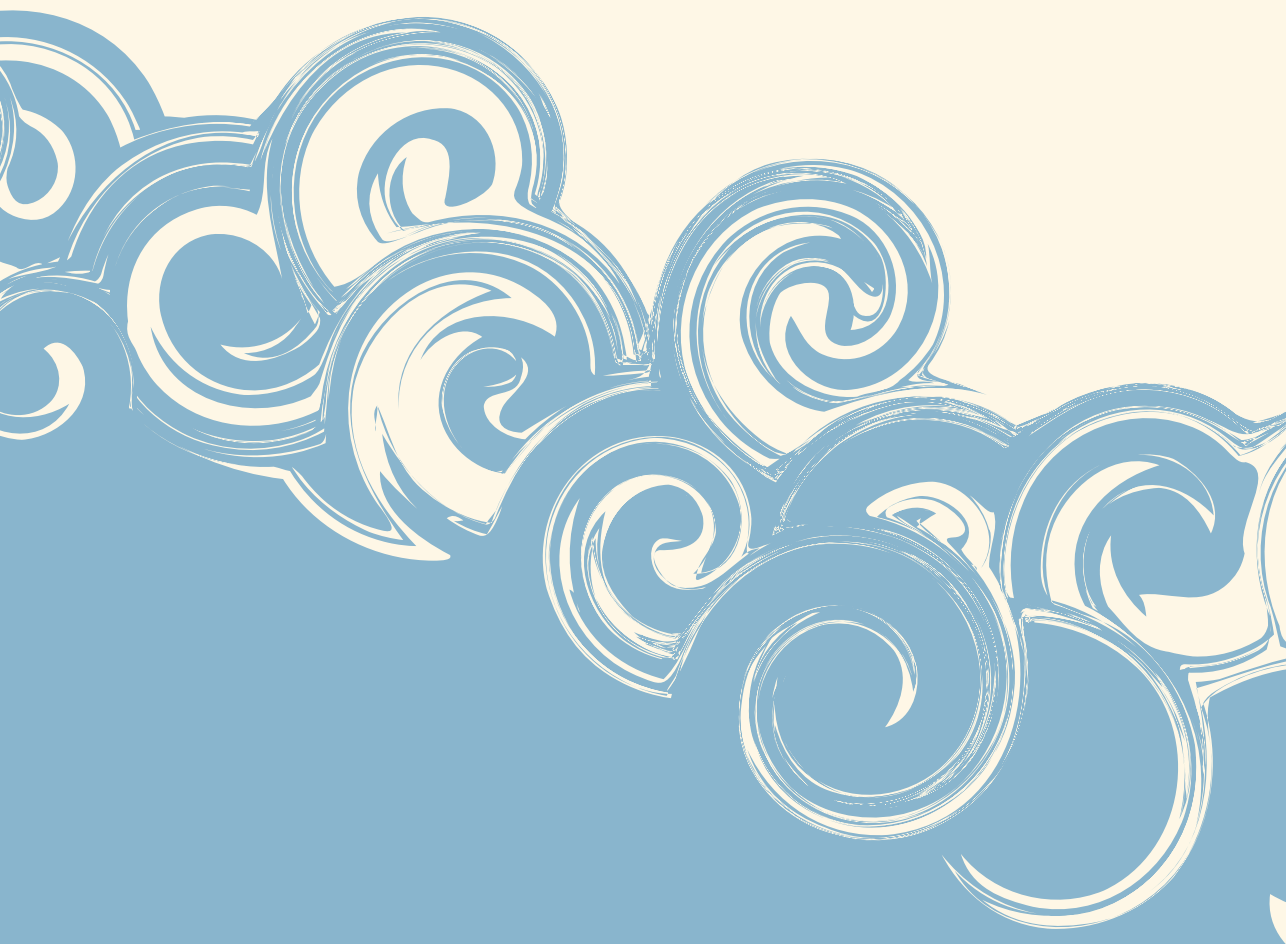
Na het behandelen van de vier subonderzoeksvragen wordt nu gefocust op het beantwoorden van de primaire onderzoeksvraag: 'In welke mate laten vastgoedmarkten een neergaand proces zien in kustbuurten?' Deze studie stelt dat de reactie van de vastgoedmarkt op het overstromingsrisico aan de kust het proces van verval van kustbuurten praktisch kan aantonen. Deze studie introduceert ook twee nieuwe termen om de achteruitgang van kustwijken aan te tonen: ruimtelijke dynamiek van de submarkt voor huisvesting en substitutie tussen submarkten. Bewijsmateriaal in hoofdstuk 2 en hoofdstuk 3 illustreert hoe de dynamiek van de submarkt voor huisvesting reageert op kustoverstromingen. De ruimtelijke dynamiek van de submarkt voor huisvesting toont dus praktisch de dynamiek aan van de verandering en achteruitgang van woonbuurten, zoals geïnitieerd door Grigsby et al. (1987). Bovendien laten de gegevens uit hoofdstuk 4 en hoofdstuk 5 zien hoe kopers van onroerend goed reageren op kustoverstromingen in hun beslissing om een huis te kopen. De woonmobiliteit die deelmarkten binnen de stad verplaatst, laat de veranderingen van bewoners zien. Daarom kan de substitutie tussen deelmarkten in de praktijk de opeenvolging van buurten aantonen.

Bovendien illustreert het hedonische vastgoedmodel, een benadering voor risicokapitalisatie in vastgoedprijzen, conceptueel en praktisch hoe kopers van vastgoed reageren. Op basis van het hedonische vastgoedmodel, dat is geworteld

in de vraagtheorie van Lancaster, kan de achteruitgang van kustwijken eenvoudig worden begrepen als de koppeling tussen goederen (huizen) en consumenten (mensen). Uiteraard heeft deze koppeling betrekking op de basisveronderstelling van buurtverandering: verandering van plaats en mensen. Tot slot biedt dit proefschrift een nieuw perspectief om het proces van de neergang van kustwijken te verklaren. Het kustrisico doet zijn intrede op de onroerendgoedmarkt en beïnvloedt de voorkeur van kopers van onroerend goed in hun woonconsumptie.

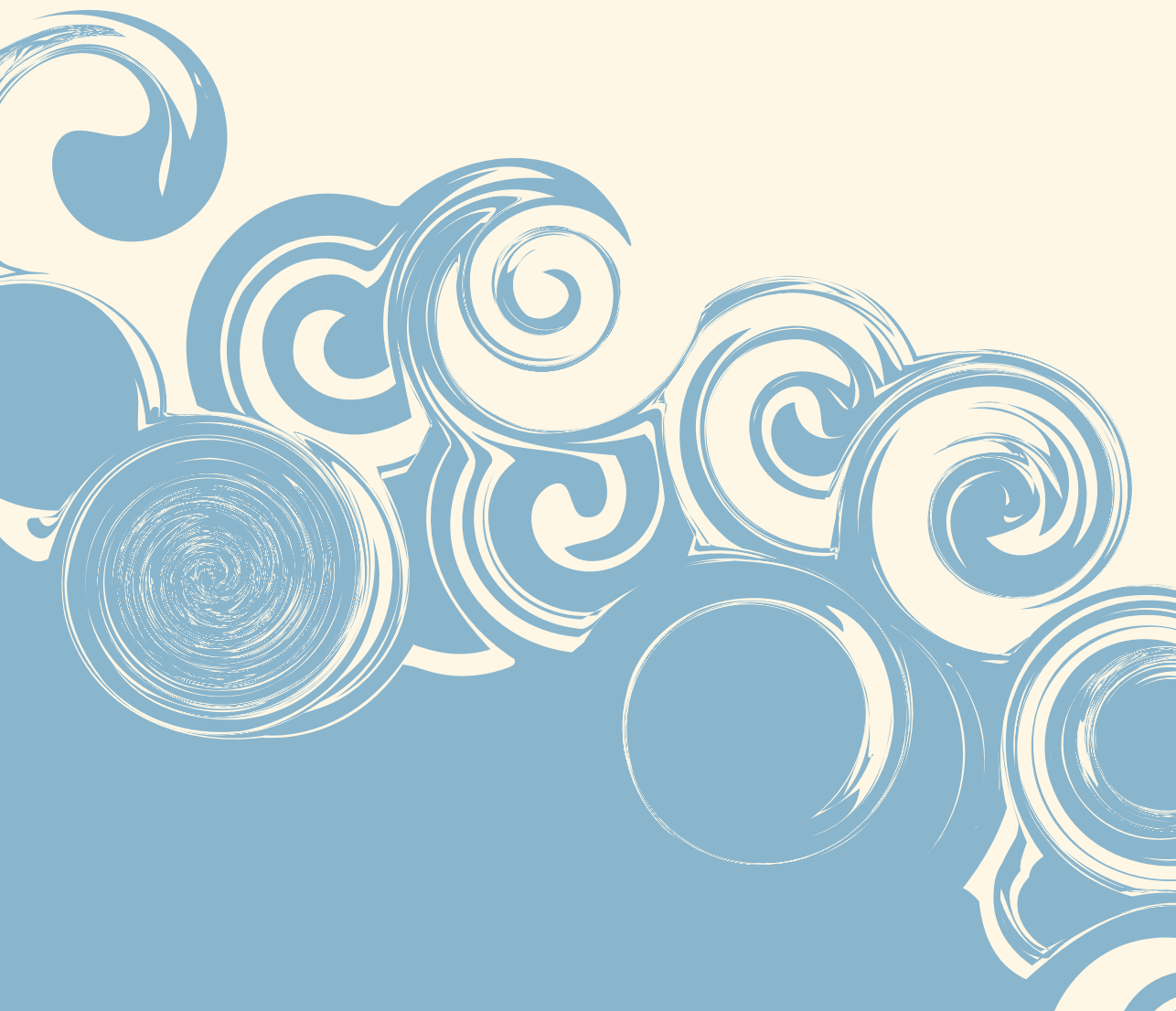
Deze dissertatie breidt de theorie van Grigsby et al. (1987) uit, die verandering in een buurt toeschrijft aan desinvestering in woningen als gevolg van financiële beperkingen en veranderingen in eigendom, door het gedrag op de onroerendgoedmarkt te beschouwen op basis van het hedonische onroerendgoedmodel dat werd geïnitieerd door Rosen (1974). Overstromingsgevaar, een urgente kwestie in veel kustgebieden, heeft een aanzienlijke invloed op de manier waarop bewoners hun huizen consumeren en beïnvloedt de ruimtelijke dynamiek van de submarkt voor huisvesting. Het transformerende effect van overstromingsgevaar blijkt duidelijk uit de zelfaanpassingsstrategieën van bewoners, die hun huizen of funderingen verhogen, wat leidt tot een last voor elk huishouden. Dit zet bewoners ertoe aan om naar veiligere gebieden te verhuizen, waardoor de prijzen van onroerend goed dalen en mensen met een lager inkomen worden aangemoedigd om huizen te kopen in overstromingsgevoelige gebieden, wat weer resulteert in de opvolging van buurten. Het gevolg is dat onroerend goed in overstromingsgevoelige gebieden in prijs daalt en daardoor verandert van fatsoenlijke huisvesting in noodlijdende buurten.

Door de theorie van Grigsby et al. (1987) uit te breiden, weerspiegelt dit proefschrift ten minste drie theoretische kaders. Ten eerste toont deze studie praktisch aan hoe exogene schokken verandering en verval van buurten beïnvloeden (Lee, 2017). Ten tweede levert deze studie bewijs en theoretische verklaringen waarom het marktgeheugen, het teruggeven van de waarde van onroerend goed na overstromingen, niet wordt waargenomen in het zuiden. De transformatie van fatsoenlijke huisvesting naar sloppenwijken is aantoonbaar het antwoord op dit fenomeen (Fletcher et al., 2022; Ortega & Taşpınar, 2018). Ten derde kan deze studie ook bijdragen aan het lopende debat over ruimtelijk adaptatiebeleid. Marktconforme instrumenten, geïnitieerd door Filatova (2014), moeten mogelijk worden overwogen voor overstromingsrisico-beheer en om te voorkomen dat kustbuurten achteruitgaan.



CHAPTER 1

General Introduction



Changes in the spatial dynamics of housing submarkets in response to coastal flood risk illustrate the decline of neighborhoods, both conceptually and practically. This reaction is crucial for understanding housing behavior in most countries in the Global South, which currently face multiple challenges in relation to coastal disaster. Hallegatte et al. (2013) predict future flood losses in coastal cities in these countries to be greater than their counterparts in the Global North due to a lack of adaptation. Moreover, uncontrolled land use change emerges as the next potential exposure (Wolff et al., 2020), which aligns with a statement from the IPCC (2012) that vulnerability is greater than hazard in coastal areas. Some researchers have also documented voluntary outflow migration induced by coastal flooding, for example, in Indonesia (Buchori et al., 2018; Khairulbahri, 2022), Bangladesh (Kartiki, 2011), and India (Desai, 2021), and concluded that this migration relates to mitigation and adaptation to vary the spatial risk caused by coastal flooding. Some evidence from the Global South shows neighborhoods that have suffered flooding becoming slum housing (Braun & Aßheuer, 2011). Furthermore, Desai and Loftus (2013) provide empirical evidence about property speculation and transactions in slum areas suffering from flooding in Mumbai, India. Thus, property markets may influence the spread of slum housing in flood-prone areas, resulting in neighborhood decline. The property market's minimal role in coastal adaptation may thus exacerbate economic loss and the decline of coastal neighborhoods (Filatova, 2014).

Grigsby et al.'s (1987) extensive theorizations about neighborhood change and decline from a property market viewpoint remain relevant, as demonstrated by Bates (2006), He and Zhang (2023), Mordechay and Terbeck (2023), and Terbeck (2023), who argue that neighborhood succession, especially from higher- to lower-income inhabitants, influences residents' capability to conduct maintenance by themselves. In conjunction, many lower-income people purchase new homes to secure lower prices. The inflow migration of lower-income people to hazardous areas in Indonesia has been well documented by Permana and Miyata (2008). In this context, decreasing property quality, including in flood-prone areas, is reflected in lowered property prices (Filatova, Mulder, & van der Veen, 2011). This phenomenon occurs because many coastal communities, including in Indonesia (Mercy Corps, 2021), have lower risk perceptions related to coastal flooding (Filatova et al., 2011). Thus, Filatova (2014) has proposed including property in the analysis of spatial adaptation through market forces to reduce potential economic losses caused by spatial externalities.

However, although the idea of neighborhood change and decline is conceptually well established, it remains unclear how the property market reflects neighborhood decline in practice. Previous insights focused on the conceptual framework of

housing disinvestment rather than practically demonstrating the process of housing decline. Additionally, the established theory on neighborhood change and decline from Grigsby et al.'s (1987) does not explain the structure of house prices. In contrast, recent disaster studies explain that property price change represents neighborhood change (Lee, 2017), assuming that price filters the inhabitants, including in disaster risk areas - by securing the lowering property price. Current research in flood disasters also revealed that property buyers internalize the risk into the price. Hence, this study aims to brighten the gap by incorporating the hedonic pricing model from Rosen (1974). to explain the spatial dynamic of the housing market through the structure of hedonic prices. Accordingly, a theoretical gap in property-based neighborhood change and decline and the role of property price structure should be identified. As such, this thesis answers this research question: *To what extent do property markets demonstrate a process of decline in coastal neighborhoods?*

Previous studies in the Global South have employed various theoretical frameworks and thus presented mostly fragmented, inconclusive evidence. Coastal flooding in the Global South may spur different property market responses than in the Global North. While some flood literature has reported property prices returning to normal after 3–6 years, to the best of our knowledge, no similar reports exist from the Global South, where most research has reported property price decreases in response to flooding (Bin & Landry, 2013), a phenomenon called “market memory” (Blackledge & Lamphiere, 2022). As such, if property prices show no signal of rebounding after flooding, it can be assumed that the neighborhood quality has changed and will continue to decrease or even shrink (Lee, 2017). Outflow migration and transactions in flood-affected slum areas may signal the shrinkage of cities in the Global South. Desai (2021) has even introduced the term “widowhood” to describe an abandoned neighborhood in Mumbai, India.

To address the knowledge gap, this study aims to conceptualize the framework of declining coastal neighborhoods from property market viewpoints. We built the conceptual framework by combining two theories: the dynamics of neighborhood change and decline from Grigsby et al. (1987) and hedonic property modeling from Rosen (1974). This allows us to conceptualize and develop a method for tracking coastal neighborhood change and decline. The remainder of the chapter comprises a contextual background, theoretical problem, conceptual framework, methodology for tracking declining coastal neighborhoods, and conclusion.

Contextual Background

Coastal flooding is causing property damage worldwide, forcing inhabitants to perform maintenance and self-repair. This deterioration leads to an added financial burden for each household. In Indonesia, for example, Bott and Braun (2019) revealed that inhabitants in the north coastal city of Java spend around IDR 10 million every 5 years on elevating their house or foundation. Likewise, coastal flooding has induced property abandonment in various regions, such as Southeast Asia (see: Bui, Wen, & Sharp, 2022; W. Handayani, Chigbu, Rudiarto, & Putri, 2020), Africa (Alves, Angnuureng, Morand, & Almar, 2020; Dada et al., 2023), Europe (Martinez, Costas, & Ferreira, 2020), and the US (Bukvic & Barnett, 2023). Many inhabitants have left their properties to avoid the extra costs of adaptation. This relocation, known in urban economics as spatial demand displacement, has decreased demand for properties in at-risk areas, leading to falling property prices. Market failure may occur, resulting in housing investment illiquidity.

Two significant phenomena are observed in the Global South when addressing the decline of coastal neighborhoods. First, housing submarkets in flood-prone areas likely tend to be distressed, signaled by property abandonment. Although no clear evidence exists, some studies in the Global South have signaled a transformation from decent housing to slum properties. Property transactions in the slum area may be a clue to the property market response to coastal flooding. They may differ from the Global North, including the unclear evidence of market memory in the Global South. Second, in- and outflow migration occurs in slum areas that suffer from flooding. Most studies focus on climate gentrification, relocation for adaptation induced by sea level rise, rather than inflow displacement to at-risk areas. This study may align with previous research on buyouts or retreat programs by acquiring homes in at-risk areas and restoring land to natural floodplains, often reported in the Global North (Loughran & Elliott, 2019; Pierce Holloway & BenDor, 2023). This program may explain why nonclear evidence of market memory exists in the Global South, unlike in the Global North.

Housing Submarket Emergence

Flood hazards influence the emergence of spatial housing submarkets and decreasing property prices. Some empirical evidence signals the transformation of inhabitants living in vulnerable areas into people experiencing poverty (Lee, 2018). For example, Permana and Miyata (2008) documented the in- and outflow migration of low-income people in flood-prone areas. Emerging housing submarkets in areas at risk of flood, particularly in the Global South, may transform into slum areas. Because property sale transactions occur in slum areas, this may be the second reason for the lack of evidence related to market memory in the Global South.

Property prices tend to decrease in flood-prone areas, with studies revealing reductions of 4%–6% (Gourevitch et al., 2023; Mutlu, Roy, & Filatova, 2023). Most of those studies applied the hedonic pricing model and explain that it occurred because property buyers modify their expectations of a utility value (Pryce & Chen, 2011). In hedonic theory, property price describes the bundle of structure, locational service, and environmental quality (Freeman, 1979). When flooding damages the building and environment, the expectations of homebuyers change, and they require extra maintenance costs, resulting in property price drops. As such, decreasing property prices can sometimes be understood as a discount, with the knowledge that homebuyers must self-repair (Van Ham, 2012a).

In- and Outflow Migration

Property price decreases serve as neighborhood decline indicators and are associated with spatial demand displacement, an idea based on the basic argumentation of property price indicating spatial equilibrium, namely the meeting point between the demand and supply curves (Filatova, 2014; Fujita & Thisse, 2013). A decline in property prices creates a new convergence point for both prospective sellers and potential property buyers. New homebuyers with lower incomes consequently purchase houses in flood-prone areas to fulfill their basic housing needs (Van Ham, 2012a). This phenomenon, known as reverse or anti-gentrification, is often observed in neighborhoods experiencing decline, typically due to property foreclosures (Ashton, 2023). The authors concluded that declining neighborhoods are strongly related to spatial demand, displacement, and anti-gentrification.

Evidence suggests that hazardous locations, including flood-prone areas, have become a pull-and-push migration factor (Lee, 2017). As economic agents, Brasington (2021) explains that migration is simply an adaptation strategy to ensure the balance of household expenditure. In flood-prone areas, households must spend extra on maintenance, part of marginal costs. Thus, some individuals migrate to reduce marginal costs and improve their benefits. Mendelsohn (2000) also explains that effective adaptation is based on rational economic choice and argues that the adaptation can be effective if the marginal benefit (MB) is greater than (or at least equal to) the marginal cost (MC) and marginal externalities (ME): $MB \geq MC + ME$. Local inhabitants consequently abandoned flood-prone areas and their properties, and demand decreased, resulting in a drop in property prices (Filatova, 2014). Conversely, the falling of property prices emboldens lower-income homebuyers to secure the price. They replace the previous homeowners, and neighborhood succession occurs in the flood-prone areas.

Theoretical Problem

Grigsby et al. (1987) who developed their theory by considering post-war events as shocks that enter the property market and affect neighborhood decline, have clearly established the dynamics of neighborhood change and decline. However, several issues remain unclear: (i) whether the theory is relevant for different shocks such as coastal flooding; (ii) how the spatial housing market demonstrates the dynamics of neighborhoods in decline; (iii) the spatial pattern for neighborhood succession; and (iv) the relationship between market memory and neighborhood decline. Moreover, Grigsby et al. (1987) built the theory on observations in developed countries, particularly the US, which may differ from those in developing countries.

Furthermore, it desires to demonstrate the role of the property market in the dynamics of neighborhood change and decline. Based on Lancaster's demand theory (1966), this housing behavior may be influenced by individuals' preferences in housing consumption, including their choice of where to live. To comprehensively explain neighborhood decline in coastal flood-prone areas, gathering at least two additional pieces of information concerning property market behavior in response to a shock is imperative.

Lack of Information on Property Market Response to Coastal Flooding

Previous studies have primarily focused on the emergence of property submarkets in flood-prone areas. However, the spatial dynamics of housing submarkets in response to coastal flooding are rarely reported. According to Bhattacharjee et al. (2016), property buyers with similar characteristics tend to gather in a single location to share locational services within their budget constraints. They often shape geographical delineation based on data-driven boundary, administration, or substitute characteristics (Bourassa, Hamelink, Hoesli, & MacGregor, 1999; Usman, Lizam, & Adekunle, 2020). Because property prices define household preferences in housing consumption, including risk acceptance, housing submarkets demonstrated homogenous property prices. In conjunction, at least two gaps in information must be addressed to understand the spatial dynamics of the housing submarket in response to coastal flooding.

First, information is lacking about the spatial dynamics of the housing submarket, and it is unclear how these dynamics relate to the magnitude of coastal flooding. Although the emergence of property markets in flood-prone areas is well documented worldwide, little evidence exists regarding how dynamic spatial property submarkets can potentially increase coastal vulnerability in medium-sized cities. In ecology studies, Lee (2018) has contributed to the understanding of dynamic neighborhood

change using census tract data with the adjusted interrupted time series model. However, this method has limitations in the dynamic spatial housing submarket demonstrating neighborhood change, specifically in flood-prone areas.

Second, the impact of coastal flooding as an exogenous shock on property price adjustment over space and time remains unclear. While extensive research has been conducted on the decrease in property prices in response to flood risk, it remains unclear whether this decline also negatively spills over. With the knowledge that coastal hazard-induced neighborhood change is represented by property price correction (Jun, 2022; Lee, 2017), investigating the property price spillover effect may support the understanding of urban planners and policymakers to prevent the decline of further neighborhoods. According to Meen (1999), who revealed a property price ripple effect in response to new investment in the UK, coastal shock may influence similar spillover on property price in a negative way: property price decrease. The spatial lag of property price adjustment may correlate with the spatial dynamics of the housing submarket due to the direct response of property market behavior to coastal flooding.

Lack of Information on Residential Mobility in Correlation with Property Price Decreases

Most studies in the field of residential mobility have focused primarily on “where people move to” rather than “where they move from.” These limited studies have led to uncertainty about whether the properties affected by flooding are abandoned. Regional studies literature provides a good understanding of the correlation between property price increases and gentrification. Meen (1999) even introduces the term “gentrification agent” to support the argument that increasing property prices follow gentrification. From this follows the hypothesis that decreasing property prices in at-risk areas may be correlated with anti-gentrification. As such, at least two limited pieces of information address the lack of information on residential relocation and its correlation with various decreasing property prices.

First, what is less clear is the nature of the relationship between the decrease in property prices and anti-gentrification. While in- and outflow migration in flood-prone areas has been thoroughly investigated, it remains unknown whether it is associated with the heterogeneity of property price decreases. Liao et al. (2015) explain that in- and outflow inhabitants are house purchasers who directly influence the property market. However, studies on the heterogeneity of property price decreases are limited, which sometimes escapes the attention of policymakers and urban scholars. Moreover, determining whether neighborhoods that suffer from flooding are abandoned is crucial; this could inform future urban development and housing policies.

Second, much uncertainty remains about the relationship between relocation decisions and coastal flood risk. Many studies have how demonstrated the valuable contribution of housing adaptation and anticipation through residential mobility and immobility. However, the influence of coastal flood risk variables on relocation decisions has remained unclear. Marfai et al. (2015) thoroughly investigated residential immobility adaptation in the form of house and floor elevations and mini-dam construction. For example, using questionnaires to investigate residential mobility adaptation, Buchori et al. (2018) found that vulnerable people move to safer areas to mitigate risks. It remains unclear whether their mobility could be explained by the property market and its correlation with coastal flood risk.

Research Objective and Research Question

To fill the knowledge gap presented above, this study answers the following question: *To what extent do property markets demonstrate a declining process in coastal neighborhoods?* This study focuses on property market behavior through investigating two sectors: consumer behavior and price behavior. As an object, property market behavior will be examined according to the location and price. Meanwhile, as the subject, people's behavior will be studied through their decisions in adaptation investments.

To answer the main research question, four sub-research questions are investigated:

1. To what extent do housing sub-markets react to coastal flood risk?
2. To what extent do property prices adjust and spill to nearby houses?
3. To what extent does neighborhood succession affect the heterogeneity of property price decline?
4. To what extent does coastal flooding affect residential mobility?

Conceptual Framework

The first question seeks to show how property market behavior reveals a declining process in coastal neighborhoods. Thus, the systematic conceptual framework of neighborhood decline integrates the theory of neighborhood change (Grigsby et al., 1987) and the hedonic price model (Rosen, 1974). According to Grigsby et al. (1987), a neighborhood is a property submarket that is dynamically formed by changes in supply and demand. The dynamics of a housing submarket could thus be interpreted as neighborhood change either increasing or decreasing. Furthermore, property prices also represent environmental quality, including flood risk, with the knowledge that property price is the bundle of the building structure, locational service, and environmental amenities (or dis-amenities). Changes in environmental quality are thus capitalized into property prices. In the context of flood risk, Zhang et al.

(2010) explain that property price materializes flood risk based on perceived risk of economic loss. This assumption aligns with Tobin and Newton (1986), who assert that flood risk is capitalized into property prices based on factors such as flood severity, frequency, and land use patterns.

Drawing inspiration from Lee (2017), a flood is arguably an exogenous shock in the property market that leads to neighborhood change, and property price adjustments thus represent neighborhood change. The shock that enters this market influences structural physics and households. Damaged residences require extra maintenance, which influences the balance of family expenditures. Through this, some households decide to displace themselves to secure financial balance (Brasington, 2021). As a result, property prices decrease due to lower demand in flood-prone areas (Filatova, 2014). In some countries, falling property prices have emboldened lower-income buyers to purchase homes and gather in the same location in flood-prone areas (Desai & Loftus, 2013; Rajapaksa, Wilson, Hoang, Lee, & Managi, 2017). As a consequence, a property market emerges in flood-prone areas, which some scholars refer to as distressed properties (Pierce Holloway & BenDor, 2023). In essence, floods, as exogenous shocks entering the property market, result in the creation of housing submarkets for distressed properties and trigger in- and outflow migration (or anti-gentrification).

Dynamics of Housing Submarkets

A natural hazard, such as a coastal flood, shocks the property market, leading to damage to physical properties and decreasing prices (Lee, 2017). In real estate literature, distressed properties are often described as abandoned or vacant units, which create separate housing submarkets. Bhattacharjee et al. (2016) defines *housing submarkets* as encompassing (a) similarities in house features, (b) commonalities in hedonic prices, and (c) the substitutability of dwellings. This new housing submarket is spatially dynamic because lowering property prices may attract specific homebuyers to inhabit these submarkets. Bayer et al. (2017) highlight that the specific characteristics influencing housing demand in distressed properties include factors such as race, income, and environmental quality. As a consequence, the submarket for distressed properties exhibits spatial growth and spreads into neighboring areas. Because property prices serve as indicators of neighborhood changes (Lee, 2017), the expansion of the submarket for distressed properties may be similarly reflected through property price spillover effects.

The spillover, or ripple effect pertains to the movement of property prices in response to shocks occurring over both time and space (Meen, 1999), from economic or

non-economic factors that influence the perceptions of house purchasers in their decisions. Coastal flooding is arguably a non-economic shock that influences the perceived perceptions of homebuyers and suppliers to adjust prices (Y. Zhang et al., 2010); decreasing property prices thus compensate for the extra budget needed to conduct maintenance by individuals. Thus, some literature also uses the term “discount” to explain the percentage of property price decrease. Because property prices reflect spatial equilibrium, the adjustment of prices may occasionally lag over time and space following transactions between suppliers and the emergence of new demands. This lag in price adjustments illustrates the transmission of property prices or spillover effects.

In the context of physical property, a coastal neighborhood in decline comprises residential damage that spreads to nearby areas. Grigsby et al. (1987) explain that neighborhood decline can occur despite the number of lower-income inhabitants not increasing significantly. This spread is also captured by property price movement or spillover because property price also represents environmental quality. In brief, the process of coastal neighborhoods declining from the physical context of property occurs due to coastal flooding damaging properties, and their inhabitants have a lower ability to conduct maintenance.

Neighborhood Succession

Coastal flooding enters the property market, leading to the various responses of property buyers and influencing their displacement decisions. The heterogeneity of homebuyers' responses refers to the financial ability of each individual to balance their expenditures. As explained above, adaptation is part of MC and influences family expenditure (Mendelsohn, 2000). Thus, the ability of property buyers to adapt is highly influenced by their financial capacity, which aligns with adaptive capacity (Adger, 2006). Marfai et al. (2015) provide an excellent example of how various adaptations relate to the financial capacity of a household, in documenting that various high houses relate to the financial ability of each individual to elevate their house (or at least the foundation) in the coastal area of Java, Indonesia. Furthermore, Brasington (2021) explains that household adaptation is done by not only renovating houses but also relocating to safer areas for the same reason: economics.

Give Grigsby et al. (1987), the in- and outflow displacement of households may refer to neighborhood succession. In regional literature, Meen (1999) explains that gentrification agents are individual property buyers who replace existing homeowners and influence demand speculation to increase prices. Thus, when the property price is correct, either increasing or decreasing, demand and supply

arguably also adjust, following the market. Adjustments are individual responses that influence property price volatility. Bates (2006) documented how increasing property prices relate to the inflow migration of new purchasers to benefit from improving neighborhood quality, a phenomenon describing the linkage between property price increases and gentrification (Bates, 2006).

According to Black et al. (2011), relocation is only one adaptation strategy for households to adjust their expanse in housing consumption. In urban economics, housing consumption relates to locational quality to take advantage of budget constraints (Filatova, 2014; Fujita & Thisse, 2013). The quality of location is usually associated with proximity to urban amenities and environmental quality, which strongly influence an individual's expenditures. For example, houses in better-quality environments are more expensive than those in lower-quality ones, because households benefit more from livable residences with low maintenance budgets, which compensates for price, and vice versa. Because inhabitants need extra money for maintenance in flood-prone areas, some may decide to displace for adaptation (Black et al., 2011; Brasington, 2021). In the context of housing consumption, this displacement occurs to balance their expenses.

Coastal neighborhoods in decline relate to the low ability of local inhabitants to conduct maintenance by themselves, which aligns with arguments that the presence of housing disinvestment significantly influences the declining neighborhood rather than physical decay. Given the serious impact of coastal flooding given a lack of adaptation, this adaptation arguably represents a burden to each household. This phenomenon is frequently found, particularly in the Global South. As such, elevating the house (or at least its foundation) could be considered a voluntary adaptation of each household, which is determined by individual financial capacity in housing investment.

Conceptual Framework

Neighborhood succession is the heart of the concept of submarket-based neighborhood change. The idea that housing submarkets correspond to a dynamic spatial equilibrium continually shaped by housing supply and demand shifts was pioneered by Grigsby et al. (1987) and echoed by Bates (2006). As such, the price elasticity of property is a response to the dynamics of property market equilibrium, as the intersection points of the supply and demand curve (Filatova et al., 2011). Thus, changes in property prices enable shifts in both consumers and suppliers, which are also identified in the dynamics of spatial submarkets. Demand can change in response to the composition of households, income distribution, employment patterns,

and population, including migration in and out of submarkets, which often alters demand structure. Thus, this study illustrates the conceptual framework of declining coastal neighborhoods in Figure 1-1, incorporating four sub-research questions.

In response to natural hazards, housing displacement is one adaptation strategy that households, as economic agents, use to adjust their expense in housing consumption. In the field of urban economics, Winstanley et al. (2002) divided the literature on residential mobility into three approaches: the life-cycle model, cost-benefit model, and neighborhood change model. Given the financial consequences for all models, Brasington (2021) argues that researchers can reduce these three models into a cost-benefit model, if losses and benefits can be appropriately defined. Housing displacement could be explained by expenditure adjustments for housing consumption determined by rental value, including purchases for residential use. Mendelsohn (2000) argues that efficient adaptation can only be achieved if the cost is less than the resulting benefit. Leaving or avoiding areas at risk of flood is a form of location-based adaptation that occurs when people leave such areas to lower risks and improve individual equilibrium. Filatova (2014) has emphasized that flood risk management can be achieved through land use adaptation, because the property market plays an essential role in spatial patterns. As such, investigating residential mobility makes it possible to observe the spatial dynamics of housing submarkets to explain neighborhood change.

Furthermore, because natural hazards induce neighborhood change, we can assume that submarkets will also change in response to hazards. Grigsby et al. (1987) explain that submarkets connect to each other through complicated linkages driven by elasticities in customer demand for housing. In the spatial cluster of the housing submarket, dynamics may also be indicated by the size of the geographical area, where obsolescence is spread due to the growth of low-income inhabitants in risky areas. In addition to environmental damage, most studies also report that natural hazards significantly push out specific neighborhood groups and attract others (Lee, 2017, 2018). As a result, natural hazards result in changes in places and people, which meet the basic assumption of neighborhood change.

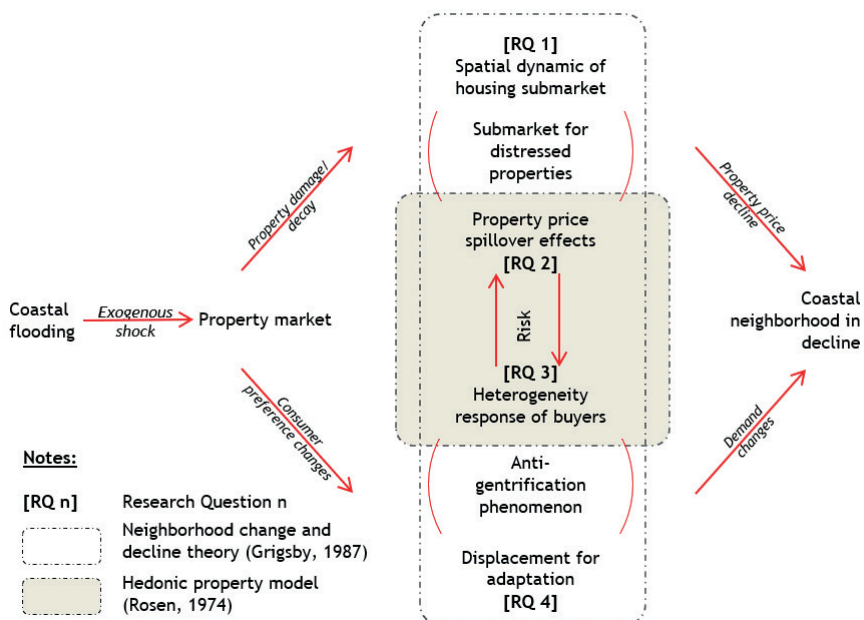


Figure 1-1 Conceptual Framework of Coastal Neighborhoods in Decline

Methodology Design

Research Design

To investigate the empirical behavior of the property market, this research employed an empirical–analytical approach. By considering established scientific information from international literature, deductive research has revealed the causality between flood zones and property market behavior. As such, the theoretical framework from setting information would underpin this research. With different flooding characteristics (coastal flooding with land subsidence), this research will explain the causality between property market behavior and coastal flood risk. Post-positivist assumptions such as beliefs about reality and patterns to be known are the primary reason this research uses an explanatory research approach, including a quantitative approach with an experimental research strategy to observe and measure an empirical phenomenon (Bisel & Adame, 2017).

Case Study: Pekalongan City

Pekalongan (Indonesia) seems to require attention as a medium-sized coastal city in a developing country suffering a severe coastal disaster. The study of this city might contribute to the global discussion stressing that coastal cities in developing

countries experience tidal floods worse than those in developed nations (Murray et al., 2019). Most previous studies have revealed that tidal flooding in Pekalongan results in environmental deterioration (A. Handayani, 2021; Rudiarto, Handayani, & Sih Setyono, 2018), housing damage (Buchori et al., 2022), and outflow migration (Khairulbahri, 2022). To illustrate the geographic context and the extent of the affected area, refer to the map of the study area provided in Figure 1-2.

Research Method and Data Collection

To practically operationalize the conceptual framework, we have conceptualized how to track coastal neighborhoods in decline based on spatial hedonic models. Building on the works of Rosen (1974) and Freeman (1979), the equation for the hedonic price model is formulated as Equation 1. This model utilizes panel data from the property market dataset, the most relevant and comprehensive source of information for research. The panel datasets primarily contain information on property sale transactions and property tax history. By screening the information on changes to buildings' information based on cadastral registration numbers, we can gather information about ownership changes, price adjustments, land and building attributes, geographical location, and tax records. Equation 1 express the hedonic property model.

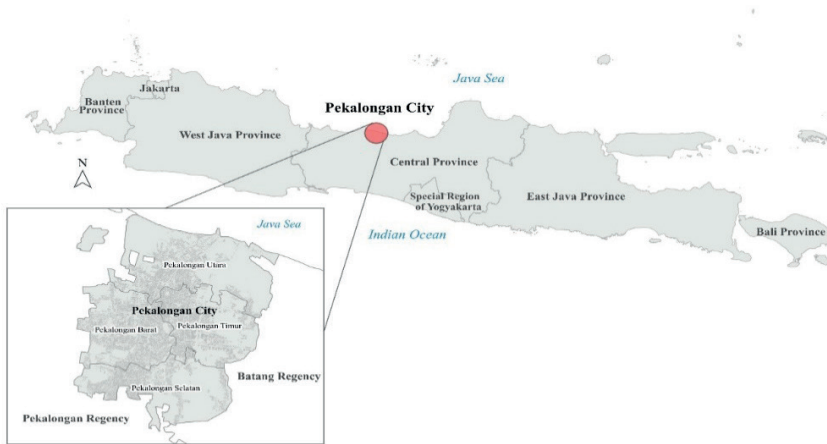


Figure 1-2 Research Area, Pekalongan City

$$P_{hi} = P_h(S_{i1}, \dots, S_{ip}, N_{i1}, \dots, N_{ik}, Q_{i1}, \dots, Q_{im}) \quad (1)$$

where P_{hi} is the price for H ; refers to the structural house for location i ; refers to the neighborhood for a location i ; and refers to environmental quality for location i .

Based on this panel dataset of spatial hedonic data, we can track the neighborhoods in decline with at least two steps, as follows:

A. Tracking The Dynamics of the Housing Submarket for Distressed Properties

The first step involves tracking the emergence and dynamics of the housing submarket for distressed properties. As such, this first step has three aims: (i) identifying whether properties suffering from flooding are abandoned by their inhabitants; (ii) identifying whether properties in at-risk areas are shaping the housing submarket and spreading to nearby housing submarkets; and (iii) observing whether property prices decrease and spill over to adjacent areas. The explanation for each aim is as follows:

First, we track abandoned property by examining the tax-delinquency status of each land parcel in the property tax history database. We screen for property owners who neglect their obligation to pay the taxes for 5 years or more. Moreover, we plot the distribution of abandoned properties to identify whether they are clustered in similar locations. Geographic information system software, such as QGIS and ArcMap, can help the observer understand the spread of abandoned properties. Gathering in a similar location may represent the emergence of a housing submarket for distressed properties.

Second, we identify whether the affected properties are shaping new housing submarkets and spreading to nearby areas. The disaster literature contributes to our understanding that property markets react by shaping new housing submarkets in flood-prone areas (Rajapaksa, Wilson, Hoang, Lee, & Managi, 2017a). To identify the housing submarket, we can define it based on either (1) the administration boundary or (2) data-driven delineation, or (3) by substituting housing units (Bhattacharjee et al., 2016). In this case, we can use data-driven delineation based on the similarity of spatial hedonic variables to allow for dynamic spatial delineation of the housing submarket, which aligns with Bates' (2006) recommendation, which facilitates the identification of the housing submarket's spatiotemporal structure based on a panel of spatial hedonic datasets. After identifying cluster data, we may plot them on a map with GIS software to observe the geographical delineation. This step will address the first sub-research question: *To what extent do housing sub-markets react to coastal flood risk?*

Third, we must examine whether property prices decrease and affect nearby areas. According to Grigsby (1987), abandoned properties and obsolete housing

can negatively impact nearby locations by attracting lower-income buyers seeking discounts. The abandoned and foreclosed properties have adverse effects on property prices in neighboring areas. This issue arises because buyers factor in the risk when making purchasing decisions. As a result, property prices in at-risk areas decrease and move, illustrating the property price spillover effect, which is the spatial lag in price adjustment over time and space. With the understanding that price illustrates flood risk (Y. Zhang et al., 2010) as well as environmental quality (Freeman, 1979), their transmission could be understood as the capitalization of blighted flood risk and environmental quality. To model the spillover effect, we can observe the lag of property prices in correspondence with the risk variable. We can use the Spatial Autoregressive Model (SAR) to model property price spillover effects. This step will address the second sub-research question: *To what extent do property prices adjust and spill to nearby houses?*

B. Tracking Neighborhood Succession and the Variety of Property Price Decreases

The second step encompasses tracking the response of property buyers as economic agents to coastal flooding. Following Grigsby et al. (1987), this step arguably observes patterns of neighborhood succession. Thus, this second step has three aims: (i) observing to what extent the pattern of housing succession based on screening on property tax history; (ii) identifying the relationship between residential mobility and the heterogeneity on property price decrease; and (iii) examining whether residential mobility has causality with coastal flood risk variables. The explanation for each aim is as follows:

First, we validate tax delinquency-based property abandonment through residential mobility. Using property tax history, we examine the changes in property ownership for each building and trace their mobility within the city. Thus, we can illustrate internal residential mobility, which is believed to show problems in the town (Black et al., 2011; Brasington, 2021). Of course, we must consider the housing submarket in illustrating residential mobility to understand whether internal mobility comprises cross-housing submarket displacement or replacement. For each housing displacement, this illustration is based on the land parcel, so we can observe the specific household as an (anti) gentrification agent (Meen, 1999). By doing so, we may better understand the pattern of housing succession through property owners' changes and housing displacement. We subsequently observe the relationship between this residential mobility pattern and heterogeneity in property price decreases.

Second, we identify the heterogeneity of property price decreases and their relationship with residential mobility. Considering the established knowledge of the relationship between gentrification and property price increases, this step is essential. This association may be a property price, representing the spatial equilibrium, the meeting point between the supply and demand curve (Filatova, 2014; Fujita & Thisse, 2013). A decrease in the heterogeneity in property prices may thus be observed in each single transaction. For this case, geographically weighted regression (GWR) allows us to observe the variety of property price adjustments and how property buyers respond to coastal flood risk variables, based on the coefficients of each variable. This step will address the third sub-research question: *To what extent does neighborhood succession affect the heterogeneity of property price decline?*

Third, we examine the causality between housing displacement decisions and coastal flood risk variables. According to Filatova (2014), the selection of housing location is part of the spatial decision in housing consumption to maximize the benefit under budget constraints. Because living in flood-prone areas requires regular extra maintenance costs, households will consider whether to displace or stay based on rational economics. Thus, relocation is their attempt to vary spatial risk and only one of spatial-based adaptation (Black et al., 2011; Brasington, 2021). Since the decision to displace is an odds ratio function, we may consider multinomial logistic regression with spatial hedonic data for independent variables. This step will address the fourth sub-research question: *To what extent does coastal flooding affect residential mobility?*

Scientific and Practical Relevance

Scientific Relevance

This research is expected to contribute to the current discussion on the role of property markets for flood risk management. We presume that internal residential mobility may comprise relocation between submarkets. In addition to seeking individual equilibrium (Mendelsohn, 2000), households also need a feeling of security (Quinn, Bousquet, Guerbois, Sougrati, & Tabutaud, 2018). Conversely, the scarce evidence of property market behavior in slow-onset flooding will enrich the empirical findings to support the creation of market-based instruments for flood risk management (Filatova, 2014).

