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**UNIVERSITY OF NEW ZEALAND**

**How Climate Change and Natural Hazard Risk affect the  
Auckland Property Market**

**A thesis presented in complete fulfillment of the requirements for  
the degree of**

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## **Abstract**

This thesis examines the effects of natural hazard and climate change risks on the Auckland property market. The study incorporates a quantitative comparative research design, and integrates diverse data sources, including Auckland Council, Barfoot & Thompson, Ministry of Education, Reserve Bank of New Zealand and so on for investigation. The key variables considered in this study are natural hazard and climate change risks, school equity, socioeconomic deprivation, distance to the central business district, proximity to tertiary institutes, Official Cash Rate, GDP per capita, Inflation and Price to Rent ratio. This study also examines the impact of Natural Hazard risks on Property Sales prices and rental prices. Analytical techniques comprise descriptive statistics, stationarity tests, multicollinearity test, regression modelling and additional analyses to comprehensively analyze the impacts of climate related risks while controlling locational, social, and economic factors.

The outcomes indicate that properties that are in areas with higher environmental hazard risks, have lower property sale prices and consequently, lower price to rent ratio. However, the rental prices remain stable and don't reflect significant deviations due to climate risks. This suggests a market adjustment to anticipated environmental vulnerability and buyer's preference to factor climate risks in the long-term buying decision. Whereas rental demands are short term and reflect immediate needs and thus don't deviate due to climate risks. These also indicate tangible implications for investment decision-making, property valuation, and urban planning strategies.

This study contributes to the expanding field of environmental economics and property market research by linking the environmental risks to the property market outcomes. The outcomes suggest the investors, urban planners, policymakers, and other related stakeholders to integrate climate risks into property market assessments, sustainable urban planning and development. This thesis also underlines the importance of necessity of adopting evidence-based strategies to mitigate the financial and social impacts of environmental hazards in urban areas, positioning Auckland's housing market as a case study for broader implications in similarly exposed metropolitan contexts.

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# Chapter 1: Introduction

## 1.1 Background and Context

Auckland, the largest city and commercial hub of New Zealand, has been experiencing a surge in its population. Especially, in recent times, both migrants and residents are flocking into Auckland due to better job opportunities, business growth potential, better education facilities and so on. After COVID-19 pandemic, the Government allowed more migrants to come in, to fill up the labor shortages in New Zealand and a large chunk of those migrants also found their living mostly in Auckland. Auckland has attracted half of the new working migrants that have arrived in New Zealand since August 2022 (Infometrics, 2024). Auckland made up 35% of total employment in New Zealand in 2023, but 49% of migrants living in New Zealand (Infometrics, 2024). This surge of population has resulted in a growing demand for properties in most suburbs in Auckland, which is gradually fueling the property prices and rents in Auckland. Many people try to share their living accommodation with others to reduce their living expenditures, which allows them to live in a costly suburb, yet spend their money for rent within their budget. Some people also try to rent a full house, if their family size is larger. And there are also some people who are either financially solvent enough or can get a home loan from banks to buy a property themselves. In every way, there is a growing demand for the properties in Auckland and people often find a way to either rent them in most cases or buy them in a few cases.

Affordability is a challenge for people in Auckland either for renting or buying. The housing market did not expand with the same rate as the demand increased. People who are earning more than the living wage are also finding it difficult to rent due to the soaring prices. Auckland is therefore one of the world's least affordable housing markets, and this has worsened substantially over time (Auckland Council, n.d.). However, the Government has taken measures over time to reroute the population flow to other cities and tried to increase the availability of properties in Auckland.

Auckland also faces various types of natural hazards and climate change risks, and the city is at the forefront of climate related vulnerabilities. Natural hazards are an integral part of Auckland's geography and every year, there are incidents of flood, storms, lightning, coastal erosion and so on. Rising Sea levels, the growing frequency of weather events and coastal inundations are reshaping the urban structuring in Auckland. Auckland Council segregated Auckland's geographical areas into various levels of nature related hazards and uses a comprehensive GeoMap to track and share the current data (Auckland Council, n.d.). Therefore, although many factors influence the decision of the renters and the buyers, the Natural Hazard and Climate Change risks can also be a potential factor influencing their decision making and choice.

The Price-to-Rent ratio, a real estate metric, helps identify whether it is financially beneficial to buy or rent a property (Rathburn, 2009). A higher ratio indicates that buying is more expensive than renting a property, whereas a lower ratio indicates that renting a property is more expensive than buying. This ratio helps to analyze affordability and potential investment returns. It is a key tool to identify how Climate Change and Natural Hazard Risk affect the Auckland Property Market. In addition, the property sale prices and rental prices also suggest if they are impacted by Climate Change Risks.

Besides population expansion, the real estate market in Auckland is influenced by wider Social, environmental and macroeconomic factors. The price-to-rent ratio provides an effective way of analyzing the market dynamics, specifically under natural events and climate change risks. Housing prices tend to exhibit longer-term risks more than the rents do. This causes a decrease in the price-to-rent ratios areas which are at high risk, where rental costs do not change much, however, housing prices decrease.

Other factors also impact the real estate housing prices and people's ability to buy them, such as the School Equity Index (EQI), Socioeconomic Deprivation, Distance to the CBD, and Proximity to Tertiary Institutions. Additionally, macroeconomic factors also influence both the buying and renting markets significantly, such as the Official Cash Rate (OCR), GDP per Capita, and Inflation. The current research does not provide an idea about how these factors interact collectively to affect the Price-to-Rent ratio, specifically in an urban geographical location like Auckland. This research intends to address that gap by

assessing how these factors interact collectively, particularly in the broader context of climate change threats and real estate housing market dynamics.

## **1.2 Research Problem and Justification**

The way people used to perceive the housing market and consider the factors for decision making, has evolved over time. The growing concern regarding climate risks and natural hazards now play a key role in the consumer decision process. The property market used to consider the traditional aspects such as urban planning, household income, consumer behavior etc. However, this has now changed, and people are now focusing more on the climatic risks and natural hazards vulnerabilities to ensure their investment is put in the right basket.

Climate change and natural hazard risks are expected to grow over time and therefore, there is a pressing need to analyze and identify whether this has already been impacting the property market dynamics and housing prices. Highly overvalued properties are concentrated in the areas along the coast where there are no flood risk disclosure laws and where the inhabitants are not concerned about climate change risks as the risks are low (Gourevitch, Porter, & Hsiang, 2023). This means, climate change and natural hazard risks play a critical role for the buyers and renters while considering their properties for purchasing or renting.

A key parameter to measure the overall situation of the Price-to-Rent ratio (P/R ratio). This is a fundamental metric in real estate which is applied to assess the affordability of rent versus purchasing properties in a specific housing market. At the market level, this ratio can be used by using the property price or sales value and annual rent, instead of the property level figures to assess broader trends. This is why the Price-to-Rent ratio is an essential indicator for real estate investors since it provides information on property's potential return on investment (ROI).

The price-to-rent ratio is influenced by the increasing challenges caused by the environmental hazard risks. The price of housing typically incorporates the long-term risks and vulnerabilities related to potential climate changes, however, rental costs tends to incorporate instant housing needs and do not incorporate long-term climate change risks.

This difference results in important changes in the price-to-rent ratio climate-vulnerable areas. It highlights the way environmental risks affect the customers' behavior differently. Therefore, understanding these dynamics is important, especially at a time when climate change risks significantly affect consumer decisions in the real estate housing market. However, existing study on this matter remains limited, especially in the context of New Zealand, which a country prone to natural disasters and climate change.

In addition, the property sale prices and rental prices can also suggest their impact due to natural hazard and climate change risks. The sale prices can indicate if they change due to the risk conditions of different areas. A change in the Sales price due to climate risks can indicate that the sale price is influenced by the climate risks involved in the area. Rental prices can also show it's effect due to climate risks, and this can be identified by analyzing if the rental price gets changed due to the risk conditions of an area. If the rental prices change from safer areas to hazard-prone areas, it will indicate it also has an impact due to the climate risk conditions.