Practical Relevance

This research is projected to contribute to the discussion of spatial planning as mitigation measures in Indonesia. Currently, the role of spatial planning as a mitigation measure, regulated by Law No. 24 the Year 2007 (Article 35), is still being

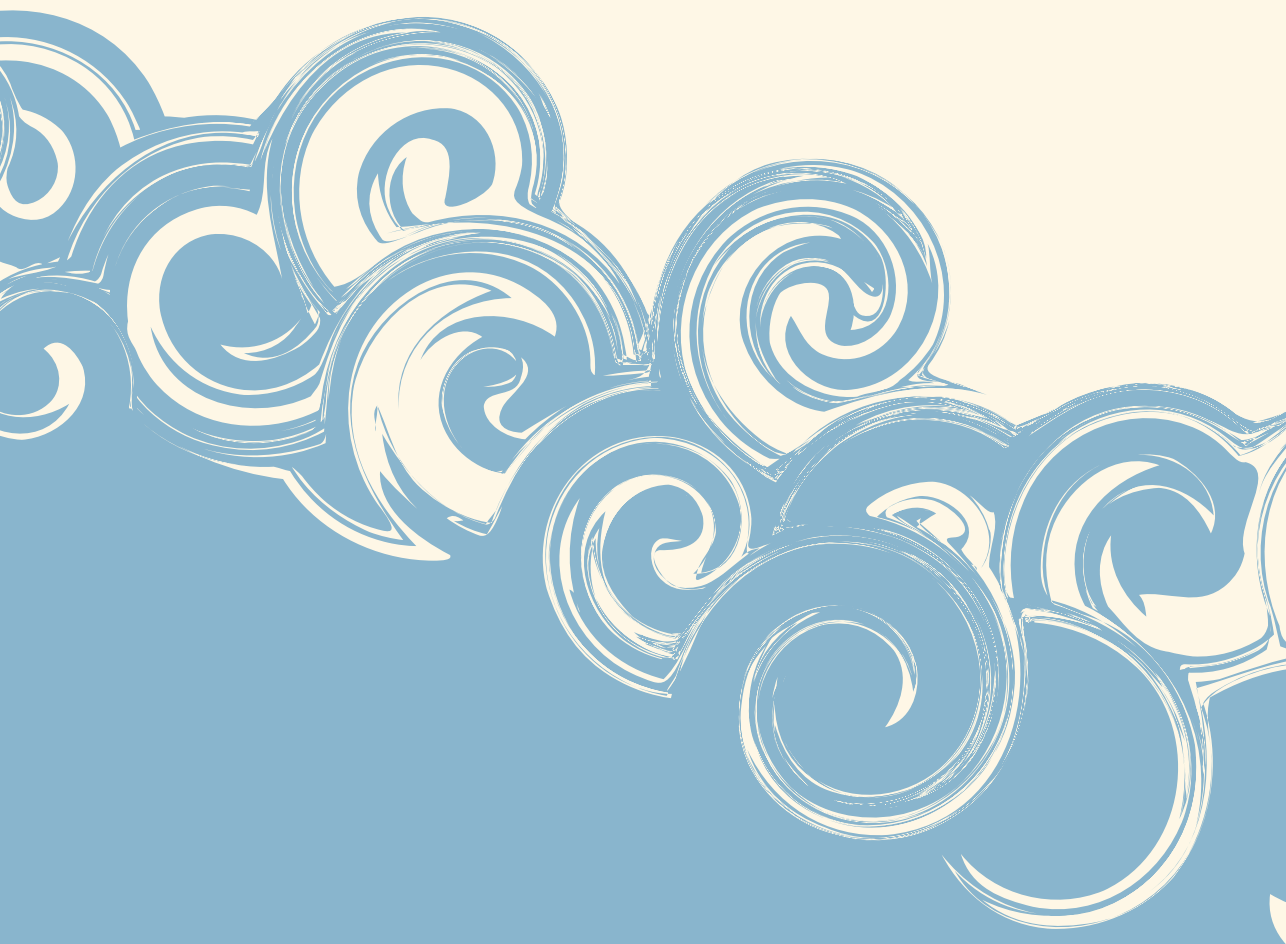
formulated. However, the higher concentration of planned adaptation for FRM is currently due to the lack of research on market behavior in responding to floods. In addition, the contribution of research on property market responses from developing countries, including Indonesia, is still considered low.

Outline of the Thesis

The thesis consists of six chapters, starting with a conceptual framework (Chapter 1) and followed by four empirical chapters. It concludes with a final chapter. The conceptual framework and methodology for tracking declining coastal neighborhoods are developed in Chapter 1. Each research question outlined in this chapter is addressed in four empirical chapters (chapters 2, 3, 4, and 5) of the dissertation. The final chapter, Chapter 6, combines insights from the previous empirical chapters and discusses them within the conceptual framework. This chapter presents the theoretical reflections and findings. Table 1-1 provides an overview of the chapters and the current publication status of the dissertation.

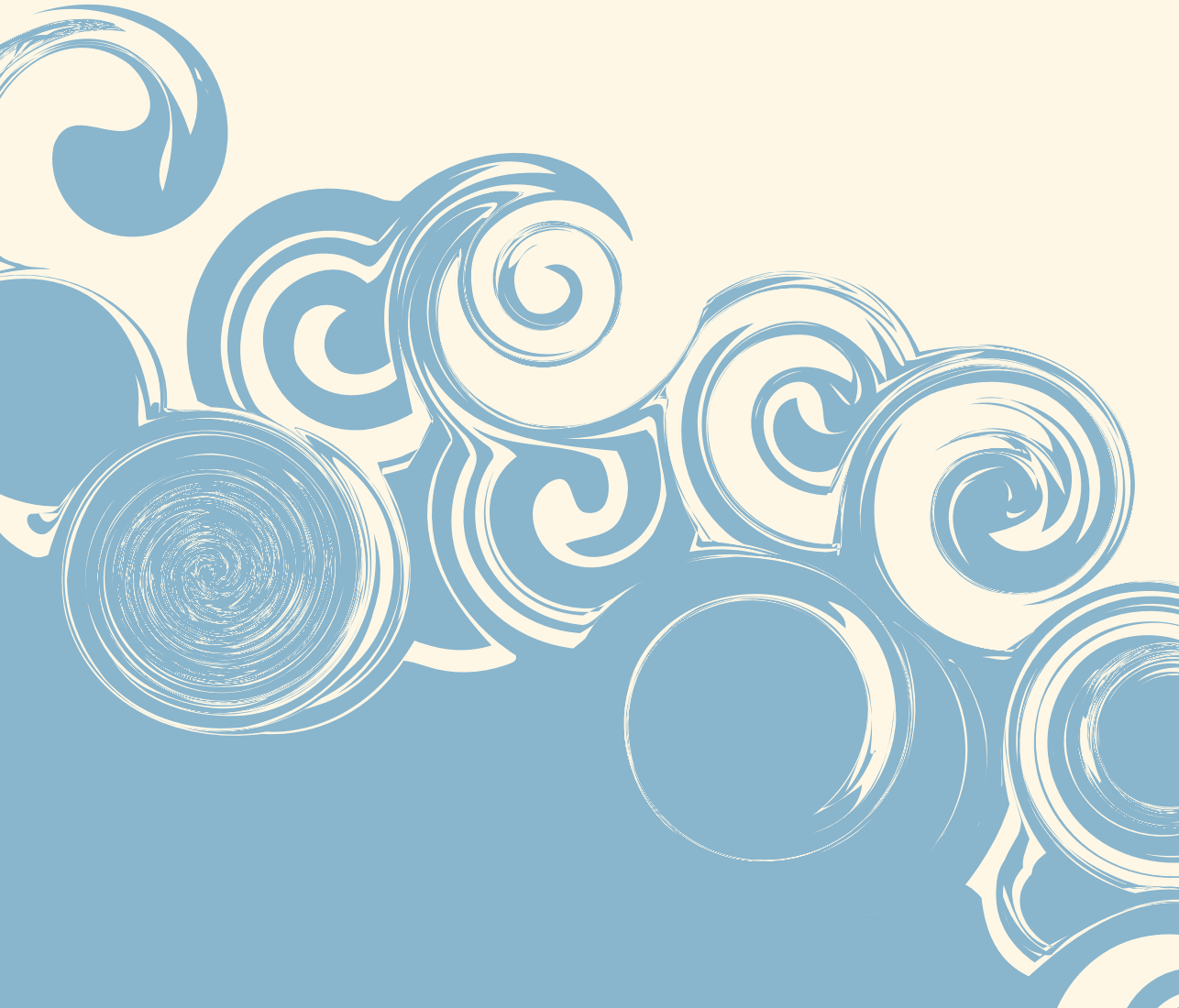
Table 1-1 PhD Dissertation Overview

Chapter	Title	RQ	Publishing journal	Publication status
1	General Introduction	-	-	-
2	Toward obsolete housing: A complementary explanation of increasing coastal vulnerability	RQ1	International journal of disaster risk reduction	Published
3	Distressed property and spillover effect: A study of property price response to coastal flood risk	RQ2	Land use policy	Published
4	Declining Coastal Neighborhoods and Anti-Gentrification: Understanding the Response of Indonesian Property Buyers	RQ3	Cities	Under review
5	Housing displacement and replacement in coastal flood-prone areas: evidence from a land and building tax-based study in Indonesia	RQ4	ADBI Book Chapter	Published
6	Conclusion	-	-	-



CHAPTER 2

**Toward Obsolete Housing:
A Complementary Explanation of
Increasing Coastal Vulnerability**



Abstract

This chapter explains the process of increasing coastal vulnerability in response to coastal flooding, from the property market viewpoint. Rooted in knowledge about housing submarket-based neighborhood change, this study adds new understandings of how housing obsolescence influence vulnerability following rapid land use changes, which are currently studied as a new exposure by many researchers. We employ six years of house sales transaction data (n=1,440) in a spatial data-driven delineation with k-means, through which the submarket shift can be visualized. This approach addresses weaknesses in the existing methods to measure neighborhood change. We find that second-hand houses purchased by low-income people tend to cluster close together in newly formed submarkets creating submarkets for high-risk and very high-risk areas. Our data series also show that the geographical growth of the sub-market for very high-risk areas is expanding, creating further blight in the submarket for high-risk areas. Bearing in mind that the consequences of a flood will cover a wide range of issues, such as the future of education, health, public services, and the welfare of citizens in general, disaster risk management is fundamental to socio-economic development of a country. This study can enrich discussions around housing vulnerability and neighborhood change and support the current debate over spatial adaptation.

Keywords: Adaptive Capacity; Submarket; Obsolete; Neighborhood Change; Coastal Flooding

This chapter has been published as a research article in the International Journal of Disaster Risk Reduction. The reference is: Sariffuddin, S., Samsura, D. A. A., van der Krabben, E., Setiyono, B., & Pradoto, W. (2024). Toward obsolete housing: A complementary explanation of increasing coastal vulnerability. *International Journal of Disaster Risk Reduction*, 111, 104709. doi:10.1016/j.ijdr.2024.104709

Obsolete housing in at-risk areas may comprise a complementary explanation of how property customers play a central role in increasing spatial vulnerability. Empirically, the reaction of the property market in response to coastal flood risks not only involves a price discount (Beltrán, Maddison, & Elliott, 2018; Chiang Hsieh, 2021; Rajapaksa, Wilson, et al., 2017) but also implies changes in housing demand (Filatova, 2014). Declines in property prices in flood-prone areas have emboldened lower-income households to purchase such homes (Yakubu, 2021), while natural hazards have become push-and-pull factors determining where inhabitants choose to dwell (Lee, 2017). Since adaptation highly relates to economic viability, the ability of lower-income inhabitants to themselves repair and recover their homes in at-risk areas seems questionable. As such, environmental deterioration in coastal flood-prone regions might be caused not only by natural hazards but also by the limited ability of each household to conduct repairs, which results in locational obsolescence.¹ In disaster and climate change studies, many experts note that the ability to conduct repairs is the most relevant indicator in defining adaptive capacity (Spalding et al., 2014), which strongly influences vulnerability (Reisinger et al., 2020). In short, obsolete housing may clarify the process of increasing vulnerability in flood-prone areas and make a valuable contribution to the ongoing discourse on the climate-related investments (Reisinger et al., 2020).

Currently, the increasing vulnerability in coastal areas is often associated with at least three factors, namely government policy, rapid urbanization, and socioeconomic issues. First, Hallegatte et al. (2013) explain that the national budget for coastal environmental preservation reflects the government's commitment to adaptation; as a result, external factors related to government projects and policies dynamically influence coastal vulnerability. Second, using remote sensing, Wolff et al. (2020) demonstrate that uncontrolled land use change in coastal areas can potentially spread to at-risk areas; hence, he concludes that rapid urbanization can potentially be a new exposure factor spurring coastal vulnerability. Third, regarding the minimal impact of coastal flooding, Filatova et al. (2011) note the dissonance of risk perception in coastal communities, which influences residents' lack of awareness and explains why most inhabitants ignore flooding in their housing purchase decisions; coastal vulnerability consequently grows more quickly due inhabitants conducting insufficient repairs themselves.

^{1.} Locational obsolescence is the process by which shifts in demand for shared attributes of a neighborhood (owing to location, housing and site characteristics) make entire neighborhoods obsolete ((Grigsby et al., 1987)).

At the same time, price discounts are often followed by the relocation and grouping of specific purchasers in similar areas or the response by the property market to flood risk through price and location adjustments (Bosker, Garretsen, Marlet, & van Woerkens, 2019; Brasington, 2021; Cobián Álvarez & Resosudarmo, 2019; Rajapaksa, Zhu, et al., 2017; Samarasinghe & Sharp, 2010). In housing studies, Grigsby et al. (1987) explained that the housing consumption of low-income people strongly depends on higher-income inhabitants who sell their homes at lower prices; this supports Pryce and Chen (2011), who argue that property prices filters households into specific locations. From this, natural hazards cause neighborhood change (Lee, 2017), which can arguably also be explained by property market response. Thus, property-based neighborhood change, pioneered by Grigsby et al. (1987), which is still relevant today, is generally considered underpinning knowledge (see: Caramaschi and Chiodelli (2022), Aouad (2022), He and Zhang (2023)). Because it is closely related to location, the dynamic of spatial delineation in the housing submarket might be considered as an alternative approach to address the weak difference-in-differences method in measuring neighborhood change (Lee, 2018).

Although the response of property markets in risk areas is well investigated worldwide, evidence is lacking regarding how dynamic spatial property submarkets can potentially increase coastal vulnerability in medium-sized cities. This is understandable, since many previous studies have focused on spatial econometrics to investigate the dynamics of property price adjustments and submarket emergence, rather than neighborhood change. In ecology studies, Lee (2018) has contributed to improving the understanding of the dynamic change of neighborhoods using census tract data with the adjusted interrupted time series (AITS) model. However, this method has limitations in observing housing submarket-based neighborhood change, which is essential in terms of the dynamic spatial response of property. As such, this paper uses the spatial cluster method with k-means to add a new illustration of how the risk of coastal flooding is growing more quickly than the hazard. Through this lens, we can better understand the vital role of the property market as one player in spatial adaptation, which is considered key to flood-risk management (Filatova, 2014; Fujita & Thisse, 2013). Furthermore, we argue that the spatially clustered homes purchased by low-income inhabitants in at-risk areas tend to be obsolete due to their low capacity to repair and maintain their neighborhoods.

Regarding research area, we also agree that rapid urbanization occurs not only in metropolitan areas but also in medium-sized cities such as those on the north coast of Java, Indonesia (Fahmi, Hudalah, Rahayu, & Woltjer, 2014), which have limited capacity to manage the growth (Mardiansjah, Rahayu, & Rukmana, 2021). Meanwhile,

property submarket emergence in flood-prone areas is most widely investigated in metropolitan areas such as Brisbane (Rajapaksa, Wilson, et al., 2017), Seoul (Seo, Oh, & Kim, 2021), and Auckland (Mario Andres Fernandez & Bucaram, 2019). Their studies conclude that the existence of submarkets exhibits differing capitalizations of flood risk, as part of environmental dis-amenities, on property value. However, studies are limited to medium-sized cities, which have sometimes escaped the attention of central governments. As such, we chose Pekalongan (Indonesia), a medium-sized city located on the north coast of Java, as the case study. It is, of course, possible that this study enriches the current discussion on coastal vulnerability in medium-sized cities in the developing world. Moreover, medium-sized cities tend to have less complex land use in coastal areas than metropolitan areas. Therefore, medium-sized cities could provide a better understanding of how coastal flood risk as an environmental dis-amenity affects property market response.

To fill these knowledge gaps, this paper attempts to understand housing behavior in at-risk areas through housing submarket dynamics. Thus, this paper begins by presenting a theoretical framework on adaptive capacity in housing maintenance and submarket-based neighborhood change as underpinning knowledge. The second part explains the material and methods, including how we gathered the dataset, as well as information about the research area. The third section presents the data analysis and results, and the concluding section discusses the significant finding and the conclusion.

Theoretical Framework

Adaptive Capacity in Neighborhood Maintenance

Obsolete housing refers to neighborhoods or properties that have become uninhabitable due to shifting demand (Grigsby et al., 1987) and natural hazards (Lee, 2017). This issue may arise due to physical deterioration brought on by damage or aging, which is also directly impacted by residents' limited abilities to perform maintenance (Megbolugbe, Hoek-Smit, & Linneman, 1996). As a result, the property loses its value thereby attracting low-income residents to live there or demand changes. These changes in housing demand are usually associated with endogenous and exogenous factors affecting residents' financial abilities. Endogenous factors such as shifting employment and income patterns can also affect obsolescence (Megbolugbe et al., 1996). The disaster literature finds that, in addition to impacting physical damage, natural hazards as exogenous factors have triggered household ownership succession, affecting new occupants' ability to maintain their

neighborhoods (Lee, 2017). In disaster studies, the ability of households to recover post-hazard corresponds to adaptive capacity, which is determined by earned income, in addition to the experience and knowledge of each household (Lee, 2017). Considering the IPCC concept of risk, it is arguable that this indirect risk is from the property market's response to life in slum areas (Reisinger et al., 2020).

Household capacity to adapt to natural hazards can be reflected in how homeowners allocate their resources for maintaining and improving their substandard dwellings (Lee, 2018). Due to maintenance being closely related to income, many experts believe that decisions regarding housing maintenance and improvement are based on rational economic choices (Filatova, 2014; Fujita & Thisse, 2013). Much disaster literature has noted that improving less habitable houses is only one household strategy in adaptation and is included in extra costs in family expenditures. Mendelshon (2000), using the cost-benefit model, explains that effective adaptation could be achieved when the marginal cost (MC) is less than, or at least equal to, marginal benefit (MB) and marginal externalities (ME). The elevation of houses (or their foundations) every five years by residents living in the northern coastal areas of Java is an excellent example of how adaptation is part of the MC burden for local households (Bott & Braun, 2019; Marfai, 2014).

Furthermore, homebuyers in at-risk areas often change due to relocation activities such as inflow and outflow displacement (Bukvic & Barnett, 2023; Kartiki, 2011; Lee, 2018). Outflow relocation is widely accepted as a household's adaptation strategy to vary the risk by decreasing extra costs for housing consumption: households are price-takers that factor fear into their decisions to purchase houses (Brasington, 2021; Van Ham, 2012a). Households as economic agents behave very rationally; they think that their expenses would be worthless in the at-risk areas and would produce higher returns elsewhere (Filatova et al., 2011; Grigsby et al., 1987). Rational economic decisions also serve to inflow household displacement into substandard housing because property buyers face limited stock, even though they have many choices in the housing market. As a result, they reuse the abandoned substandard housing or exchange used capital assets to fulfill their basic need for shelter (Van Ham, 2012a). Due to the lower house prices, housing stock in at-risk areas becomes favorable for the low-income group and tends to be geographically concentrated, thus causing new housing submarket emergence, a situation in which environmental deterioration and spatial demand displacement meet broad assumptions of neighborhood change regarding changes in people and place (Lee, 2017, 2018; Schwirian, 1983).

Submarket-based Neighborhood Change

Demand changes are the heart of the concept for submarket-based neighborhood change. The idea that housing submarkets correspond to a dynamic spatial equilibrium continually shaped by housing supply and demand shifts was pioneered by Grigsby et al. (1987) and echoed by Bates (2006). Demand can change in response to the composition of households, income distribution, employment patterns, and population, including migration in- and outflow over submarkets, which often changes the demand structure. As a result, the price elasticity of property is a response to the dynamics of property market equilibrium as the intersection points of the supply and demand curve (Filatova et al., 2011). Thus, changes in property prices enable shifts in both customers and suppliers, which is also identified in the dynamics of spatial submarkets.

Defining geographical submarkets is necessary at both the conceptual and practical levels. Bhattacharjee et al. (2016) define property submarkets as comprising (a) similarities in house features, (b) similarities in hedonic prices, and (c) the substitutability of dwellings. Conceptually, people with similar tastes, incomes, and preferences tend to be geographically organized in similar regions to maximize the location benefit within their budget constraints (Filatova, 2014; Fujita & Thisse, 2013; Van Ham, 2012a). At the empirical level, Bates (2006) suggests defining neighborhoods based on housing submarkets instead of administration as targets of revitalization policy. She argues that housing submarkets reflect consumer behavior, which responds to changes in the neighborhood, such as positive spillover effects in surrounding locations. At the conceptual level, Grigsby et al. (1987) use submarket dynamics to define neighborhood change. Their essential contribution is characterizing neighborhood changes in terms of customers rather than the physical condition of housing stock.

As mentioned in the previous section, natural hazards induce neighborhood change. Thus, we can assume that submarkets will also change due to natural hazards. The dynamic of the submarket shows the changes in the neighborhood. Grigsby et al. (1987) explain that submarkets connect to each other through complicated linkages driven by housing elasticities in customers. The cross-elasticities in demand serve the submarket's dynamic, and then the neighborhood changes pattern. In the spatial cluster of the housing submarket, dynamics may also be indicated by the size of the geographical area, where obsolescence is spread due to the growth of low-income inhabitants in risky areas.

Furthermore, a natural hazard can induce neighborhood change, particularly during disaster recovery. In addition to environmental damage, most studies also report that natural hazards significantly push out specific neighborhood groups and attract others (Lee, 2017, 2018). As a result, natural hazards result in changes in places and people, which meet the basic assumption of neighborhood change. Every change is accelerated by severe environmental damage and the variety of recovery processes that potentially influence the array of neighborhood changes (Lee, 2017). Lee (2017) also explains that the recovery process is highly influenced by neighborhood characteristics, which then affect patterns of neighborhood change.

Material and methods

Research Area

Pekalongan (Indonesia) seems to require attention as a medium-sized coastal city in a developing country suffering a severe coastal disaster. The study of this city might contribute to the global discussion stressing that coastal cities in developing countries experience tidal floods worse than those in developed nations (Murray et al., 2019). Most previous studies have revealed that tidal flooding in Pekalongan results in environmental deterioration (Rudiarto et al., 2018), housing damage (Buchori et al., 2022; A. Handayani, 2021), and outflow migration (Khairulbahri, 2022). The government of Pekalongan has consequently estimated economic losses of IDR 6,810 trillion (€417.75 billion) for land damage and IDR 1,723 trillion (€105.70 billion) for urban infrastructure. Additional monetary losses due to crime during flooding (e.g., robbery) equal IDR 244,101–492,612 billion per flood event (Mahfudz, 2020).

Handayani et al. (2020) explain the primary problem of flood events in Pekalongan as being due not only to high rainfall but also land use changes, which correlate with the number of flood events. The land use conversion has a loss of mixed plantations of about 13.98% in the watershed, whereas built-up areas increased from 2,071.17 Ha (2005) to 2,603.51 Ha (2020) in Pekalongan. The landform change is believed to have increased the number of flood events by a total of 54 from 2009 to 2018. Furthermore, open field area decreased by 500 Ha (Suharini, Hanafi, & Sidiq, 2017), and the city also experiences land subsidence (Wijaya et al., 2019) about 12 cm per year, which causes very significant tidal flooding. Yulianto et al. (2019) highlight that the coastal area has flooded 3–5 km from the shoreline. It has been reported that Pekalongan city is one of the most rapid subsidence in Indonesia and tend to sink in 2035 (Estelle Chaussard, Amelung, Abidin, & Hong, 2013; Rayda, 2021). Figure 2-1 shows the research area of Pekalongan.

Syam et al. (2021) have contributed to previous studies about climate risk and impact assessment in Pekalongan and reported that the villages (*kelurahan*) in the coastal area of Pekalongan are at risk area due to moderate–high sensitivity levels and exposure. In coping with these issues, the government consents to more structural adaptation through engineering flood defenses, such as water pumps and dikes. Meanwhile, the local community has also reacted by elevating their houses or just the foundations, which has resulted in varying house heights. This situation is similar to coastal housing in Jakarta, well explained by Marfai et al. (2015), and Semarang (Bott & Braun, 2019). Figure 2-2 shows the residential conditions in the submarket for distressed properties.

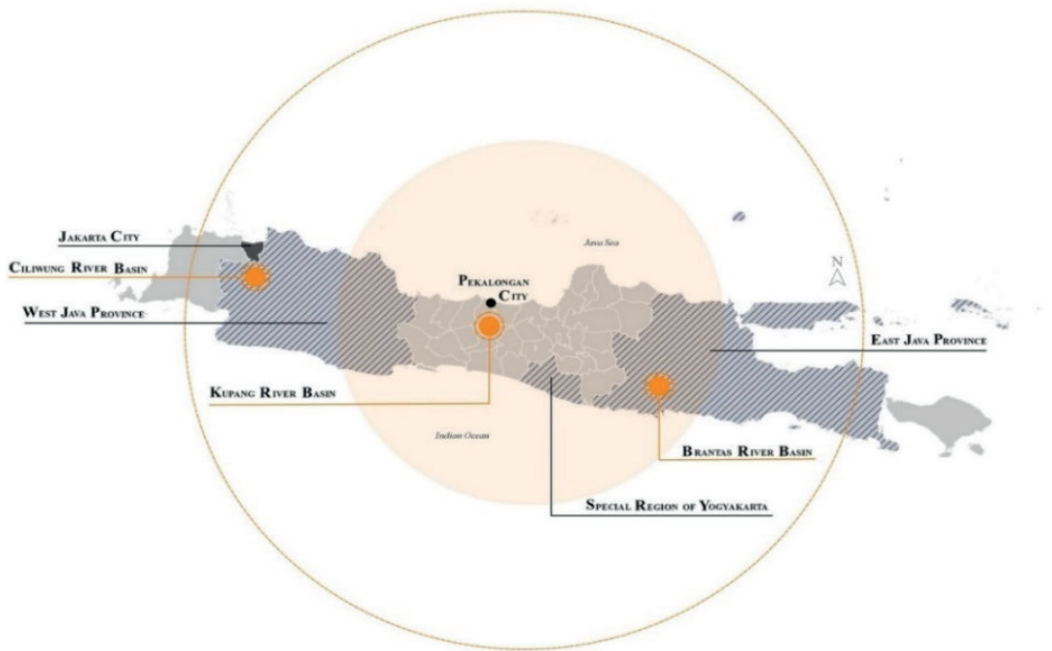


Figure 2-1 Research Area, Pekalongan City



Figure 2-2 Residential Conditions in the Submarket for Distressed Properties

Data and Variables

We obtained two dynamic datasets covering 2015–2020 representing hazards and vulnerabilities to then compare visually. First, we gathered data for a time series of coastal flooding with the understanding that flood frequency influences property market responses (Tobin & Newton, 1986) in the form of price and location adjustments to measure the hazards. We used multitemporal imagery to observe areas and calculate the annual maximum surface water body. This produced multitemporal coastal flood area hazard maps serve as the first objects of comparison. Second, we obtained spatial panel data for hedonic property prices ($n=1,440$) to visualize spatial clusters of housing submarkets. Using a census tract approach, we filtered panel data by year (2015–2020) to delineate the spatial dynamic of property submarkets. A similar method investigated the dynamic housing market segmentation in Buffalo, NY (Hwang & Thill, 2009), Ohio (Whitaker & Fitzpatrick IV, 2013), and Turkey (Keskin & Watkins, 2016). Using census tracts, the previous studies can identify the variables that are persistently important in explaining spatial housing submarkets. Thus, we have the spatial dynamics of housing submarkets to serve as the second objects of comparison. In short, we compared two visualizations (hazard maps and dynamic spatial housing submarkets) to explain whether housing vulnerability increases more quickly than hazards.

We mapped the dynamic coastal hazard in the following manner: based on the change detection approach, we mapped coastal flooding using Sentinel 1 SAR data in the Google Earth Engine (GEE). We compared multitemporal Sentinel 1 imagery from before and after a flood event using the GEE script provided by UN-SPIDER UN-SPIDER from 2015–2020. Similar methods have been used to investigate flood events in Texas (DeVries et al., 2020), China (Hu et al., 2021), and India (Behera et al., 2022). Their studies concluded that GEE allows for rapid, effective flood monitoring, despite the need to consider the landscape characteristics of the terrain to improve mapping accuracy. Behera et al. (2022) hence suggest accounting for surface geometry to address this limitation. As such, we also consider recent research by Syam et al. (2021), who employed a combination of surface topography and land subsidence to map flooding in Pekalongan. Their validated map becomes the base information of coastal flooding, and our map visualizes the expansion of the flood area in the same location for 6 years.

In addition to visualizing inundation expansion, a flood map also functions to classify properties into at-risk and safe areas by locating the property transaction points on the map. Our study uses sales transactions for properties experiencing inundation, rather than using proximity to flood zone, to measure the influence of flood risk

on the property market (for example, see: Daniel et al. (2009), Beltran et al. (2019)). We agree that proximity to flooded areas is indicative of flood-risk perception, with properties closer to the coastal flood zone having a higher probability of being flooded (Y. Zhang et al., 2010). However, It is noteworthy that many coastal communities have low flood-risk perceptions (Ludy & Kondolf, 2012). A similar conclusion of perceived low flood risk was previously reported in Pekalongan (Mercy Corps, 2021). From these observations, we argue that properties experiencing flooding are more appropriate than proximity to flood zone in measurement because they have similar probabilities of facing floods.

We gathered property price data to identify spatial housing submarkets. Based on the similarity of hedonic prices, we employed data-driven clustering to delineate housing submarkets. This approach allows price spatial datasets to be geographically grouped based on similarity and contiguity (Usman et al., 2020). A similar approach was investigated for housing submarkets delineation in previous studies in Austria (Helbich, Brunauer, Hagenauer, & Leitner, 2013), Taiwan (Chen et al., 2021), and China (Shen & Karimi, 2017). These authors concluded that a data-driven approach with k-means can estimate local structural variables and achieve better accuracy for hedonic price predictions.

We collected the data from three sources: the municipal government, spatial computing with Google BigQuery, and remote sensing. Table 2-1 shows the selected variables and data sources. First, we collected sales property prices from the duty report on the acquisition of land and building rights (Bahasa: Bea Pengalihan Hak atas Tanah dan Bangunan [BPHTB]) provided by the authorities of Pekalongan. This dataset is typically used in Indonesia for property tax assessment (Hartoyo, S. Damanhur, Saefuddin, & Triguna, 2015) and land value capture studies (Sidik, 2021). Their research concluded that the data could be considered as the basis for alternative source finance policy. Because the dataset lacked spatial attributes, we retrieved geographical information (x_i , y_i) from a cadaster map issued by the Ministry of Agrarian Affairs and Spatial Planning. We finally joined those two datasets based on the similar identity number of land tax as a unique number. BPHTB's dataset informs at least five pieces of information: house transaction price, land area (m^2), building area (m^2), year of the transaction, and tax. We also gathered electricity subscriptions as proxy data for household income from building construction permits (Bahasa: Ijin mendirikan bangunan [IMB]).

Second, based on spatial computing using Google BigQuery, we obtained locational quality data from each parcel to the nearest urban facilities: schools, hospitals, and

business centers. We computed proximity based on travel time, which is currently believed to be more statistically accurate for property hedonic modeling (Cao, Diao, & Wu, 2018). Third, we extracted slope and land subsidence data using a simple remote sensing approach. The latter was extracted using the Sentinel Application Platform (SNAP 8.1) for Sentinel 1 imagery provided by the European Space Agency and captured on February 17, 2017, and December 4, 2019. Meanwhile, slope data was also obtained from DEMNAS Indonesia (Bahasa: Digital Elevation Model Nasional) using Quantum GIS 3.20.2. For flooded areas, we took advantage of previous research conducted by Mercy Corps (2021) that mapped the inundated areas based on a combination of sea level rises, land subsidence, land use, and surface topography models. Furthermore, we utilized Sentinel 1 data through Google Earth Engine to observe surface water bodies, aiming to identify potential increases in flood exposure induced by land subsidence. Recent studies employing similar methods, such as those conducted by Cigna and Tapete (2021) and Chaussard et al. (2021) in Mexico City, concluded that Sentinel 1 could observe the levels of flood exposure caused by land subsidence.

Table 2-1 Selected Variables and Sources

Variables	Description	Sources
prop_price	House sales prices from 2013 to 2020 (IDR; n=1,440)	Government
land_m ²	Total area of land (m ²)	Government
building_m ²	Total area of the building (m ²)	Government
d.floor_ce	Dummy variable: 1 if the floor is ceramic tile, 0 otherwise	Government
electricity	Proxy data of social welfare from the electricity (KwH)	Government
prox_ES	Travel time (minutes) to elementary school (ES)	Google BigQuery
prox_JHS	Travel time (minutes) to junior high school (JHS)	Google BigQuery
prox_SHS	Travel time (minutes) to senior high school (SHS)	Google BigQuery
prox_HSPT	Travel time (minutes) to hospital (HSPT)	Google BigQuery
prox_MRoad	Travel time (minutes) to the business center	Google BigQuery
subsidence	Land subsidence (meters)	Remote sensing
slope	Land slope (meters)	Remote sensing
flooded	Flooded area: 1 flooded, 0 otherwise	Remote sensing
xcoord, ycoord	Geographical coordinates: longitude and latitude	Remote sensing

Statistical Analysis

We employed semi-supervised cluster analysis to investigate submarket changes and factor analysis to estimate the primary variable forming the cluster. A similar method was employed in recent research by Wu et al. (2020) in Utah, US, and Wiersma et al. (2022) in Germany, which has provided a better understanding of the use of spatial cluster analysis in housing submarket delineation. We categorized housing submarkets according to their proximity to urban amenities and housing characteristics. This classification was inspired by a previous study conducted by Wu and Sharma (2012) in Milwaukee (USA) and Costello et al. (2019) in Perth (Australia). In those study, housing groups were labeled for inner-city and suburban areas, and specific names were indicated using locations, like western and eastern regions. In our study, the housing group experiencing flooding then is labelled as at-risk areas consisting of submarket for western-inner city and submarket for distressed properties. Appendix, Figure A.1 shows the semi-supervised cluster analysis with k-means.

Statistical analysis was performed in RStudio 4.1.2. This study combined cluster and factor analyses to explain submarket emergence and the determinant variables that greatly influence a cluster. For cluster analysis, we computed panel data (2004–2020) with a k-means method and plotted it according to latitude and longitude. A similar method in a previous study was investigated in Manchester (Doan & Rae, 2023). To investigate the dynamic process, we analyzed the k-means with cross-sectional data from the panel data. Moreover, we used factor analysis to investigate the determining variable for the cluster (see appendix A.2, factor analysis).

Results

Coastal Flooding Monitoring

Our flood monitoring enriches the previous modeling by Mercy Corps (2021), which assumed that inundation increases linearly. They modeled the inundation based on the watershed approach (Kupang watershed), accounting for two factors: climate scenario and sea level rise. In the climate scenario, they noted that decades of climate data indicate decreases in wet extreme index intensity. In contrast, the number of extreme wet events has tended to increase. Meanwhile, sea level rise tends to increase by 0.81 cm/year ($r^2=0.8341$). Based on the observation period (2015–2019), they consequently concluded that coastal flooding dominated the total inundation composed of tidal and rain (>2 m) and estimated an increase of >2.4 m by 2035. In addition, they estimated that inundation in dry land (far from shoreland)

is dominated by extreme wet events. Taking advantage of the previous research by Mercy Corps (2021), this study accounts for their coastal flood map as a primary reference for coastal flooding and Sentinel 1 to observe the surface water body induced by inundation. This is important to monitor in considering whether coastal flooding contributes to the surface water body.

As mentioned above, we observed surface water body with remote sensing using GEE. From multitemporal Sentinel 1 (2015–2020), we identified that the surface water body tends to decrease by 21.17 ha each year. Figure 2-3 shows the coastal flooding and water body extension of Pekalongan (2015–2020). We can identify those surface water body areas as being 128.43 ha in 2016, increasing to 149.90 ha in 2017, continuing to decrease to 80.73 ha in 2018 and decreasing to 50.36 ha in 2019 and 43.75 ha in 2020. A possible explanation is that the government built an engineered flood defense, dikes, sea wall and flood pump station, in 2017 and may have successfully decreased the surface water body (Ramadhani Maharlika, Prawata Hadi, Kismartini, & Lenty Hoya, 2020; Widiyanto, 2017). The state government has constructed 7.4 km sea dikes from Pekalongan Regency to Pekalongan City and installed 20 flood pumps at 17 flood pump stations. The budget for these flood adaptation measures is IDR 10 billion for the sea dikes and IDR 10 billion for the flood pump stations. It's important to note that this study examined coastal and inland flooding from 2015 to 2020. A period of five years may be too short for a comprehensive understanding of floodwater extent. In summary, the decreasing water body in coastal areas may be influenced by the engineering flood defense which prevent the increasing water body area.

To compare the dynamic changes between hazard and vulnerability, we observed spatial clusters of housing submarkets on the coastal flood maps. Spatial cluster analysis with k-means was employed to identify geographic housing submarkets based on similarities in hedonic prices. These similarities represent the spatially homogenous housing purchasers within the heterogeneous consumers, which could be understood as local submarkets. As a result, we identify three submarkets, wherein two groups experience coastal flooding, noted by the presence of flood variable, whereas the other group is the safer housing submarket. Since we observe the role of coastal flood risk in property markets, we only focus on two submarkets suffering flooding: submarket for western-inner city and submarket for distressed properties. Figure A.1 (appendix) shows the process of the semi-supervised cluster analysis with k-means. Considering report studied by Syam et al. (2021), coastal area of Pekalongan is frequently affected by severe coastal and tidal flooding causing for the 1,2 million residents. Table A.1 (appendix) shows the descriptive statistics for both submarkets. Therefore, it is believed that the submarket for distressed properties experiences

more regular flooding due to its proximity to coastal areas. Conversely, the submarket for western-inner city caters to a group that encounters less frequent flooding.

Submarket Dynamics in at-Risk Areas

To explain the submarket dynamic, the cluster analysis with a cross-sectional dataset presents an overview of geographic submarket growth. Figure 2-4 shows the dynamic expansion of housing submarkets in Pekalongan City. Even though dynamic change occurs for all submarkets, the submarket for distressed properties seems to grow rapidly. This submarket emerged in 2015 with a small region in a coastal area and has since expanded each year. In contrast, the submarket for western-inner city becomes smaller because the submarket for distressed properties pushes out these housing groups. In other words, housing purchasers are rapidly growing in the submarket for distressed properties. When comparing to flood maps, it is clearly concluded that the property market reacts more than its hazard. In accordance with this, we then observe the characteristic of housing consumers with the knowledge that the property submarket exhibits endogenous evolution of demand (Bhattacharjee et al., 2016).

In addition to hazard levels, factor analysis shows the spatially different characteristics of two separate housing submarkets. First, locational quality influences the submarket for distressed properties more in the form of proximity to a hospital (*Prox_HSPT*: 0.93), to a senior high school (*Prox_SHS*: 0.80), to a train station (*Prox_TRAIN*: 0.89), to a CBD (*Prox_CBD*: 0.57), and to a bus station (*Prox_Bus*: 0.37). Second, property price, structure, and location quality determine the spatially grouped submarket for western-inner city. Property price is the most decisive influence for this submarket (0.82), whereas the structural variables consist of *land_m2* (0.92) and *building_m2* (0.71). Although statistically, no location quality variables—including senior high school and hospital—influenced households' decision to group, most urban facilities were in this submarket. As such, they still take advantage of local urban amenities. Table A.2 (appendix) shows factor matrix obtained from factor analysis.

Building tax history (2013–2020) retrieved from tax-due notification letters shows that most housing transactions were existing housing stock in both submarkets. New buildings comprise less than 10% of transactions. On the one hand, on average, homes purchased in distressed properties are more than 30 years old. This is because the purchasers are low income, represented by their electricity subscription (450–900 kWh). In short, the submarket emergence in distressed properties comprises existing housing stock inhabited by low-income people. On the other hand, the houses sold in western-inner city areas are more than 20 years old. As such, their financial ability is better than in distressed properties, which are subscribed to ≥ 900 kWh of electricity.

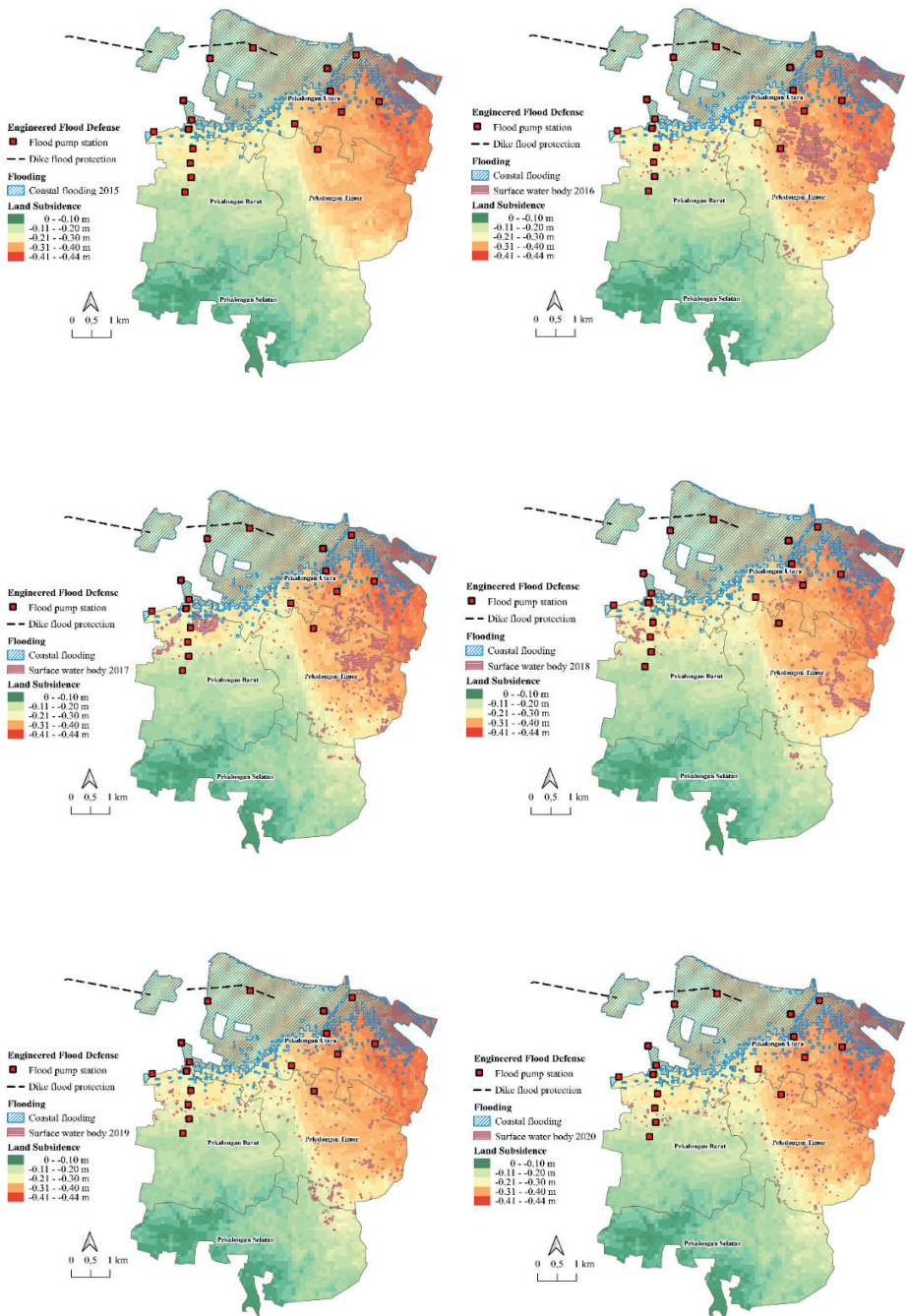


Figure 2-3 Flood Water Extension of Pekalongan

Discussion

This study indicates that coastal vulnerability increases more quickly than hazards through the rapid expansion of submarket for existing housing stock, which spatially reacts more than coastal flooding. This result supports Wolff et al. (2020), who argue that urban expansion caused by land use conversion potentially leads to increased exposure. This study considers the dynamic of housing submarkets, which provides a new understanding that following the changes in land use lie neighborhood change and decline that is reflected by housing submarket emergence and expansion. This change is shown by the phenomenon of one housing submarket for distressed properties expanding and blighting the adjacent housing group (submarket for western-inner city). In addition, tax history shows that most purchasers in the submarket for distressed properties are low-income people who replace the previous occupants, often known as housing ownership succession. It is thought that the housing submarket for distressed properties tends to become slum areas. This supports Filatova (2014), who argues that changes in socio environmental systems exhibit non-linear dynamics and then influence households' AC. Theoretically, because self-adaptation corresponds to earnings, low-income inhabitants potentially have little capacity to adapt. As a result, physical damage in distressed properties is induced not only by natural hazards but also by the limited capacity of each household to perform repairs and maintenance themselves.

The critical finding, demonstrated by low-income inhabitants shown in electricity subscriptions, is that households in distressed properties have a variety of adaptive capacities to conduct repairs and maintain the neighborhood. Thus, the phenomenon of the difference in house height is a reflection of the coping abilities of each household (Bott & Braun, 2019; Marfai et al., 2015). Bott and Braun (2019) note that just 17% of urban inhabitants save IDR 11 million or more in frequent expenses to elevate their houses every five to ten years. In accordance with this, Mendelsohn (2000) explains the adaptation approach based on a cost–benefit model, assuming that adaptation becomes efficient when MB is greater than (or at least equal to) MC and ME. Because adaptation is part of MC, the decision to repair and maintain one's home strongly affects the balance of expenses, which is then represented by the variety of house heights.

Moreover, with knowledge of the housing submarket representing homogenous customers (Bhattacharjee et al., 2016), the new demands in housing are spatially clustered in similar regions to maximize the locational quality within residents' budget constraints. Empirically, submarket expansion results from property transactions by

lower-income people taking advantage of the cheaper housing stock in distressed properties. This is because demand changes, and lower-income inhabitants become the new customers (Grigsby et al., 1987), in line with the endogenous evolution of space (Bhattacharjee et al., 2016), which produces the dynamics of the property submarket. Thus, distressed properties still become favorable stock and grow spatially more expansive, as noted by the geographical area of housing submarkets. This finding confirms previous research on property submarket emergence in flood-prone areas (Rajapaksa, Wilson, et al., 2017). One interesting result is that this study demonstrated not only emerging submarkets but also their dynamics in coastal flood risk by which neighborhood change could be explained and illustrated.

Furthermore, this study also confirms that housing submarket emergence in coastal flood-prone areas is also identified in a medium-sized city, which considerably adds to the global discussion about property customers' response. Respecting the research method, spatial cluster analysis with k-means for series data for hedonic property prices could be employed to observe the dynamics of neighborhood change. This alternative method considerably complements Lee (2018) use of the AITS model to investigate dynamic change. However, this alternative method failed to visualize the cross-submarket, even though its tendency of it could be clearly illustrated. This may have occurred because we removed spatial data outliers to support the more robust model.

With respect to Grigsby et al, (1987), echoed by Bates (2006), neighborhood changes through the property submarket lens may arguably explain the AC of dwellers in at-risk areas. Their economic viability to conduct repairs and maintain the neighborhood could be understood as the voluntary adaptation of each household. It is, of course, possible that the response of the property market could be used to explain the AC of the neighborhood and could extend the discussion on coastal vulnerability. Moreover, evidence is growing that the property market is responding to the flood risk, and it might be considered to stimulate property owners' active adaptation through market forces (Filatova, 2014). This finding could further contribute to Mendelsohn (2000) who initiated on effective adaptation to climate change. It encourages property buyers to voluntarily avoid flood-prone areas to maintain their budget balance and reduce the burden on the government's adaptation budget. Considering the accessibility of the property market dataset, it is conceivable that this study could be replicated in different locations.

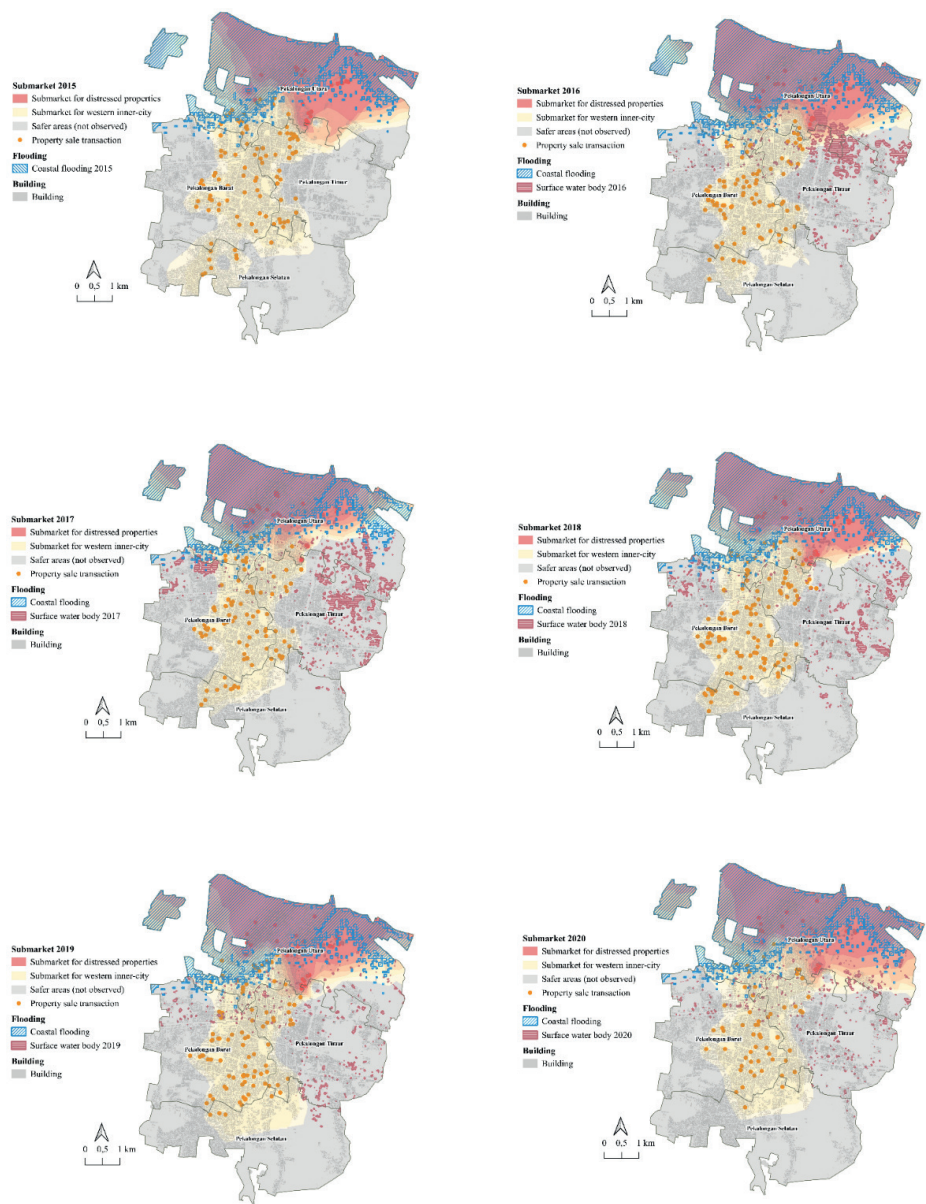


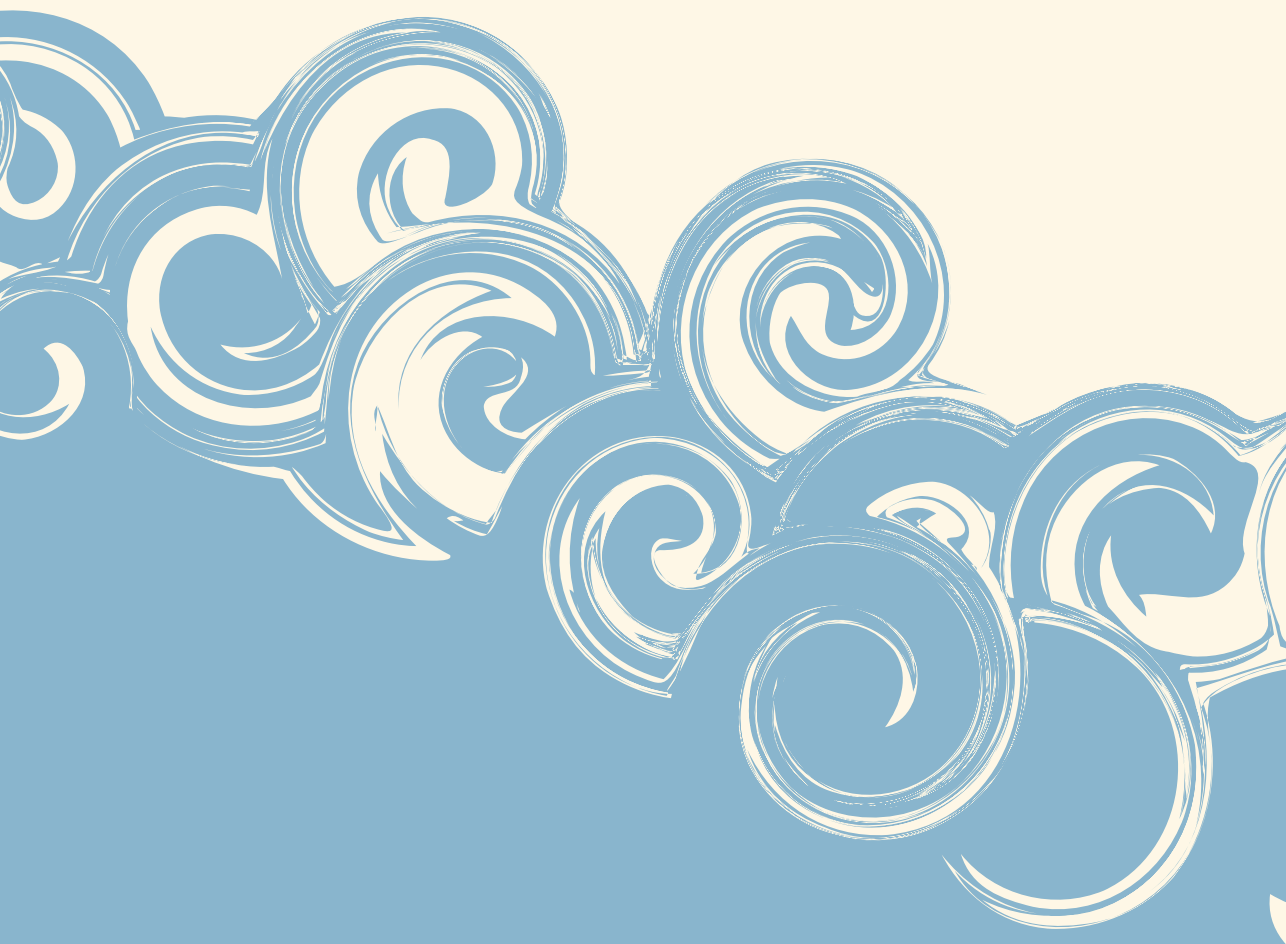
Figure 2-4 Housing Submarket Dynamics

Conclusion

This chapter has argued that housing obsolescence contributes to increased vulnerability more than flooding area in flood-prone coastal areas. It is shown by the spatial dynamic of expansion of second-hand housing submarkets inhabited by low-income people that grow more widely and quickly. Furthermore, due to a lack of capability in household maintenance, housing obsolescence occurs and then spreads to adjacent locations. This phenomenon adds a new understanding of how the property market reacts to uncontrolled land use conversion in at-risk areas. This study also confirms that medium-sized cities experience similar issues to metropolitan areas, particularly in terms of property market response through demand changes. Additionally, housing submarket emergence was also identified in slow-onset flooding. Accordingly, there is growing evidence that the reaction of the property market to flood risk is not only property price adjustment but also the emergence of the housing submarket.

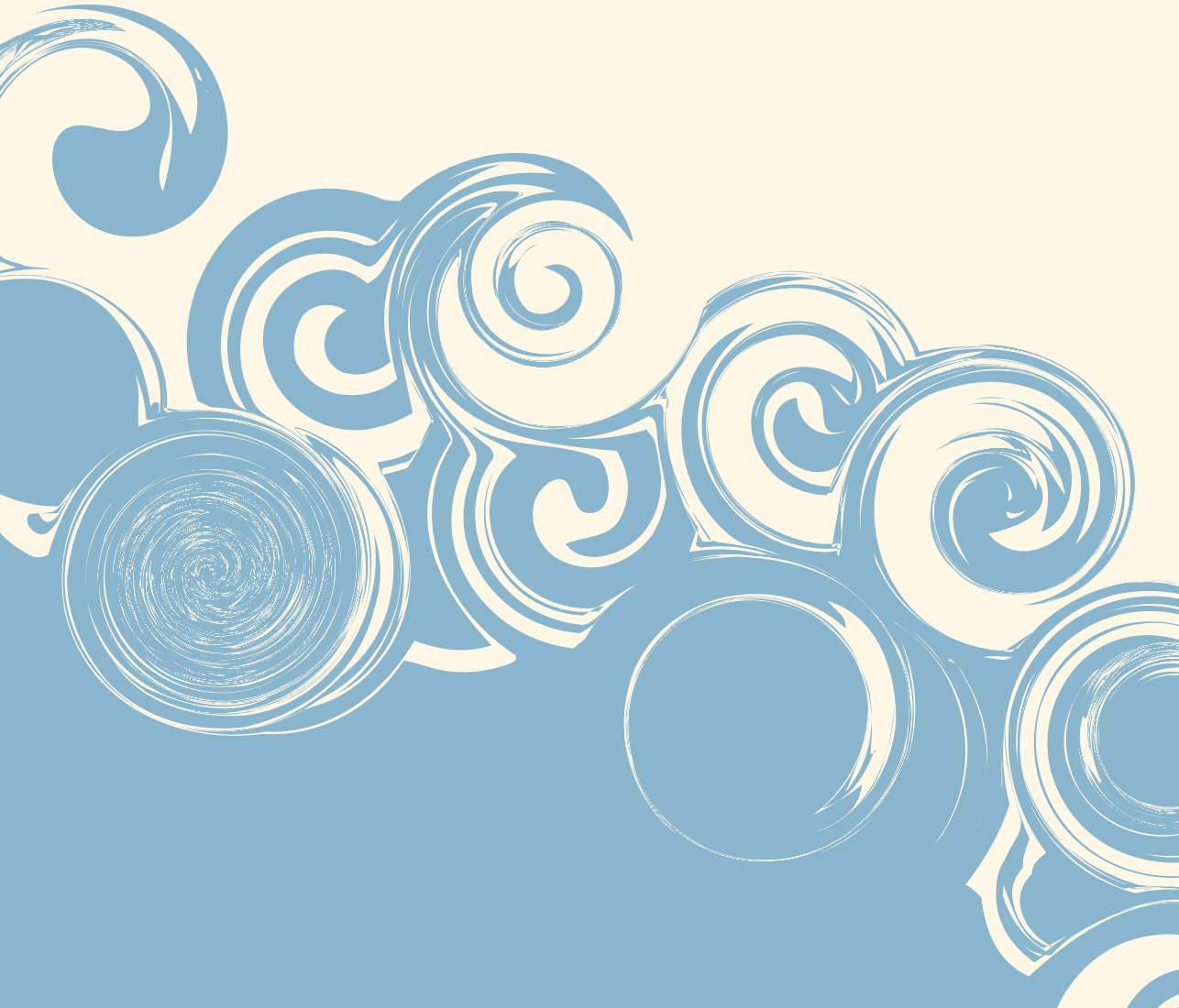
The methodology may reflect recent discussions on the dynamics of neighborhood change from a property submarket viewpoint. Spatial cluster analysis of the series dataset to visualize the dynamic could be considered in the future to address the limitations of the previous methodological structure, which only measures the difference between the target and control neighborhoods. Integrating series data and spatial datasets to observe the geographical dynamic of housing submarkets could further be regarded in terms of the dynamic of neighborhood change for further research. Furthermore, there is growing evidence that property submarket dynamics could explain neighborhood changes induced by natural hazards.

However, this study has potential limitations. First, we failed to illustrate the spatial cross-submarket between the changes of clustered houses either in distressed properties or western-inner city. Even though their dynamic tends to show feedback influence, the submarket for distressed properties expands, while the submarket for western-inner city becomes smaller. Second, as we lacked income data, we utilized electricity subscriptions as proxy data for the income of each household; many scholars have used similar datasets to explain the economic ability of community. For more precise results, it is strongly recommended to use real income data. Thirdly, our paper did not consider the different damage and risk caused by different flood depth. It is strongly recommended to provide further elaboration on these variables, particularly considering that low-lying areas are more susceptible to coastal flooding risks compared to higher-elevated areas. Fourth, this study examined floodwater extent from 2015 to 2020. More than five years may be needed to understand surface water dynamics in coastal areas comprehensively. Future studies should consider the factors influencing both coastal and inland flooding.



CHAPTER 3

Distressed Property and Spillover Effect: A Study of Property Price Response to Coastal Flood Risk



Abstract

This chapter presents evidence of distressed property spillover in coastal flood-prone areas. By utilizing a hedonic pricing model, this study may contribute to the global discussion on how property markets react to deterioration in coastal areas, specifically from the perspective of the Global South. Spillover effects in housing prices were observed through a spatial autoregressive model by investigating lags in price adjustment over time and space. The authors employed two large datasets comprising property information, including property tax history ($n = 1,933,037$; 1993–2020) and real estate transactions ($n = 1,029$; 2013–2020). These datasets are also recorded in the cadaster map of the Indonesian government. The property tax history provides crucial evidence regarding delinquent taxes, signifying distressed properties abandoned by their inhabitants. Property sales transaction data offers evidence of lowered prices and their spillover effects. As a result, this chapter contends that neighborhood decay induced by coastal flooding represents a non-economic shock that permeates to the property market, leading to price movement. The most important finding is that land subsidence has a more significant influence than distressed properties on lowering prices and their spillover effects. These findings have the potential to initiate new discussions about environmental deterioration from a property market perspective.

Keywords: Property Prices; Spillover Effect; Submarket; Neighborhood Decline

This chapter has been published as a research article in the Land Use Policy. The reference is: Sariffuddin, S., Samsura, D. A. A., van der Krabben, E., Setiyono, B., & Pradoto, W. (2024). Distressed property and spillover effect: A study of property price response to coastal flood risk. *Land Use Policy*, 147, 107379. <https://doi.org/10.1016/j.landusepol.2024.107379>

Urban planners and policymakers must enhance their understanding of property price spillover in coastal flood-prone areas, recognizing it as a key indicator of neighborhood decline, particularly in countries situated in the Global South (Bates, 2006; Jun, 2022). Spillover or ripple effects, often defined as property price movements in response to economic shocks entering the property market (Liao et al., 2015), have been the focus of studies examining spatial econometrics and changes in regional housing and neighborhoods (Feng, Zou, Yuan, & Dai, 2022; Jun, 2022; Lo Cascio, 2021). In the property market, shocks are believed to be caused by not only monetary variables, such as interest rate changes, but also non-market factors, including coastal flood risk. Recent studies on neighborhood change have revealed that natural hazard-induced migration and environmental degradation are reflected in property price adjustments (Jun, 2022; Lee, 2017). In the flood literature, risk can be capitalized into property prices based on changes in subjective perceptions of adjustments to the utility value of property through severity, frequency, or land use patterns (Pryce et al., 2011; Tobin & Newton, 1986). Thus, property prices reflect non-economic factors. In addition, studies in the Global South conducted by Desai and Loftus (2013) and have revealed property transactions with lower prices occurring in slum areas that experience flooding and tend to be abandoned by higher-income inhabitants, a phenomenon known as “widow-hood.” Rothenberg et al. (1991) also explains that household move that directly influences quality dwelling-quality change significantly affects the neighborhood decline and potentially spill to nearby housing submarkets. Understanding spillover effects on house prices can help policymakers and urban planners comprehend the dynamics of neighborhood conditions and anticipate expanded deterioration.

Most previous studies indicate that coastal flooding influences property price decreases, submarket emergence, and even property abandonment (Filatova et al., 2011). Decreasing property prices in flood-prone areas result from the decisions of property buyers and suppliers, who recognize the potential for additional maintenance costs; the discounts arguably comprise compensation for these costs (Van Ham, 2012a). Declining property prices evidently embolden lower-income people to buy such homes (Yakubu, 2021), which creates housing submarkets in flood-prone areas (Rajapaksa, Wilson, et al., 2017). The concentration of lower-income purchasers in these vulnerable areas occurs due to the limited affordable stock available to them in the property market (Van Ham, 2012a). Furthermore, empirical evidence also reveals property abandonment in flood-prone areas (Michael Paulo Sulle, Michael, Mwakyusa, & Massawe, 2023). Abandoned properties also appear to accelerate property price decreases, which can lead to blight in neighboring areas. This spillover has been observed in abandoned properties in Japan (Suzuki, Hino,

& Muto, 2022), China (Y. Wang, Yue, Wu, Zhang, & Liu, 2023), and Cleveland and Detroit, USA (Dewar, 2006).

However, most studies in flood-prone areas focus primarily on property price discounts and housing submarket reactions; spillover has not yet received much attention. Recent research by Jun (2022) and Lee (2017) reveals coastal hazard-induced neighborhood deterioration and property abandonment to also be represented by property price correction. This article thus attempts to fill this gap by answering two research questions: To what extent does the abandonment of property initially form a housing submarket? Second, to what extent does the housing submarket for distressed property influence property price decreases and spillovers? To answer these research questions, this article innovatively considers three coastal flood risks—land subsidence, slope, and flooded areas as well as distressed properties. A previous study by Rajapaksa, Wilson, et al. (2017) demonstrates that slope and proximity to flood hazards significantly influence property price discounts and emerging housing submarkets in hazardous areas. This study adds land subsidence, which has been considered a central problem of coastal flood risks that statistically influences property price adjustment (Andreas, Abidin, Sarsito, & Pradipta, 2018; Hallegatte et al., 2013; Mercy Corps, 2021; Willemsen, Kok, & Kuik, 2020), as an explanatory variable. In addition, this study also observes the spillover effect of property prices to complement our understanding of the response of prices to coastal flood risk in the Global South.

This article comprises three sections. The following section describes the theoretical framework of risk capitalization and spillover effects in at-risk areas. The second section presents the materials and methods, explaining the data, variables, and statistical analysis process. The final section outlines the results, followed by a discussion and conclusion. Statistical data analysis is described in this section, including the theoretical debate.

Theoretical Framework

Abandoned Property and Deterioration

Property abandonment, caused by housing disinvestment, is both a symptom and a problem of neighborhood deterioration, including in flood-prone areas (Accordino & Johnson, 2000). Abandoned property generally indicates a low ability of households to perform self-repair, as well as accelerated deterioration. Reduced self-maintenance investment in housing has a greater impact on decline than the physical

decay resulting from building age (Grigsby et al., 1987). Concerning hazardous areas, residence damage caused by flooding requires extra expenditures to conduct maintenance, which is strongly determined by residents' financial ability. Hence, residences inhabited by higher-income people may recover faster than those inhabited by lower-income ones (Dinh, Ubukata, Tan, & Ha, 2021). Marfai et al. (2008) provide an excellent example of how coastal communities in northern Java conduct self-adaptation every 5 years to elevate their houses or foundations, resulting in a variety of building designs. Each local inhabitant needs at least IDR 10 million to adapt to coastal flooding (Bott & Braun, 2019). Since adaptation costs can quickly over-burden family budgets, some families have decided to abandon their properties and relocate to safer areas (Buchori et al., 2018; Khairulbahri, 2022). As a result, abandoned areas experience property price decreases and form new housing submarkets that suffer from flooding (Filatova et al., 2011; Rajapaksa, Wilson, Managi, Hoang, & Lee, 2016).

The emergence of housing submarkets that suffer from flooding, often called distressed properties, is usually driven by demand changes. Changes in population characteristics occur due to lower-income purchasers replacing higher-income inhabitants. Lower-income buyers are encouraged to purchase flood-affected properties to secure more affordable property prices (Bhattacharjee et al., 2016). As a result, they gather in certain areas to share location benefits according to budget constraints (Filatova, 2014; Fujita & Thisse, 2013). Such clusters of purchasers could be explained by hedonic price theory, which sees home location selection as both a demand and production good (Rosen, 1974), where each individual needs relatively the same location quality. Hence, it is assumed that they will gather in one area and that the location of each house is not an accident of dispersion. Given that lower-income purchasers have low financial ability to maintain their homes, their flood-damaged property may decay and subsequently influence neighboring stock. Grigsby et al. (1987) explain how housing disinvestment affects deterioration, especially from house decay to neighborhood decay. As a result, declining property conditions spread to neighboring stock, despite the number of lower-income inhabitants remaining stable. As declining neighborhoods are associated with decreased property prices, this spread can be illustrated by the spillover effect on property price decreases.

Property Price Spillover Effects

The spillover or ripple effect refers to the property price movement in response to shocks over time and space (Meen, 1999). Housing price shock and its spread could have a spillover effect in one location that is transmitted to other areas. Macroeconomic studies provide long-standing research in the field of spillovers, including a wide range of understandings of how property markets respond to shocks.

These shocks, stemming from either economic or non-economic factors, lead to adjustments in property prices, thereby influencing the decisions of property buyers. In terms of the economic factor, Zhang et al. (2019) provide an excellent example of how economic shocks through interest rate changes influence buyer behavior in purchasing houses, resulting in property price spillover. Foreign investment in the form of new home buyers with higher incomes in the inner city has also triggered the spread of property price changes (Liao et al., 2015). In addition, Loberto (2023), Turnbull and van der Vlist (2023), and Suzuki et al. (2022) also reveal the influence of foreclosure properties as a non-economic shock on property price adjustment and spillover effects.

This could theoretically be explained by the basic concept of property price as the intersection point of the demand and supply curves (Filatova et al., 2011). The new buyers are novel agents who change the behavior of consumers and then move to a specific location. A positive feedback effect may occur due to the presence of new homebuyers with higher incomes, which then influences house builders' speculation and any subsequent homebuyers. Bates (2006) explains how neighborhood change in the form of housing upgrading through revitalization influences increasing property prices and spillover following the in-and-outflow of housing consumers in a given location. This finding supports the fundamental theory of the ripple effect, comprising migration, spatial arbitrage, equity transfer, and spatial patterns (Meen, 1999). In the case of neighborhood decline, Rothenberg et al. (1991) also emphasized that dwelling-quality changes determined by household moves may contribute to the dynamic of neighborhood change that spreads throughout the housing submarket. Conversely, a negative response may occur in coastal flood-prone areas due to neighborhood succession from higher- to lower-income households, which, in line with Jun's findings (2022) regarding property price adjustment in coastal flood-prone areas, indicates neighborhood change. Correspondingly, environmental degradation in coastal flood-prone areas might have a similar impact on negative spillover effects.

At least three assumptions underlie the hypothesis that coastal deterioration affects property price spillover. First, coastal flooding is an external factor with a non-marketable price in hedonics that induces neighborhood change. Environmental degradation followed by occupant shifts meets the basic assumption of neighborhood change: changes in people and place. In real estate studies, neighborhood change (upward/downward) influences demand changes through spatial demand displacement (Hamnett, 2009). As property prices represent spatial equilibrium, Jun (2022) also uses property prices as a proxy to explain neighborhood change. Second, most studies on property price adjustment in at-risk areas provide a better

understanding of how property prices decrease linearly following proximity to flooding (Bosker et al., 2019; Ismail, Karim, & Basri, 2016; Zhai, Fukuzono, & Ikeda, 2003). The closer the house is to the flood hazard, the more significant the drop in property prices, because the household has better information on flood risk through direct experience (Y. Zhang et al., 2010). Third, the emergence of housing submarkets in flood-prone areas indicates that property markets do not avoid risky areas; demand changes may in fact replace existing submarkets.

Materials and Methods

Data and Variables

The present study utilizes two segments from the property dataset. The authors initially conducted a screening of property tax delinquencies from a large dataset of property tax history ($n = 1,933,037$) from 1993–2020, with a specific emphasis on the period from 2008–2020. Next, the authors retrieved a property hedonic dataset derived from house sales transactions and spatial queries. The study utilizes the property transaction price ($n = 1,029$) from 2013–2020 as the dependent variable, with three hedonic vectors serving as independent variables: structural quality, locational quality, and environmental amenities (dis-amenities). Equation 1 is a hedonic pricing model that incorporates environmental amenities and space (Bowen, Mikelbank, & Prestegaard, 2001; Freeman, 1979; Rosen, 1974).

$$P = f(S, E, L) \quad (1)$$

where P is the property price; S refers to the structural characteristics; E refers to the natural environment; and L refers to locational characteristics.

First, property sales transactions (P) serve as the dependent variable in the hedonic pricing model. The dataset was collected from duty reports on acquiring land and building rights (Bahasa: Bea Pengalihan Hak atas Tanah dan Bangunan [BPHTB]) between 2013–2020. Because this is not spatial data, we retrieved the geographical information (x_i, y_i) from a cadaster map issued by the Ministry of Agrarian Affairs and Spatial Planning. This dataset has been validated by the taxpayer and 2 governmental institutions: the Ministry of Agrarian Affairs and Spatial Planning and Regional Finance Agency of Pekalongan City. Previous studies that used a similar dataset (BPHTB) were identified for calculating potential revenue (Putu Eka Wima, Gusti Bagus, & Agung, 2023), tax behavior and financial discipline (Ahmad Khalimaya, Insan Al Ha Za Zuna Darma, & Sri Endah, 2019) and tax estimation

(Hogantara, Ma, #039, & ruf, 2018). Although Ahmad Khalimaya et al. (2019) Ahmad Khalimaya et al. (2019) found underpayment in Semarang city, most previous observers argue that this dataset could represents the regional finance and revenue. Second, building structures (S) is the structure variables of hedonic regression. The building structure dataset was collected from a building permit database (available at <https://pbb.pekalongankota.go.id/peta>, accessed on May 20, 2021). Because there is a lack of information regarding informal settlements in coastal hazards, this study focuses on licensed or formal buildings as the basis for its findings. Third, Locational characteristics (L) is the accessibility of each house to urban amenities such as schools, hospitals, train stations, bus stations, and the central business district. To measure this, this study computed the travel distance from each house to the nearest urban amenities using Google BigQuery. We followed the methods of estimating travel time used by Woodard et al. (2017), Fan et al. (2019), Krause and Zhang (2019), Adnan et al. (2019), Cui et al., (2016), and Jimenez-Meza et al. (2013), who used geographical information such as coordinates, speed, and distance recorded by phone GPS. Fourth, environmental quality (E) in the HRM includes flood areas, land subsidence, and surface topography.

To extract environmental variables, this study employed Sentinel-1 imaginary to model land subsidence, to update Andreas et al. (2017) model. The data was retrieved from the ESA on February 17, 2017 and December 4, 2019 and modeled with SNAP 8.0, following RUS-Copernicus's training on land subsidence mapping using Sentinel-1 (available at <https://rus-copernicus.eu/portal/rus-webinar-land-subsidence-mapping-with-sentinel-1/>, accessed on March 7, 2023). The land subsidence data was inputted into the house transaction dataset as a dependent variable (xi). Second, the surface topography (slope) was calculated from surface topography in two-dimensional space, represented by a digital elevation model. The data was retrieved from DEMNAS, provided by the Geospatial Information Agency, with an accuracy of 5 m (data available at <https://tanahair.indonesia.go.id/demnas>, accessed on January 18, 2022).

Table 3-1 Hedonic Property Variables

Variable	Description	Source
price (P)	House sales prices 2013–2020 (IDR; n = 1,029)	Government
land	Total land area (m2)	Government
home	Total building area (m2)	Government
n_floors	Number of floors	Government
d.floor_ce	Dummy variable: 1 if the floor is ceramic tile, 0 otherwise	Government
prox_ES	Travel time (minutes) to elementary school (ES)	Google BigQuery
prox_JHS	Travel time (minutes) to junior high school (JHS)	Google BigQuery
prox_SHS	Travel time (minutes) to senior high school (SHS)	Google BigQuery
prox_UNIV	Travel time (minutes) to university (UNIV)	Google BigQuery
prox_TRAIN	Travel time (minutes) to train station	Google BigQuery
prox_BUS	Travel time (minutes) to bus station	Google BigQuery
prox_HSPT	Travel time (minutes) to hospital (HSPT)	Google BigQuery
prox_CBD	Travel time (minutes) to business center	Google BigQuery
subsidence	Land subsidence (meters)	Remote sensing
slope	Land slope (meters)	Remote sensing
flood	Flooded area: 1 flooded, 0 otherwise	Remote sensing
distressed	Delinquent property tax over 5 years: 1 distressed, 0 otherwise	Government
income	Proxy data of income from electricity (KwH)	Government
xcoord, ycoord	Geographical coordinates: longitude and latitude	Remote sensing

Statistical Analysis

This study employed spatial cluster analysis and the spatial autoregressive model (SAR) in three steps to observe property price spillover. Spatial cluster analysis with k-means was initially applied to spatial hedonic attributes to identify housing submarkets. Our prior study shows the analysis process for semi-supervised cluster analysis (Sariffuddin, Samsura, van der Krabben, Setiyono, & Pradoto, 2024). These groups were subsequently categorized into submarkets for both inner-city and suburban areas. Previous studies adopting a similar categorization approach were conducted by Wu and Sharma (2012) and Costello et al. (2019), who concluded that the results represent the location quality of the city. Second, the delinquent tax was screened through property tax history in each submarket. Previous studies assume that tax delinquency over 2–3 years represents abandoned property (Alfaro, Paredes,

& Skidmore, 2022; Alm, Hawley, Lee, & Miller, 2016; Park & von Rabenau, 2014), yet this study considered 6 years of neglected property tax as abandoned property because some studies in Indonesia have reported the issue of tax non-compliance (see: Inasius, 2019; Rosid, Evans, & Tran-Nam, 2018; Rosid & Romadhaniah, 2023). As such, the authors validated the duration of the neglected property tax through an interview with a local officer in Pekalongan. Thirdly, the authors utilized SARs to examine the spatial lag of property price adjustments, allowing for the identification of spillover effects. We focused on the property price spillover effect (dependent variable) and incorporated environmental dis-amenity variables: flood, land subsidence, slope, and abandoned properties.

Before modeling the spatial spillover effects with SAR, the authors included the property hedonic variables in the econometric regression models. Equation 2 presents the econometric models with the hedonic variables. In the given formula, P represents the observed transaction sales of the housing units on the market; X_s is a vector of structural attributes, X_e represents environmental quality (including flood risk, determined by land subsidence, flood, and slope), X_L is a vector of variables reflecting locational quality, and μ represents the stochastic disturbance. Moreover, we include a spatial contiguity matrix in the econometric regression models to account for spatial dependence. The spatial contiguity matrix, W , has elements w_{jk} , where the jk index is calculated based on Euclidian distance from each observation data point. Accordingly, Equation 2 can be modified by including the spatial contiguity matrix, W , in equation 3. The specified error term (ϵ_i^*) would be expressed in Equation 4.

$$P = \beta_1 + \beta_s \beta_s + \beta_e \beta_e + \beta_L \beta_L + \mu \quad (2)$$

$$P = \beta_1 + \beta_s \beta_s + \beta_e \beta_e + \beta_L \beta_L + \rho WP + \epsilon \quad (3)$$

$$\epsilon_i^* = \epsilon_i + \rho WP \quad (4)$$

where WP represents the spatial dependence of the observation, ρ is a spatial autoregressive coefficient, and all other symbols are the same as in the previous formula.

Statistical analysis was performed in RStudio version 4.1.2. An SAR was conducted with the `spdep` package for RStatistics, and the statistically significant association was evaluated at $P < 0.1$ (see: Bivand, 2002; Suesse, 2018). In addition, the authors also used spatial dependence diagnostic tests to measure various spatial dependences,

including the LMerr, LMlag, RLMerr, and RLMlag tests (see: Anselin, Bera, Florax, & Yoon, 1996). Table A.3 of appendix shows the spatial dependence diagnostic test. To measure the housing submarket, we computed panel data (2013–2020) with a k-means method for spatial cluster analysis and then plotted it according to latitude and longitude. The housing submarket was derived based on data-driven housing segmentation using cluster analysis, previously examined in our prior study (see: Sariffuddin et al., 2024).

Research Area

This study was conducted in Pekalongan, a coastal city in Central Java, Indonesia, experiencing abandoned properties due to coastal flooding. The coastal flooding in Pekalongan slowly expands to dry land and potentially sinks the city. According to research conducted by the national research and innovation agency (Bahasa: Badan Riset dan Inovasi Nasional [BRIN]), most national and international media report that Pekalongan is predicted to sink by 2035 due to the climate crisis, land subsidence, and abrasion (Rayda, 2021). Mercy Corps (2021) concludes that coastal flooding in Pekalongan increases linearly, primarily due to sea level rise and land subsidence. Nonetheless, housing investment in coastal flood risk continues. Coastal flooding has spurred environmental damage (Andreas et al., 2017) and outflow migration (Khairulbahri, 2022) in Pekalongan. Environmental degradation in the coastal area of Pekalongan, together with Jakarta, Cirebon, Semarang, and Demak, is now a national concern. To prevent deterioration, the government now allocates more than IDR 54.9 trillion (€33.94 million) for preventing and reducing coastal flood risk through engineering flood defenses such as dikes in those five coastal cities in north Java. Figure 1-2 shows the research area of Pekalongan City, Indonesia.

Moreover, residents in the coastal areas of Pekalongan are increasingly abandoning their neighborhoods. Utilizing nexus dynamics, Khairulbahri (2022) observed that households along the coast are relocating to safer areas. This migration outflow is understandable, given the ongoing degradation of environmental quality, compelling residents to allocate more budget for adaptation measures, such as elevating their houses, or at the very least, their foundations, every 5 years (Marfai, 2014). Our prior study on residential mobility also found that lower-income residents are moving from safer to riskier areas, particularly distressed property markets, which adds new insight into inflow migration (Sariffuddin, Samsura, Krabben, Setiyono, & Pradoto, 2023). As the ability of households to adapt varies, the height of houses also fluctuates according to the financial capacity of each family to undertake adaptation efforts (Buchori et al., 2022). As illustrated in Figure 3-1, abandoned properties are a consequence of this outward migration.



Figure 3-1 Abandoned Property and Structural Adaptation for Distressed Properties

Results

Distressed Housing Submarket Emergence

The first research question aimed to identify abandoned properties and form a submarket for distressed properties. The result, as shown in Figure 3-2, indicates that delinquent property tax reached more than 2,000 houses and increased annually by an average of 1.72%, concentrated in the coastal area of Pekalongan, particularly in four villages: Bandengan, Degayu, Kandang Panjang, and Padukuhan Kraton. These properties were abandoned and experienced structural damage, such as cracks and permanent flooding. This coastal hazard has left local people to need to repair their homes by themselves every 5 years, by elevating the house or only its floor. Figure 3-2 shows the delinquent property tax over 6 years in coastal flood-prone areas.

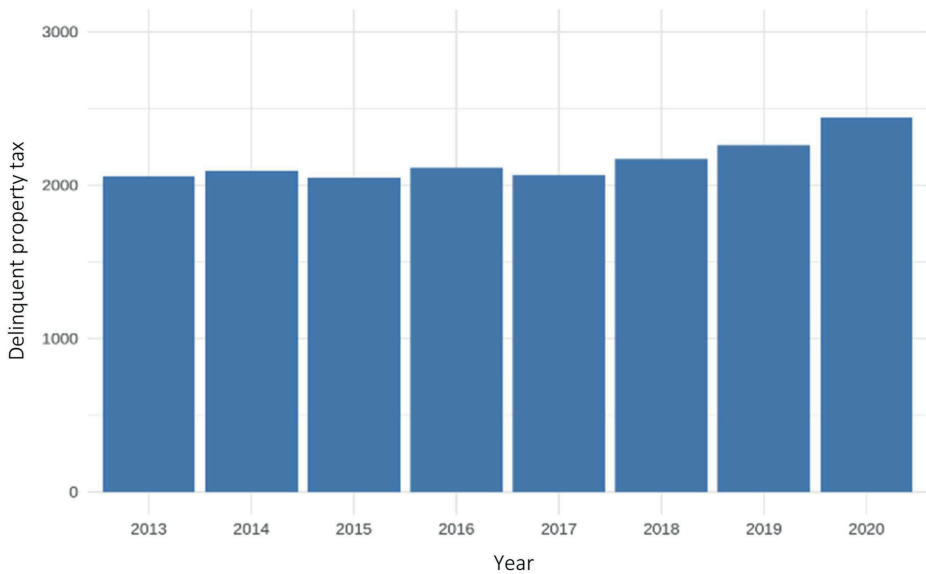


Figure 3-2 Delinquent Property Taxes Over A 5-Year Period

Further analysis reveals that distressed properties constitute a distinct housing submarket. In our prior study, Sariffuddin et al. (2024) explain the spatial cluster analysis using k-means, resulting in four identified housing submarkets. Through data-driven delineation, this study has identified two housing submarkets within the inner city (western and eastern inner city) and two in suburban areas (safer areas and coastal flood-prone areas). The submarket for the western inner city also experiences coastal flooding and land subsidence. Abandoned properties are notably concentrated in the housing submarket for suburban areas that are vulnerable to coastal flooding, defining the submarket for distressed properties. Distressed properties are consequently delineated, situated in coastal areas experiencing flooding almost twice a week and land subsidence, leading to blight and abandonment by inhabitants.

Submarkets for distressed properties situated in suburban areas have suffered from coastal flooding and are inhabited by low-income people. Inhabitants benefit from the proximity to an elementary school, junior high school, and hospital. Meanwhile, the neighborhood next to distressed properties is a housing submarket for the western inner city of Pekalongan, which is near the central business district, senior high school, and university. Middle-income people inhabit this neighborhood. The average travel time from each household to nearby urban facilities is less than 10 minutes by motorcycle, except for the transportation time to the hospital and

senior high school, located in the fringe area. This area is inhabited by a middle-income group, represented by an electricity subscription of 900–2,200 kWh and a property tax burden of over IDR 120,000.

Negative Spillover Effects in at-Risk Areas

The second research question aimed to observe a negative spillover on property prices. The analysis showed at least two important findings. First, this study revealed a property price decrease, as well as a negative spillover effect in response to neighborhood deterioration in coastal flood-prone areas. Submarkets for distressed properties seem to be the epicenter of shock and spread to neighboring submarkets. Second, the land subsidence variable exerts the most influence on the negative spillover effect. Another key finding may be that distressed property is not statistically significant in influencing property price decreases or spillover effects. In addition, other environmental dis-amenity variables, including flood and slope, were not statistically significant ($p\text{-value} > 0.1$). Table 3-2 shows the SAR model, as well as direct and indirect effects.

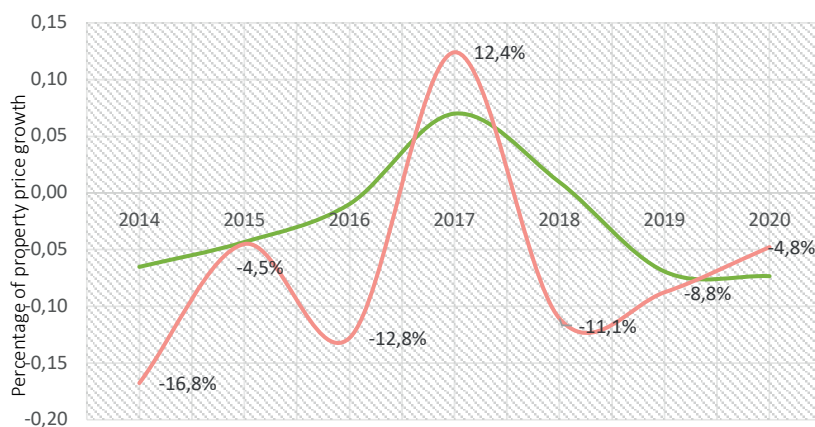
This study revealed a property price decrease in response to neighborhood deterioration, followed by a negative spillover effect. The volatility of property prices in the two submarkets differed (see Figure 3-3). Property prices in submarkets in the western inner city tend to increase, despite experiencing coastal flooding. Prices increased in 2016–2017 and then decreased in 2018–2020. This may result from the CBD being located in this housing submarket. Conversely, although property prices in submarkets for distressed properties tend to decrease, property prices increased by 12.4% in 2017, perhaps due to luxury real estate being located less than 1 km from the shoreline. The negative spillover effect is another interesting finding following a property price decrease. The rho was identified as 0.27535 ($p\text{-value} < 0.1$), indicating moderate spatial dependence.

Moreover, land subsidence influences spillover more than distressed properties. The total effect of land subsidence is -0.2629 , consisting of 0.1931 ($p\text{-value} < 0.1$) for the direct effect and -0.0698 for the indirect effect. This result indicates that property price decreases of -0.19% were influenced by land subsidence. Meanwhile, other coastal flood risk variables, including slope and flood, have $p\text{-values}$ greater than 0.1 , indicating statistical non-significance. Moreover, the distressed property variable also has a $p\text{-value}$ greater than 0.1 , which is statistically non-significant. In addition, income as a control variable shows statistically significant influence on property price spillover, with a total effect of 0.1954 ($p\text{-value} < 0.1$). Table 3-3 shows the direct and indirect effects of each variable on property price spillover.