The analysis of the effects on price-to-rent ratio needs to consider the important socioeconomic and macroeconomic factors which also affect the price to rent, along with the environmental hazard risks. These socioeconomic and macroeconomic factors such as school equity (EQI), socioeconomic deprivation index, proximity to urban centers and educational institutions, as well as broader economic indicators like the official cash rate (OCR), GDP per capita, and inflation, all of these have crucial impacts on the Price to rent ratio, interacting collectively to affect the real estate housing prices and rental costs. The motivation for this study is to address the existing gaps in research as well as knowledge, acknowledging the necessity for an integrated approach which analyzes the important interactions of these factors alongside environmental risks and vulnerabilities, thus delivering more holistic understanding into Auckland's housing market.

The research aims to identify how the Natural Hazard and Climate Change risks, along with the above socioeconomic and macroeconomic factors, impact the Property Market in Auckland and how. This research is driven by 2 key issues- (1) the lack of evidence in New Zealand in terms of the impact of climate-related vulnerabilities on the property

markets, and (2) the urgency to analyze whether the Price-to Rent ratio is impacted by the Natural hazards and climatic risks and if impacted, then how far.

### **1.3 Research Objectives and Questions**

This research aims to analyze and identify whether and in what way, the property market in Auckland, is impacted by the environmental risks and vulnerabilities and how it responds to these vulnerabilities. It also aims to analyze and identify how the stated socioeconomic and macroeconomic factors impact the Property Market in Auckland. To do so, the Price-to-Rent ratio will be used for the various suburbs in Auckland who have different status in terms of climatic and natural hazard risks, and the Socioeconomic and macroeconomic factors. This is because the growing evidence suggests that climate change is a reality and environmental risks have already started taking a fundamental role in affecting the property market dynamics, even though there is very limited study on this in New Zealand. In addition, the other variables, which also affect the Real Estate Property Market, interact in the broader context of climate risks and vulnerabilities.

The central research objective is:

- To analyze the impact of climate change and natural hazard risks on the price-to-rent ratio (P/R ratio) in Auckland's residential property market.
- To analyze the impact of Socioeconomic and macroeconomic factors on the price-to-rent ratio (P/R ratio) in Auckland's residential property market.

Accordingly, the main research question is:

- I. How do climate change and natural hazard risks affect the price-to-rent ratio in the housing market in Auckland?

### **1.4 Significance of the Study**

In many places of the world including Auckland, the changes in the environmental events and the occurrence of climate events have been impacting the real estate housing markets significantly. The Sea Level rising, coastal inundation and erosion, flooding, earthquakes, tsunamis etc. are impacting how the housing market dynamics work in the real world. The housing market, urban planning and architecture, and the choice of

materials are now influenced by these natural risks and vulnerabilities, and Auckland is no exception. Despite regulation and considerable effort, Auckland's environment continues to be affected by various factors including the climate change risks (Auckland Council, 2023). Hence, this study aims to analyze and identify how the environmental changes and the risks associated with these changes impact the housing market dynamics, property values, rental prices and the price-to-rent (P/R) ratio in Auckland, which is a very timely and important study.

In different parts of the world where the areas are prone to natural disasters and climate risks, the properties sell at a lower and discounted price. People are usually not inclined to live in those places, unless they rent temporarily to stay close to their workplace or for other reasons. Global research consistently indicates that properties situated in areas exposed to significant environmental risks often experience declining market values and evolving rental dynamics, influenced by both current and anticipated hazards. For instance, Bin and Landry (2013) found that properties in the hurricane-affected areas have seen their declining market prices, and the price difference between those areas and the areas that are not prone, have identifiable differences in their market prices and buyer interests. Similarly, Vanessa E. Daniel, Raymond J.G.M. Florax and Piet Rietveld found that in United States, the increase of an amount of 0.01 annually in the flood risk probability results in a difference in the transaction price of a similar type of house of – 0.6%. Yukiko Hashida and Steven J. Dundas (2020) found that in highly vulnerable coastal areas, managed retreat – usually via government-managed buyouts- is getting a very important and useful strategy, indicating how climate change risks and natural hazards are impacting the real estate housing prices and urban planning. In contrast, rental prices of the properties in these natural hazard prone areas often remain stable, because of lack of housing supply and continuous demand for rental options among the inhabitants.