Table 3- 2 Spatial Autoregressive Model

Variable	Estimate	Std. Error	Z value	Pr(> z)	VIF
(Intercept)	3.9457746	0.4095808	9.6337	< 2.2e-16	
Log(land)	0.5888678	0.0273130	21.5600	< 2.2e-16	1.729167
Log(home)	0.1105985	0.0291634	3.7924	0.0001492	1.824714
Prox_ES	0.0239151	0.0066087	3.6187	0.0002961	2.370750
Prox_JHS	-0.0106385	0.0065109	-1.6339	0.1022711	1.861492
Prox_SHS	0.0058781	0.0073459	0.8002	0.4235983	2.246424
Prox_UNIV	0.0020601	0.0068369	0.3013	0.7631651	2.014676
Prox_TRAIN	-0.0253085	0.0089987	-2.8125	0.0049164	4.657561
Prox_BUS	-0.0167479	0.0064211	-2.6083	0.0091002	4.033281
Prox_HSPT	0.0011071	0.0100764	0.1099	0.9125110	3.828264
Prox_CBD	0.0033646	0.0064197	0.5241	0.6002016	3.127465
Log(subsidence)	-0.1905460	0.0693809	-2.7464	0.0060258	2.896670
Log(slope)	0.0987032	0.0668953	1.4755	0.1400818	1.025078
Flood	-0.0094240	0.0553311	-0.1703	0.8647581	4.279463
Distressed	-0.0442701	0.0722373	-0.6128	0.5399805	6.504929
Log(income)	0.1928427	0.0310007	6.2206	4.953e-10	1.128153

Note: Rho: 0.27535, LR test value: 70.795, p-value: < 2.22e-16

**Figure 3-3** Property Price Volatility in Coastal Flood-Prone Areas

Note: — Submarket for western inner-city — Submarket for distressed properties

Table 3-3 Direct and Indirect (Spillover) Effects

Variables	Direct	Indirect	Total
Log(land)	0.596850250 ***	0.2157691228 ***	0.812619373
Log(home)	0.112097740 ***	0.0405247901 **	0.152622530
Prox_ES	0.024239322 ***	0.0087628298	0.033002152
Prox_JHS	-0.010782693 .	-0.0038980835	-0.014680776
Prox_SHS	0.005957818	0.0021538288	0.008111647
Prox_UNIV	0.002088063	0.0007548619	0.002842925
Prox_TRAIN	-0.025651555 **	-0.0092733706	-0.034924926
Prox_BUS	-0.016974943 **	-0.0061366625	-0.023111605
Prox_HSPT	0.001122126	0.0004056632	0.001527790
Prox_CBD	0.003410226	0.0012328411	0.004643067
Log(subsidence)	-0.193128991 **	-0.0698186405	-0.262947632
Log(slope)	0.100041180	0.0361661869	0.136207367
Flood	-0.009551776	-0.0034530911	-0.013004867
Distressed	-0.044870210	-0.0162211643	-0.061091375
Log(income)	0.195456781 ***	0.0706601667 ***	0.266116948 ***

Signif. codes: *** = 0; ** = 0.001; * = 0.01; 0.05 ' ' 0.1 ' ' 1

Discussion

This study confirms that the spillover effect follows property price decreases in a coastal neighborhood in decline. The most obvious finding to emerge from the analysis is the connection between coastal flooding, abandoned properties, and property price decreases, including their negative spillover. This may be explained by coastal flooding, as natural stress enters the property market, affecting abandoned properties, decreasing property prices, and spillover; these decreases in property prices may be influenced by changes in expectations for the utility value of property. In addition, abandoned property creates and emboldens a housing submarket for distressed properties inhabited by lower-income people. This finding regarding the housing submarket for distressed property may contribute to a new understanding of Filatova et al. (2011) finding that property price decreases are followed by negative spillover in coastal flood-prone areas. This new understanding is, of course, due to the fact that the study was conducted in Indonesia, a developing country in the Global South. Another possible explanation is that this study also supports Desai

(2021), who observed property speculation in the Global South, specifically regarding property transactions in slum areas in Mumbai, India.

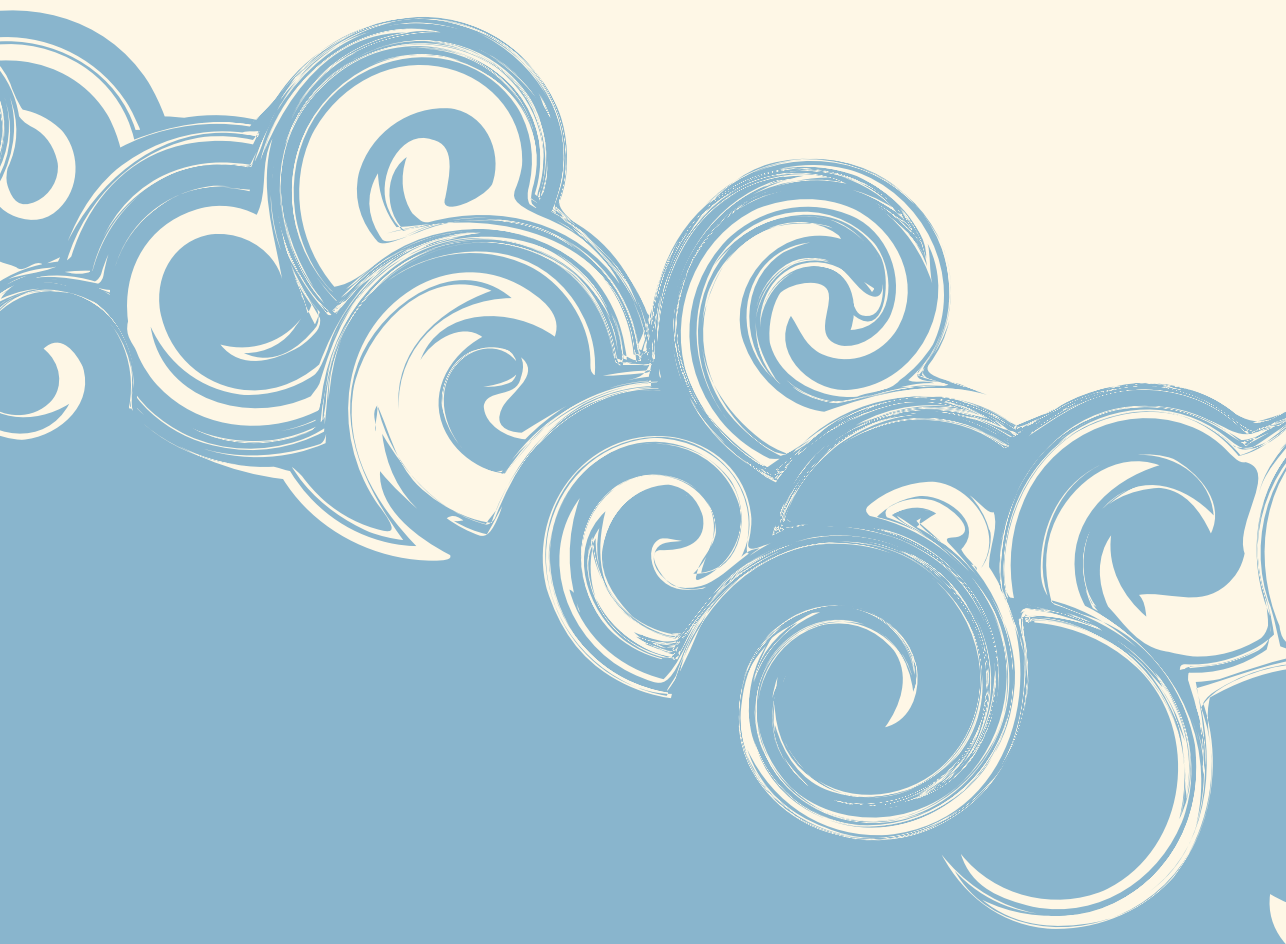
Housing submarkets emerge in areas of abandoned properties and often correspond to slum areas or submarkets for distressed properties. Houses afflicted by coastal flooding are abandoned by their inhabitants, as evidenced by delinquent property taxes over a 6-year period. This finding may comprise a complementary explanation of Rajapaksa, Wilson et al. (2017) about housing submarket emergence in flood-prone areas. We can accordingly infer that the property price spillover effect might be influenced by abandoned properties and inflow migration by lower-income inhabitants in the housing submarket for distressed properties. These results reflect those of Suzuki et al. (2022), who also found distressed property spillover in Japan, and may contribute to new insights and growing evidence about property market reactions in Indonesia, as a middle-income country. Likewise, the spillover effect may also be influenced by the outflow migration of higher-income people replaced by lower-income residents. This finding supports Rothenberg et al. (1991), who argue that the adjustment through dwelling-quality conversion spreads or spills throughout the submarket complex. In the Global South, growing evidence exists that the formation of housing submarkets in coastal flood-prone areas may relate to abandoned properties (Rajapaksa, Zhu, et al., 2017) and in-outflow migration (Rothenberg et al., 1991).

Furthermore, the marginal impact of spillover is identified in the response variable (P), commonly known as global spillover, supported by the SAR model and LM test. This finding supports Liao et al. (2015) and Lo Cascio (2021), who find that a property price spillover occurs in global variables due to new investments by housing purchasers, as well as through decreases in property prices. Our findings could be explained on the environmental side through neighborhood deterioration induced by coastal flooding. A possible explanation is that the new property buyers in at-risk areas are low-income people, as reflected by their electricity subscriptions, especially those purchasing in the submarket for distressed properties. Property price decreases in at-risk areas are also identified, supporting the previous research on flash and river floods (Bosker et al., 2019; Ismail, Abd Karim, & Hasan-Basri, 2019; Zhai et al., 2003) and coastal areas (Bakkensen, Ding, & Ma, 2019) in a medium-sized city (Pekalongan). Another interesting finding is that the influence of the land subsidence variable on property price decreases, and its spillover is greater than other variables, including flood, slope, and distressed properties. These results provide further support for the hypothesis that neighborhood deterioration in coastal flood-prone areas relates to land subsidence.

Conclusion

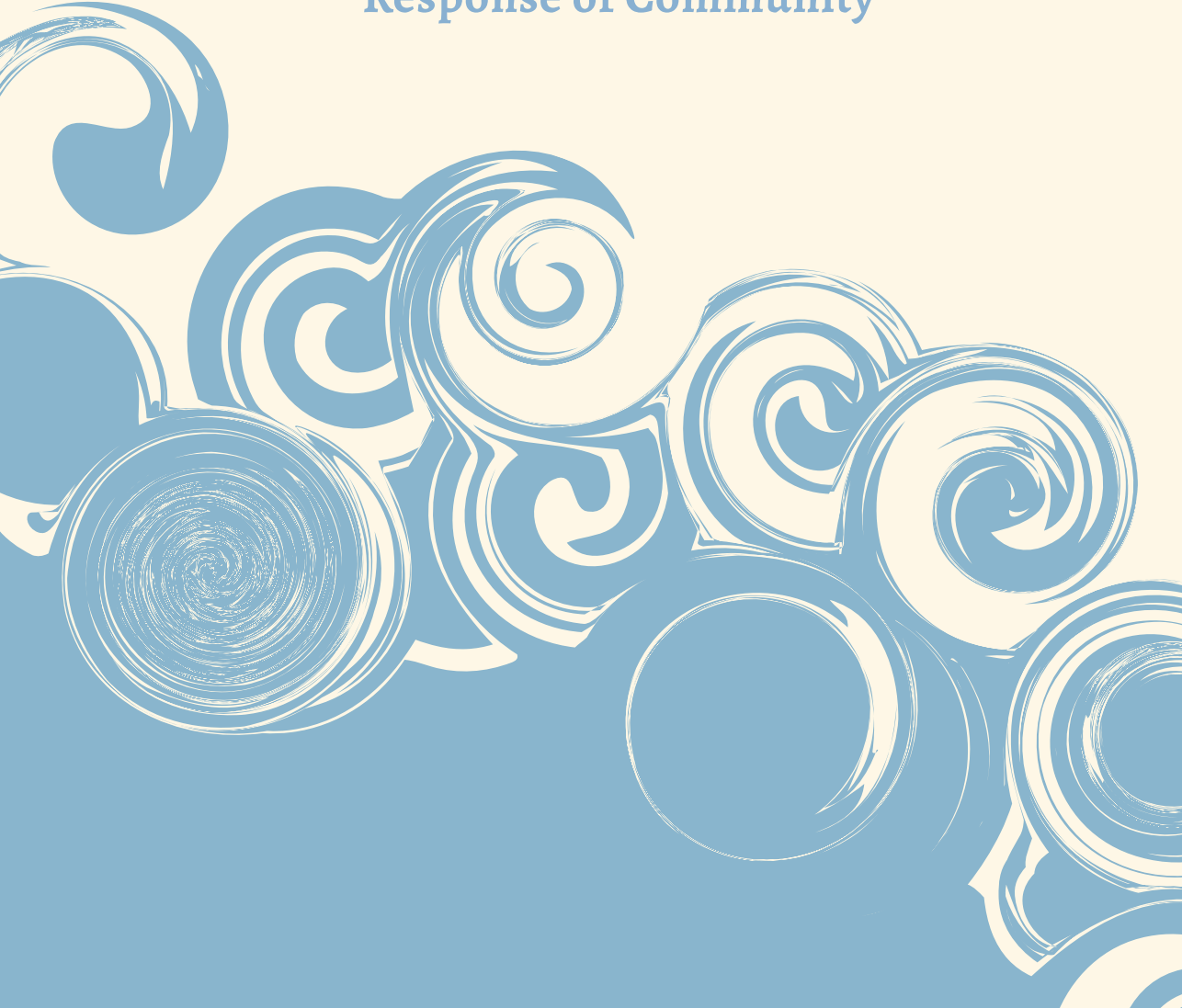
This study has identified the novel finding that coastal neighborhood deterioration negatively affects property prices and spillover. Abandoned properties, resulting from delinquent taxes, comprise a new housing submarket, vulnerable to coastal flooding. This submarket for distressed property appears to negatively impact neighboring properties through a spillover effect on property prices. The abandoned properties have been linked to decreases in existing demand, which further lower property prices. Perhaps the most important finding is that land subsidence has a more pronounced impact on property prices than distressed properties. Furthermore, the indirect effect of land subsidence is the most significant. This finding indicates a closed causality between distressed properties and land subsidence and their interconnected impact. In short, the spillover effect serves as a signal of deteriorating neighborhoods in coastal flood-prone areas. An implication of this finding is the close correlation between neighborhood decline, land subsidence, and the spread of these effects, represented by property price spillover. This information can be used to formulate targeted interventions aimed at improving neighborhood quality in at-risk areas. This study may open further discussion about property market control in the at-risk areas to prevent the declining process.

Nevertheless, a key limitation of this study lies in the lack of purchaser characteristics. Due to insufficient data, this study relies solely on household income derived from electricity subscriptions as a proxy to explain the submarket. Moreover, given the underpaid tax in Semarang City, it is better to observe the validity of the BPHTB dataset in Pekalongan for future study. Likewise, future studies should encompass a more comprehensive investigation of submarket characteristics, incorporating additional social and economic information, such as race, religion, and social beliefs. Moreover, this study focuses on licensed or formal construction registered in the government's Cadaster database. Unlicensed/ informal buildings also need to be covered in this study, but this limitation may be considered for future studies. Regarding the research area, this study further discusses coastal disasters and vulnerability in the Global South. Similarly, the impact of coastal flood risk on the property market may be considered when assessing neighborhood decline.



CHAPTER 4

**Declining Coastal Neighborhoods
and Anti-Gentrification:
Understanding the Heterogeneity
Response of Community**



Abstract

This chapter presents comprehensive evidence on the link between anti-gentrification and property depreciation in coastal neighborhoods, resulting in a decline in property prices. Our study, firmly rooted in the understanding of hedonic property pricing, significantly contributes to the global discourse on the property market's response to coastal flood risk, particularly from the global south perspective. The authors employed spatial cluster analysis and geographically weighted regression (GWR) on two extensive property datasets: property tax history and property sales transactions. The regression model, with an r -squared value of 0.86, highlights its statistical robustness. We utilized 1,761 property sales transaction datasets to examine property price heterogeneity and the responsiveness of each property buyer to coastal flood risk variables. To illustrate residential mobility based on changes in property ownership, we screened over 1.9 billion datasets on property tax history. Our study uncovers that anti-gentrification interacts with the emergence of submarkets for distressed properties, contributing to the decrease in property prices within a declining neighborhood, which has significant implications for urban development and property market analysis.

Keywords: Anti-Gentrification Agents; Neighborhood in Decline; Stability; Property Price; Geographically Weighted Regression; K-Means

This chapter has been submitted as a research article in the *Cities*. The reference is: Sariffuddin, S., Samsura, D. A. A., van der Krabben, E. (2024). Declining Coastal Neighborhoods and Anti-Gentrification: Understanding the Heterogeneity Response of Property Buyers. *Cities* (under review)

House price change, increasing or decreasing, serves as an essential indicator of buyers' response to neighborhood change and its association with gentrification (Bates, 2006; Deng, 2024). Numerous studies have identified similar patterns for both neighborhoods in increase and decline. In a study of increasing neighborhood, Bates (2006) found that property price raised following gentrification. This phenomenon occurred as higher-income buyers replaced lower-income ones, aligning with findings from various studies exploring the relationship between relocation and increased property prices (Deng, 2024). In regional literature, communities who replace the existing demand and increase property prices through influencing demand speculation are often called gentrification agents (Meen, 1999). On the other hand, Gu et al. (2019) and Han (2019) described a similar signal for neighborhood in decline. They argued that property price decreases in hazardous areas and blighted neighborhoods have attracted lower-income buyers to reside there after the out-migration of higher-income households. For this case, they are often referred to as lower-income agents – gentrification or anti-gentrification agents.

Many prior studies have demonstrated observable responses from communities in coastal flood-prone areas. These responses include clustering in vulnerable zones, the establishment of housing submarkets, a decline in property prices, and relocation to safer areas. Most studies reported falling property prices in flood-prone areas and triggering housing submarket emergence (Desai, 2021; Desai & Loftus, 2013; Rajapaksa, Wilson, et al., 2017). Some studies also revealed outflow migration for adaptation and anticipation (Buchori et al., 2018; Bukvic & Barnett, 2023; Marfai, 2014). Many studies from developing countries also signaled the neighborhood decline caused by coastal flooding, such as in Indonesia (Buchori et al., 2018; Marfai, 2014; Sunarti, Helmi, Widjajanti, & Purwanto, 2020), Bangladesh (Braun & Aßheuer, 2011), and India (De & Vupru, 2017; Desai, 2021). These findings in developing countries, often referred to as the global-south, align with the study conducted by Hallegatte et al. (2013) who reported that developing countries, including Indonesia, may experience more severe economic losses compared to their developed counterparts.

However, previous studies in developing countries have mostly provided partial evidence rather than showing a comprehensive and causal explanation of the process. For example, Buchori et al. (2018) presented evidence of outflow migration, Sunarti et al. (2020) documented the neighborhood change based on qualitative research, Cobián Álvarez and Resosudarmo (2019) demonstrated the decrease of property prices in response to coastal flood risk in Jakarta. Additionally, Desai (2021) uncovered the emergence of slum housing markets in flood-prone areas of Mumbai, India. What remains to be clarified is to what extent an abandoned neighborhood

forming property submarkets. Moreover, what are the characteristics of communities who reduce property prices? This lack of information is understandable because the previous studies employed disparate datasets, methods, and theoretical frameworks that are not easy to integrate into this study. Moreover, the majority of studies on residential mobility have placed greater emphasis on the destination rather than the origin area (Brasington, 2021). Consequently, there is a lack of understanding regarding the property market dynamics in declining areas. Hence, this study attempts to fill the gap by using property sell transaction data and property tax history to study the behavior of communities in a declining neighborhood situated in a coastal flood prone area.

To address these two research questions, the authors employed a property dataset linked to the governmental Cadaster database. We examined over 1,9 million pieces of property tax history data spanning from 1993 to 2020, aiming to visualize internal housing displacement that could shed light on the anti-gentrification phenomenon. Subsequently, we analyzed eight years of data on single-house sales transactions ($n = 1,761$) to comprehend the responses of individual buyers to coastal flood risk variables. This analysis used geographically weighted regression for the spatial hedonic price model. The paper is structured across six sections, encompassing the theoretical framework, research method, analysis and results, discussion, and conclusion.

Theoretical Framework

Neighborhood Decline

While a variety of definitions of the term “neighborhood” have been suggested, this study uses the definition from a property market viewpoint that was first suggested by Grigsby et al. (1987). This definition remains pertinent in current discourse, as evidenced by Bates (2006), and He and Zhang (2023). Grigsby et al. (1987) explains that a property submarket is a neighborhood that is dynamically formed by changes in supply and demand. Due to this dynamic shift, there are usually distinct submarkets within the housing market that are often seen as substitutes by households (Bhattacharjee et al., 2016; Rabiei-Dastjerdi, McArdle, & Hynes, 2022). The characteristic differences in submarkets make some submarkets more sensitive than others in responding to changes in housing demand and supply (Grigsby et al., 1987; Rajapaksa, Wilson, et al., 2017). Demand can change due to changes in income, household composition, employment, and population. As a result, changes in demand can potentially affect a household’s ability to invest in repairs and maintenance on their houses. If they have low financial ability, the house would potentially be poorly maintained, damaged, and then deteriorate the neighborhood. Grigsby et al. (1987)

even highlighted the link between house damage and neighborhood decline, namely from house decline to neighborhood degradation.

In urban economics, a neighborhood in decline is typically attributed to a disinvestment process in the existing stock rather than natural physical decay (Megbolugbe et al., 1996). This places a burden on both individual households and the government. On one hand, housing investment is undertaken individually by households, often referred to as private investment. Since maintenance and repairs require extra budget, this investment becomes part of the marginal cost, impacting the household expense equilibrium (Mendelsohn, 2000). On the other hand, the government also invests in maintaining and improving public facilities such as water, roads, and drainage, which is often understood as public investment. For example, household recovery after a disaster illustrate how individual financial capacity influences the ability to renovate and maintain residences (Barrage & Furst, 2019). In the aftermath of disasters, numerous pieces of literature have indicated that households with higher incomes tend to recover more rapidly compared to those with lower incomes (Dinh et al., 2021). In short, the lack of investment in areas leads to neighborhood decline.

Besides repairing and maintaining their houses, some households move to a better location that fits their budget constraints. They think that it is more rational to reduce their MC and increase MB (Brasington, 2021; Filatova, 2014; Mendelsohn, 2000), since they must spend extra money for regular maintenance in declining neighborhoods. Households incorporate the risk associated with flood frequency and severity into their decision-making process (Pryce et al., 2011; Tobin & Newton, 1986). One possible reason for households to leave a declining neighborhood is to maximize their benefits within their financial constraints, based on the assumption that they act rationally (Brasington, 2021; Grigsby et al., 1987; Hunter, Luna, & Norton, 2015). This leads to further deterioration of the neighborhood, as residents avoid the high costs of maintenance, and the property prices drop. Consequently, the property market in the declining neighborhood suffers and becomes a submarket for distressed property. For example, Desai (2021) showed how property prices decreased and housing market in slum area in Mumbai, India.

Anti-Gentrification

Some neighborhoods that decline in quality and value may attract lower-income households who can afford the lower property prices (Lee, 2017). They replace the previous property inhabitants and is a signal of neighborhood succession, which shows the changes in property demand (Grigsby et al., 1987; van Ham, 2012b). This

phenomenon is often referred to as reverse- or anti-gentrification and is frequently found in neighborhoods in decline due to disasters (Han, 2019; Lee, 2018; L. Zhang & Leonard, 2018) or property foreclosures (Fujii, 2021; Whitaker & Fitzpatrick Iv, 2013). Thus, the authors define the new home buyers who contribute to the property price decrease as anti-gentrification agents. This paper will use this term throughout.

The diversity in property price decreases reflects distinct responses from buyers who function as anti-gentrification agents. This variability is grounded in the assumption that property prices signify spatial equilibrium, representing the juncture where supply and demand curves intersect. Hence, the heterogeneity of property price decrease could be seen as the result of various response property purchasers internalize the declining neighborhood. According to the hedonic theory of property, environmental amenities (and dis-amenities) are part of the non-marketable factors that determine the property price (Tobin & Newton, 1986). Rosen (1974) and Freeman (1979) explained that property price is the bundle of marketable and non-marketable factors composed of the building structure, the locational quality, and the environmental amenities (and dis-amenities). When a neighborhood declines due to coastal flooding, the environmental dis-amenities affect the buyers' risk perception and then lead to a property price decrease. Risk perception is very subjective and is influenced by education, income, and beliefs (Filatova et al., 2011). Therefore, the buyers and sellers may have different responses to the environmental benefits and costs. This leads to the variation of property price decrease due to different expectations on housing investment (Grigsby et al., 1987).

Additionally, the stability of the buyers' responses to the declining neighborhood is often used to measure the stability of the alternative housing submarkets in terms of space and time. Kopczewska and Ćwiakowski (2021) provided an excellent example of how the stability of housing submarkets varies according to time and space in Warsaw-Poland, based on the coefficient stability of geographically weighted regression. Based on its stability, the observers can better understand which agents or home buyers influence the property price decrease. Therefore, they can be regarded as potential groups of anti-gentrification agents.

Research Method

Data and Variables

For the purpose of analysis, the authors extracted two segments from the property dataset. First, we filtered the property owners who changed from a large dataset of

property tax history ($n = 1,987,333$) from 1993 to 2020 and focused on 2015 to 2020 ($n = 874$), where household migration increased and was clearly captured by property tax history. From the migration of household, we then can assume the in-and-out migration to housing market which is maybe influence the existing housing submarket. Accordance with this and their character of income group of households, the authors examined the gentrification phenomenon in the research area. Second, the authors then extracted property hedonic dataset from house sell transactions and spatial query. This study used property transactions price ($n = 1,751$) from 2013 – 2020 as dependent variable and 3 hedonic vectors for independent variables including structural, locational quality and environmental condition. Following Rosen (1974) and Freeman (1979), the equation of hedonic price model can be expressed in equation 1. The explanation of the data source is explained in the following section.

Firstly, property sales transactions serve as the response variable in the hedonic pricing model. This data is sourced from duty reports related to the acquisition of land and building rights (Bahasa: Bea Pengalihan Hak atas Tanah and Bangunan [BPHTB]) issued by the Office for the Management of Regional Revenue between 2013 and 2020. Secondly, the neighborhood is a locational quality vector, specifically addressing the accessibility of each house to urban amenities. Travel time distances from each household to nearby urban facilities, such as schools, hospitals, train stations, bus stations, and the central business district, were computed. For these calculations, we utilized the Googleway package for RStatistics 4.3.1 and the direction API from the Google Cloud Platform. Thirdly, environmental quality is represented by coastal flood risk variables, namely slope, land subsidence, and coastal flooding. We computed slope using digital elevation model (DEM) which is provided by DEMNAS (Digital elevation model nasional, Indonesia) available at: <https://tanahair.indonesia.go.id/> (accessed on 20 May 2021). For land subsidence, we renew the land subsidence modelling which previously done by Andreas et al. (2017) by using the recent satellite imaginary of sentinel 1 taken on 17 February 2017 and 4 December 2019. The modelling was conducted using SNAP software from ESA. Meanwhile for coastal flooding, we took advantage from Mercy Corps (2021) Indonesia that have mapped coastal flooding based on 3 criteria: land subsidence, sea level rise and land use change.

Table 4- 1 Property Hedonic Variables

Variables	Description	Sources
price	House sales prices 2013–2020 (IDR; n = 1,760)	Government
land	Total land area (m2)	Government
building	Total building area (m2)	Government
d.floor_ce	Dummy variable: 1 if the floor is ceramic tile, 0 otherwise.	Government
electricity	Proxy data of social welfare from electricity (KwH)	Government
prox_es	Travel time (minutes) to elementary school (ES)	Google BigQuery
prox_jhs	Travel time (minutes) to junior high school (JHS)	Google BigQuery
prox_shs	Travel time (minutes) to senior high school (SHS)	Google BigQuery
prox_hspt	Travel time (minutes) to hospital (HSPT)	Google BigQuery
prox_cbd	Travel time (minutes) to business center	Google BigQuery
subsidence	Land subsidence (meters)	Remote sensing
slope	Land slope (meters)	Remote sensing
flooded	Flooded area: 1 flooded, 0 otherwise	Remote sensing
xcoord, ycoord	Geographical coordinates: Longitude and latitude	Remote sensing

Statistical Analysis

This study applied spatial cluster analysis and geographically weighted regression (GWR) to explore how communities responded to declining neighborhoods. There were three steps of analysis. First, the spatial cluster analysis with k-means was used on two datasets: spatial hedonic attributes to identify housing submarkets and GWR's coefficients stability to investigate how communities reacted to neighborhood decline. In the housing submarket examination, the authors applied semi-supervised cluster analysis to group housing attributes based on data-driven boundaries and then categorized the group into submarket for inner city and suburban areas. The previous study categorized to the same submarket was conducted by Wu and Sharma (2012) and Costello et al. (2019). They concluded that the results has important role for submarket modelling within an urban area in corporate with demand elasticities. (see Appendix 3). Second, we included both housing submarkets as dummy variables in the GWR and obtained the GWR's coefficients that represented the reactions of each household to property price heterogeneity. Third, we used the GWR's coefficients as a dataset to be clustered with k-means to group the property buyer's response. The explanation of how each analysis is performed is described as follows.

Initially, this study utilized the k-means algorithm to observe housing submarkets. The basic idea of this function is minimizing the intra-cluster variation which is pioneered by Hartigan and Wong (1979). The variation is measured based on the sum of squared distances Euclidean distances among observable data point. Some previous scientific papers observing housing submarket with k-means are found in Austria (Helbich et al., 2013), City of Milwaukee, USA (Changshan Wu & Sharma, 2012), and Shenzhen, China (Chao Wu, Ye, Ren, & Du, 2018). They concluded that k-means cluster analysis could effectively demonstrate the existing housing submarket. In their methodology, the researchers employed the cluster package for RStudio. This study used the same method, determining the number of clusters using the silhouette and the cluster plot. This analysis provided insights into the first research question, addressing whether declining neighborhoods formed distinct housing submarkets.

Second, this study uses the heterogeneity of hedonic property prices to identify the anti-gentrification agents and their stability in response to the coastal flood risk. Property price variation in term of spatial and time is the basic argumentation of how to observe property purchasers deal with their purchased house and the neighborhood including coastal flood risk. In some previous studies, some researchers used GWR to study the spatial heterogeneity of property price (Y. Lu, Shi, & Pettit, 2023; Wen, Xiao, Hui, & Zhang, 2018) and to understand the stability of substitute housing submarket (Bhattacharjee et al., 2016; Kopczewska & Ćwiakowski, 2021). On one hand, many researchers interpreted the spatial heterogeneity of property price based on the variance of coefficient, local r-squared and standard deviation by which the local linear regression could be understood. On the other hand, the change of coefficient of each variable representing the stability of how purchasers responding to the variance of local variables. For numerous independent variables, a basic GWR can be written as follows:

$$Y = b_0(x_i, y_i) + \sum_{j=1}^n b_j(x_i, y_i) \cdot X_j + e_i \text{ for } j = 1, 2, \dots, n \quad (5)$$

The weighted is valued based on the distance of each location expressed by the coordinates (x_i, y_i) . The estimation of weights is similar to the classical model. The weight of observation can be formulated as follows:

$$\hat{b}(x_i, y_i) = (X^T W_{(i)} X)^{-1} X^T W_{(i)} Y \quad (6)$$

where W is weights matrix. This is a function of the coordinate distance (x_i, y_i) to its neighborhood. The weighted matrix can be formulated as follows:

$$W_{(i)} = \begin{bmatrix} w_{i1} & 0 & 0 & 0 \\ 0 & w_{i2} & 0 & 0 \\ 0 & 0 & \dots & 0 \\ 0 & 0 & 0 & w_{in} \end{bmatrix} \quad (7)$$

Furthermore, the authors employed the GWModel package for RStudio to conduct a GWR analysis (see: B. Lu, Harris, Charlton, & Brunsdon, 2014) and utilized the exponential kernel function to measure its bandwidth. Several prior studies employing the same kernel function for GWR were investigated to observe the spatial heterogeneity of property price (B. Lu et al., 2022; Oshan et al., 2019) and the same function were examined to study the influence of urban amenities on property price variance (Colaninno & Morello, 2022; Gao, Yang, Han, Tang, & Li, 2022; Putra, Fadhlurrahman, & Gunardi, 2023). The preceding researchers concluded that exponential bandwidth is suitable for point datasets to accommodate the varying distances between data points. The exponential function can be expressed as follows:

$$w_j(u_i, v_i) = \sqrt{\exp\left(-\left(\frac{d_{ij}}{h}\right)^2\right)} \quad (8)$$

d_{ij} : The distance between the location with index i and the location with index j is denoted by. The value of h , which is always positive, is a parameter that controls how smooth the function is.

Research Area

This study was conducted in Pekalongan (see Figure 1), a coastal city in Central Java, Indonesia, facing environmental degradation and experiencing a trend of residents leaving. The decline in environmental quality is attributed to factors such as coastal flooding and land subsidence. In relation to flooding, Yulianto et al. (2019) reported that the coastal area within 3 to 5 km from the shoreline is regularly inundated by coastal flooding twice a week. Additionally, Wijaya et al. (2019) have documented that land subsidence is occurring at a rate of 12 cm per year in the coastal region. In line with these findings, various international newspapers and research organizations have predicted a future decline for Pekalongan. For instance, Rayda (2021) reported that Pekalongan could experience sinking by the year 2036. Furthermore, Mercy Corps (2021) projected that coastal flooding might encompass over half of the city's area by 2045.

Furthermore, inhabitants in the coastal areas of Pekalongan are increasingly abandoning their neighborhoods. Employing nexus dynamics, Khairulbahri (2022) observed that households along the coast are relocating to safer areas. This migration outflow is comprehensible given the ongoing degradation of environmental quality, necessitating residents to allocate more budget for adaptation measures such as elevating their houses or, at the very least, their foundations every five years (Marfai, 2014). As the ability of households to adapt varies, the height of houses also fluctuates according to the financial capacity of each family in undertaking adaptation efforts (Buchori et al., 2022). As shown in Figure 2, the abandoned properties are a consequence of the outflow migration.

Analysis and Result

Submarket for Distressed Properties

The first set of questions aimed to investigate how a neighborhood in decline influences the creation of housing submarkets and the succession of property ownership. Firstly, the authors employed spatial cluster analysis to identify housing submarkets based on the similarity of hedonic attributes. The analysis unveiled that declining neighborhoods constituted a distinct housing submarket. This study confirmed the presence of four housing submarkets: two in the inner city and two in the suburban areas (see Figure 7 refer to Appendix 1). The suburban submarket comprised two housing groups, delineated by the inner city submarket. One of these groups resided in the coastal flood-prone area, while the other lived in a safer location. The authors subsequently supervised the clustering process, designating the housing group in the coastal flood-prone area as a new housing submarket, termed the "submarket for distressed properties". Secondly, the authors explored internal housing mobility by screening property tax history and integrating it with the previous housing submarket analysis. This study, as shown in figure 4-1 (A), identified three types of housing displacement across housing submarkets: safe-to-risk displacement, risk-to-safe displacement, and risk-to-risk displacement. Based on the housing displacement and replacement across housing submarkets, the authors then categorized it as "neighborhood succession" (see figure 3 (B)). Through this, the study delved into the phenomenon of anti-gentrification, further elaborated in the subsequent section.

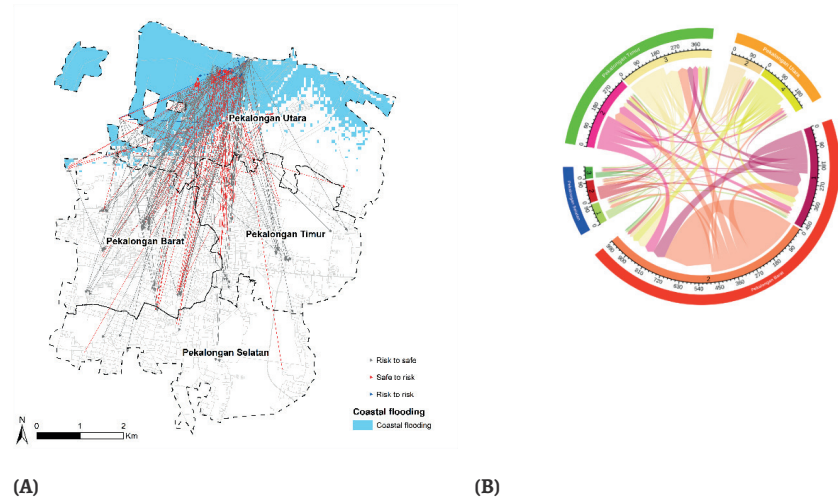
The hedonic attributes indicated that the location and flood risk variables played a significant role in defining the characteristics of each housing submarket. The submarket for distressed property and its neighboring counterpart, situated in the

inner city and termed the submarket for west-inner city, were impacted by coastal flooding and land subsidence. The Submarket for west-inner city was predominantly occupied by middle-to-high-income individuals, while the submarket for distressed property housed low-to-middle-income households, as evidenced by their electricity consumption. Most residents in the submarket for west-inner city subscribed to over 900 kWh of electricity, whereas the majority of households in the submarket for distressed property subscribed to 450 – 900 kWh. The submarket for distressed property had also experienced a loss of amenities, such as a university and stores, which had relocated to safer areas due to coastal flooding. This submarket faced flooding almost twice a week. In contrast, the other two submarkets, the submarket for east-inner city, and suburban areas, are situated in safer areas with minimal flooding occurrences. These two submarkets concentrate urban amenities such as schools, hospitals, markets, and economic services.

Furthermore, property price volatility varies depending on the characteristics of each housing submarket. As shown in Figure 8 (refer to Appendix 1), property prices tend to decrease in the housing submarket affected by coastal flooding, particularly in the submarket for distressed property. The property price decline exceeds 7.4% in the submarket for distressed property, whereas in the submarket for west-inner city, it registers an increase of 2.3%. This is understandable due to the concentration of urban amenities in the submarket for west-inner city. The other two housing submarkets in safer areas, namely the submarket for east-inner city and suburban area, witness increases of 3.4% and 2.5%, respectively. In summary, housing submarkets in safer areas experience rising property prices, while those in flood-prone areas face declining property prices.

To investigate internal housing mobility, the authors integrated the submarkets with the neighborhood succession and observed the displacement across housing submarkets within the city. This combination reveals that the submarket for distressed property serves as both the origin and destination of housing displacement. Approximately 15% of houses have relocated from the submarket for distressed property to neighboring submarkets (submarket for west-inner city), while 12% have moved from this location to safer areas in submarket for east-inner city and submarket for suburban area. Conversely, the submarket for distressed property has also received 24% from the submarket for suburban areas and 12% from submarkets for west-inner city. Consequently, this study affirms that the housing replacement process not only occurs through property owner succession but also through cross-submarket housing displacement. In other words, anti-gentrification through housing replacement was identified in both housing submarkets: the submarket for

distressed property and its nearby neighborhood (submarket for west-inner city). Taken together, these results suggest an association between the emergence of the submarket for distressed property and gentrification. The next section of this study delves into property price heterogeneity and the agents of anti-gentrification.



Notes:

- 1: Submarket for suburban (safer areas)
- 2: Submarket for western inner-city

- 3: submarket for eastern inner-city (safer areas)
- 4: Submarket for distressed properties

Figure 4-1 (A) Housing submarket and (B) Housing displacement and replacement

Anti-Gentrification Agents

The anti-gentrification agents are low-income individuals purchasing properties in vulnerable or at-risk areas. As indicated in Table 4 (refer to Appendix 2), there are three groups of agents categorized by their location and income. In response to location, agents exhibit varying reactions to land subsidence, including decreasing property prices, showing no response, or increasing property prices. However, the remaining variables—flood, slope, and distressed properties—did not exhibit the same distinct influence. Thus, land subsidence had the most significant impact on distinguishing characteristics among communities. The decrease in property prices in reaction to land subsidence was identified in at-risk areas, specifically within the submarkets for distressed properties and the Submarket for west-inner city. Conversely, agents in safer areas, such as the submarkets for east-inner city and suburban areas, did not demonstrate any response to land subsidence. In line with income, lower-income buyers in both the submarket for west-inner city and submarket for distressed properties react by decreasing property prices but do not

exhibit a similar response in safer areas. Figure 4 shows the distinguish of property agents and their response to land subsidence. Meanwhile, the coefficient stability for flood and slope are illustrated in the Figure A.4 (refer to appendix)

The anti-gentrification agents exhibit volatility in both the submarket for west-inner city and the submarket for distressed properties, as depicted in Figure 4-4. In submarket for distressed properties, the increasing number of lower-income agents gentrification was identified in 2013 – 2015 and 2018, then they decreased in 2016 – 2017 and 2019 – 2020. Conversely, the number of this agents exhibited stable in the submarket for west-inner city. One interesting finding is the higher-income purchasers increasing the property price in submarket for distressed properties. The number of this agents increased by 4% from 2013 – 2017 and then decreased by 2% between 2017 – 2022. Meanwhile, the number of this agent in submarket for west-inner city was stable. A potential explanation for this could be that they acquired luxury houses, supported by the fact that one of the largest real estate developers in Indonesia constructed a cluster of luxury homes near the coastal area (within a distance of less than 1 km).

Furthermore, land subsidence emerged as the most influential factor in spatial heterogeneity, evident from the substantial coefficient value and a widespread p-value of less than 0.1. As depicted in Figure 4-5, the significance of land subsidence covered all areas of Pekalongan city. In contrast, the coefficients for flood, slope, and distressed variables were lower than that of land subsidence and were concentrated in specific areas. The significance of flood in relation to spatial hedonic prices was identified in the inner city area, while slope and distressed variables exhibited a significant effect in safer areas. The spatial heterogeneity of property prices may reflect the distinct characteristics of homebuyers, considering that property prices represent the meeting point between supply and demand curves.

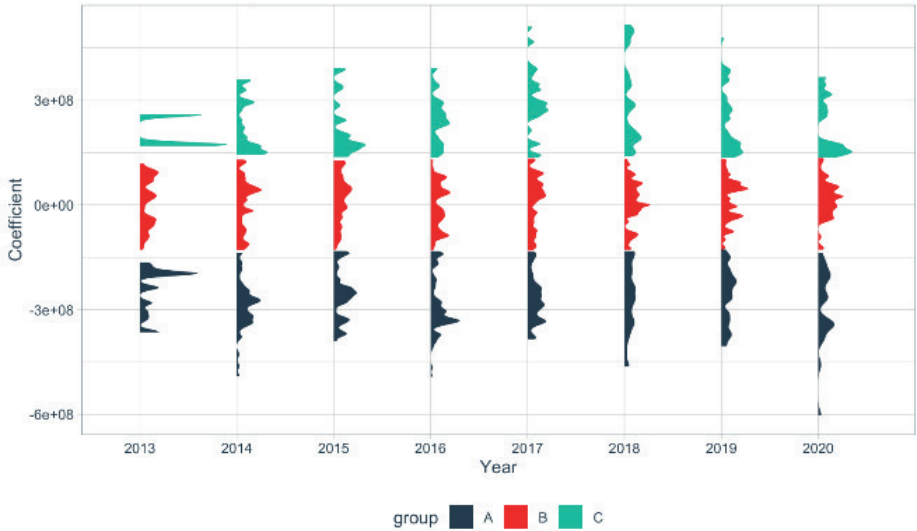
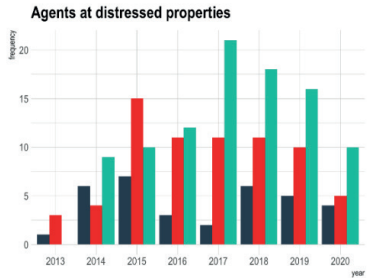
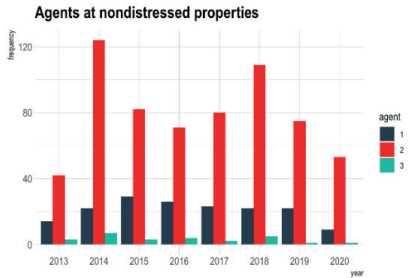


Figure 4-2 Coefficient Stability for Land Subsidence



Communities in submarket for distressed properties



Communities in submarket for west-inner city

Figure 4-3 Property Buyers in Submarket for Distressed Properties and Submarket for West-Inner City

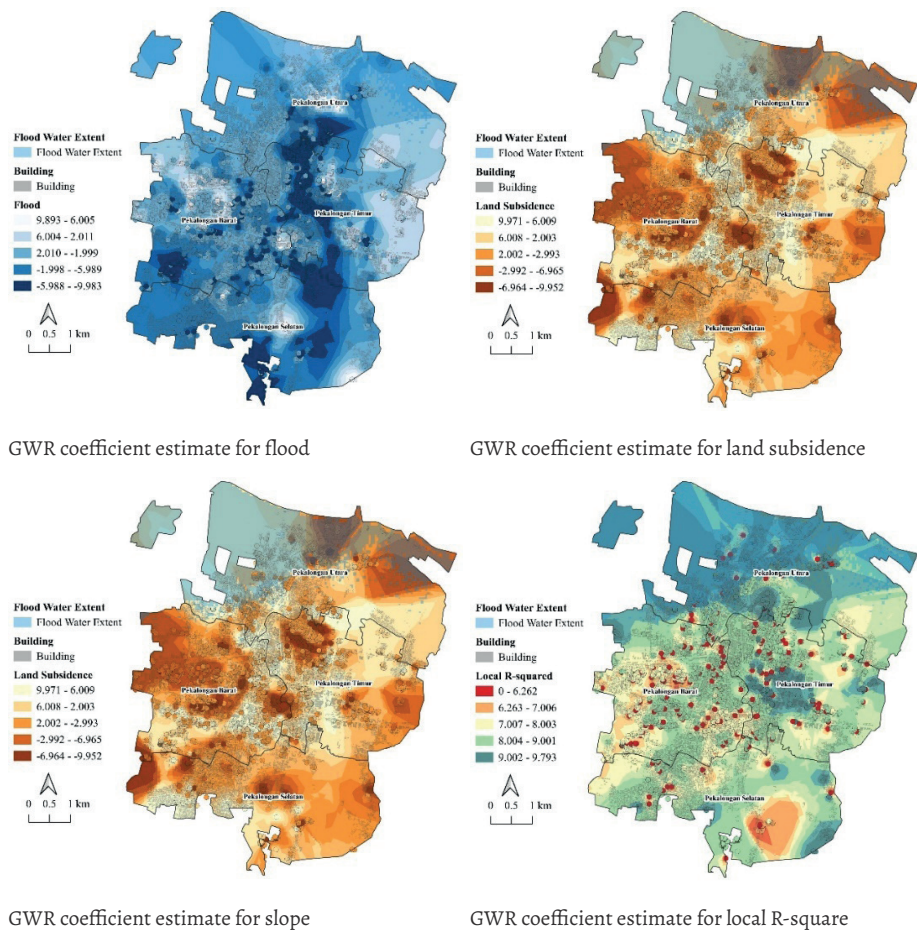


Figure 4-4 Spatial Heterogeneity of Property Price

Discussion and Conclusion

This study unveils that anti-gentrification through housing replacement appears to have an interaction with the emergence of the submarket for distressed properties. A critical finding, highlighted by property ownership change and internal housing displacement, is that anti-gentrification occurs through both ownership succession and cross-submarket housing displacement. Perhaps the most interesting finding is that housing displacement in the submarket for distressed property is followed by replacement by new housing purchasers. This finding is consistent with the previous study by Desai (2021) on property transactions in distressed or slum areas. Additionally, it contributes new insights to the findings of Buchori et al. (2018),

suggesting that housing displacement in coastal flood-prone areas is subsequently followed by replacement. Moreover, the emergence of the property submarket for distressed properties also aligns with the findings of Rajapaksa et al. (2016) from coastal flooding.