More research on this suggests that a severe natural disaster event in the United States causes declining housing prices/rents in a county over the decade. It suggests that environmental disasters and climate events reduce firm productivity, thereby lowering wages in the area, which encourages outflow of migration and falling housing prices

(Boustan, Kahn, Rhode, & Yanguas, 2020). Inhabitants tend to be afraid after a natural disaster that potentially causes loss of lives and many things. Hence, they try to look for safer places where the risks of natural disasters and climatic events are lower. And this suggests a growing concern and awareness on Environmental incidents and vulnerabilities while choosing or purchasing or renting and selecting a location. Surprisingly, although the property prices in these natural hazard prone areas decline worldwide, the rental prices, on the other hand, remain comparatively stable over time. This is mostly because of the convenience of a location, shortage of affordable alternatives and so on. This is how the Price-to-Rent ratio gets changed, whereas for the areas prone to natural disasters, the Price-to-Rent tends to be lower and in safer places, the ratio tends to be higher. Empirical studies further show that houses that are exposed to Sea-Level-Rise (SLR) sell for approximately 7% less than the visibly equivalent unexposed properties located in safer areas, and this discount has increased with the flow of time, driven by the concern of the buyers and communities about natural hazard vulnerabilities and climate change risks (Bernstein, Gustafson, & Lewis, 2019).

In New Zealand, although there are studies that were undertaken to understand how climate risks and environmental hazards affect the property market, these are still gaps in research to identify exactly how the Price-to-Rent ratio in New Zealand's Real Estate Housing market react to varying levels of climatic risks and natural hazards. Since this is becoming a growing concern now for the buyers, sellers, investors and other related groups, it is necessary to research more into this to fill those gaps and support the wider community in terms of better decision making and urban planning. Hence, this study aims to utilize available data from Auckland Council for the Natural risks and climate hazard status of the suburbs in Auckland, Real estate property data for housing and rental prices, School Equity Index (EQI) of the suburbs in Auckland and their respective Socioeconomic Deprivation Index.

The analysis of price-to-rent ratio is mainly important in identifying the way both short term and long-term changes take place within the property markets, which are influenced by environmental and socioeconomic risks. The price-to-rent ratio is a potent metric that illustrates how different property purchasers and renters capitalize climate vulnerabilities,

such as sea level rise, flood susceptibility, or seismic risk. People who rent- focus mostly on immediate short-term needs such as costs, convenience and accessibility to the urban centers. On the other hand, purchasers often take decisions differently- their focus is more on the longer-term factors such as availability of insurance, resale value and access to mortgage. This deviation causes varying responses in prices and rentals, which recurrently results in the lower price-to-rent ratios in the high-risk areas. In addition to the ratio, the study also aims to assess if the natural hazard and climate change risks have impact of the Sales prices and rental prices of the properties.

Apart from environmental risks and climate hazards, the Price-to-Rent ratio is also significantly affected by various other structural elements, such as the School Equity Index (EQI), Socioeconomic Deprivation Index, proximity to the Central Business District (CBD), and proximity to postsecondary educational institutions. For example, real estate housing prices tend to correlate school quality in a stronger than the rental costs, and deprivation frequently increases the rental yields in the lower-income suburbs due to the continuous high demand for the rental housing options. Investor attitude and affordability of housing are further affected by the macroeconomic factors, specifically by the changes in Official Cash Rate (OCR), GDP per capita, and inflation rates. Because of these, the price-to-rent ratio delivers an effective perspective for assessing the dynamics of Auckland's housing market, where notable geographical inequality as well as high exposure to environmental risks coexist. This is why, a more comprehensive snapshot of how the real estate property market reacts in the face of compounding and complex dangers, can be obtained by analyzing how the Price-to-Rent ratio fluctuates among the several suburbs in Auckland with different environmental, economic and educational features.

In addition to the ratio, the study also aims to identify if the natural hazard and climate change risks have impact of the Sales prices and rental prices of the properties.