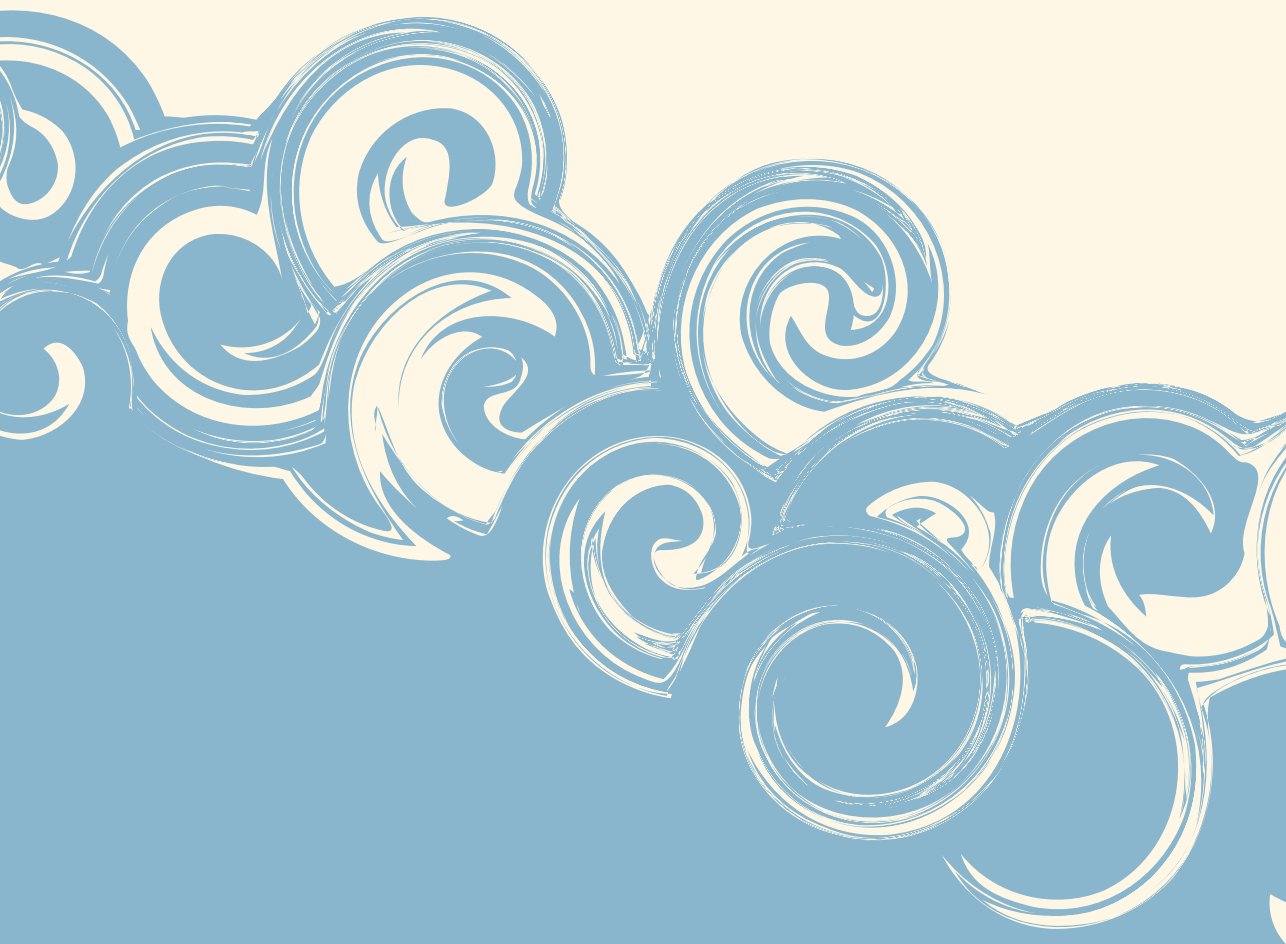
Furthermore, the combination of housing submarkets and housing displacement reveals that internal housing mobility is cross-submarket, providing a clear understanding of how housing submarkets emerge in distressed properties. Low-income purchasers in distressed properties could arguably be considered as anti-gentrification agents who replace the displaced middle-to-upper-income households. This result offers a fresh perspective in line with Brasington (2021). It suggests that instead of placing a primary emphasis on the destination of relocation, we can gain a better understanding of distressed properties by focusing on the residents are leaving.

Analysis of property tax history data in this study revealed that households displaced from the submarket for distressed property subscribed to more than 900 kWh, which could be considered middle-income individuals. On the other hand, the households primarily replacing them in this submarket subscribed to 450 kWh, suggesting they could be classified as low-income households. Consequently, this situation arguably explains the anti-gentrification phenomenon. In line with the current findings, previous studies have indicated that housing displacement from coastal areas on the north coast of Java was reported by Buchori et al. (2018) due to coastal flooding adaptation and anticipation. Meanwhile, the finding related to housing replacement aligns with the study conducted by Permana and Miyata (2008) from a different perspective. Permana and Miyata (2008) investigated housing replacement in illegal housing experiencing river flooding in Palangkaraya (Indonesia), while our study focused on legal housing facing coastal flooding.

The most obvious finding is the heterogeneity of housing purchasers lowering the price. This study also reveals that some purchasers do not response coastal flood risk variables by lowering the price. These results in line with those of previous studies about existence of non-spatial equilibrium in the housing submarket (Bhattacharjee et al., 2016; Kopczewska & Ćwiakowski, 2021; Changshan Wu & Sharma, 2012). This study also exhibits the similar evidence that some agents do not response the risk by lowering the price, in contrast they even increasing the price. A possible explanation for this might be because they live in safer neighborhood within risky areas. By this, the water paradox either as amenities or as dis-amenities explained by Rajapaksa et al. (2017) perhaps can explain the phenomenon.

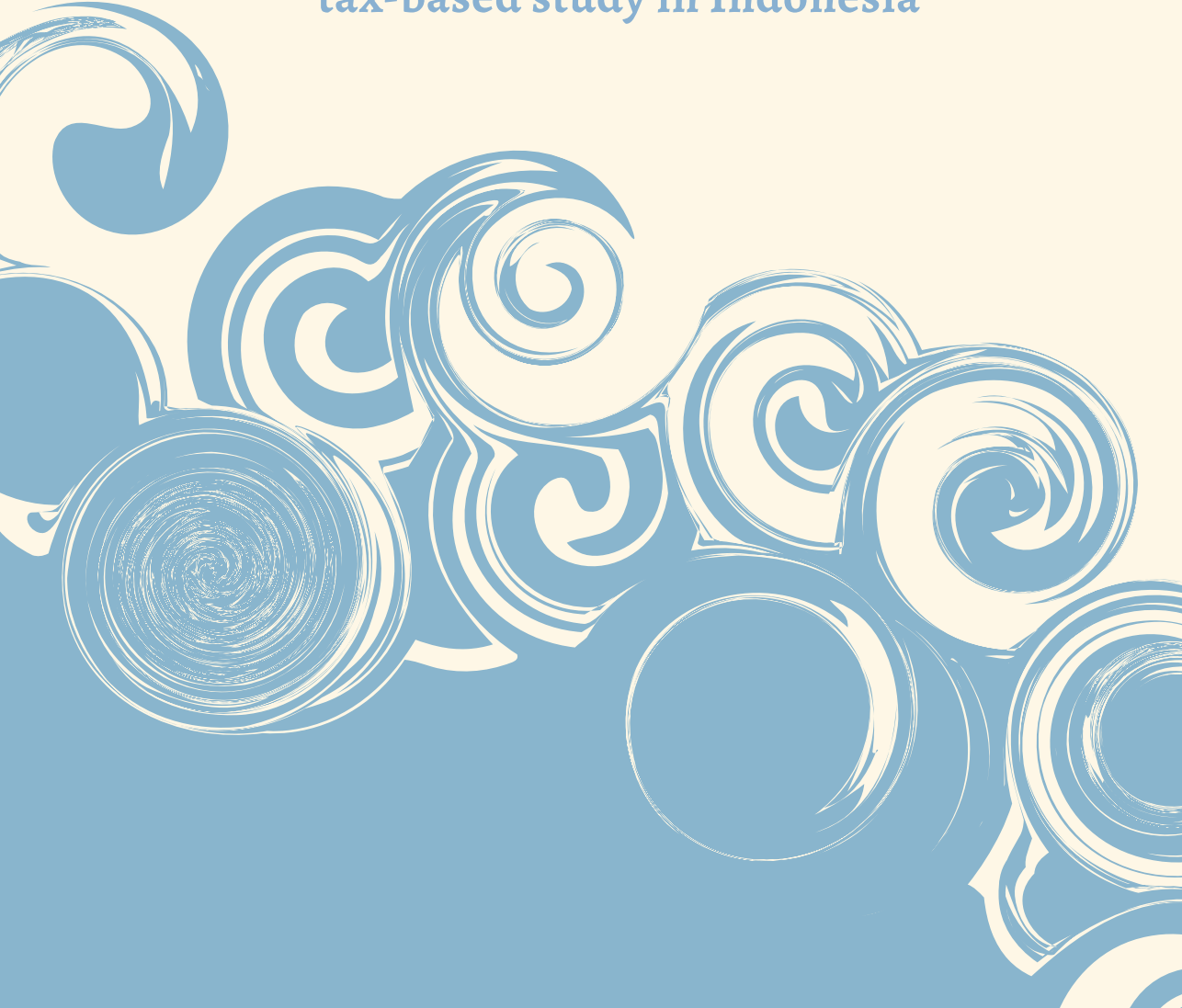
Yet, the most communities' responses the coastal flood risk by lowering the price. These findings support Filatova et al. (2011) who find that property price decrease occurs in coastal flood risk areas. One interesting finding is the role of distressed properties that also influence the property price. Although, the relationship is non-statistically significant ($p\text{-value} > 0.1$), the existence of distressed neighborhood may could be considered as the driver of housing displacement and replacement by which neighborhood change in coastal flood prone areas could be understood better. Perhaps, it is the most compelling finding instead of coastal flood risk variables. With respect to Tobin and Newton (1986) who explain that flood risk could be capitalized on property price through land use, flood frequency and flood severity, this study may could explain the risk capitalization through flood severity with considering the fact that distressed properties are found in research area.

However, this study has at least four limitations. Firstly, it did not explore the relationship between housing displacement and flood risk variables. It remains unclear whether all buyers respond in the same way to coastal flood risk when deciding to relocate. Secondly, while we gain a better understanding of how displaced households to distressed and nearby areas impact property price decreases, the impact of displaced families from risky areas to safer areas is still uncertain. Do they contribute to increasing property prices as gentrification agents? Thirdly, this study did not measure the speculation of property demand. Lastly, while this study confirms that distressed properties are suffering in the property market, what remains unclear is whether this distressed property market influences urban growth.



CHAPTER 5

Housing displacement and replacement
in coastal flood-prone areas:
evidence from a land and building
tax-based study in Indonesia



Abstract

Our chapter uses land and building tax history to illustrate housing displacement and replacement in response to coastal flood risk. To understand residential mobility, we use the cost-benefit model to examine whether housing behavior is dependent on rational economic decisions. Given that most research on property responses in at-risk areas focuses on price changes rather than site relocation, we aim to address this gap by investigating voluntary residential relocation induced by the property market's response in a flood risk area. The study data originate from the coastal city of Pekalongan (Java, Indonesia), which is increasingly vulnerable to coastal flooding. From 493,065 data points on tax payment history, we found that 181 houses were displaced from 2015 to 2020 because of coastal flood risk. We employ multinomial logistic regression to measure the correlation between flood risk variables and displacement decisions. The r-square is 0.897, which could be considered statistically robust. Furthermore, the model demonstrates that the flood risk variables affect a higher number of middle-income people than lower-income inhabitants regarding the decision to displace. This chapter may support the current discussion on spatial adaptation from a property market point of view.

Keywords: Displacement; Replacement; Property Market; Land And Building Tax

This chapter has been published as a research article in the Resilient compensation and restitution for post-disaster recovery in Asia and the Pacific. The reference is: Sariffuddin, S., Samsura, D. A. A., Krabben, E. v. d., Setiyono, B., & Pradoto, W. (2023). Housing Displacement and Replacement in Coastal Flood-Prone Areas: Evidence from a Land and Building Tax-Based Study in Indonesia. In P. Tiwari, D. B. Rahut, & K. S. Ram (Eds.), Resilient compensation and restitution for post-disaster recovery in Asia and the Pacific. Asian Development Bank Institute. <https://doi.org/10.56506/DWKU4071>

Growing pressure is being placed on policymakers to involve property markets in flood risk management by providing more room for water. Regarding coastal flood risk, rapid urbanization in at-hazard areas is causing a housing market boom, and the incidence of coastal hazards, such as uncontrolled land use change, is increasing. Therefore, many experts think that the property market should adapt to coastal flooding in response to the exponential growth of coastal vulnerability. Voluntary action of the property market, often called autonomous adaptation, is needed for adapting to coastal flooding (Filatova, 2014). For example, Wolff et al. (2020) argued that land-use change would be a new exposure for coastal cities, supporting the argument that coastal flooding is not only a hydrometeorological disaster but also an anthropogenic issue (Daniel et al., 2009). Given that potential loss and damage are strongly associated with land use, autonomous adaptation should complement planned adaptation for flood risk management (Filatova, 2014). This concept is in line with the recent debate about how risk management should focus more on managing vulnerability receptors (including the property market) than using engineering defenses for flood protection (Sayers, 2017).

International experience shows that the shift from flood protection to flood risk management is receiving attention in many countries for being more suitable and offering complementary engineering measures. Flood risk management can be interpreted from two perspectives: hydrological and planning policy (Schanze, 2006). The hydrological perspective emphasizes using engineering measures to regulate water flow for flood protection, especially “keeping water away from land” and “defending against floods,” (Löschner & Nordbeck, 2020). In contrast, the planning policy perspective serves as a complementary measure by considering risk analyses for decisions and actions to mitigate the residual risk of flood protection (Sayers, 2017). However, it is also important to acknowledge that spatial adaptation plays a vital role in flood risk management (Filatova, 2014) through the active adaptation of individual households before and after purchasing their houses in flood-prone areas. Keeping these points in mind, it is possible that individuals’ voluntary displacement to avoid flood-prone areas could be considered as the property market’s active role in supporting spatial adaptation. People move from dangerous locations to safer areas to reduce risk and achieve individual equilibrium by adjusting their household expenditures (Brasington, 2021; Hunter et al., 2015).

From an economic perspective, adaptation is an extra cost that directly influences the balance of family expenses. Hence, Mendelsohn (2000) proposed the cost-benefit model that housing displacement is only one attempt of households to find their new individual equilibrium in housing consumption. In this model, housing displacement

can be interpreted as decisions that individuals make as economic agents to reduce extra housing consumption costs, which is, at a minimum, a balance between marginal benefits (MB), marginal costs (MC), and marginal externalities (ME). When individuals face spending inequality due to adaptation, they make rational decisions based on economic conditions (Filatova, 2014; Fujita & Thisse, 2013). This concept also serves as the framework for effective adaptation to climate change (Mendelsohn, 2000) and a market-based instrument for flood risk management (Filatova, 2014) that informs flood risk through price signals. Instead of being a command-and-control system, this alternative approach is a response to the lack of flood risk perception for most coastal flood risks due to dissonant perception (Filatova et al., 2011).

Many studies have demonstrated the valuable contribution of housing adaptation through residential mobility and immobility. Marfai et al. (2008) thoroughly investigated residential immobility adaptation in the form of house and floor elevations and mini-dam construction. They found that local community capacity, including economic viability, plays an essential role in household adaptation. Survey-based evidence also shows that coastal flood risk influences housing displacement. For example, using questionnaires to investigate residential mobility adaptation, Buchori (2018) found that vulnerable people move to safer areas to mitigate risks. However, according to interview survey data, Quinn et al. (2018) concluded that the main reason individuals move is to improve quality of life by increasing their income. Unfortunately, most of this previous research does not account for whether these individuals' relocations are permanent. What remains unclear is whether their original locations become abandoned areas with no property sale transactions. Additionally, no clear information exists regarding whether housing succession occurs in at-risk areas. This lack of information is understandable because the previous investigations employed aggregated statistics with survey-based evidence (questionnaires and interviews). Therefore, according to land and building tax data, housing-based relocation can be generalized as permanent house-based relocation, and disaggregated data could address these knowledge gaps.

Research has also associated housing displacement decisions with relocation destinations. This tendency is not surprising because most studies pay more attention to where people move rather than their origins or where they move from. For example, Loughran and Elliott (2019) examined people's relocating destination after they accepted residential buyouts in Houston, Texas, without investigating the condition of abandoned areas. Regarding residential mobility literature, Brasington (2021) summarizes three factors that need to be considered in the study of property displacement, namely "whether to move," "where to move," and "what to move

into.” Given that facts about housing immobility indicate that abandoned areas are still habitable for particular people, it is essential to investigate abandoned areas, especially because some researchers have identified the replacement phenomenon in Palangkaraya (Permana & Miyata, 2008) and Bangladesh (Braun & Aßheuer, 2011). However, limited evidence exists of a correlation between relocation and coastal flood risk in abandoned areas.

To address this gap, our population-based research study aimed to examine the correlation between coastal flood risk and housing displacement and replacement. We used the innovative method of examining land and building tax history, and we hypothesized that property displacement would correlate with coastal flood risk.

Private Adaptation: Housing Displacement and Replacement

Housing displacement is only one adaptation strategy of households as economic agents (Black et al., 2011) to adjust their housing consumption (Hanushek & Quigley, 1978; D. Wang, He, Webster, & Zhang, 2019). This idea has been widely discussed and is associated with climate change (Call & Gray, 2020; Walelign & Lujala, 2022), the labor market (Chan, O'Regan, & You, 2021), residential satisfaction, stress (D. Wang et al., 2019), and crop failure (Gray & Mueller, 2012). For example, Cattaneo et al. (2019) demonstrated that income loss caused by crop failure led people to look for new land for agricultural purposes. Another example is that residential buyout programs for households in flood-prone areas in the United States stimulate voluntary relocation (Loughran & Elliott, 2019). However, numerous studies have also noted that many people stay in flood-prone areas because of economic constraints (Blondin, 2021; Cundill et al., 2021; Piggott-McKellar & McMichael, 2021). Therefore, the private adaptation model could serve as a framework to explain relocation as an adaptation strategy.

In the field of urban economics, Winstanley et al. (2002) divided the literature on residential mobility into three approaches: the life-cycle model, cost-benefit model, and neighborhood change model. Given the financial consequences for all models, Brasington (2021) argued that researchers can reduce those three models into a cost-benefit model if the losses and benefits can be defined appropriately. In the cost-benefit model, housing displacement could be explained by expenditure adjustments for housing consumption determined by rental value, including the purchases for residential use (Ahlfeldt, 2011; Alonso, 1964). If a household experiences a property value adjustment, relocation to an urban area, and transportation costs, it will adjust its expenditure to balance income and expenses, moving to a safer area to do so. It also explains the paradoxical housing displacement of individuals from safe regions

to risky areas in Palangkaraya (Permana & Miyata, 2008). As a result, displacement is a coping mechanism of private adaptation (Black et al., 2011) for achieving individual equilibrium.

Mendelsohn (2000) argues that efficient adaptation can only be achieved if the cost is less than the resulting benefit. Since adaptation requires additional charges, people try to adjust their expenses accordingly. From the perspective of private adaptation, individual equilibrium is an attempt to make the marginal benefit (MB) greater than the marginal cost (MC) and marginal externalities (ME) or to balance the MB and $MC + ME$. This model also underlies the market-based instrument for flood risk management before an individual household decides to buy a house (Filatova, 2014). When homebuyers have to pay extra for adaptation by purchasing insurance (for example) before the transaction, it is expected that they will decide rationally. This assumption is based on the postulated rational behavior of price-takers (Fujita & Thisse, 2013). Behavioral changes for private adaptation occur quickly due to expenditure adjustments for achieving individual equilibrium.

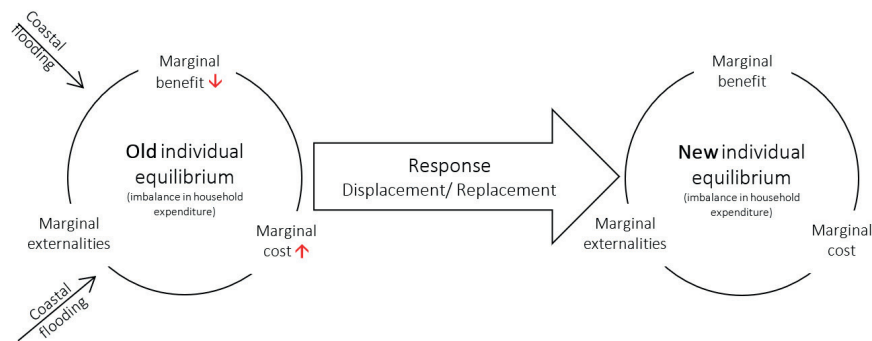


Figure 5-1 The Conceptual Framework of Property Displacement for Individual Equilibrium

With these points in mind, displacement can be understood as the individual household behavior in deciding whether to relocate. Therefore, housing displacement for adaptation could be considered to be voluntary private adaptation. Leaving or avoiding flood risk areas is A form of location-based adaptation occurs when people leave or avoid flood risk areas to lower risks to improve individual equilibrium. Filatova (2014) emphasized that flood risk management can be achieved through land-use adaptation, as the property market plays an essential role in spatial patterns. Inspired by Black et al. (2011), we propose a conceptual framework of housing displacement for individual equilibrium (see Figure 5-1).

Methods

Data and Variables

We obtained the housing displacement and replacement data by screening the land and building tax history to obtain the property ownership changes ($n = 493,065$) from 2015 to 2020. Researchers generally agree that a tax payment for a property indicates that the property owner is a permanent resident (Firman, 2004). Fussell (2014) employed a similar method in using data from the Internal Revenue Service (IRS) and Statistics of Income Division (SOI). Our search process was based on the identity number of the land tax (Bahasa: nomor obyek pajak; NOP) and the tax payment history. To reduce the large dataset, we screened the changes of property ownership using the available taxpayer information, either name, single identity number (Bahasa: nomor induk kependudukan; NIK), or tax identification number (Bahasa: nomor pokok wajib pajak; NPWP). By doing so, we were able to illustrate the housing displacement and replacement in geographic and statistical visualizations. In addition, we collected data on household experiences from the tax payment records. We used electricity subscription as a proxy for household income data, as energy consumption is an excellent source of information on the welfare of people in Indonesia (Deutsch, Silber, Wan, & Zhao, 2020; Sambodo & Novandra, 2019). Using previous research results, we classified flood-prone areas according to the physical coastal characteristics strongly associated with risk, including slope (Bao, Gayes, Pietrafesa, & Ieee, 2018; Martínez-Graña, Boski, Goy, Zazo, & Dabrio, 2016), land subsidence (Catalao, Raju, & Nico, 2020; Miller & Ravens, 2022), and proximity to the shoreline (Bosker et al., 2019; Y. Zhang et al., 2010).

We gathered data for all the variables with the understanding that household displacement is an adaptation measure (Black et al., 2011; Hunter et al., 2015) carried out by individual households as economic agents (Brasington, 2021) to achieve personal equilibrium for household consumption (Hanushek & Quigley, 1978). Since displacement is motivated by socioeconomic factors (Brasington, 2021), we also considered adaptation ability, determined by finances, experience, and education (Adger & Vincent, 2005) as control variables. Rogers et al. (2020) and Pathak (2021) examined the impact of economic viability on possible adaptation solutions, and some researchers have confirmed that flood experience influences adaptation mechanisms (Budhathoki, Paton, A. Lassa, & Zander, 2020; Budhathoki, Paton, Lassa, Bhatta, & Zander, 2020; Ullah, Saqib, Ahmad, & Fadlallah, 2020). Because this study was based on property-level adaptation and data regarding education were unavailable, we agreed that economic and income factors would be more appropriate (Hudson, Bubeck, & Thieken, 2021) than education.

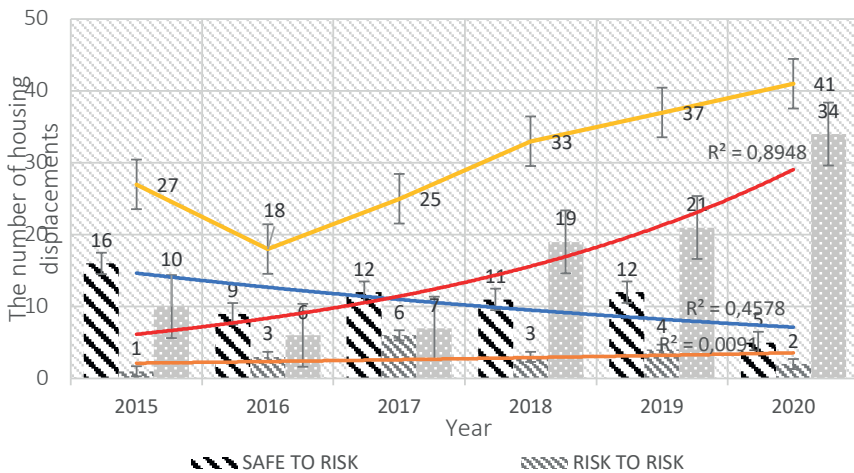
We gathered data from the authorities of Pekalongan City (Indonesia) and through remote sensing. The local government provided tax-due notification letters (Bahasa: surat pemberitahuan pajak terhutang; SPPT) from 2015 to 2020, which we call the land and building tax history. We investigated previous research that used similar data to study the optimization of original income in Aceh (Fitriyeni, Kadir, Bahri, & Sufyan, 2020) and to estimate the tax value of buildings and land in Jambi (Delis & Hodijah, 2015). As proxy data for household income, we collected data from the municipality on electric power subscriptions from the building construction permits (Bahasa: Ijin mendirikan bangunan; IMB). We used simple remote sensing to extract slope and land subsidence data, and we used the Sentinel-1 data captured on 17 February 2017 and 4 December 2019, provided by European Space Agency (ESA), to model the land subsidence using the Sentinel Application Platform (SNAP 8.1). We renewed the land subsidence model previously carried out by Andreas et al. (2017), and we used the same method to extract slope data from the digital elevation model provided by DEMNAS Indonesia (national digital elevation model) using QGIS (Quantum Geographically Information System) 3.20.2. We also used the research by Syam et al. (2021) on climate risk and impact assessment of Pekalongan, Indonesia. They mapped flooded areas using a combination of sea-level rises, surface topography models, land subsidence, and land use.

Statistical Analyses

We used rStatistics (version 4.1.2) to perform statistical analysis. The dependent variable (y_{ij}) includes categorical data for housing displacement: risk-to-risk, risk-to-safe, and safe-to-risk displacement. The independent variables (x) include numerical data for land subsidence (x_i [meters]), proximity to the shoreline (u_{ij} [meters]), and slope (e_{ij} [meters]). The control variables are household electricity (w_{ij} [kWh]) and experience (p_{ij} [years]). We performed a multinomial logistic regression to estimate the odds ratio (OR) of housing displacement with 95% confidence intervals (95%CI). This study determined significance of the statistical model at $p < 0.05$. In previous research by Jarvis (2018), Gabriel and Painter (2008), and Jiang et al. (2009), the authors carried out similar methods. According to Nagayasu (2021) we can interpret housing displacement as choosing the location randomly, assuming the location decision for displacement is unordered. Retrieved from Nagayasu (2021), the fundamental equation of multinomial logistic regression is expressed in Equation 5.

Results

A total of 181 houses were displaced from 2015 to 2020 ($n = 493,065$), and a sharp increase occurred from 2017 to 2020 (38%). In contrast, displacements from risk-to-risk and safe-to-risk tended to decrease, even though displacements from risk-to-risk increased in 2017 (6 houses). After 2017, both risk-to-risk and safe-to-risk displacements tended to fall. Figure 5-2 shows the number of housing displacements from 2015 to 2020 divided into displacement patterns. Essential differences existed between risk-to-safe and safe-to-risk displacements, and 38% of average housing was displaced from safe-to-risk locations. However, housing displacements in risk-to-risk areas were mostly constant, even though the number increased (24%) in 2017. This result might have been a response to the embankment building that was constructed in 2016. The safe locations as displacement destinations included Pekalongan Barat (45%), Pekalongan Selatan (32%), and Pekalongan Timur (23%). Pekalongan Barat has become a favorable displacement location possibly because of urban facilities, which is one consideration in housing consumption (Hanushek & Quigley, 1978). In contrast, safe-to-risk displacements also originated from Pekalongan Barat (22%), Pekalongan Selatan (37%), and Pekalongan Timur (41%).



Expon : Exponential Functions

Figure 5-2 Housing Displacements in Response to Coastal Flood Risk (2015–2020)

Comparing the three displacement patterns revealed risk-to-safe relocation in the form of group movement, while the other two patterns were individual displacements. Households that moved from risk-to-safe came from adjacent neighborhood groups indicated by the same zone according to identity numbers of land tax (Bahasa:

Nomor objek pajak; NOP), whereas the households that moved both from risk-to-risk and safe-to-risk came from scattered individual households. Both risk-to-risk and safe-to-risk replacements tended to replace abandoned areas, and they displaced an average of 3 to 5 km from their original location. This pattern might have occurred because of less destructive slow-onset flooding and perceptions of low risk among the community (Syam et al., 2021). Figure 5-3 shows the relocation visualization and geographical relocation of house displacement within the city of Pekalongan.

This section describes the housing displacements and replacements. As mentioned in the methods section, this study used property tax history to screen property ownership using the unique numbers of property tax identities (Bahasa: nomor objek pajak; NOP), which are also embedded on each house parcel. Property tax history provided two critical pieces of information for this study; (a) tax payments and (b) property ownership records. The tax-due notification letters housing displacements and replacements according to the property ownership succession on each house parcel. Using geospatial data of housing parcels, we illustrated the residential mobility and recognize that new property buyers occupied the sold houses. In short, there is no doubt that housing replacement occurred in coastal flood risk areas.

In this section, we draw together displacement decisions and coastal flood risk variables. We begin with flood zone, slope, and land subsidence. Figure 5-3 (right) shows risk-to-safe displacements (black lines), safe-to-risk displacements (red lines), and risk-to-risk displacements (blue lines). These migration lines also illustrate housing replacement, indicated by the arrows. The origins of the black lines are similar areas that experienced coastal flooding, and the destinations of the red lines are abandoned areas (the origin areas of the black lines).

Further analysis showed that the risk-to-safe housing displacements tended to avoid 0–5 m of slope and move to elevations of 16–25 m in Pekalongan Barat, Pekalongan Selatan, and Pekalongan Timur. The highest slope destination was 30 m, in Pekalongan Selatan, while the lowest slope destination was 20 m, in Pekalongan Barat. Both the risk-to-risk and safe-to-risk displacements tended to occupy 0–5 m of slope in a similar area of Pekalongan Utara. A similar situation occurred regarding land subsidence. In the destination area for risk-to-safe displacement, land subsidence was about -5 cm in Pekalongan Selatan, Pekalongan Barat, and Pekalongan Timur. In Pekalongan Utara, the land subsidence for risk-to-risk and safe-to-risk displacements was about -2 cm. Although most of our findings support Andreas et al. (2017), this study also revealed a 40–60 cm subsidence in certain areas

(see Figure 5-4). After displacement, most household origins experienced a land subsidence of 40–60 cm. They moved to West Pekalongan and East Pekalongan, which had a lower land subsidence of 10–20 cm and 20–30 cm, respectively.

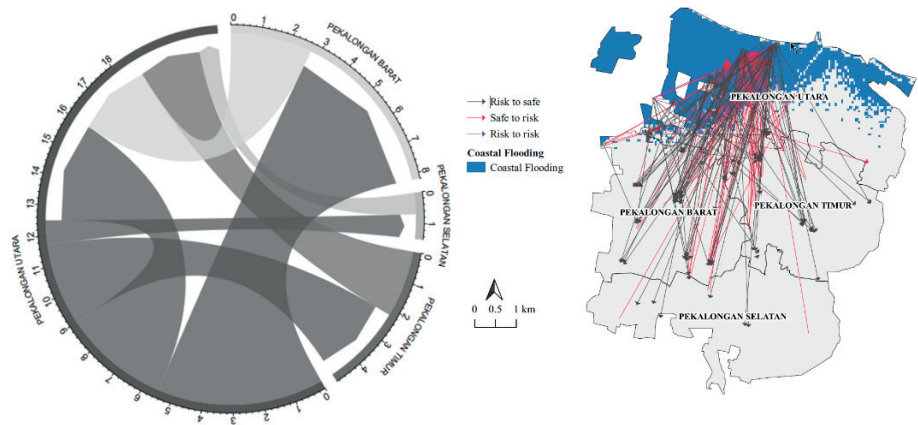


Figure 5-3 Internal Housing Displacement

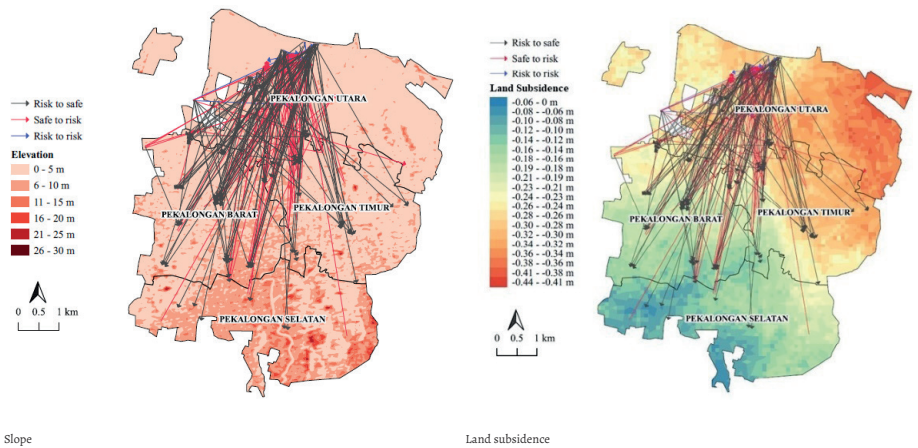


Figure 5-4 Coastal Flood Risk and Property Displacements

Further analysis revealed that income and experience strongly influenced risk-to-safe displacements but not risk-to-risk and safe-to-risk displacements. Most individual

households displaced from risk-to-safe areas subscribed to 900–1,300 kWh, which we defined as medium-income inhabitants. Displaced houses from risk-to-risk and safe-to-risk subscribed to 450 kWh, which we defined as low-income inhabitants. This finding indicates that middle-income people tended to move from risk-to-safe areas, and the low-income people replaced them. Experience is another essential aspect of socioeconomic factors. Experienced people (those living in flood risk areas more than ten years) tended to relocate to safe areas. The longer middle-income people had resided in flood risk areas, the more likely they were to migrate to safer areas, and the less experienced low-income communities tended to replace them.

A multinomial logistic regression was used to explain the relationship between the decision to displace and coastal flood risk variables. Table 5-1 shows the results for three forms of housing displacements. The risk-to-risk displacement was the reference for the statistical model. The r -squared is 0.897, so it can be considered a robust statistical model. The p -value of most of the coastal flood risk variables is <0.001 . Thus, we interpret the variables to be statistically significant, influencing the dependent variable. In this model, the variable of proximity to the shoreline has a p -value of 0.170 (>0.05), which is not statistically significant. In safe-to-risk displacements, all variables of coastal flood risk have a p -value greater than 0.05. Therefore, we interpret them to be not statistically significant in explaining the dependent variable. Based on the p -value (statistically significant, <0.005), coastal flood risk influenced only the property displacement from risk-to-safe areas. The property owners had higher odds ($OR[95\%CI] = 0.32094$) of relocating to higher slopes than those relocating from risk-to-risk areas. Those with higher incomes had higher odds ($OR[95\%CI] = 0.35051$) of relocating to higher regions than those from risk-to-risk displacements. The variable of land subsidence ($OR[95\%CI] = 2.25e-08$) and experience ($OR[95\%CI] = 0.00030$) also influenced the decision of risk-to-safe displacement, and higher than those relocating from risk-to-risk areas.

In this chapter, we argue that residential mobility is only one adaptation process of households as economic agents. To explore this idea, this study also employed two controlled adaptation variables: experience and income. As can be seen in Table 5-1, the two variables are significant contributory factors to the decision to displace from at-risk to safe areas. Furthermore, this result shows that experience in middle-income people positively correlate with coastal flood risk variables (land subsidence and slope). In summary, we interpret the results to mean that middle-income inhabitants considered coastal flood risk and avoided moving to high-risk areas. The two controlled variables did not significantly contribute to safe-to-risk displacements.

Table 5-1 Multinomial Logistic Regression

Predictors	Reference: risk-to-risk displacement			
	risk-to-safe displacement		safe-to-risk displacement	
	Odds Ratios	P	Odds Ratios	P
(Intercept)	0.00	<0.001	0.20	0.343
Land subsidence	0.00	<0.001	1.32	0.263
Proximity to shoreline	1.19	0.170	1.00	0.234
Slope	0.32	<0.001	1.87	0.191
Experience	0.00	<0.001	1.31	0.187
Electricity (welfare)	0.35	<0.001	1.31	0.532
Observations	154			
R ² Nagelkerke	0.897			

Discussion

This study indicates that housing replacement underlies displacement through the succession of house ownership and that three kinds of coastal flood risk affect housing mobility: risk-to-risk, risk-to-safe, and safe-to-risk displacement. The critical finding, demonstrated by house ownership successions recorded in tax history, is that individuals in risk-to-safe displacements were replaced by inhabitants in safe-to-risk displacements. Middle-income people in at-risk areas sold their houses, which were then occupied by lower-income inhabitants. This evidence of risk-to-safe displacement supports the previous research of Buchori et al. (2018), who investigated migration patterns in Semarang, on the north coast of Java, Indonesia. The replacement finding also supports the work of Permana and Miyata (2008) from a different point of view. They investigated the replacement phenomenon in illegal housing, whereas we conducted this research on legal housing, as indicated by tax payment history. In summary, this study adds to the previous knowledge that replacement is an important part of housing displacement.

Moreover, housing replacement occurred because of the succession of house ownership in at-risk areas. This study also confirms an emergence of a used-property market in at-risk regions, which is potentially favorable for low-income people because of its lower prices. Thus, the house displacement in our study (risk-to-risk and safe-to-risk) contrasts with that of Brasington (2021), who argued that adaptation is an extra cost that influences the individual equilibrium. The individual

equilibrium model suggests that people displace from situations that impose higher costs for adaptation (and added marginal costs) to situations with lower or no costs, and the need for shelter, the most basic dwelling requirement, could explain this situation. Van Ham (2012a) argued that even though housing customers have many choices, the actual market choices are limited, and house buyers' choices depend on opportunities and constraints in the housing market, including their financial housing consumption abilities.

Another significant result is that the middle-income inhabitants responded more to coastal flood risks than low-income inhabitants. Risk-to-safe displacement provides deeper insight into the rational behavior of housing adaptation (Filatova, 2014; Fujita & Thisse, 2013), and we interpret the results to mean that middle-income people might consider risk in their decision in an economically rational manner, and lower-income people might not. This situation indicates that the property market still exists in flood-prone areas, especially for transitioning used houses of middle-income people to low-income inhabitants. A strong possibility exists that the situation will increase coastal vulnerability because of low-income people deciding to live in flood-prone areas. Indeed, this finding supports Wolff et al. (2020) in that the land-use issue is the next exposure in coastal studies. Also, Daniel et al. (2009) supports the idea that coastal flood risk is not only a hydrometeorological disaster but also as an anthropogenic issue.

Another important finding is that group relocation occurs because of coastal flooding. People relocate from similar zones of residential areas, albeit at different times. It is possible that the areas become non-habitable due to sinking, which is influenced by land subsidence and sea-level rise. Therefore, this study supports Black et al. (2011) in highlighting the environmental influence of non-habitable areas as a driver of migration. Of course, group relocation also indicates that the problem occurs in a particular area and impacts most inhabitants.

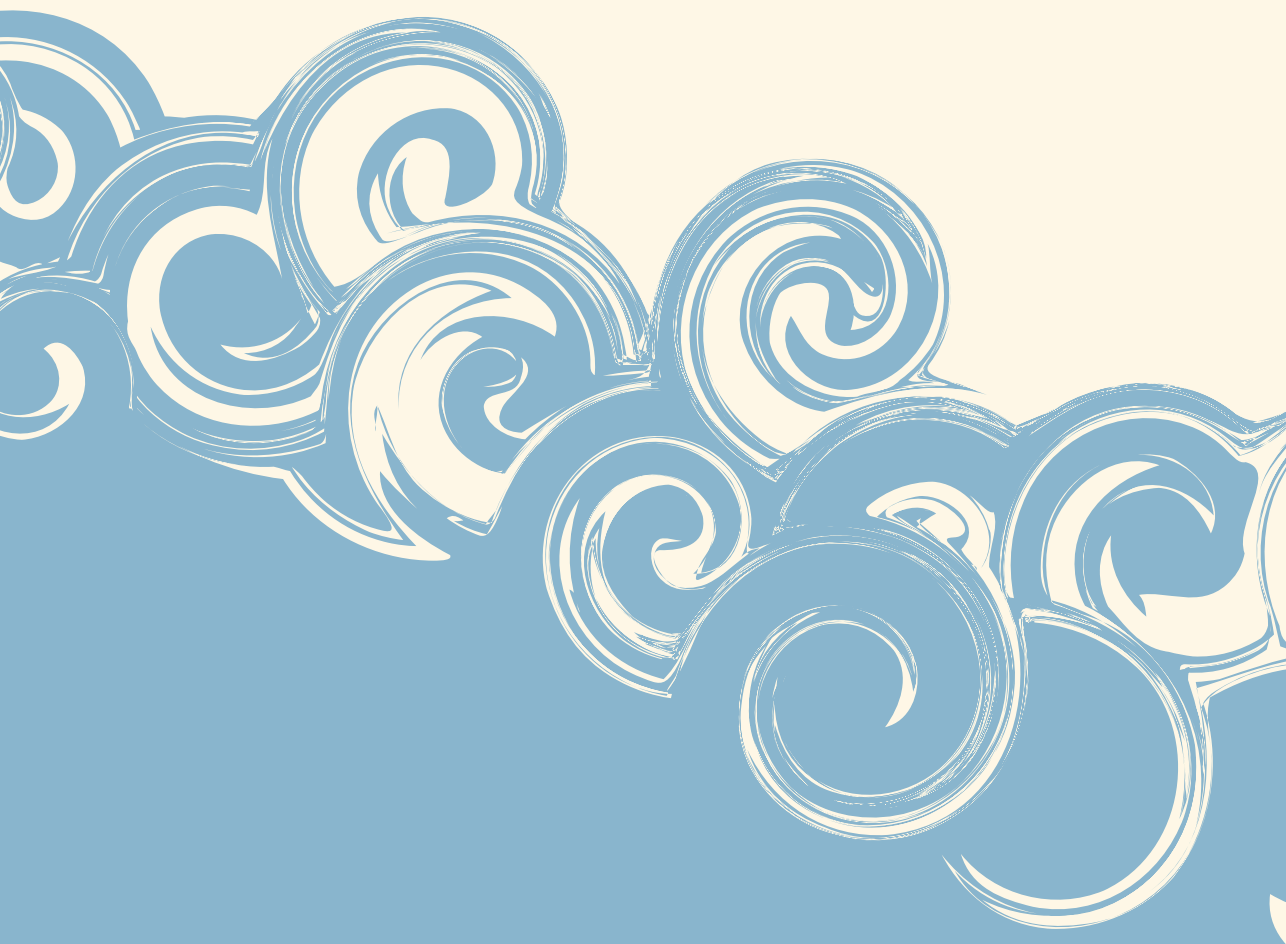
This chapter also confirms that income influences the rational decisions of individual households as economic agents in response to coastal flood risk. It has been demonstrated that risk influences housing behavior, although it occurs mostly in the middle-income groups of society (Fujita & Thisse, 2013), and low-income inhabitants might replace the middle-class inhabitants for a similar purpose: individual equilibrium (Permana & Miyata, 2008). Concerning our statistical results, we also found that the influence of coastal flood risk on property displacement decision is low, even though the variable is significant ($p\text{-value} < 0.001$). It might be that other factors determine the decision to relocate instead of considerations based

on the cost-benefit model. There might be phenomena of replacement rather than displacement because our research areas were in zones of slow-onset flooding. Our study shows that the property market is not absent in abandoned regions, as these locations are often occupied by low-income people who ignore flood risks.

Conclusion

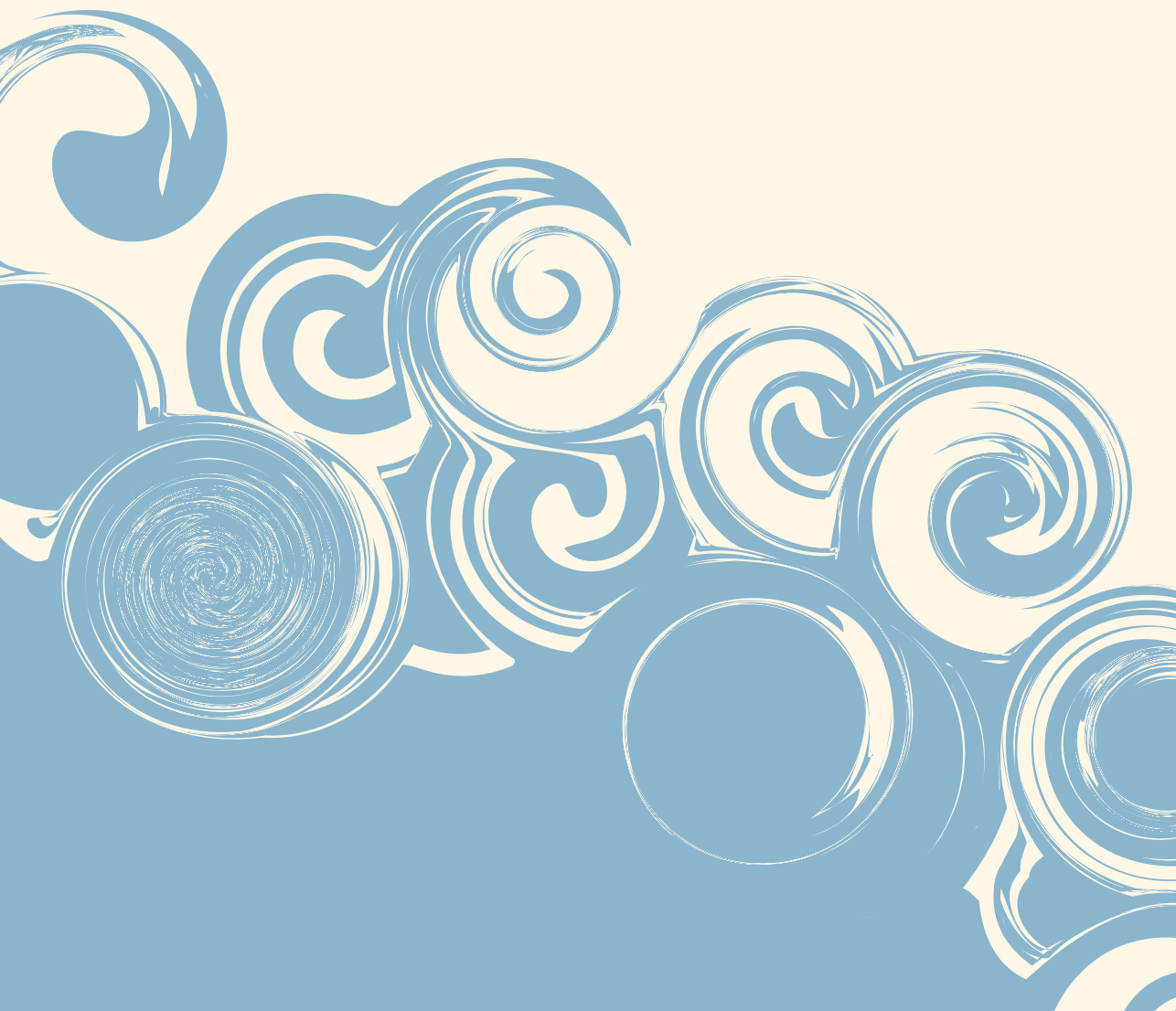
This chapter examined the role of flood risk variables on housing displacement decisions. The statistical results indicate that our hypothesis was supported for middle-income but not lower-income inhabitants. Housing displacement and replacement, which is housing behavior in response to slow-onset flooding, should be considered in property-based flood risk management. The contrasting findings regarding low-income communities responding to coastal flood risk suggest that they face limited viable options in the property market. An implication of this finding is that environmental deterioration might be influenced not only by coastal hazards but also by inability of inhabitants to maintain their neighborhoods. An advantage of this research is that we conducted a property-based displacement study, which revealed individual behavior in response to coastal flood risk. The active role of middle-income residents and the passive role of lower-income residents shows that economic viability still influences adaptation.

However, we would also like to identify a limitations of our study, particularly the lack of demographic data (such as income, education, and gender) to classify the community as economic agents more precisely. We also did not identify property prices at the origins and destinations, and these limitations warrant further research that includes these aspects. In addition, several questions remain, such as whether displacement influences the environmental condition. For example, it is unknown what socioeconomic characteristics displaced communities present. Therefore, a second broad recommendation is that the property market be considered as an alternative approach to flood risk management. Due to the spatial property market response, coastal flood risk may support spatial-based flood risk management and complement the government's planned adaptation.



CHAPTER 6

Conclusion



This thesis argues that property market dynamics in response to flooding may offer a new perspective on the “theory of the problem” concerning changes and decline in coastal neighborhoods, particularly in the Global South. Grigsby et al. (1987) proposed this theory with arguments that neighborhood succession is the heart of the dynamic of neighborhood change and decline. This succession directly correlates with the possibility of housing disinvestment due to financial constraints, which can result in house decay and spread to neighborhood deterioration. Accordingly, this thesis extends Grigsby’s theory (1987) by introducing *cross-submarket replacement* to illustrate neighborhood succession and *the spatial dynamic of housing submarkets* to demonstrate the dynamic of neighborhood change and decline. Given Lee (2017), who argues that property price adjustment represents neighborhood change, this thesis innovates by utilizing risk capitalization with the hedonic property model to define the connection between goods and their consumers in the dynamic of housing submarket. This assumption is consistent with the core ideas about neighborhood change: changes in people (consumers) and place (goods). Flood hazards directly affect how the inhabitant “consumes” their house and can impact the dynamic of the housing submarket. Through this, consumer change or neighborhood succession occurs in the at-risk areas.

In the ongoing debate, studies typically focus on the drivers of neighborhood change, from several theoretical perspectives. We can understand that at least two primary forces affect neighborhood change: endogenous and exogenous. On the one hand, Grigsby et al. (1987) align with Bhattacharjee et al. (2016) who explain changes in property ownership based on the endogenous evolution of demand or neighborhood succession. This explanation is understandable because the dynamics of housing submarkets are highly affected by changes in inhabitant characteristics. This assumption aligns with the basic theory of neighborhood change, often constructed by the life cycle model, cost–benefit analysis, invasion, and migration, which shapes the structure of the family and affects their homes and consequently the neighborhood. On the other hand, in the context of disaster studies, Lee (2017) provides the compelling argument that natural hazards, such as those experienced during recovery, also significantly influence neighborhood change. These events can act as pull-and-push factors for residential mobility. The neighborhood transforms, with local people migrating for adaptation and new purchasers securing property price discounts in hazardous areas. Based on this, Lee (2017) emphasizes that property price adjustments represent neighborhood change.

However, although several studies have explored the relationship between property prices, relocation, and housing submarkets, they provide scattered evidence and an inconclusive understanding, particularly regarding how the property market

demonstrates neighborhood change and decline in response to coastal flood risk in practice. This gap is understandable, because previous studies have explained the changes based on a number of different theoretical viewpoints. In addition, investigations in developing countries lag globally. Hence, this thesis aims to answer the following primary research question: To what extent do property markets demonstrate a declining process in coastal neighborhoods? To address this question, this thesis also poses four sub-questions: (i) To what extent do housing sub-markets react to coastal flood risk? (ii) To what extent do property prices adjust and spill over to nearby houses? (iii) To what extent does neighborhood succession affect the heterogeneity of property price decline? And (iv) To what extent does coastal flooding affect residential mobility? The first two questions concern the spatial dynamics of the housing submarket, while the final two examine cross-submarket replacement.

Many studies in the Global South have presented at least three fragmented pieces of evidence regarding property market responses to flooding. First, property price declines in flood-prone areas have been documented, but no clear evidence exists regarding a return to regular prices or market memory. For instance, Cobián Álvarez and Resosudarmo (2019) observed declining property prices in flood-prone areas in Jakarta (0.0952% in a 1% of flood increase), and Armal et al. (2020) reported a similar trend in the US (1%). Second, housing submarkets may emerge in flood-prone areas. Several scholars have reported similar evidence in the Global North, including in Brisbane (Gibson & Law, 2022; Rajapaksa, Wilson, et al., 2017), New Zealand (Mario Andres Fernandez & Bucaram, 2019; Mario A. Fernandez, Joynt, Hu, & Martin, 2023; Samarasinghe & Sharp, 2010), and the Netherlands. Housing submarkets with flood risk in the Global South appear to lean toward becoming slum areas (Desai & Loftus, 2013; Permana & Miyata, 2008; Sunarti et al., 2020). For example, Desai (2021), documented property speculation and transactions in slum areas that had suffered from flooding. Third, evidence exists of outflow migration from flood-prone areas to safer ones for adaptation and mitigation, as reported by Buchori et al. (2018) and Khairulbahri (2022).

This thesis addresses significant gaps in understanding how property markets react to coastal flooding. These reactions demonstrate the spatial dynamics of housing submarket and cross-submarket replacement, providing a new perspective on how housing submarket dynamics illustrate the process of neighborhood decline in at-risk areas. We argue that coastal flooding shapes housing submarkets for distressed properties, which are often abandoned by higher-income inhabitants. Such submarkets are spatially dynamic, expanding more quickly than the actual coastal flooding and influencing nearby housing submarkets. We further argue that cross-

submarket replacement mirrors neighborhood succession within a city. Based on our empirical evidence, we offer a new perspective on how the property market, through flood-risk capitalization, illustrates the decline of coastal neighborhoods in practice. The remainder of this chapter comprises five sections: main findings, theoretical reflection, policy implications, limitations, and suggestions for future research.

Main Finding

To What Extent do Housing Sub-markets React to Coastal Flood Risk?

This research question, explored in Chapter 2, aims to observe the emergence and reaction of housing submarkets in at-risk areas. We employ spatial cluster analysis with k-means to investigate the spatial dynamic of these submarkets. We also compare the geographical delineation of the submarkets with that of the surface water body caused by flooding. Through this process, we uncover a unique finding: Housing submarkets for distressed properties emerge in the at-risk areas and grow more quickly than the surface water body. This new evidence offers a complementary explanation of how coastal vulnerability increase more quickly than its hazard, a point highlighted by the IPCC (2012). Given the main research question and the theoretical foundation of property-based neighborhood change (Grigsby et al., 1987), this sub-section contributes to demonstrating the dynamics of neighborhood decline through the spatial dynamics of housing submarkets.

In Chapter 2, we provide new evidence that supports at least three previous studies. First, this evidence confirms the findings of Wolff et al. (2020), who argue that uncontrolled land use change in coastal areas may become the next exposure. This study supports their finding by documenting property market transactions in coastal flood-risk areas. Second, this evidence adds a new understanding of the emergence of housing submarkets in at-risk areas, as previously presented by Rajapaksa et al. (2017). This finding indicates that coastal flood risk impacts not only the emergence of the housing submarket but also its dynamics, as evidenced by the growth in geographical delineation. Third, this discovery also supports Grigsby et al. (1987) in suggesting that the spatial dynamics of housing submarkets could mirror the dynamics of neighborhood change and decline. This result may explain how property buyers react to environmental quality in housing consumption.

According to Bhattacharjee (2016), property buyers with similar tastes in housing gather in similar locations to share the benefits of locational quality within their budget constraints. Declining property prices in flood-prone coastal areas

have emboldened lower-income purchasers to relocate there. These buyers can afford the lower prices in at-risk areas to fulfill their basic housing needs, such as securing dwellings (Van Ham, 2012a). Filatova (2014) also explains that coastal areas are traditionally the center of urban amenities, which influences the housing consumption of the community, so lower-income people who live in flood-prone coastal areas benefit from locational services and lower housing prices. Property sale transactions and speculation occur over time and space, impacting the dynamics of spatial delineation in the housing submarket.

The delineation of the housing submarket may grow more quickly than associated hazards. Chapter 2 explains the spatial dynamics of the housing submarket for distressed properties in response to coastal flooding. The phenomenon of fear in housing investment in at-risk areas may be responsible for this. Lower-income purchasers are attracted by lower property prices in coastal regions and choose to live there. However, they also have reason to choose safer areas; they prefer to reside far from flood-prone coastal areas to avoid the extra costs of adaptation, such as elevating houses or their foundations. As a consequence, the boundaries of these housing submarkets become broader, following property purchases by lower-income people. As a result, the coastal flood-prone area, a vulnerable location, comes to be inhabited by lower-income people. According to Lee (2017), this represents the phenomenon of vulnerability to poverty. Thus, we argue that the transformation of a housing submarket from decent to slum or obsolete housing may be the complementary answer to why coastal vulnerability in developing countries grows more quickly than actual hazards (IPCC, 2012). Furthermore, the negative property price spillover effect may also represent the spread of a housing submarket for distressed properties.

To What Extent do Property Prices Adjust and Spill Over to Nearby Houses?

This research question, explored in Chapter 3, aims to understand property price behavior in response to coastal flood risk. Using hedonic property modeling with the SAR, this chapter examines property price behavior by considering coastal flood risk, which includes land subsidence, slope, and flooding. This study also includes a dummy variable for the housing submarket for distressed properties, identified in Chapter 2. This study reveals that the response of property prices to coastal flood risk comprises not only a decrease in value but also a spillover to nearby areas. Because property prices reflect coastal flood risk, the spillover effect could be seen as the risk extending to nearby areas.

Negative property price spillover in response to coastal flood risk variables is evidence of risk capitalization, confirming the findings of at least three previous studies. First, the property price discount in response to flood risk, as described by Rajapaksa (2017) and Zhang (2010), is an established understanding. However, our study reveals that property prices respond to the risk via decreasing value and spillover to surrounding areas. Second, our study of coastal flood-prone areas, which typically experience slow-onset flooding, also reveals a similar phenomenon to those documented in river flooding, including by Tobin and Newton (1986). Third, the spillover effect may also indicate the existence of a blighted neighborhood, as previously explained by Grigsby et al. (1987). The presence of a submarket for distressed properties in nearby areas supports this.

The spillover, or ripple effect, describes the movement of property prices over time and space in response to shocks (Meen, 1999). The spatial lag in property price adjustment within the panel dataset indicates the price movement aspect. In the case of a flood, prices usually decrease because purchasers understand that an extra budget is required for adaptation, and the price subsequently decreases. The discount arguably compensates buyers for maintaining units (Van Ham, 2012a). Thus, knowledge about the spatial diffusion of property price degradation following proximity to flood hazards is well established, and the spillover effect demonstrates the process of decreasing property prices. Thus, if no effort is made to prevent coastal flooding, property prices will continually decrease and may not return to normal, and vice versa. Notably, most coastal areas in the Global South, including Indonesia, lack adaptation measures (Hallegatte et al., 2013).

Moreover, coastal flooding shocks property buyers, and the risk materializes in their purchase decisions. In the flood literature, Zhang et al. (2010) explain that this is caused by the materialization process of flood risk in the decision to purchase property by each buyer. They capitalize the risk into the property price, usually based on proximity to a flood hazard, representing the risk information. This assumption follows Freeman (1979), who argues that property price is a bundle of house structure, locational quality, and environmental quality. Hedonic theory explains the basic concept of property price as the intersection of the demand and supply curves (Filatova, 2014). Residents change their behavior by moving to a specific location. Since purchasers budget extra for maintenance, they choose locations far from hazardous areas, assuming that proximity to flood-prone regions parallels the probability of flood risk (Y. Zhang et al., 2010). As a result, property prices decrease, people move from hazardous areas, and they push nearby housing submarkets. Decreases in property price may vary depending on the transaction between property

buyer and supplier. This process may follow residential mobility and neighborhood succession; lower-income purchasers benefit from second-hand property from higher-income inhabitants.

To What Extent Does Neighborhood Succession Affect The Heterogeneity of Property Price Decline?

This research question, explored in Chapter 4, aims to understand neighborhood succession by observing internal residential mobility and its relationship with the heterogeneity of property price decline. This study screened more than 1.9 million datasets of property tax history to observe property owner succession. Based on our observation of the housing submarket in Chapter 2, we illustrate internal residential mobility based on the housing submarket. Based on this, we investigated neighborhood succession, and cross-submarket replacement may be considered empirical evidence to explain neighborhood succession. Moreover, utilizing the hedonic property model and geographically weighted regression, we observed the heterogeneity of property price decline and investigated the connection between cross-submarket replacement and heterogeneity in declining property prices.

The empirical evidence suggests that neighborhood succession occurs through a process known as cross-submarket replacement. Grigsby et al. (1987) explain that this succession occurs when lower-income residents replace higher-income ones through the migration process. Lower-income individuals can purchase properties at discounted prices, particularly in at-risk areas. This finding is also supported by Desai (2021), who observed property speculation and transactions in a slum area of Mumbai, India. This phenomenon may explain why coastal neighborhoods transition from decent housing to slum living. Hedonic property modeling describes this as a spatial equilibrium phenomenon represented by property sale transactions between sellers and buyers.

Property prices are subject to adjustments that vary among households, depending on individual equilibrium. Hedonic price theory explains that when property prices change, either increase or decrease, this indicates an adjustment in the supply or demand curve. More specifically, Rosen (1974) explains that property price is a spatial equilibrium issue for each consumer who buys a specific house in a particular location and area. The adjustment in property price arguably occurs for every individual who makes a transaction in the property market, so the discount on property prices may not be similar for all buyers. Because a housing submarket indicates homogenous characteristics among home buyers, the dynamic of property price discounts may describe the economic agents who influence the speculation of house demand to

decrease prices. In regional literature, Meen (1999) defines purchasers who increase property prices as gentrification agents. In the case of property price decreases, they may be defined as converse- or anti-gentrification agents.

The regional literature shows a well-established understanding that gentrification correlates with increasing property prices. Gentrification agents could be new investors who alter speculation on existing demand to change prices. Gentrification is strongly related to inflow and outflow migration, representing the displacement of property buyers as economic agents. Thus, decreases in property price represent the characteristics of property buyers (as economic agents) and their behavior in materializing risk into their bidding to decrease the cost. This assumption aligns with the basic argumentation of the hedonic price model rooted in Lancaster's demand theory (1966). Lancaster (1966) argues that consumers, not the product, determine its utility. Thus, the hedonic price can be retrieved by extracting the property price into composed vectors (Muto, Sugawara, & Suzuki, 2023). As a result, increasing numbers of anti-gentrification agents in flood-prone coastal areas may result in continual property price decreases and the vagueness of the returning property price signal. In real estate literature, the signal of returning property prices after a flood event could be understood as market memory. As such, it is understandable why studies reporting market memory, which occurs due to the existence of property market volatility in flood-prone areas, are lacking in the Global South.

To What Extent Does Coastal Flooding Affect Residential Mobility?

This research question, explored in Chapter 5, aims to investigate the relationship between coastal flood risk variables and the decision to move. The study defines four types of displacement: risk to risk, risk to safe, safe to risk, and safe to safe. The study illustrated spatial residential mobility using geographical locations (x_i , y_i). Based on this, the study found that residential mobility involves both moving from and into risky areas. Furthermore, the study investigated the correlation between risky variables and the decision to move. The decision to move from risky to safer areas was found to be highly correlated with risk variables but not with those in safe-to-risk displacement. Therefore, this study provides a new understanding regarding residential mobility: *the property market does not abandon risky areas*.

Environmental experts such as Black et al. (2011) and Brasington (2021) believe that relocation or migration is only one adaptation strategy for households to balance their housing consumption. On the one hand, higher-income people can afford to relocate voluntarily, which could also be understood as spatial demand displacement. In areas prone to hazards, every household must incur additional maintenance costs,

which are a part of the MC. When $MC > MB + ME$, they might consider relocating to maintain their economic balance. Thus, many experts relate the relocation decision to risk variables such as slope, flood-prone areas, and land subsidence. However, before relocation, every individual must spend their budget on observing (searching cost), which sometimes influences their decision whether to displace (Donnelly & Melstrom, 2023; Guglielminetti, Lalive, Ruh, & Wasmer, 2024). On the other hand, lower-income people rely on higher-income people for housing consumption via the purchase of used homes (Grigsby et al., 1987). Van Ham (2012a) explains that even if lower-income people have the freedom to purchase their houses, the unit stock in the property market is limited. Thus, they “consume” houses in flood-prone areas due to lower prices, which fit their affordability.

Accordingly, inflow migration to flood-prone areas occurs to secure lower property prices, which has received little scholarly attention, specifically in the Global South. Most studies focus on outflow migration for adaptation and anticipation in flood-prone areas (see: Buchori et al., 2018; Khairulbahri, 2022). Brasington (2021) has even summarized the factors of migration for adaptation as focusing on “where to move,” “what to move into,” and “whether to move.” Scholars typically focus less on “where they move from.” Permana and Miyata (2008) provide insight into inflow migration in flood-prone areas of Palangkaraya, which then transform into slum areas. Considering property price as one factor in the purchasing decision, we learned that the market influences each household’s decision to relocate to or from flood-prone areas. Thus, a growing understanding exists that the property market is vital in spatial demand displacement or that price may be an intermediate consideration for individual household decisions.

Summary of Findings: A Framework of Coastal Neighborhoods in Decline

After answering the four sub-research questions above, we now answer the main research question: To what extent do property markets demonstrate a declining process in coastal neighborhoods? This study argues that the reaction of the property market can demonstrate the process of declining coastal neighborhoods in practice. Accordingly, we introduce *the spatial dynamic of the housing submarket*, a way to illustrate neighborhood change, and the concept of *cross-submarket replacement*, a way to demonstrate neighborhood succession or demand changes. Moreover, changes in property prices also explain this response, which can be clearly understood through the hedonic property model from Rosen (1974).

This thesis further enriches Grigsby’s theory (1987) by incorporating the hedonic property model, an approach for risk capitalization into property price, thereby

influencing the rational economic decision of property buyers in response to coastal flood risk. We argue that coastal flood risk enters the property market, shaping a new housing submarket and leading transformation from decent housing to slum living. This transformation is illustrated by the spatial dynamics of housing submarkets and by cross-submarket replacement. The emergence of new housing submarkets in at-risk areas dynamically grows simultaneously with in-and-outflow migration. The property price discount in at-risk areas has emboldened lower-income inhabitants to purchase and live there. Therefore, the delineation of geographical housing submarkets grows, even beyond the surface water body caused by coastal flooding. The explanation of the process of declining coastal neighborhoods is presented below:

1. Spatial Dynamics of Housing Submarkets

The housing submarket's spatial dynamics refer to the neighborhood change and decline process. Based on Grigsby's theory (1987), the spatial dynamics of the housing submarket may illustrate the internal changes or evolution of demand. Changes in the spatial housing submarket represent changes in the population residing in specific areas, including those in at-risk areas. According to Bhattacharjee et al. (2016), individuals who have similar housing preferences will choose to live in similar locations to ensure the quality of the area fits within their budget constraints. As a result, the housing submarket is often defined based on the identical characteristics of properties in various places within the city.

The housing submarket's spatial dynamics comprise property buyers' reactions to coastal flooding over time and space. Utilizing the hedonic property model's panel dataset, we can observe changes in spatial delineation and the composition of the housing submarket. Because property price represents spatial equilibrium, changes in it alter either supply or demand, which results in changes in the geographical delineation of the housing submarket. Chapter 2 provides evidence for this dynamic through changes in the geographical delineation of the housing submarket. Likewise, Chapter 3 demonstrates how property prices also negatively spill over from the housing submarket for distressed properties to nearby areas. The dynamics of the housing submarket illustrate the property market's reaction in practice, which helps urban planners and policymakers understand neighborhood change and decline.

Coastal flooding enters the property market, shaping submarkets for distressed properties. This thesis further suggests that the behavior of property prices in response to coastal flooding highlights the process of neighborhood deterioration. Statistical evidence about the property price spillover effect following decreasing

property prices aligns with the spatial dynamics of housing submarkets. The growth of submarkets for distressed properties follows the negative spillover effect of property price decreases, pushing into nearby areas. This spreading of the broader area of distressed properties is an “unwanted effect” or negative externality (van der Krabben, 2009). This phenomenon occurs due to “waste investment” in flood-prone areas that receive no additional benefits other than to survive coastal disasters. The spreading of these new housing submarkets for distressed properties in response to coastal flooding may be the primary distinction between the countries situated in the Global South and Global North.

2. Cross-submarket Replacement

“Cross-submarket replacement” describes the process of neighborhood succession or experiencing changes in demand. Grigsby et al. (1987) explain that neighborhood succession is the heart of neighborhood change and decline, through the changes in inhabitants, particularly from higher-income people to lower-income ones. This change affects their capability to maintain their house by themselves. As a result, their houses become damaged and blighted the neighborhood. Moreover, internal residential mobility can illustrate demand changes or neighborhood succession. Brasington (2021) explains that residential mobility is only one adaptation strategy in housing consumption to ensure the balance between MC, MB, and ME. This argumentation is based on rational economic choice in spatial adaptation: that each household choose a specific location to ensure individual equilibrium, namely $MB \geq MC + ME$.

Coastal flooding negatively impacts property prices in at-risk areas. However, urban amenities that are historically concentrated in coastal areas have a positive effect. In at-risk areas, property prices typically decrease because residents know the risk involved and factor it into their purchasing decisions. Both sellers and buyers understand that additional funds are required for maintenance, and a discount is thus applied for maintenance costs. Conversely, property buyers optimize their expectation of utility value by considering locational quality and relying on government coastal maintenance (Filatova, 2014). As a result, inflow migration occurs to secure lower property prices in at-risk areas. As such, inhabitants are affected by coastal flooding and decreased property prices but also benefit from locational quality. Due to the negative spillover effect, property prices continue to decrease, and there is no signal of a return to normal. This negative spillover could represent the increasing inflow migration of lower-income purchasers, which could create new demand for property in at-risk areas. As such, property price volatility can be

understood simply as the function of what consumers want to secure in a house as a good.

Furthermore, the spatial dynamic of the housing submarket is represented by residential mobility or spatial demand displacement. Outflow migration from risky areas causes decreasing property demand, resulting in property price drops. Lower-income people consequently purchase houses in at-risk areas to fulfill their basic housing needs, namely, to dwell (Van Ham, 2012a). Meanwhile, higher-income households leave the area to reduce their extra maintenance costs. Lower-income families purchase lower-priced properties in at-risk areas to balance their expenditures, while “accepting” the risk. As a result, the concentration of lower-income families in at-risk areas shapes a new housing submarket, which tends to transform the existing housing submarket into slum housing. As such, internal residential mobility can be understood simply as the function of why consumers want to buy a house.

In summary, the decline of coastal neighborhoods can be understood simply as the link between goods (houses) and consumers (people). This may enrich our understanding of the basic assumption of neighborhood change, usually described as changes in people and place. From a property market perspective, neighborhood change can be explained through the linkage between goods and consumers in response to shock. This relationship may also explain consumer responses to shock through shaping new consumer segmentation (submarket) and modifying their preferences for goods (house).

Theoretical Reflection

After answering the above four research questions, this thesis argues that the dynamic of neighborhood change and decline initiated by Grigsby et al. (1987) can be used to explain coastal neighborhoods in decline. We agree with Lee (2017) that property price adjustment indicates neighborhood change because price becomes the economic factor for property owners to react with shock. Thus, we argue that the hedonic property model may practically demonstrate housing behavior in response to coastal flooding as an exogenous shock entering the property market (Freeman, 1979; Rosen, 1974).



Figure 6-1 The framework coastal neighborhood in decline among coastal flooding, property market, and property submarket for distressed properties

First, this study extends the existing neighborhood change and decline theory in a different context. We develop a theoretical framework for coastal neighborhoods in decline from a property market viewpoint by combining two ideas: (1) neighborhood change induced by exogenous shocks, from Lee (2017) and (2) property-submarket-based neighborhood change, from Grigsby et al. (1987). We must combine these two perspectives to complement the idea of neighborhood change and decline from the property market perspective. On the one hand, Grigsby et al. (1987) argue that endogenous factors influence neighborhood change. They explain that property owner succession, rather than physical decay, which is determined by building age, is the heart of neighborhood change. Changes in home ownership represent the shifting their ability to conduct self-repair, which is also highly determined by income, experience, and education (Brody, Lee, & Highfield, 2017; Shao et al., 2017; Thistlethwaite, Henstra, Brown, & Scott, 2018). Because of this, construction property decay occurs and blights nearby areas, arguably due to physical property decay or neighborhood deterioration. This assumption aligns with a shared understanding of housing submarket dynamics, which are influenced by the endogenous changes of property buyers. Thus, Bhattacharjee et al. (2016) explain that the housing submarket dynamic is the phenomenon of endogenous demand evolution. In other words, neighborhood change occurs due to internal change.

On the other hand, Lee (2017) explains natural hazards, an exogenous shock, as induced neighborhood change. Rooted in ecology, Lee (2017) argues that natural hazards become the pull-and-push factor for inhabitants to relocate to vary and reduce the risk. This idea aligns with Brasington (2021), who highlights individuals as economic agents displaced to secure their balance between benefit and cost. In conjunction, our study demonstrates that coastal flooding as an exogenous shock

induces neighborhood change and decline from a property market perspective, which complements Lee's idea (2017). We argue that exogenous shock-induced neighborhood change (Lee, 2017) can be explained through the dynamics of property markets in response to coastal flooding. Likewise, this study also complements the idea of neighborhood change and decline initiated by Grigsby et al. (1987). Property market changes are driven by the endogenous evolution of demand and exogenous shock, resulting in new housing submarkets.

Second, our study provides at least two new pieces of empirical evidence on market memory and spatial externalities from the Global South. The majority of declining property price returns occur 4 – 6 years after the flood event (Fletcher et al., 2022; Ortega & Taşpınar, 2018), which is commonly understood as collective or flooding memory (Song et al., 2020). Utilizing 8 years of property sale transactions, we find no signal of a decline in returning property in flood-prone coastal areas. This study even identifies the signal of a continued decline in property prices. We argue that the housing submarket has changed from decent housing to slum living and that the demand has changed from higher- to lower-income inhabitants. Thus, the new lower-income inhabitants are less able to conduct house maintenance.

Moreover, properties decay and neighborhoods deteriorate and become slums. From a property perspective, the slum area could be understood as a spatial externality, an adverse consequence of the lack of relationship between land use planning and property markets (Hartmann & Needham, 2012; van der Krabben, 2009). The absence of a declining return property price after flooding may occur due to property transactions in submarkets for distressed properties. This evidence aligns with empirical studies in some countries in the Global South, such as Bangladesh (Braun & Aßheuer, 2011), India (De & Vupru, 2017; Desai, 2021), and Indonesia (Buchori et al., 2018; Marfai, 2014; Sunarti et al., 2020). For example, Desai and Loftus (2013) uncovered property transactions and speculation in the slum areas of Mumbai, India. In conjunction, we argue that we have evidence of the absence of market memory and the presence of spatial externalities from the Global South.

Third, this study may also contribute to the ongoing debate on spatial adaptation policy. Filatova (2014) theorized a market-based instrument for flood risk management and summarized its implementation in several countries. The main idea is to influence the decisions of property buyers in at-risk areas through market forces. In other words, the government must control property markets in at-risk areas to prevent economic loss due to hazards and allow individuals to conduct voluntary adaptation by choosing safer areas. Through this, economic loss could be prevented

by regulating land use to complement engineering flood defenses such as dikes and levees. Considering the transformation of property submarkets from decent housing to slum living, it is apparent that controlling property markets in at-risk areas is also required to prevent spatial externalities and distressed properties. As such, the property market's active role is arguably required for spatial adaptation in both flood risk management and preventing slum living.

Policy Implications

Given the IPCC's finding (2012) that documented coastal vulnerability increases more quickly than exposure, the active role of the property market in spatial adaptation may be a complementary strategy to support planned government adaptations. Property transactions occur in at-risk areas, while new housing submarkets with substandard property and lower environmental quality are being shaped. Moreover, housing submarkets emerge due to residential mobility via displacement and replacement, especially from higher- to lower-income inhabitants. The most important finding is the identification of submarkets for distressed properties of substandard quality that blight nearby neighborhoods. Through this, it is apparent that growing housing submarkets for distressed properties result in blighted and obsolete housing, from decent property to slums. In conjunction, at least four policy implications can be drawn according to the property market viewpoint to address coastal neighborhoods in decline, as follows:

First, the government must control property transactions in at-risk areas. Research by Mercy Corps (2021) revealed low risk perceptions of flooding among coastal residents, which influences their decisions to purchase housing. Our study also revealed the property sale transaction in the at-risk areas, which is capitalized to decreasing property prices in response to coastal flood risk (see Chapter 2). Despite understanding the risk, they may expect higher value due to location, through the urban amenities historically gathered in coastal areas (Filatova, 2014). Decisions by lower-income households living in flood-prone areas may be influenced by property price decreases. They fulfill their basic need for housing, namely, a place to dwell, by taking advantage of sinking property prices (Van Ham, 2012a). Because property price is essential in a buyer's decision, signaling the risk through price must be considered. Filatova (2014) has proposed a market-based instrument to involve property buyers in voluntary actions to support spatial adaptation. The active role of the property market arguably not only comprises flood risk management but also preventing coastal neighborhoods from decline.

Second, considering the spatial delineation of the housing submarket for neighborhood improvement projects to accommodate market volatility may be increasingly necessary. This idea comes from Bates (2006), who strongly recommends defining housing submarkets based on neighborhoods rather than administrative delineations because improvements in environmental quality are believed to spill over to nearby areas and create new housing submarkets. This study also revealed similar conclusions: decreasing coastal neighborhood spread and negative spillover to nearby areas (see Chapter 3). Decreasing property prices and spillover may signal that a neighborhood has become blighted. Through this, urban planners and policymakers could understand the property market dynamic well and prevent it. Likewise, property price adjustments in at-risk areas in response to flood risk are volatile. For example, price increases in 2017 occurred due to the government building levees to prevent rising sea levels (see Chapter 3); higher property price transactions in at-risk areas arguably respond to the government's engineering flood defenses. Of course, the active role of individuals in voluntary or autonomous adaptation (Filatova, 2014) must be considered, and the property market needs to take place to prevent neighborhoods from declining.

Third, targeted adaptation by individuals rather than community groups may need to be considered in flood-prone areas following Meen (1999) and Filatova (2014), who explain the role of property buyers as economic agents who influence the expectations of existing demand to modify their speculation on property prices. Following Meen (1999), who describes gentrification agents who stimulate speculation about increasing property prices, urban planners and policymakers may need to consider the anti-gentrification agents who decrease property prices as targeted individuals for adaptation. By doing so, autonomous adaptation for flood risk reduction and preventing neighborhood declining could be achieved (see Chapter 4). Of course, this should be a complementary strategy to support the government's planned adaptations.

Finally, coastal neighborhoods are in decline and have ecological and anthropologic problems, as well as property market issues. This study finds that property price may be the intermediate variable for property buyers to relocate, either to or from at-risk areas (see Chapter 5). As such, the idea of efficient adaptation initiated by Mendelsohn (2000) may need to occur in utilizing property market forces to change the behavior of property buyers in at-risk areas. Of course, this idea also aligns with Filatova (2014), in terms of signaling the risk through price.

The growing scientific evidence highlighted those four policy implications; this study suggests that the property market may play a role in adaptation. In the ongoing debate, the idea of 'land for climate' may be considered to address the spatial risk variation. Thus, spatial adaptation through the property market may contribute to risk reduction from receptors. We reduce the risk through property market intervention to manage the land to reduce the potential risk. Of course, this policy implication supports the established understanding that spatial planning is the heart of flood risk management.

Moreover, this study also has policy implications for Indonesia. Today, spatial planning in Indonesia is not just a mitigation instrument, but a responsibility that we all share, as regulated by Law 26/2007 about spatial planning and Law 24/2007 about disaster management, which is renewed by The Omnibus Law or the Job Creation Law. With Indonesia facing uncontrolled urbanization and a lack of coastal adaptation (Hallegatte et al., 2013), spatial adaptation by incorporating the property market is a task that we must all undertake.

Limitations

This study has at least four limitations, especially in terms of empirical evidence and data quality. Rooted in the hedonic price theory, property buyers materialized the coastal flood risk through risk information, which influenced them to modify their utility value expectations. Risk information influences this materialization based on financial ability, experience, and even race, which affects the variation in property buyers' responses. Some studies have even uncovered information asymmetries in the housing market (see: Hirsch & Hahn, 2018; Rajapaksa et al., 2016; Votsis & Perrels, 2016). Our study assumes that property buyers respond to risk information conveyed through property price decreases without deeply observing this information. We utilized previous research conducted by Mercy Corps (2021), which concluded that coastal communities have low awareness and risk perceptions of coastal flood risk. Notably, however, Mercy Corps (2021) studied vulnerability and resilience based on a social-ecological system framework rather than property markets.

Second, this study lacks the required empirical evidence of the relationship between property prices and housing displacement; we have made a theoretical argument based on established theory and the empirical findings of previous researchers (Filatova, 2014). Most studies argue that property buyers' decisions to relocate to safer or riskier areas are influenced primarily by property price as an intermediate

variable. However, our study fails to provide this empirical evidence because not all family relocation is followed by a property sale. Likewise, relocation beyond city boundaries sometimes occurs. Data availability may be a concern if researchers utilize property markets to investigate neighborhood change.

Third, this study concerns data quality, specifically regarding spatial datasets of property sale transactions and income. Although recorded in the cadaster database, our dataset (BPHTB) is not geospatial. No geographic information, such as coordinates (Xi, Yi), exists to specify location. In the analytical process, we had to retrieve geographic information from a cadaster map, which was not sufficiently clean; this influenced the accuracy of our spatial queries. Likewise, the income dataset comprises proxy data from electricity subscriptions, in the form of categorical data on energy consumption to determine the economic ability of each household.

The final limitation of this thesis concerns qualitative research regarding the subjective reason for inhabitant displacement. This study provides the statistical evidence and theoretical reason for inhabitants displacing by leaving risky areas. The subjective motive needed to complement this finding may be through qualitative research.

Suggestions for Future Research

Based on the above limitations, we suggest directions for future research. First, because risk information is necessary for property purchasers, we recommend framing risk information in terms of housing investment. This information may correlate with the structure of household expenses, considering that households are economic agents who decide on adaptation based on benefit and cost (see: Mendelsohn, 2000). This thesis also constructs the theoretical framework based on this argumentation (see Chapter 2 for a detailed explanation). Observing changes in structural expenses may provide an overall picture of individual equilibrium for adaptation and thus contribute to the discussion of how voluntary adaptation can support spatial adaptation strategies.

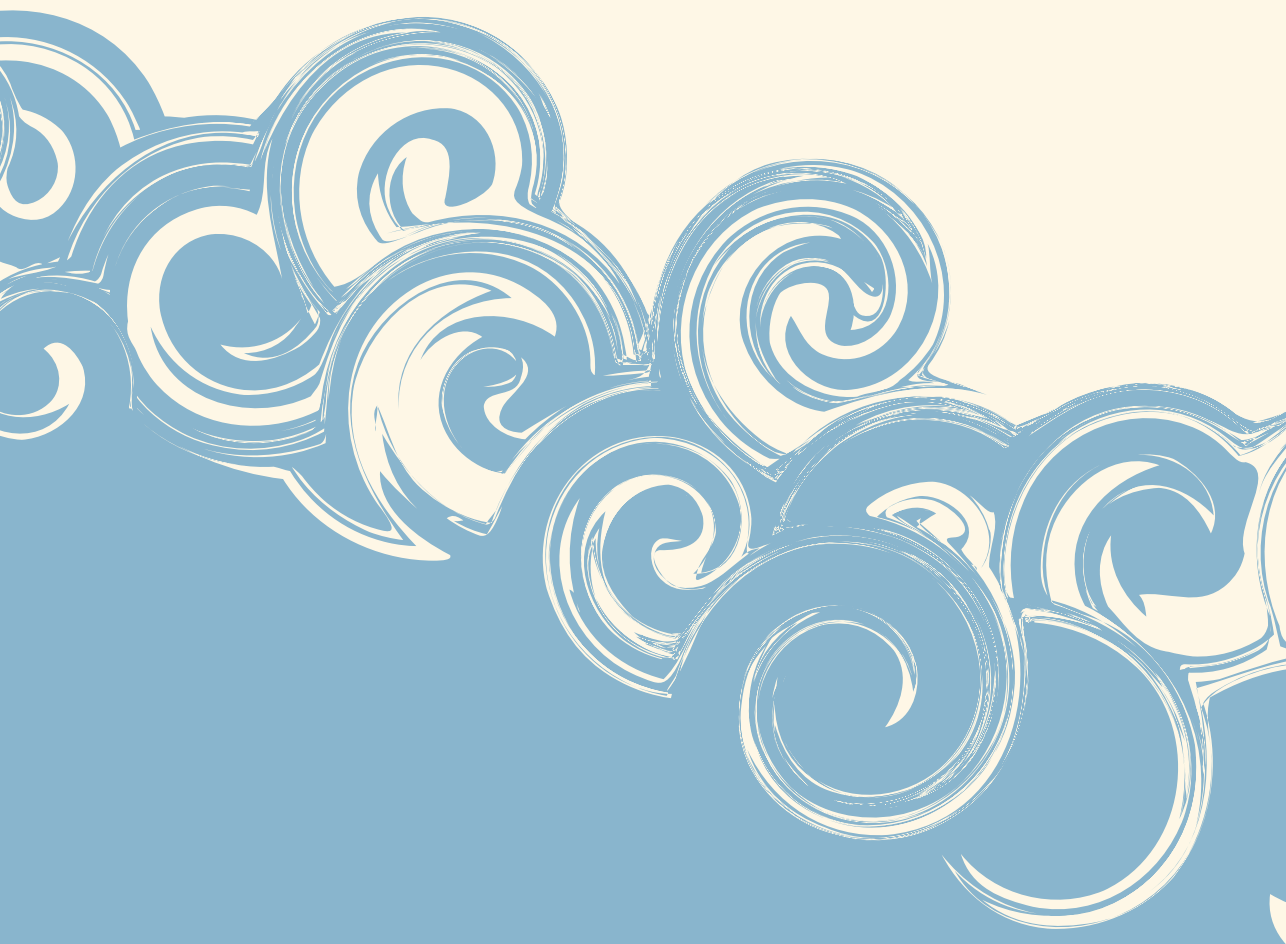
In addition, effective and efficient adaptation to prevent spatial externalities may need to occur. Following Hartmann and Needham (2012) and van der Krabben (2009), spatial externalities may result from ineffective and inefficient investment. It may contribute to the ongoing debate on market-based approaches for adaptation, such as transfer development rights (TDR), incentives and disincentives, and insurance.

Our study also identified the adverse effects of property abandonment and blight property price spillover (see Chapter 3), representing market behavior. Through this, future research on a market-based approach for adaptation may contribute to property-based adaptation for neighborhood decline in the countries in the Global South. Because discussion occurs primarily in developed countries rather than developing ones, it may be necessary to consider the possibility of market-based approaches in developing countries.