Overall, this research is crucial since it fills in the gap that is existing | the current research and by filling up that gap, it aims to support the buyer communities, seller groups and wider investor segments to take effective decisions in terms of selecting, selling and

investing their capital in the right properties and also to stay safe during the events of climatic disasters.

## **1.5 Structure of the Thesis**

The thesis will follow the standard structure, which is as follows:

### **Chapter 1: Auckland's Housing Market in the Era of Climate and Natural Hazard Risk (Introduction)**

This chapter discusses the background and context of the topic, Research Problem and Justification, Research Objectives and Questions, Significance of the Study, Structure of the Thesis, scope and limitations of the study.

### **Chapter 2: Review of Global and Local Literature on Climate Risk and Real Estate Valuation (Literature Review)**

This chapter discusses and analyzes the existing research on the topic, provides a comprehensive summary of what is already known about the research topic, presents the theories, concepts and arguments, showcases a critical evaluation of the literature, highlights the strengths, weaknesses, and contradictions in previous research. This chapter also identifies the gaps and areas where further research is needed, justifying the importance of this thesis. By analyzing the existing research, the literature review also demonstrates the rationale for the selected methodology and approach for the thesis.

### **Chapter 3: Data Sources, Climate Risk Indicators, and Analytical Methods (Materials and Methods)**

This chapter discusses how the research is conducted. It informs the specific data, their sources and procedures that are used, so that the research can be further contributed by others. This chapter provides a very clear and specific idea regarding the methods followed to analyze and answer the research question.

### **Chapter 4: Findings on the Impact of Climate Risk and Control variables and Interpreting the Relationship Among Environmental Risks, Control Variables and Market Responses (Results and Discussion)**

This chapter displays the key findings and outcomes from the research, focusing on the data collected and the analysis conducted. It discusses, analyzes, and interprets the findings of the research considering the research question and the existing knowledge. This chapter discusses the significance of the research, what the outcomes mean, how they help the current available knowledge, and it also discusses limitations and further research directions.

## **Chapter 5: Summary of Findings, Policy Implications, and Recommendations for Future Research (Conclusion)**

This chapter summarizes the key findings to the research question and provides an ultimate overview of the work. It reiterates the core arguments and their importance. This chapter recaps a holistic overview of the entire thesis, illustrating the contribution to the field. It also discussed the value and impact of the research.

After these chapters, the thesis finishes up with a **References/Bibliography** section which includes comprehensive citation information for all academic sources, datasets, articles, reports and policy documents mentioned in the study.

### **1.6 Scope and Limitations**

This study includes research on how natural disasters and climate change risks, along with Socioeconomic and Macroeconomic factors, impact the residential property market in Auckland, especially the Price-to-Rent Ratio. The coverage of the thesis is only concentrated in Auckland, the largest city and commercial hub in New Zealand and considers a variety of natural hazard risks and vulnerabilities such as flooding, coastal erosion, coastal inundation etc. as well as the other Socioeconomic and Macroeconomic factors which are- School Equity Index (EQI), Socioeconomic Deprivation Index, Distance to Central Business District, Proximity to Tertiary Institutes, Official cash rate (OCR), GDP per Capita and Inflation.

The thesis particularly focuses on and considers the data for residential properties and does not include the data for commercial properties, which might have different dynamics and reactions to natural hazard and climatic risks as well as the above Socioeconomic and Macroeconomic factors. The real estate housing data has been considered at the

suburb level due to its availability and the focus on the natural hazard proneness by smaller area. Also, this research considers the average of the property prices and rents, rather than considering the prices individually. The research scope includes the real estate property data from 2019 up to 2025, which is significant considering the recent past, however, it does not contain property data of the previous years, which could have provided more insights of the year before that.

Although this study provided significant empirical insights on how the environmental incidents and climatic change impact the price-to-rent ratios of the residential properties in the real estate housing market in Auckland, the results need to be interpreted considering the limitations mentioned above. should be considered with an understanding of these limitations. This study aims to widen the understanding of environmental hazard risks and threats, delivering crucial insights to various groups of stakeholders such as investors, buyers, sellers, policy makers, planners and so on regarding the market responses now to the environmental hazards and vulnerabilities. policymakers, investors, and planners regarding present market responses to climate issues and Socioeconomic and Macroeconomic factors.