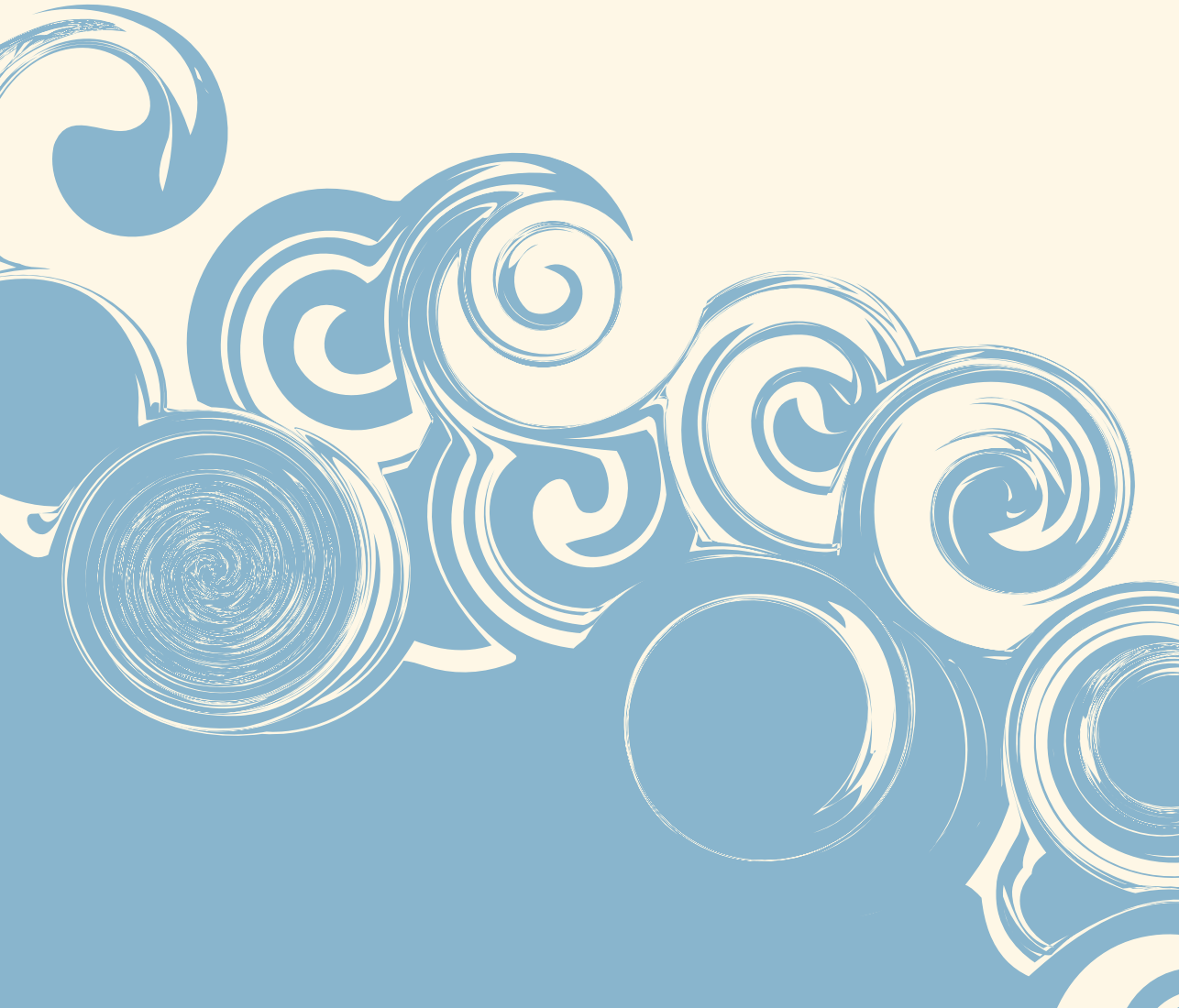
We identified the various responses of property buyers to coastal flood risk. Chapter 4 explains each household's heterogeneous property price decline, representing the various trade-offs for property buyers in their transactions. Property price represents a spatial equilibrium, a meeting point between the demand and supply curve; these findings show how each household, as an economic agent, internalizes the risk into its decision to purchase the property. These findings contribute to future research on how involving voluntary adaptation can prevent neighborhood change and decline in coastal flood-prone areas.

As highlighted in the limitations, the use of qualitative research is crucial in understanding the subjective reasons that drive local inhabitants to abandon risky areas and relocate to safer ones, and vice versa. This understanding is essential for a comprehensive grasp of the spatial housing submarket in destination locations or safer areas. Furthermore, it is important to investigate whether that displacement influences the increasing value and potential gentrification in safer areas. By exploring the spatial dynamics of housing submarkets in destination areas, we can gain a more comprehensive understanding of spatial demand displacement, which may contribute to the discussion of spatial adaptation.

Concerning displacement and the dynamic of housing submarkets, it is necessary to explore the potential climate-induced gentrification and urban sprawl more. This study is arguably crucial for addressing the ongoing discussion on spatial-based risk reduction. The global literature indicates that climate change poses various spatial risks, reinforcing that spatial planning is central to flood risk reduction. Empirically, Yanto et al. (2017) support this argument with the evidence that while rainfall in Java island, Indonesia, remains constant, the mountainous locations receive more rainfall than do the low-lying areas. Thus, spatial adaptation may need to take the role of local adaptation to tackle the global issue by considering planning by law from the government and property market. In the current system of urban planning, the property market is believed to complement the planned adaptation by encouraging purchasers to prefer voluntary adaptation before making purchase decisions (Filatova, 2014).



References



- Accordino, J., & Johnson, G. T. (2000). Addressing the Vacant and Abandoned Property Problem. *JOURNAL OF URBAN AFFAIRS*, 22(3), 301-315. doi:10.1111/0735-2166.00058
- Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, 16(3), 268-281. doi:10.1016/j.gloenvcha.2006.02.006
- Adger, W. N., & Vincent, K. (2005). Uncertainty in adaptive capacity. *Comptes Rendus Geoscience*, 337(4), 399-410. doi:10.1016/j.crte.2004.11.004
- Adnan, M., Ahmed, S., Shakshuki, E. M., & Yasar, A.-U.-H. (2019). Determinants of Pro-Environmental Activity-Travel Behavior Using GPS-Based Application and SEM Approach. *Procedia Computer Science*, 160, 109-117. doi:10.1016/j.procs.2019.09.450
- Ahlfeldt, G. (2011). If Alonso was right: modeling accessibility and explaining the residential land gradient. *Journal of Regional Science*, 51(2), 318-338. doi:10.1111/j.1467-9787.2010.00694.x
- Ahmad Khalimaya, N., Insan Al Ha Za Zuna Darma, I., & Sri Endah, W. (2019). Roles and Responsibilities Land Deed Official (PPAT) of Tax Duty in the Implementation of Acquisition of Land and Buildings (BPHTB) Underpayment by the Taxpayers in Semarang. *Jurnal Akta*, 6(4). doi:10.30659/akta.v6i4.7580
- Alfaro, F., Paredes, D., & Skidmore, M. (2022). New Public Transportation Infrastructure and Tax Delinquency in Shrinking Cities: The Case of Detroit. *International Regional Science Review*, 46(4), 410-427. doi:10.1177/01600176221145875
- Alm, J., Hawley, Z., Lee, J. M., & Miller, J. J. (2016). Property tax delinquency and its spillover effects on nearby properties. *Regional Science and Urban Economics*, 58, 71-77. doi:10.1016/j.regsciurbeco.2016.02.006
- Alonso, W. (1964). *Location and Land Use: Toward a General Theory of Land Rent*: Harvard University Press.
- Alves, B., Angnuureng, D. B., Morand, P., & Almar, R. (2020). A review on coastal erosion and flooding risks and best management practices in West Africa: what has been done and should be done. *Journal of Coastal Conservation*, 24(3), 38. doi:10.1007/s11852-020-00755-7
- Andreas, H., Abidin, H. Z., Sarsito, D. A., & Pradipta, D. (2018). Insight analysis on dyke protection against land subsidence and the sea level rise around northern coast of Java (Pantura) Indonesia. *Geopanning: Journal of Geomatics and Planning*, 5(1), 14. doi:10.14710/geopanning.5.1.101-114
- Andreas, H., Usriyah, Zainal Abidin, H., & Anggreni Sarsito, D. (2017). Tidal inundation ("Rob") investigation using time series of high resolution satellite image data and from institu measurements along northern coast of Java (Pantura). *IOP Conference Series: Earth and Environmental Science*, 71. doi:10.1088/1755-1315/71/1/012005
- Anselin, L., Bera, A. K., Florax, R., & Yoon, M. J. (1996). Simple diagnostic tests for spatial dependence. *Regional Science and Urban Economics*, 26(1), 77-104. doi:10.1016/0166-0462(95)02111-6
- Aouad, D. (2022). Neighborhood Planning for a Divided City: The Case of Beirut. *Urban Planning*, 7(1). doi:10.17645/up.v7i1.4694
- Armal, S., Porter, J. R., Lingle, B., Chu, Z., Marston, M. L., & Wing, O. E. J. (2020). Assessing Property Level Economic Impacts of Climate in the US, New Insights and Evidence from a Comprehensive Flood Risk Assessment Tool. *Climate*, 8(10), 116. Retrieved from <https://www.mdpi.com/2225-1154/8/10/116>
- Ashton, P. (2023). Collateral Damage: Racial Logics of Property in the Adjudication of the U.S. Foreclosure Crisis. *Geoforum*, 140, 103705. doi:10.1016/j.geoforum.2023.103705
- Bakkensen, L. A., Ding, X., & Ma, L. (2019). Flood Risk and Salience New Evidence from the Sunshine State. *Southern Economic Journal*, 85(4), 1132-1158. doi:10.1002/soej.12327
- Bao, S. W., Gayes, P., Pietrafesa, L., & Ieee. (2018). The Need and Rationale for a Coastal Flood Risk Index. *OCEANS 2018 MTS/IEEE Charleston*. doi:10.1109/oceans.2018.8604927
- Barrage, L., & Furst, J. (2019). Housing investment, sea level rise, and climate change beliefs. *Economics Letters*, 177, 105-108. doi:10.1016/j.econlet.2019.01.023

- Bates, L. K. (2006). Does Neighborhood Really Matter?: Comparing Historically Defined Neighborhood Boundaries with Housing Submarkets. *Journal of Planning Education and Research*, 26(1), 5-17. doi:10.1177/0739456X05283254
- Bayer, P., Casey, M., Ferreira, F., & McMillan, R. (2017). Racial and ethnic price differentials in the housing market. *Journal of Urban Economics*, 102, 91-105. doi:10.1016/j.jue.2017.07.004
- Behera, M. D., Prakash, J., Paramanik, S., Mudi, S., Dash, J., Varghese, R., . . . Srivastava, P. K. (2022). Assessment of tropical cyclone amphan affected inundation areas using sentinel-1 satellite data. *Tropical Ecology*, 63(1), 9-19. doi:10.1007/s42965-021-00187-w
- Beltrán, A., Maddison, D., & Elliott, R. (2019). The impact of flooding on property prices: A repeat-sales approach. *Journal of Environmental Economics and Management*, 95, 62-86. doi:10.1016/j.jeem.2019.02.006
- Beltrán, A., Maddison, D., & Elliott, R. J. R. (2018). Is Flood Risk Capitalised Into Property Values? *Ecological Economics*, 146, 668-685. doi:10.1016/j.ecolecon.2017.12.015
- Bhattacharjee, A., Castro, E., Maiti, T., & Marques, J. (2016). Endogenous Spatial Regression and Delineation of Submarkets: A New Framework with Application to Housing Markets. *Journal of Applied Econometrics*, 31(1), 32-57. doi:10.1002/jae.2478
- Bin, O., & Landry, C. E. (2013). Changes in implicit flood risk premiums: Empirical evidence from the housing market. *Journal of Environmental Economics and Management*, 65(3), 361-376. doi:10.1016/j.jeem.2012.12.002
- Bisel, R. S., & Adame, E. A. (2017). Post-Positivist/Functionalist Approaches. In *The International Encyclopedia of Organizational Communication* (pp. 1-22).
- Bivand, R. (2002). Spatial econometrics functions in R: Classes and methods. *Journal of Geographical Systems*, 4(4), 405-421. doi:10.1007/s101090300096
- Black, R., Bennett, S. R. G., Thomas, S. M., & Beddington, J. R. (2011). Migration as adaptation. *Nature*, 478(7370), 447-449. doi:10.1038/478477a
- Blackledge, J., & Lamphiere, M. (2022). A Review of the Fractal Market Hypothesis for Trading and Market Price Prediction. *Mathematics*, 10(1), 117. doi:10.3390/math10010117
- Blondin, S. (2021). Staying despite disaster risks: Place attachment, voluntary immobility and adaptation in Tajikistan's Pamir Mountains. *Geoforum*, 126, 290-301. doi:10.1016/j.geoforum.2021.08.009
- Bosker, M., Garretsen, H., Marlet, G., & van Woerkens, C. (2019). Nether Lands: Evidence on the Price and Perception of Rare Natural Disasters. *Journal of the European Economic Association*, 17(2), 413-453. doi:10.1093/jea/jvy002
- Bott, L.-M., & Braun, B. (2019). How do households respond to coastal hazards? A framework for accommodating strategies using the example of Semarang Bay, Indonesia. *International Journal of Disaster Risk Reduction*, 37, 101177. doi:10.1016/j.ijdrr.2019.101177
- Bourassa, S. C., Hamelink, F., Hoesli, M., & MacGregor, B. D. (1999). Defining Housing Submarkets. *Journal of Housing Economics*, 8(2), 160-183. doi:10.1006/jhec.1999.0246
- Bowen, W. M., Mikelbank, B. A., & Prestegard, D. M. (2001). Theoretical and Empirical Considerations Regarding Space in Hedonic Housing Price Model Applications. *Growth and Change*, 32(4), 466-490. doi:10.1111/0017-4815.00171
- Brasington, D. M. (2021). Housing Choice, Residential Mobility, and Hedonic Approaches. In *Handbook of Regional Science* (pp. 449-466).
- Braun, B., & Alsheuer, T. (2011). Floods in megacity environments: vulnerability and coping strategies of slum dwellers in Dhaka/Bangladesh. *Natural Hazards*, 58(2), 771-787. doi:10.1007/s11069-011-9752-5
- Brody, S. D., Lee, Y., & Highfield, W. E. (2017). Household adjustment to flood risk: a survey of coastal residents in Texas and Florida, United States. *Disasters*, 41(3), 566-586. doi:10.1111/disa.12216

- Buchori, I., Pramitasari, A., Sugiri, A., Maryono, M., Basuki, Y., & Sejati, A. W. (2018). Adaptation to coastal flooding and inundation: Mitigations and migration pattern in Semarang City, Indonesia. *Ocean & Coastal Management*, 163, 445-455. doi:10.1016/j.ocecoaman.2018.07.017
- Buchori, I., Zaki, A., Pangi, P., Sejati, A. W., Pramitasari, A., & Liu, Y. (2022). Adaptation strategies and community participation in government-led mitigation projects: A comparison between urban and suburban communities in Pekalongan, Indonesia. *International Journal of Disaster Risk Reduction*, 81, 103271. doi:10.1016/j.ijdrr.2022.103271
- Budhathoki, N. K., Paton, D., A. Lassa, J., & Zander, K. K. (2020). Assessing farmers' preparedness to cope with the impacts of multiple climate change-related hazards in the Terai lowlands of Nepal. *International Journal of Disaster Risk Reduction*, 49, 101656. doi:10.1016/j.ijdrr.2020.101656
- Budhathoki, N. K., Paton, D., Lassa, J. A., Bhatta, G. D., & Zander, K. K. (2020). Heat, cold, and floods: exploring farmers' motivations to adapt to extreme weather events in the Terai region of Nepal. *Natural Hazards*, 103(3), 3213-3237. doi:10.1007/s11069-020-04127-0
- Bui, N., Wen, L., & Sharp, B. (2022). House Prices and Flood Risk Exposure: An Integration of Hedonic Property Model and Spatial Econometric Analysis. *The Journal of Real Estate Finance and Economics*. doi:10.1007/s11146-022-09930-z
- Bukvic, A., & Barnett, S. (2023). Drivers of flood-induced relocation among coastal urban residents: Insight from the US east coast. *Journal of Environmental Management*, 325, 116429. doi:10.1016/j.jenvman.2022.116429
- Call, M., & Gray, C. (2020). Climate anomalies, land degradation, and rural out-migration in Uganda. *Population and Environment*, 41, 507-528. doi:10.1007/s11111-020-00349-3
- Cao, K., Diao, M., & Wu, B. (2018). A Big Data-Based Geographically Weighted Regression Model for Public Housing Prices: A Case Study in Singapore. *Annals of the American Association of Geographers*, 109(1), 173-186. doi:10.1080/24694452.2018.1470925
- Caramaschi, S., & Chiodeli, F. (2022). Reconceptualising housing emptiness beyond vacancy and abandonment. *INTERNATIONAL JOURNAL OF HOUSING POLICY*, 1-24. doi:10.1080/19491247.2022.2074268
- Catalao, J., Raju, D., & Nico, G. (2020). Insar Maps of Land Subsidence and Sea Level Scenarios to Quantify the Flood Inundation Risk in Coastal Cities: The Case of Singapore. *Remote Sensing*, 12(2), 296. doi:10.3390/rs12020296
- Cattaneo, C., Beine, M., Fröhlich, C. J., Kniveton, D., Martinez-Zarzoso, I., Mastroiello, M., . . . Schraven, B. (2019). Human Migration in the Era of Climate Change. *Review of Environmental Economics and Policy*, 13(2), 189-206. doi:10.1093/reep/rez008
- Chan, S., O'Regan, K., & You, W. (2021). Migration choices of the boomerang generation: Does returning home dampen labor market adjustment? *Journal of Housing Economics*, 53, 101760. doi:10.1016/j.jhe.2021.101760
- Chaussard, E., Amelung, F., Abidin, H., & Hong, S.-H. (2013). Sinking cities in Indonesia: ALOS PALSAR detects rapid subsidence due to groundwater and gas extraction. *Remote Sensing of Environment*, 128, 150-161. doi:10.1016/j.rse.2012.10.015
- Chaussard, E., Havazli, E., Fattahi, H., Cabral-Cano, E., & Solano-Rojas, D. (2021). Over a Century of Sinking in Mexico City: No Hope for Significant Elevation and Storage Capacity Recovery. *Journal of Geophysical Research: Solid Earth*, 126(4), e2020JB020648. doi:10.1029/2020JB020648
- Chen, J.-H., Ji, T., Su, M.-C., Wei, H.-H., Azzizi, V. T., & Hsu, S.-C. (2021). Swarm-inspired data-driven approach for housing market segmentation: a case study of Taipei city. *Journal of Housing and the Built Environment*, 36(4), 1787-1811. doi:10.1007/s10901-021-09824-1

- Chiang Hsieh, L.-H. (2021). Is it the flood, or the disclosure? An inquiry to the impact of flood risk on residential housing prices. *Land Use Policy*, 106, 105443. doi:10.1016/j.landusepol.2021.105443
- Cigna, F., & Tapete, D. (2021). Present-day land subsidence rates, surface faulting hazard and risk in Mexico City with 2014–2020 Sentinel-1 IW InSAR. *Remote Sensing of Environment*, 253, 112161. doi:10.1016/j.rse.2020.112161
- Cobián Álvarez, J. A., & Resosudarmo, B. P. (2019). The cost of floods in developing countries' megacities: a hedonic price analysis of the Jakarta housing market, Indonesia. *Environmental Economics and Policy Studies*, 21(4), 555–577. doi:10.1007/s10018-019-00242-w
- Colaninno, N., & Morello, E. (2022). Towards an operational model for estimating day and night instantaneous near-surface air temperature for urban heat island studies: outline and assessment. *Urban Climate*, 46, 101320. doi:10.1016/j.uclim.2022.101320
- Costello, G., Leishman, C., Rowley, S., & Watkins, C. (2019). Drivers of spatial change in urban housing submarkets. *The Geographical Journal*, 185(4), 432–446. doi:10.1111/geoj.12303
- Cui, J., Liu, F., Hu, J., Janssens, D., Wets, G., & Cools, M. (2016). Identifying mismatch between urban travel demand and transport network services using GPS data: A case study in the fast growing Chinese city of Harbin. *Neurocomputing*, 181, 4–18. doi:10.1016/j.neucom.2015.08.100
- Cundill, G., Singh, C., Adger, W. N., Safrá de Campos, R., Vincent, K., Tebboth, M., & Maharjan, A. (2021). Toward a climate mobilities research agenda: Intersectionality, immobility, and policy responses. *Global Environmental Change*, 69, 102315. doi:10.1016/j.gloenvcha.2021.102315
- Dada, O. A., Almar, R., Morand, P., Bergsma, E. W. J., Angnuureng, D. B., & Minderhoud, P. S. J. (2023). Future socioeconomic development along the West African coast forms a larger hazard than sea level rise. *Communications Earth & Environment*, 4(1), 150. doi:10.1038/s43247-023-00807-4
- Daniel, V. E., Florax, R. J. G. M., & Rietveld, P. (2009). Flooding risk and housing values: An economic assessment of environmental hazard. *Ecological Economics*, 69(2), 355–365. doi:10.1016/j.ecolecon.2009.08.018
- De, U. K., & Vupru, V. (2017). Location and neighbourhood conditions for housing choice and its rental value. *International Journal of Housing Markets and Analysis*, 10(4), 519–538. doi:10.1108/ijhma-10-2016-0072
- Delis, A., & Hodijah, S. (2015). Estimasi Nilai Basis Pajak Bumi dan Bangunan di Kota Jambi: Pendekatan Hedonic Price Function. *Jurnal Perspektif Pembiayaan dan Pembangunan Daerah*, 2(3), 147–160. doi:10.22437/ppd.v2i3.2271
- Deng, H. (2024). Understanding the impact of city government relocation on local residential property prices in Hangzhou, China. *Habitat International*, 143, 102969. doi:10.1016/j.habitatint.2023.102969
- Desai, V. (2021). Urban widows: living and negotiating gendered dispossession in speculative slum housing markets in Mumbai. *Gender, Place & Culture*, 28(10), 1387–1407. doi:10.1080/0966369X.2020.1811642
- Desai, V., & Loftus, A. (2013). Speculating on Slums: Infrastructural Fixes in Informal Housing in the Global South. *Antipode*, 45(4), 789–808. doi:10.1111/j.1467-8330.2012.01044.x
- Deutsch, J., Silber, J., Wan, G., & Zhao, M. (2020). Asset indexes and the measurement of poverty, inequality and welfare in Southeast Asia. *Journal of Asian Economics*, 70, 101220. doi:10.1016/j.asieco.2020.101220
- DeVries, B., Huang, C., Armston, J., Huang, W., Jones, J. W., & Lang, M. W. (2020). Rapid and robust monitoring of flood events using Sentinel-1 and Landsat data on the Google Earth Engine. *Remote Sensing of Environment*, 240, 111664. doi:10.1016/j.rse.2020.111664
- Dewar, M. (2006). Selling Tax-Reverted Land: Lessons from Cleveland and Detroit: New This Spring Westchester. *JOURNAL OF THE AMERICAN PLANNING ASSOCIATION*, 72(2), 167–180. doi:10.1080/019443606008976737

- Dinh, N. C., Ubukata, F., Tan, N. Q., & Ha, V. H. (2021). How do social connections accelerate post-flood recovery? Insights from a survey of rural households in central Vietnam. *International Journal of Disaster Risk Reduction*, 61, 102342. doi:10.1016/j.ijdrr.2021.102342
- Doan, L.-V.-L., & Rae, A. (2023). Are we looking in the right place? Housing search mismatches: evidence from Greater Manchester in the UK. *Open House International*, ahead-of-print(ahead-of-print). doi:10.1108/OHI-06-2022-0145
- Donnelly, E., & Melstrom, R. T. (2023). Residential mobility and the value of water quality improvements in the Milwaukee Estuary Area of Concern. *Agricultural and Resource Economics Review*, 52(2), 250-272. doi:10.1017/age.2023.10
- Fahmi, F. Z., Hudalah, D., Rahayu, P., & Woltjer, J. (2014). Extended urbanization in small and medium-sized cities: The case of Cirebon, Indonesia. *Habitat International*, 42, 1-10. doi:10.1016/j.habitatint.2013.10.003
- Fan, J., Fu, C., Stewart, K., & Zhang, L. (2019). Using big GPS trajectory data analytics for vehicle miles traveled estimation. *Transportation Research Part C: Emerging Technologies*, 103, 298-307. doi:10.1016/j.trc.2019.04.019
- Feng, Y., Zou, L., Yuan, H., & Dai, L. (2022). The spatial spillover effects and impact paths of financial agglomeration on green development: Evidence from 285 prefecture-level cities in China. *Journal of Cleaner Production*, 340, 130816. doi:10.1016/j.jclepro.2022.130816
- Fernandez, M. A., & Bucaram, S. (2019). The changing face of environmental amenities: Heterogeneity across housing submarkets and time. *Land Use Policy*, 83, 449-460. doi:10.1016/j.landusepol.2019.02.024
- Fernandez, M. A., Joynt, J. L. R., Hu, C., & Martin, S. L. (2023). Sorting (and costing) the way out of the housing affordability crisis in Auckland, New Zealand. *International Journal of Housing Markets and Analysis*, 16(5), 955-978. doi:10.1108/IJHMA-04-2022-0061
- Filatova, T. (2014). Market-based instruments for flood risk management: A review of theory, practice and perspectives for climate adaptation policy. *Environmental Science & Policy*, 37, 227-242. doi:10.1016/j.envsci.2013.09.005
- Filatova, T., Mulder, J. P. M., & van der Veen, A. (2011). Coastal risk management: How to motivate individual economic decisions to lower flood risk? *Ocean & Coastal Management*, 54(2), 164-172. doi:10.1016/j.ocecoaman.2010.10.028
- Firman, T. (2004). Major issues in Indonesia's urban land development. *Land Use Policy*, 21(4), 347-355. doi:10.1016/j.landusepol.2003.04.002
- Fitriyeni, C. E., Kadir, M. Y. k. A., Bahri, S., & Sufyan. (2020). Customs Policy for Land and Building Rights in Optimization of Original Income in Aceh Besar District, Indonesia. *Proceedings of the International Conference on Law, Governance and Islamic Society (ICOLGIS 2019)*. doi:10.2991/assehr.k.200306.225
- Fletcher, C. S., Ganegodage, K. R., Hildenbrand, M. D., & Rambaldi, A. N. (2022). The behaviour of property prices when affected by infrequent floods. *Land Use Policy*, 122, 106378. doi:10.1016/j.landusepol.2022.106378
- Freeman, A. M. (1979). Hedonic Prices, Property Values and Measuring Environmental Benefits: A Survey of the Issues. *The Scandinavian Journal of Economics*, 81(2), 154-173. doi:10.2307/3439957
- Fujii, Y. (2021). Tax deed sales and land banking to reuse vacant and abandoned properties. *International Journal of Housing Markets and Analysis*, 14(3), 596-612. doi:10.1108/IJHMA-05-2020-0054
- Fujita, M., & Thisse, J.-F. (2013). *Economics of Agglomeration Cities, Industrial Location, and Globalization*: Cambridge University Press.
- Fussell, E., Curtis, K. J., & DeWaard, J. (2014). Recovery migration to the City of New Orleans after Hurricane Katrina: a migration systems approach. *Population and Environment*, 35(3), 305-322. doi:10.1007/s11111-014-0204-5

- Gabriel, S. A., & Painter, G. (2008). Mobility, Residential Location and the American Dream: The Intrametropolitan Geography of Minority Homeownership. *Real Estate Economics*, 36(3), 499-531. doi:10.1111/j.1540-6229.2008.00220.x
- Gao, F., Yang, L., Han, C., Tang, J., & Li, Z. (2022). A network-distance-based geographically weighted regression model to examine spatiotemporal effects of station-level built environments on metro ridership. *Journal of Transport Geography*, 105, 103472. doi:10.1016/j.jtrangeo.2022.103472
- Gibson, S., & Law, L. (2022). Barriers and opportunities for medium density housing in small, regional cities: stakeholder perspectives from Cairns. *Australian Planner*, 58(3-4), 95-109. doi:10.1080/07293682.2023.2183225
- Gourevitch, J. D., Kousky, C., Liao, Y., Nolte, C., Pollack, A. B., Porter, J. R., & Weill, J. A. (2023). Unpriced climate risk and the potential consequences of overvaluation in US housing markets. *Nature Climate Change*, 13(3), 250-257. doi:10.1038/s41558-023-01594-8
- Gray, C. L., & Mueller, V. (2012). Natural disasters and population mobility in Bangladesh. *Proceedings of the National Academy of Sciences*, 109(16), 6000-6005. doi:10.1073/pnas.1115944109
- Grigsby, W. G., Baratz, M. S., Galster, G., & MacLennan, D. (1987). The dynamic of neighborhood change and decline. *Progress in Planning*, 28, 1. doi:10.1016/0305-9006(87)90011-0
- Gu, D., Newman, G., Kim, J.-H., Park, Y., & Lee, J. (2019). Neighborhood decline and mixed land uses: Mitigating housing abandonment in shrinking cities. *Land Use Policy*, 83, 505-511. doi:10.1016/j.landusepol.2019.02.033
- Guglielminetti, E., Lalive, R., Ruh, P., & Wasmer, E. (2024). Job search with commuting and unemployment insurance: A look at workers' strategies in time. *Labour Economics*, 88, 102537. doi:10.1016/j.labeco.2024.102537
- Hallegatte, S., Green, C., Nicholls, R. J., & Corfee-Morlot, J. (2013). Future flood losses in major coastal cities. *Nature Climate Change*, 3(9), 802-806. doi:10.1038/nclimate1979
- Hamnett, C. (2009). Spatially Displaced Demand and the Changing Geography of House Prices in London, 1995-2006. *Housing Studies*, 24(3), 301-320. doi:10.1080/02673030902814580
- Han, H.-S. (2019). Exploring Threshold Effects in the Impact of Housing Abandonment on Nearby Property Values. *Urban Affairs Review*, 55(3), 772-799. doi:10.1177/1078087417720303
- Handayani, A. (2021). *Local Government Response to The Impacts of Climate Change: A Review of Climate Change Strategies in Pekalongan, Central Java, Indonesia*. Paper presented at the IOP conference series: Earth and environmental science.
- Handayani, W., Chigbu, U. E., Rudiarto, I., & Putri, I. H. S. (2020). Urbanization and Increasing Flood Risk in the Northern Coast of Central Java—Indonesia: An Assessment towards Better Land Use Policy and Flood Management. *Land*, 9(10). doi:10.3390/land9100343
- Hanushek, E. A., & Quigley, J. M. (1978). An Explicit Model of Intra-Metropolitan Mobility. *Land Economics*, 54(4). doi:10.2307/3146168
- Hartigan, J. A., & Wong, M. A. (1979). Algorithm AS 136: A K-Means Clustering Algorithm. *Applied Statistics*, 28(1). doi:10.2307/2346830
- Hartmann, T., & Needham, P. D. B. (2012). *Planning By Law and Property Rights Reconsidered*: Ashgate Publishing Limited.
- Hartoyo, H., S. Damanhur, D., Saefuddin, A., & Triguna, G. (2015). The Model of Property Tax assessment based on Straight Line Distance and Distance of Travel; Case Study in the West of Bogor City. *Kajian Ekonomi dan Keuangan*, 18(1), 1-14. doi:10.31685/kek.v18i1.29
- He, Q., & Zhang, Y. (2023). Residential locations and residential moves between the city centre and suburb in Beijing, China. *Habitat International*, 131, 102711. doi:10.1016/j.habitatint.2022.102711

- Helbich, M., Brunauer, W., Hagenauer, J., & Leitner, M. (2013). Data-Driven Regionalization of Housing Markets. *Annals of the Association of American Geographers*, 103(4), 871-889. doi:10.1080/00045608.2012.707587
- Hirsch, J., & Hahn, J. (2018). How flood risk impacts residential rents and property prices. *JOURNAL OF PROPERTY INVESTMENT & FINANCE*, 36(1), 50-67. doi:10.1108/JPIF-11-2016-0088
- Hogantara, Y. D., Ma, #039, & ruf, U. (2018). The Implementation of Determination of Duty on the Acquisition of Land and Building Right (BPHTB) on the Land or Building Sale and Purchase in Pekalongan City. 2018, 5(3), 6. doi:10.30659/akta.v5i3.3236
- Hu, Y., Tian, B., Yuan, L., Li, X., Huang, Y., Shi, R., . . . Sun, C. (2021). Mapping coastal salt marshes in China using time series of Sentinel-1 SAR. *ISPRS Journal of Photogrammetry and Remote Sensing*, 173, 122-134. doi:10.1016/j.isprsjprs.2021.01.003
- Hudson, P., Bubeck, P., & Thieken, A. H. (2021). A comparison of flood-protective decision-making between German households and businesses. *Mitigation and Adaptation Strategies for Global Change*, 27(1), 5. doi:10.1007/s11027-021-09982-1
- Hunter, L. M., Luna, J. K., & Norton, R. M. (2015). Environmental Dimensions of Migration. *Annual Review of Sociology*, 41(1), 377-397. doi:10.1146/annurev-soc-073014-112223
- Hwang, S., & Thill, J.-C. (2009). Delineating Urban Housing Submarkets with Fuzzy Clustering. *Environment and Planning B: Planning and Design*, 36(5), 865-882. doi:10.1068/b34111t
- Inasius, F. (2019). Factors Influencing SME Tax Compliance: Evidence from Indonesia. *International Journal of Public Administration*, 42(5), 367-379. doi:10.1080/01900692.2018.1464578
- IPCC. (2012). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. In C. B. Field, V. Barros, & T. F. Stocker (Eds.). England: Cambridge.
- Ismail, N. H., Abd Karim, M. Z., & Hasan-Basri, B. (2019). Hedonic Analysis of the Impact of Flood Events on Residential Property Values in Malaysia: A Study of Willingness to Pay. *Malaysian Journal of Economic Studies*, 56(1), 63-84. doi:10.22452/MJES.vol56no1.4
- Ismail, N. H., Karim, M. Z. A., & Basri, B. H. (2016). Flood and Land Property Values. *Asian Social Science*, 12(5). doi:10.5539/ass.v12n5p84
- Jarvis, B. F. (2018). Estimating Multinomial Logit Models with Samples of Alternatives. *Sociological Methodology*, 49(1), 341-348. doi:10.1177/0081175018793460
- Jiang, W., Deng, L., Chen, L., Wu, J., & Li, J. (2009). Risk assessment and validation of flood disaster based on fuzzy mathematics. *Progress in Natural Science*, 19(10), 1419-1425. doi:10.1016/j.pnsc.2008.12.010
- Jiménez-Meza, A., Arámburo-Lizárraga, J., & de la Fuente, E. (2013). Framework for Estimating Travel Time, Distance, Speed, and Street Segment Level of Service (LOS), based on GPS Data. *Procedia Technology*, 7, 61-70. doi:10.1016/j.protcy.2013.04.008
- Jun, H.-J. (2022). Spillover effects in neighborhood housing value change: a spatial analysis. *Housing Studies*, 37(8), 1303-1330. doi:10.1080/02673037.2020.1842338
- Kartiki, K. (2011). Climate change and migration: a case study from rural Bangladesh. *Gender & Development*, 19(1), 23-38. doi:10.1080/13552074.2011.554017
- Keskin, B., & Watkins, C. (2016). Defining spatial housing submarkets: Exploring the case for expert delineated boundaries. *Urban Studies*, 54(6), 1446-1462. doi:10.1177/0042098015620351
- Khairulbahri, M. (2022). The qualitative analysis of the nexus dynamics in the Pekalongan coastal area, Indonesia. *Scientific Reports*, 12(1), 11391. doi:10.1038/s41598-022-15683-9
- Kopczewska, K., & Ćwiakowski, P. (2021). Spatio-temporal stability of housing submarkets. Tracking spatial location of clusters of geographically weighted regression estimates of price determinants. *Land Use Policy*, 103, 105292. doi:10.1016/j.landusepol.2021.105292

- Krause, C. M., & Zhang, L. (2019). Short-term travel behavior prediction with GPS, land use, and point of interest data. *Transportation Research Part B: Methodological*, 123, 349-361. doi:10.1016/j.trb.2018.06.012
- Lancaster, K. J. (1966). A New Approach to Consumer Theory. *Journal of Political Economy*, 74(2), 132-157. doi:10.1086/259131
- Lee, D. (2017). Neighborhood Change Induced by Natural Hazards. *Journal of Planning Literature*, 32(3), 240-252. doi:10.1177/0885412217696945
- Lee, D. (2018). The Impact of Natural Disasters on Neighborhood Poverty Rate: A Neighborhood Change Perspective. *Journal of Planning Education and Research*, 40(4), 447-459. doi:10.1177/0739456X18769144
- Liao, W.-C., Zhao, D., Lim, L. P., & Wong, G. K. M. (2015). Foreign liquidity to real estate market: Ripple effect and housing price dynamics. *Urban Studies*, 52(1), 138-158. doi:10.1177/0042098014523687
- Lo Cascio, I. (2021). A wavelet analysis of the ripple effect in UK regional housing markets. *International Review of Economics & Finance*, 76, 1093-1105. doi:10.1016/j.iref.2021.08.001
- Loberato, M. (2023). Foreclosures and House Prices. *Italian Economic Journal*, 9(1), 397-424. doi:10.1007/s40797-021-00166-z
- Löschner, L., & Nordbeck, R. (2020). Switzerland's transition from flood defence to flood-adapted land use—A policy coordination perspective. *Land Use Policy*, 95. doi:10.1016/j.landusepol.2019.02.032
- Loughran, K., & Elliott, J. R. (2019). Residential buyouts as environmental mobility: examining where homeowners move to illuminate social inequities in climate adaptation. *Population and Environment*, 41(1), 52-70. doi:10.1007/s11111-019-00324-7
- Lu, B., Harris, P., Charlton, M., & Brunsdon, C. (2014). The GWmodel R package: further topics for exploring spatial heterogeneity using geographically weighted models. *Geo-spatial Information Science*, 17(2), 85-101. doi:10.1080/10095020.2014.917453
- Lu, B., Hu, Y., Murakami, D., Brunsdon, C., Comber, A., Charlton, M., & Harris, P. (2022). High-performance solutions of geographically weighted regression in R. *Geo-spatial Information Science*, 25(4), 536-549. doi:10.1080/10095020.2022.2064244
- Lu, Y., Shi, V., & Pettit, C. J. (2023). The Impacts of Public Schools on Housing Prices of Residential Properties: A Case Study of Greater Sydney, Australia. *ISPRS International Journal of Geo-Information*, 12(7). doi:10.3390/ijgi12070298
- Ludy, J., & Kondolf, G. M. (2012). Flood risk perception in lands “protected” by 100-year levees. *Natural Hazards*, 61, 829-842.
- Mahfudz, S. (2020). *Kebencanaan Kota Pekalongan*. Kunjungan lapangan Pokja Land Subsidence di Pekalongan. Pekalongan City Government. Pekalongan.
- Mardiansjah, F. H., Rahayu, P., & Rukmana, D. (2021). New Patterns of Urbanization in Indonesia: Emergence of Non-statutory Towns and New Extended Urban Regions. *Environment and Urbanization ASIA*, 12(1), 11-26. doi:10.1177/0975425321990384
- Marfai, M. A. (2014). Impact of Sea Level Rise to Coastal Ecology: A Case Study on the Northern Part of Java Island, Indonesia. *quageo*, 33(1), 107-114. doi:10.2478/quageo-2014-0008
- Marfai, M. A., King, L., Sartohadi, J., Sudrajat, S., Budiani, S. R., & Yulianto, F. (2008). The impact of tidal flooding on a coastal community in Semarang, Indonesia. *The Environmentalist*, 28(3), 237-248. doi:10.1007/s10669-007-9134-4
- Marfai, M. A., Sekaranom, A. B., & Ward, P. (2015). Community responses and adaptation strategies toward flood hazard in Jakarta, Indonesia. *Natural Hazards*, 75(2), 1127-1144. doi:10.1007/s11069-014-1365-3
- Martínez-Graña, A. M., Boski, T., Goy, J. L., Zazo, C., & Dabrio, C. J. (2016). Coastal-flood risk management in central Algarve: Vulnerability and flood risk indices (South Portugal). *Ecological Indicators*, 71, 302-316. doi:10.1016/j.ecolind.2016.07.021

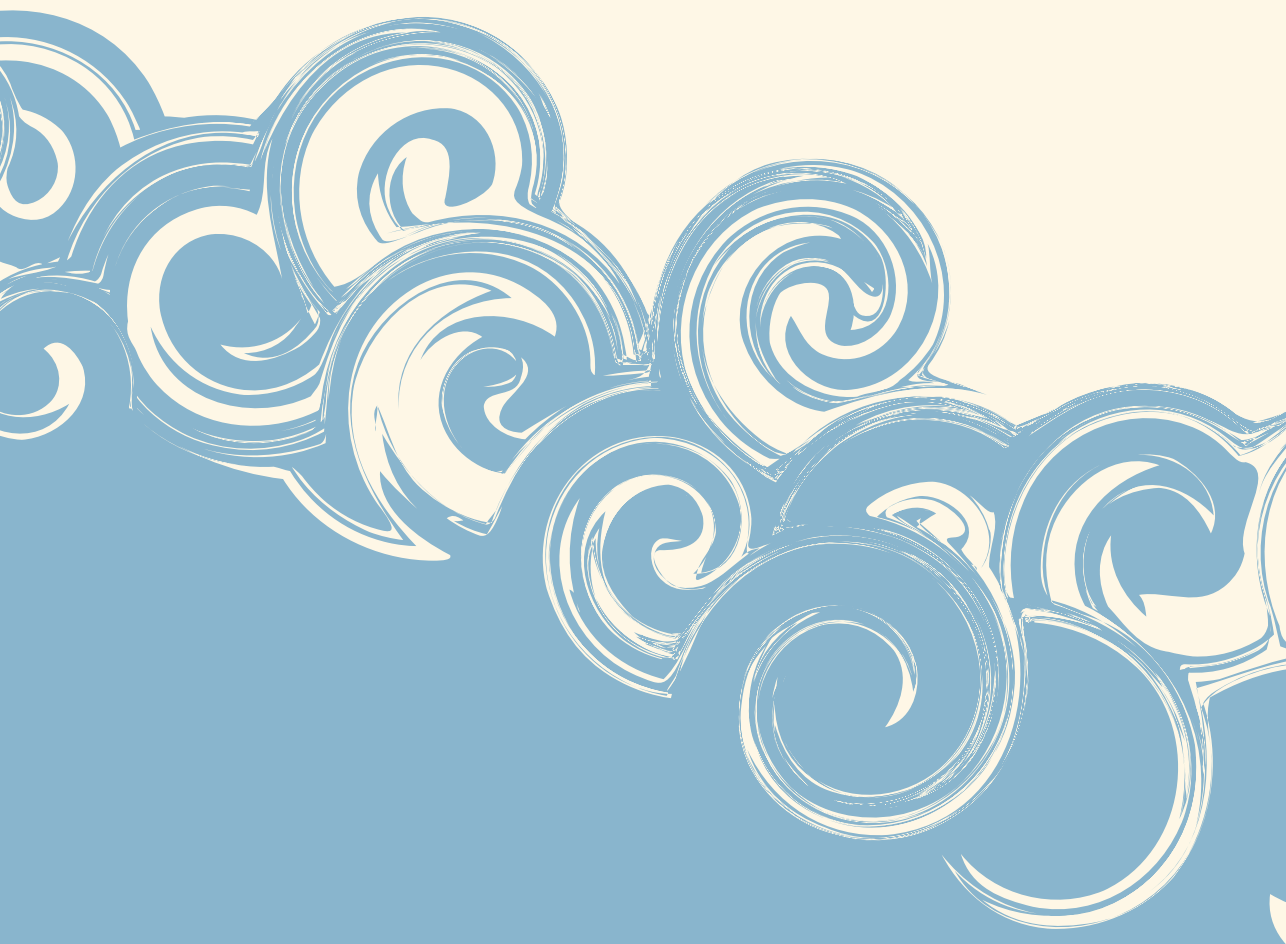
- Martinez, G., Costas, S., & Ferreira, Ó. (2020). The role of culture for coastal disaster risk reduction measures: Empirical evidence from northern and southern Europe. *Advances in Climate Change Research*, 11(4), 297-309. doi:10.1016/j.accres.2020.11.001
- Meen, G. (1999). Regional House Prices and the Ripple Effect: A New Interpretation. *Housing Studies*, 14(6), 733-753. doi:10.1080/02673039982524
- Megbolugbe, I. F., Hoek-Smit, M. C., & Linneman, P. D. (1996). Understanding Neighbourhood Dynamics: A Review of the Contributions of William G. Grigsby. *Urban Studies*, 33(10), 1779-1795. doi:10.1080/0042098966367
- Mendelsohn, R. (2000). Efficient Adaptation to Climate Change. *Climatic Change*, 45(3), 583-600. doi:10.1023/A:1005507810350
- Mercy Corps. (2021). *Kompilasi Laporan Singkat - Kajian Kerentanan Dan Risiko Pekalongan*. Retrieved from Jakarta: <https://www.mercycorps.or.id/dokumen/kompilasi-laporan-singkat-kajian-kerentanan-dan-risiko-pekalongan>
- Michael Paulo Sulle, P. S., Michael, P. S., Mwakyusa, L., & Massawe, B. H. J. (2023). Floods stress in lowland rice production: experiences of rice farmers in Kilombero and Lower-Rufiji floodplains, Tanzania. *FRONTIERS IN SUSTAINABLE FOOD SYSTEMS*, 7. doi:10.3389/fsufs.2023.1206754
- Miller, A. C., & Ravens, T. M. (2022). Assessing Coastal Road Flood Risk in Arctic Alaska, a Case Study from Hooper Bay. *Journal of Marine Science and Engineering*, 10(3), 406. doi:10.3390/jmse10030406
- Mordechay, K., & Terbeck, F. J. (2023). Moving Toward Integration or Segregation? Racial Change in Suburban Public Schools. *Educational Policy*, 0(0), 08959048231178021. doi:10.1177/08959048231178021
- Murray, N. J., Phinn, S. R., DeWitt, M., Ferrari, R., Johnston, R., Lyons, M. B., . . . Fuller, R. A. (2019). The global distribution and trajectory of tidal flats. *Nature*, 565(7738), 222-225. doi:10.1038/s41586-018-0805-8
- Mutlu, A., Roy, D., & Filatova, T. (2023). Capitalized value of evolving flood risks discount and nature-based solution premiums on property prices. *Ecological Economics*, 205, 107682. doi:10.1016/j.ecolecon.2022.107682
- Muto, S., Sugawara, S., & Suzuki, M. (2023). Hedonic real estate price estimation with the spatiotemporal geostatistical model. *Journal of Spatial Econometrics*, 4(1), 10. doi:10.1007/s43071-023-00039-w
- Nagayasu, J. (2021). Life Cycles and Gender in Residential Mobility Decisions. *The Journal of Real Estate Finance and Economics*, 62(3), 370-401. doi:10.1007/s11146-019-09743-7
- Ortega, F., & Taşpınar, S. (2018). Rising sea levels and sinking property values: Hurricane Sandy and New York's housing market. *Journal of Urban Economics*, 106, 81-100. doi:10.1016/j.jue.2018.06.005
- Oshan, T., Wolf, L. J., Fotheringham, A. S., Kang, W., Li, Z., & Yu, H. (2019). A comment on geographically weighted regression with parameter-specific distance metrics. *International Journal of Geographical Information Science*, 33(7), 1289-1299. doi:10.1080/13658816.2019.1572895
- Park, I. K., & von Rabenau, B. (2014). Tax delinquency and abandonment: An expanded model with application to industrial and commercial properties. *Urban Studies*, 52(5), 857-875. doi:10.1177/0042098014524610
- Pathak, S. (2021). Determinants of flood adaptation: Parametric and semiparametric assessment. *Journal of Flood Risk Management*, 14(2), e12699. doi:10.1111/jfr3.12699
- Permana, I., & Miyata, Y. (2008). An Urban Economic Model of Illegal Settlements In Flood Prone Areas In Palangkaraya City, Indonesia-A Partial Equilibrium Analysis. *Regional Science Inquiry Journal*, 1V(1), 29-38.
- Pierce Holloway, W., & BenDor, T. K. (2023). Residential property value impacts of floodplain buyouts in Charlotte, North Carolina. *Journal of Environmental Management*, 347, 119165. doi:10.1016/j.jenvman.2023.119165

- Piggott-McKellar, A. E., & McMichael, C. (2021). The immobility-relocation continuum: Diverse responses to coastal change in a small island state. *Environmental Science & Policy*, 125, 105-115. doi:10.1016/j.envsci.2021.08.019
- Pryce, G., & Chen, Y. (2011). Flood risk and the consequences for housing of a changing climate: An international perspective. *Risk Management*, 13(4), 228-246. doi:10.1057/rm.2011.13
- Pryce, G., Chen, Y., & Galster, G. (2011). The Impact of Floods on House Prices: An Imperfect Information Approach with Myopia and Amnesia. *Housing Studies*, 26(2), 259-279. doi:10.1080/02673037.2011.542086
- Putra, R., Fadhilurrahman, M. G., & Gunardi. (2023). Determination of the best knot and bandwidth in geographically weighted truncated spline nonparametric regression using generalized cross validation. *MethodsX*, 10, 101994. doi:10.1016/j.mex.2022.101994
- Putu Eka Wima, S., Gusti Bagus, S., & Agung, A. A. I. (2023, 2023/01/25). *Analysis of the Imposition of Final Income Tax (Final Income Tax) and Duty for the Acquisition of Land and/or Building Rights (BPHTB Tax) in the Transition of Property Rights to Land in Gianyar Regency*. Paper presented at the Proceedings of the 3rd International Conference on Business Law and Local Wisdom in Tourism (ICBLT 2022).
- Quinn, T., Bousquet, F., Guerbois, C., Sougrati, E., & Tabutaud, M. (2018). The dynamic relationship between sense of place and risk perception in landscapes of mobility. *Ecology and Society*, 23(2). doi:10.5751/es-10004-230239
- Rabiei-Dastjerdi, H., McArdle, G., & Hynes, W. (2022). Which came first, the gentrification or the Airbnb? Identifying spatial patterns of neighbourhood change using Airbnb data. *Habitat International*, 125, 102582. doi:10.1016/j.habitatint.2022.102582
- Rajapaksa, D., Wilson, C., Hoang, V.-N., Lee, B., & Managi, S. (2017). Who responds more to environmental amenities and dis-amenities? *Land Use Policy*, 62, 151-158. doi:10.1016/j.landusepol.2016.12.029
- Rajapaksa, D., Wilson, C., Managi, S., Hoang, V., & Lee, B. (2016). Flood Risk Information, Actual Floods and Property Values: A Quasi-Experimental Analysis. *Economic Record*, 92, 52-67. doi:10.1111/1475-4932.12257
- Rajapaksa, D., Zhu, M., Lee, B., Hoang, V.-N., Wilson, C., & Managi, S. (2017). The impact of flood dynamics on property values. *Land Use Policy*, 69, 317-325. doi:10.1016/j.landusepol.2017.08.038
- Ramadhani Maharlika, A., Prawata Hadi, S., Kismartini, & Lenty Hoya, A. (2020). Tidal flooding and coastal adaptation responses in Pekalongan City. *E3S Web Conf.*, 202, 06027. Retrieved from <https://doi.org/10.1051/e3sconf/202020206027>
- Rayda, N. (2021). This city in Java could disappear in 15 years, due to land subsidence and coastal flooding. *Channel News Asia*. Retrieved from <https://www.channelnewsasia.com/climatechange/indonesia-pekalongan-land-sinking-coastal-flooding-disappear-1883156>
- Reisinger, A., Howden, M., Vera, C., Garschagen, M., Hurlbert, M., Kreibieh, S., . . . Pathak, M. (2020). The concept of risk in the IPCC Sixth Assessment Report: a summary of cross-working group discussions. *Intergovernmental Panel on Climate Change: Geneva, Switzerland*.
- Rogers, B. C., Bertram, N., Gersonius, B., Gunn, A., Löwe, R., Murphy, C., . . . Arnbjerg-Nielsen, K. (2020). An interdisciplinary and catchment approach to enhancing urban flood resilience: a Melbourne case. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 378(2168), 20190201. doi:10.1098/rsta.2019.0201
- Rosen, S. (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy*, 82(1), 34-55. doi:10.1086/260169
- Rosid, A., Evans, C., & Tran-Nam, B. (2018). Tax Non-Compliance and Perceptions of Corruption: Policy Implications for Developing Countries. *Bulletin of Indonesian Economic Studies*, 54(1), 25-60. doi:10.1080/00074918.2017.1364349

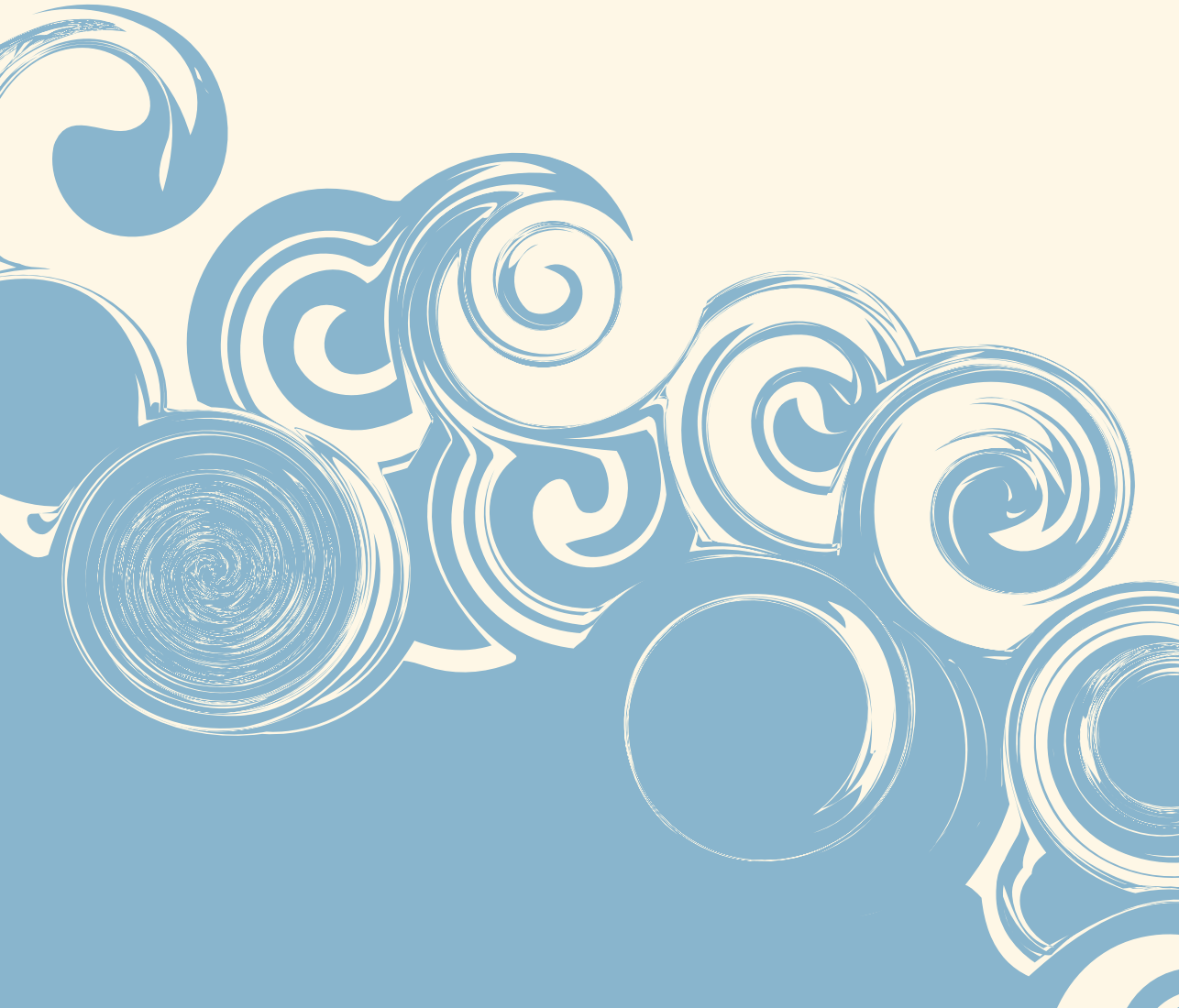
- Rosid, A., & Romadhaniah. (2023). Assessing the Effectiveness of Law Enforcement on Improving Tax Compliance in Indonesia: An Empirical Investigation. *Bulletin of Indonesian Economic Studies*, 59(2), 243-267. doi:10.1080/00074918.2021.1970110
- Rothenberg, J., Galster, G. C., Butler, R. V., & Pitkin, J. R. (1991). *The Maze of Urban Housing Markets: Theory, Evidence, and Policy*. Chicago and London: University of Chicago Press.
- Rudiarto, I., Handayani, W., & Sih Setyono, J. (2018). A Regional Perspective on Urbanization and Climate-Related Disasters in the Northern Coastal Region of Central Java, Indonesia. *Land*, 7(1). doi:10.3390/land7010034
- Samarasinghe, O., & Sharp, B. (2010). Flood prone risk and amenity values: a spatial hedonic analysis. *Australian Journal of Agricultural and Resource Economics*, 54(4), 457-475. doi:10.1111/j.1467-8489.2009.00483.x
- Sambodo, M. T., & Novandra, R. (2019). The state of energy poverty in Indonesia and its impact on welfare. *Energy Policy*, 132, 113-121. doi:10.1016/j.enpol.2019.05.029
- Sariffuddin, S., Samsura, D. A. A., Krabben, E. v. d., Setiyono, B., & Pradoto, W. (2023). Housing Displacement and Replacement in Coastal Flood-Prone Areas: Evidence from a Land and Building Tax-Based Study in Indonesia. In P. Tiwari, D. B. Rahut, & K. S. Ram (Eds.), *Resilient compensation and restitution for post-disaster recovery in Asia and the Pacific*. Japan: Asian Development Bank Institute.
- Sariffuddin, S., Samsura, D. A. A., van der Krabben, E., Setiyono, B., & Pradoto, W. (2024). Toward obsolete housing: A complementary explanation of increasing coastal vulnerability. *International Journal of Disaster Risk Reduction*, 111, 104709. doi:10.1016/j.ijdr.2024.104709
- Sayers, P. (2017). Evolution of Strategic Flood Risk Management in Support of Social Justice, Ecosystem Health, and Resilience. In *Oxford Research Encyclopedia of Natural Hazard Science*.
- Schanze, J. (2006). Flood risk management - A basic framework. In J. Schanze, E. Zeman, & J. Marsalek (Eds.), *Flood Risk Management: Hazards, Vulnerability and Mitigation Measures*. NATO Science Series (Vol. 67, pp. 1-20). Dordrecht: Springer Netherlands.
- Schwirian, K. P. (1983). Models of Neighborhood Change. *Annual Review of Sociology*, 9, 83-102. Retrieved from <http://www.jstor.org/stable/2946058>
- Seo, J., Oh, J., & Kim, J. (2021). Flood risk awareness and property values: evidences from Seoul, South Korea. *International Journal of Urban Sciences*, 25(2), 233-251. doi:10.1080/12265934.2020.1850324
- Shao, W., Xian, S., Lin, N., Kunreuther, H., Jackson, N., & Goidel, K. (2017). Understanding the effects of past flood events and perceived and estimated flood risks on individuals' voluntary flood insurance purchase behavior. *Water Research*, 108, 391-400. doi:10.1016/j.watres.2016.11.021
- Shen, Y., & Karimi, K. (2017). The economic value of streets: mix-scale spatio-functional interaction and housing price patterns. *Applied Geography*, 79, 187-202. doi:10.1016/j.apgeog.2016.12.012
- Sidik, M. (2021). A Land Value Capture: Taxation and Value for Money Perspectives. *Journal of Tax and Business*, 2(1), 1-19. doi:10.55336/jpb.v2i1.16
- Song, S., Wang, S., Fu, B., Dong, Y., Liu, Y., Chen, H., & Wang, Y. (2020). Improving representation of collective memory in socio-hydrological models and new insights into flood risk management. *Journal of Flood Risk Management*, 14(1). doi:10.1111/jfr3.12679
- Spalding, M. D., McIvor, A. L., Beck, M. W., Koch, E. W., Möller, I., Reed, D. J., . . . Woodroffe, C. D. (2014). Coastal Ecosystems: A Critical Element of Risk Reduction. *Conservation Letters*, 7(3), 293-301. doi:10.1111/conl.12074
- Suesse, T. (2018). Marginal maximum likelihood estimation of SAR models with missing data. *Computational Statistics & Data Analysis*, 120, 98-110. doi:10.1016/j.csda.2017.11.004

- Suharini, E., Hanafi, F., & Sidiq, W. A. B. N. (2017). *Study of Population Growth and Land Use Change Impact of Intrusion on Pekalongan City*. Paper presented at the Proceedings of the 1st International Conference on Geography and Education (ICGE 2016).
- Sunarti, S., Helmi, M., Widjajanti, R., & Purwanto, A. A. (2020). Modelling behavioural change from sea-based 'helicopter latrines' to land-based shared improved latrines in the Demaan, Jepara, Indonesia. *Journal of Water, Sanitation and Hygiene for Development*, 11(1), 10-25. doi:10.2166/washdev.2020.159
- Suzuki, M., Hino, K., & Muto, S. (2022). Negative externalities of long-term vacant homes: Evidence from Japan. *Journal of Housing Economics*, 57, 101856. doi:10.1016/j.jhe.2022.101856
- Syam, D. A., Wengi, K. R. L., & Gandapurnama, A. (2021). *Climate Risk And Impact Assessment Pekalongan*. Retrieved from Jakarta:
- Terbeck, F. J. (2023). The suburbanization of poverty and minority populations in the 2000s: Two parallel or interrelated processes? *JOURNAL OF URBAN AFFAIRS*, 45(8), 1434-1451. doi:10.1080/07352166.2021.1947143
- Thistlethwaite, J., Henstra, D., Brown, C., & Scott, D. (2018). How Flood Experience and Risk Perception Influences Protective Actions and Behaviours among Canadian Homeowners. *Environmental Management*, 61(2), 197-208. doi:10.1007/s00267-017-0969-2
- Tobin, G. A., & Newton, T. G. (1986). A Theoretical Framework of Flood Induced Changes in Urban Land Values. *Journal of the American Water Resources Association*, 22(1), 67-71. doi:10.1111/j.1752-1688.1986.tb01861.x
- Turnbull, G. K., & van der Vlist, A. J. (2023). Foreclosures and housing prices: does neighborhood configuration matter? *The Annals of Regional Science*. doi:10.1007/s00168-023-01206-5
- Ullah, F., Saqib, S. E., Ahmad, M. M., & Fadlallah, M. A. (2020). Flood risk perception and its determinants among rural households in two communities in Khyber Pakhtunkhwa, Pakistan. *Natural Hazards*, 104(1), 225-247. doi:10.1007/s11069-020-04166-7
- UN-SPIDER. Flood Mapping and Damage Assessment Using Sentinel-1 SAR Data in Google Earth Engine. Retrieved from <https://www.un-spider.org/advisory-support/recommended-practices/recommended-practice-google-earth-engine-flood-mapping>
- Usman, H., Lizam, M., & Adekunle, M. U. (2020). Property Price Modelling, Market Segmentation and Submarket Classifications: A Review. *Real Estate Management and Valuation*, 28(3), 24-35. doi:10.1515/remav-2020-0021
- van der Krabben, E. (2009). A Property Rights Approach to Externality Problems: Planning Based on Compensation Rules. *Urban Studies*, 46(13), 2869-2890. doi:10.1177/0042098009345537
- Van Ham, M. (2012a). Housing behavior. In *The SAGE Handbook of Housing Studies*. doi:10.4135/9781446247570
- van Ham, M. (2012b). The SAGE Handbook of Housing Studies. In. doi:10.4135/9781446247570
- Votsis, A., & Perrels, A. (2016). Housing Prices and the Public Disclosure of Flood Risk: A Difference-in-Differences Analysis in Finland. *The Journal of Real Estate Finance and Economics*, 53(4), 450-471. doi:10.1007/s11146-015-9530-3
- Walelign, S. Z., & Lujala, P. (2022). A place-based framework for assessing resettlement capacity in the context of displacement induced by climate change. *World Development*, 151, 105777. doi:10.1016/j.worlddev.2021.105777
- Wang, D., He, S., Webster, C., & Zhang, X. (2019). Unravelling residential satisfaction and relocation intention in three urban neighborhood types in Guangzhou, China. *Habitat International*, 85, 53-62. doi:10.1016/j.habitatint.2019.01.004
- Wang, Y., Yue, X., Wu, Y., Zhang, H. o., & Liu, S. (2023). Spatial Characteristics of the Abandonment Degree of Residential Quarters Based on Data of the Housing Sales Ratio—A Case Study of Kunming, China. *Buildings*, 13(1), 29. doi:10.3390/buildings13010029

- Wen, H., Xiao, Y., Hui, E. C. M., & Zhang, L. (2018). Education quality, accessibility, and housing price: Does spatial heterogeneity exist in education capitalization? *Habitat International*, 78, 68-82. doi:10.1016/j.habitatint.2018.05.012
- Whitaker, S., & Fitzpatrick IV, T. J. (2013). Deconstructing distressed-property spillovers: The effects of vacant, tax-delinquent, and foreclosed properties in housing submarkets. *Journal of Housing Economics*, 22(2), 79-91. doi:10.1016/j.jhe.2013.04.001
- Widiyanto, E. (2017). Pembangunan Tanggul Raksasa di Pekalongan dimulai. *Republika*. Retrieved from <https://news.republika.co.id/berita/poyozx280/pembangunan-tanggul-raksasa-di-pekalongan-dimulai>
- Wiersma, S., Just, T., & Heinrich, M. (2022). Segmenting German housing markets using principal component and cluster analyses. *International Journal of Housing Markets and Analysis*, 15(3), 548-578. doi:10.1108/IJHMA-01-2021-0006
- Wijaya, D. D., Andreas, H., Zainal Abidin, H., Anggreni Sarsito, D., Meilano, I., & Susilo. (2019). Investigating the tectonic influence to the anthropogenic subsidence along northern coast of Java Island Indonesia using GNSS data sets. *E3S Web of Conferences*, 94. doi:10.1051/e3sconf/20199404005
- Willemsen, W., Kok, S., & Kuik, O. (2020). The effect of land subsidence on real estate values. *Proc. IAHS*, 382, 703-707. doi:10.5194/piahs-382-703-2020
- Winstanley, A. N. N., Thorns, D. C., & Perkins, H. C. (2002). Moving House, Creating Home: Exploring Residential Mobility. *Housing Studies*, 17(6), 813-832. doi:10.1080/02673030216000
- Wolff, C., Nikolettopoulos, T., Hinkel, J., & Vafeidis, A. T. (2020). Future urban development exacerbates coastal exposure in the Mediterranean. *Sci Rep*, 10(1), 14420. doi:10.1038/s41598-020-70928-9
- Woodard, D., Nogin, G., Koch, P., Racz, D., Goldszmidt, M., & Horvitz, E. (2017). Predicting travel time reliability using mobile phone GPS data. *Transportation Research Part C: Emerging Technologies*, 75, 30-44. doi:10.1016/j.trc.2016.10.011
- Wu, C., & Sharma, R. (2012). Housing submarket classification: The role of spatial contiguity. *Applied Geography*, 32(2), 746-756. doi:10.1016/j.apgeog.2011.08.011
- Wu, C., Ye, X., Ren, F., & Du, Q. (2018). Modified Data-Driven Framework for Housing Market Segmentation. *Journal of Urban Planning and Development*, 144(4). doi:10.1061/(asce)up.1943-5444.0000473
- Wu, Y., Wei, Y. D., & Li, H. (2020). Analyzing Spatial Heterogeneity of Housing Prices Using Large Datasets. *Applied Spatial Analysis and Policy*, 13(1), 223-256. doi:10.1007/s12061-019-09301-x
- Yakubu, I. (2021). From a cluster of villages to a city: Housing politics and the dilemmas of spatial planning in Tamale, Ghana. *Land Use Policy*, 109, 105668. doi:10.1016/j.landusepol.2021.105668
- Yanto, Livneh, B., & Rajagopalan, B. (2017). Development of a gridded meteorological dataset over Java island, Indonesia 1985–2014. *Scientific Data*, 4(1), 170072. doi:10.1038/sdata.2017.72
- Yulianto, F., Suwarsono, S., Maulana, T., & Khomarudin, M. R. (2019). The dynamics of shoreline change analysis based on the integration of remote sensing and geographic information system (GIS) techniques in Pekalongan coastal area, Central Java, Indonesia. *Journal of Degraded and Mining Lands Management*, 6(3), 1789-1782. doi:10.15243/jdmlm.2019.063.1789
- Zhai, G., Fukuzono, T., & Ikeda, S. (2003). Effect of flooding on megalopolitan land prices: a case study of the 2000 Tokai flood in Japan. *Journal of natural disaster science*, 25(1), 23-36.
- Zhang, L., & Leonard, T. (2018). Flood Hazards Impact on Neighborhood House Prices. *The Journal of Real Estate Finance and Economics*, 58(4), 656-674. doi:10.1007/s11146-018-9664-1
- Zhang, W., Zhuang, X., & Li, Y. (2019). Spatial spillover around G20 stock markets and impact on the return: a spatial econometrics approach. *Applied Economics Letters*, 26(21), 1811-1817. doi:10.1080/13504851.2019.1602703
- Zhang, Y., Hwang, S. N., & Lindell, M. K. (2010). Hazard Proximity or Risk Perception? Evaluating Effects of Natural and Technological Hazards on Housing Values. *Environment and Behavior*, 42(5), 597-624. doi:10.1177/0013916509334564



Appendix



Semi-Supervised Cluster Analysis with K-Means

This study employed semi-supervised cluster analysis with k-means in RStatistics. The authors utilized the **cluster** package for R to observe the data-driven delineation based on the hedonic property variables. The optimum number of clusters was determined through the silhouette plot and cluster plot. As a result, there are 3 optimum groups for unsupervised cluster analysis. Figure A.1 shows the process of the semi-supervised cluster analysis with k-means.

Table A.1 shows the descriptive statistics of each variable for both submarket for distressed properties and submarket for western-inner city.

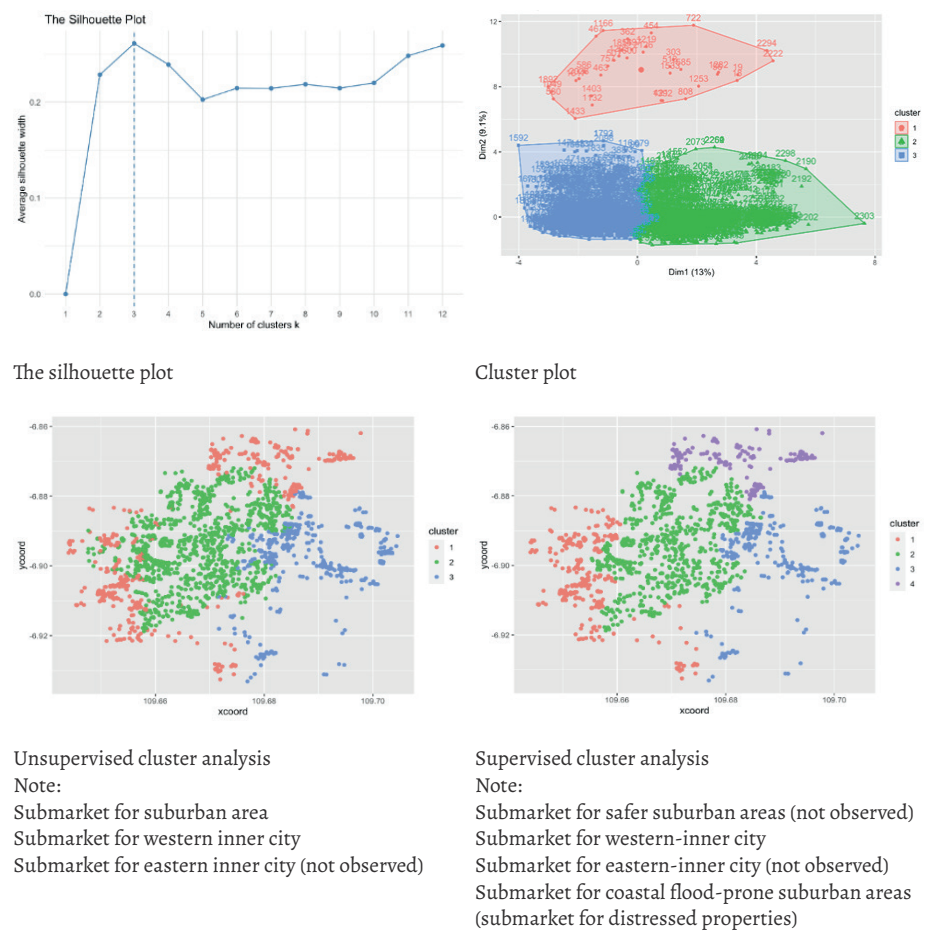


Figure A. 1 The Semi-Supervised Cluster Analysis with K-Means

Table A. 1 Descriptive Statistics

variable	Submarket for distressed properties (n = 200)			
	mean	sd	min	max
price	89.992,10	53.107,78	20.000,00	290.000,00
land	117,04	65,41	30,00	500,00
home	61,37	32,97	21,00	210,00
prox_ES	6,53	2,56	1,95	12,02
prox_JHS	5,19	3,81	0,13	12,97
prox_SHS	7,19	1,45	3,82	11,37
prox_UNIV	4,84	3,47	0,55	16,72
prox_TRAIN	11,50	1,43	8,38	16,58
prox_BUS	17,64	2,63	12,13	22,07
prox_HSPT	7,24	1,53	3,97	12,18
prox_CBD	7,04	4,56	0,05	18,52
subsidence	0,33	0,03	0,25	0,39
slope	1,03	0,17	1,00	2,00
flood	0,78	0,42	0,00	1,00
distressed	1,00	0,00	1,00	1,00
income	793,75	308,71	450,00	1.800,00

variable	Submarket for western-inner city (n = 829)			
	mean	sd	min	max
price	145.119,89	76.567,02	20.000,00	400.000,00
land	136,76	85,66	22,00	595,00
home	79,59	44,34	21,00	300,00
prox_ES	2,20	1,81	0,02	9,70
prox_JHS	2,47	1,39	0,00	8,93
prox_SHS	3,60	1,87	0,37	8,35
prox_UNIV	3,48	1,87	0,00	8,78
prox_TRAIN	6,85	2,10	1,67	11,58
prox_BUS	11,86	2,69	4,63	18,18
prox_HSPT	3,55	1,63	0,13	8,40
prox_CBD	2,18	1,49	0,02	7,42
subsidence	0,23	0,05	0,10	0,34
slope	1,07	0,26	1,00	3,00
flood	0,09	0,29	0,00	1,00
distressed	0,00	0,00	0,00	0,00
income	959.650,00	448.256,00	450,00	9.000,00

Factor Analysis

To observe the variables identified as influencing the housing submarket, factor analysis was conducted for both submarkets. Table A.2 presents the factor matrix based on hedonic property variables.

Table A. 2 Factor Matrix

Variables	Factor Matrix	
	Submarket for distressed properties	Submarket for Western-inner city
prox_SHS	0.80	0.82
prox_Train	0.80	0.92
prox_HSPT	0.93	0.71
prox_ES	-	-
prox_JHS	-	-
prox_BUS	0.93	-
prox_CBD	0.57	-
prox_UNIV	-	-
flood	-	-
price	-	-
land	-	-
building	-	-
n_floors	-	-
d.floor_ce	-	-
d.wall_bri	-	-
d.roof_asb	-	-

Housing Submarket Analysis

In the SAR model, the authors treated submarkets for distressed properties as dummy variables and included them in the modeling. Before employing this model, we calculated spatial dependency using the Moran I and spatial dependence diagnostic tests (see Table A.1). The Moran I test results in a value of 0.25, representing moderate spatial dependence. The Lagrange multiplier shows spatial dependence on spatial lag (LMlag: 87.171 [p-value < 0.1]) as well as in error (LMerr: 187.19 [p-value < 0.1]). Robust LM shows that RLMerr is 100.51 (p-value < 0.1) and RLMlag is 0.49579 (p-value > 0). This suggests that spillover in the error variable is more robust than in the dependent variables. However, because the main goal of this study is to understand spatial lag in property price decreases, the authors chose SAR, where the spatial lag is shown by the dependent variable.

Table A. 3. Spatial Dependence Diagnostic Test and Moran I Test

	Observed Moran I	Expectation	Variance
	0.251081975	-0.011320898	0.000317589
*Moran I statistic standard deviate = 14.787, p-value < 2.2e-16			
	Estimate	p-value	
LMerr	187.19	2.2e-16	***
LMlag	87.171	2.2e-16	***
RLMerr	100.51	2.2e-16	***
RLMlag	0.49579	0.4814	

Signif. codes : 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Semi-supervised cluster analysis unveiled four housing submarkets in the research area. The analysis employed k-means for data-driven cluster analysis. The unsupervised cluster analysis indicated that the property market was categorized into three housing submarkets: two for CBD and its extension, and one for suburban areas. Due to one housing group in suburban areas experiencing coastal flooding, the authors subsequently labeled it as the submarket for distressed properties, introducing it as a new housing submarket. Figure A.1 showed the semi-supervised spatial cluster analysis.

Volatility in property prices was noted within various housing submarkets. Three specific housing submarkets demonstrated an increase in property prices: the submarket for west-inner city, the submarket for east-inner city, and the submarket for suburban areas. Conversely, a decrease in property prices was observed in the



submarket for distressed properties situated in flood-prone areas. Figure A.2 illustrates the property price volatility of each housing submarket in Pekalongan city.

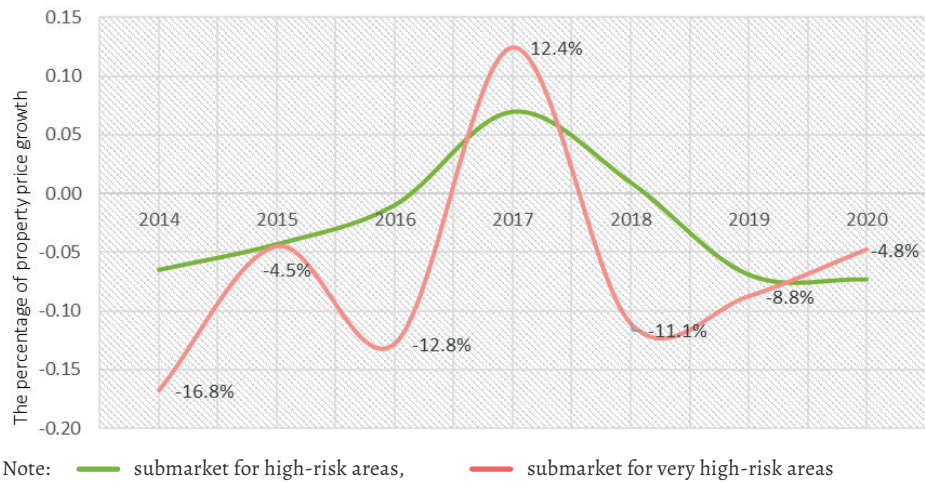


Figure A. 2 Property Price Volatility in Coastal Flood-Prone Areas

Table A. 4 Statistical Descriptive

Variable	Mean	Standard deviation	Min	Max
price	89.9 m	53.1 m	20 m	290 m
land	30	65.4	30	500
home	21	33.0	21	210
tax	60.6 m	41.8 m	8.8 m	289.8 m
age	0	13.2	0	70
slope	1	.171	1	2
subsidence	.249	.029	.249	.385
flood	0	.419	0	1
distressed	1	0	1	1
nondistressed	0	0	0	0
minute_es	1.95	2.56	1.95	12.0
minute_jhs	.133	3.81	.133	13.0
minute_shs	3.82	1.45	3.82	11.4
minute_hspt	3.97	1.53	3.97	12.2
minute_cbd	.05	4.56	.05	18.5

m = million

Before analyzing the GWR, dummy variables were created representing the submarket for distressed properties and neighboring housing submarket (submarket for west-inner city). The study of property price heterogeneity was conducted based on these 2 submarkets by filtering the dataset in both types of housing groups. Table A.4 shows the statistical descriptive and Table A.5 shows the result of geographically weighted regression.

Table A. 5 Results of Geographically Weighted Regression

	Min	1 st Qu	Median	3 rd Qu	Max
Intercept	-2.0834e+08	1.1524e+07	4.1777e+07	7.6565e+07	2.9822e+08
land	-1.0331e+05	1.5549e+05	2.2490e+05	2.7469e+05	4.4588e+05
home	-1.0027e+06	-3.1633e+05	-1.8946e+05	-4.9724e+04	4.2228e+05
age	-1.2742e+06	-2.0523e+05	-2.0484e+04	1.7287e+05	8.0472e+05
slope	-4.0645e+07	-3.6515e+06	3.9005e+06	1.1354e+07	6.4016e+07
subsidence	-6.0265e+08	-1.1560e+08	2.2307e+06	8.0825e+07	5.1745e+08
flood	-7.7582e+07	-1.3815e+07	-7.1895e+06	-7.2213e+05	1.4119e+08
distressed	-6.0353e+07	-1.5995e+07	-9.7358e+06	-1.5030e+06	9.8267e+07
nondistressed	-1.2804e+08	-1.1622e+07	-1.7458e+06	7.9373e+06	9.4933e+07
prox_es	-9.7117e+06	-2.1635e+06	-5.2421e+05	6.9470e+05	2.4685e+07
prox_jhs	-1.0027e+07	-1.7633e+06	2.7660e+05	2.3063e+06	1.1588e+07
prox_shs	-2.9613e+07	-2.8208e+06	5.1285e+05	2.3284e+06	1.9406e+07
prox_hspt	-2.0820e+07	-2.8287e+06	-3.5044e+05	2.2449e+06	2.1409e+07
prox_cbd	-2.5709e+07	-2.9001e+06	-1.0048e+06	7.0495e+05	1.6613e+07
tax	2.6057e-01	7.6829e-01	8.7919e-01	1.0190e+00	1.7124e+00

```
## Kernel function: exponential
## Fixed bandwidth: 0.002638786
## Number of data points: 1761
## Effective number of parameters (2*trace(S) - trace(S'S)): 523.5014
## Effective degrees of freedom (n-2*trace(S) + trace(S'S)): 1237.499
## AICc (GWR book, Fotheringham, et al. 2002, p. 61, eq 2.33): 65980.67
## AIC (GWR book, Fotheringham, et al. 2002,GWR p. 96, eq. 4.22): 65409.5
## BIC (GWR book, Fotheringham, et al. 2002,GWR p. 61, eq. 2.34): 66045.08
## Residual sum of squares: 1.130191e+18
## R-square value: 0.8625692
## Adjusted R-square value: 0.8043845
```

The authors utilized data-driven cluster analysis to categorize the coefficients of geographically weighted regression (GWR). This analysis aimed to observe the characteristics of property buyers or agents based on the GWR coefficient results. As depicted in Figure A.3, the optimal number of clusters is three, representing distinct groups of agents or property purchasers. The characteristics of each agent are detailed in Table A.6, and the stability of each agent's response to coastal flood risk variables is illustrated in Figure A.4.

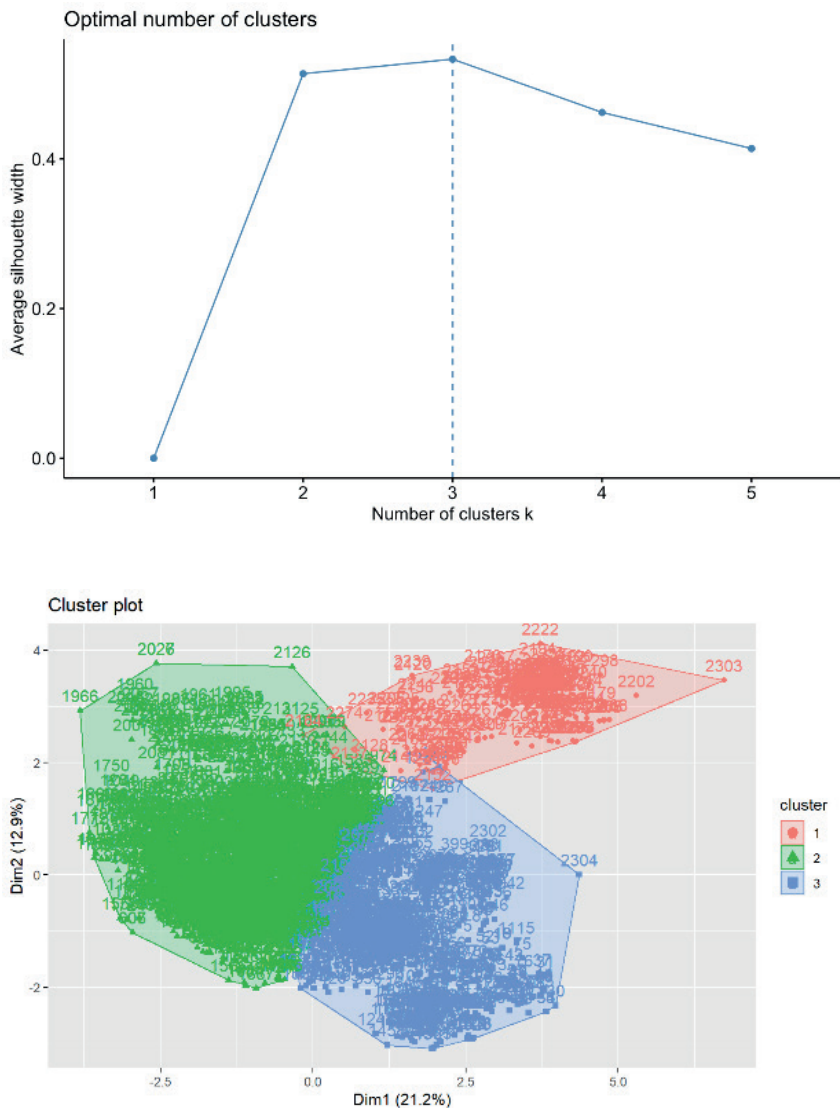
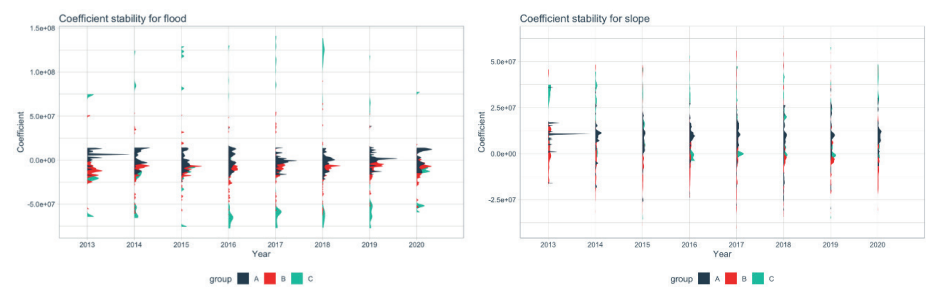


Figure A. 3 Property Price Volatility in Coastal Flood-Prone Areas

Table A. 6 The Characteristics of Agents of Gentrification

Group/ Agents	Average of Land_m²	Average of Building_m	Average of mr_ES	Average of mr_JHS	Average of mr_SHS	Average of mr_HSPT	Average of mr_CBD
1	116.08	62.96	4.38	3.86	4.85	5.18	3.95
2	128.08	70.64	4.39	3.38	4.29	4.54	3.07
3	106.35	60.12	4.20	2.81	3.49	3.87	3.60

Group/ agents	Average of land_subsi	Average of income	d.floor_ce	Slope	Land_subsi	flooded
1	-0.23	942.56	1	1	-0.341095	0
2	-0.24	977.07	1	1	-0.199419	0
3	-0.26	955.96	1	1	-0.283759	0



Coefficient stability for flood
Coefficient stability for slope
Figure A. 4 Coefficient Stability

Acknowledgement

This thesis is ultimately a product of empathy and has taught me valuable academic and personal lessons. Thus, I would like to thank my Supervisor, Prof Erwin van der Krabben, for his theoretical guidance and support during the process. He asks about my progress every month even if I do not report any progress. Such support has maximized my learning opportunities, for which I am grateful. I also want to thank Dr. Datuk Ary A Samsura, a co-supervisor who always lends his time for discussions and supervision, sometimes even on Saturdays and Sundays. I also thank Prof. Budi Setiyono, who supported me with a research grant from the Ministry of Education and Culture, Republic of Indonesia.

Moreover, I want to thank my colleagues from Radboud University and Diponegoro University. In Radboud, I thank Daan, Susanna Bicknell, Yvonne E. J. Cremers, Jol J.M. Beset, Markus van Alphen, Maarten Hogeweid, Dawit T Haile, Simone, Aris Pratomo, Ira Irawati, Dian Rahmawati, Tiara Widiastuti, and Danis. In Undip, I thank Dr Maya Damayanti, Prof Sunarti, Dr. Anang Wahyu Sejati, Dr Hadjar Achmad Chusaini, and Dr Lulut Indrianingrum.

Finally, I thank my family for being there with me always.

About the Author

Sariffuddin, born on 1 May 1983 in Magelang, is an Indonesian urban scholar with an engineering field academic background. He has a keen interest in urban analytics, spatial econometrics, and property market analysis, and his educational journey includes bachelor's and master's degrees in engineering from Universitas Diponegoro Semarang. His academic journey was during his bachelor's, where he served as a lecturer assistant in several practical on urban studies, such as location analysis and urban planning studio. His dedication to his field is further demonstrated by his freelancing with several urban planning consultants in Semarang during his bachelor's.

His experience in disaster management began with his bachelor thesis on urban quality of life in coastal flood-prone areas of Semarang. He continued in a similar field while doing his master's thesis at the same university. He published his first work in *Makara Sosio-hub Asia*, an accredited, reputable journal by Universitas Indonesia. He continued working on disaster management for 2 years in the United Nations Development Programme (UNDP). In UNDP, Sarif is responsible for urban planning review for disaster risk reduction.

For his PhD at the Institute for Management Research, Sarif conducted a study titled 'Coastal Neighborhood in Decline: Property Market Response in Indonesia's Coastal Flood-prone Areas '. In this study, he elaborated on property market analysis in flood risk reduction in coastal areas. Using spatial econometrics and property price modeling, he illustrated the property market response to flood risk variable.