## **Chapter 2: Literature Review**

### **2.1 Introduction**

Climate Change and environmental hazard risks and vulnerabilities are becoming increasingly important concerns that shape the urban architecture and real estate housing market around the world. The world is witnessing a growing number of natural hazards that are taking place throughout the world. One recent example is the flood that hit the Central Texas in the United States, that killed at least 80 people, with more heavy rain was forecast as the search for missing people entered a fourth day (The New York Times, 2025). With the increase in occurrence of such environmental events across the world, concerns about longer term sustainability and value for money of the properties in the Natural hazard-prone areas is now a serious topic of discussion. Real estate housing prices, affordability of both purchasing and renting and return on investment (ROI) are significantly impacted by the Climate Change and environmental hazard risks.

This literature review aims to critically explore how climatic risks and natural hazard events affect the residential property markets, considering the historical housing values, rental prices and Price-to-Rent Ratio (P/R Ratio). The review analyzes both existing international and local research, identifying the key theoretical foundations involving real estate valuations and climate risks, critically analyzing the International Evidence on Climate Risk and Property Markets and Local Research on Environmental Hazards and Housing in New Zealand. The review then discusses the synthesis and identifies and analyzes the gaps in the existing research, supporting the significance and necessity for this study. And finally, the review concludes with a recap of the entire discussion, analyses and identifications, emphasizing the significance of this research and how it fills up the gap in the existing research.

### **2.2 Theoretical Foundations: Real Estate Valuation and Climate Risk**

A property's value is defined as the present worth of future benefits arising from the ownership of the property (Folger, 2024). The price-to-rent ratio is often considered as a key indicator to measure the imbalance and inefficiency in the housing market, and a

central question is the extent to which the housing prices and rents constitute part of the same market and therefore, whether their responses are like parallel stimulus. (Lo, McCord, McCord, Davis, & Haran, 2021). A high price-to-rent ratio suggests that buying a property is more expensive relative to renting, whereas a low ratio indicates that buying may be more favorable than renting (Global Property Guide, 2025).

Climate change events are worsening on a regular basis, posing a substantial challenge to the existing and prospective investments in the real estate housing markets, and to face the growing landscape of natural hazards and climate change risks, it is crucial to explore how climate change affects the property investments and analyze valuation risks, as well as adaptation strategies for property resilience (Climate X, n.d.). Exposure to adverse environmental events contribute to short-term discounting and long-term challenge on capital growth of property (Fuerst & Warren-Myers, 2021). Beltrán, Maddison, and Elliott (2018) examined that other thing being equal, properties that are situated inside a floodplain suffers a price discount, and a survey of the existing evidence also reveals that this price discount lies anywhere between -75.5 percent to a +61.0 percent price premium.

Bellaver et al. (2025) found that the recurring exposure to floods in the flood-prone areas causes decrease in the prices, up to 4% in the most frequently flooded regions. Bernstein, Gustafson, and Lewis (2019) observed that real estate properties which are exposed to projected sea-level rise are sold at a significant discount, however, rents in those areas remain quite stable. However, Brennan, Srin, and Steil (2024) argued that renter households with low incomes signing new leases face a 5% rent increase in the year following a disaster, with a further 6% increase two years later, and Steil, Associate Professor of Law and Urban Planning at MIT DUSP, notes this reflects how natural hazards disproportionately impact vulnerable rental markets.

An important tool to measure the impact of Natural Hazards and climate change risks is the Price-to-Rent (P/R ratio). The price to rent ratio is the nominal house price index which is divided by rent price index and is considered as a measure of the profitability of house ownership (Organization for Economic Co-operation and Development [OECD], n.d.). Price-to-rent ratios are among the most widely used methods and tools to measure

the housing market conditions (Lo, McCord, Davis, Haran, and McGreal (2022)). This ratio is often regarded as an important indicator for identifying and measuring real estate market imbalance and inefficiency (Lo, D., McCord, M., McCord, J., Davis, P. T., & Haran, M. (2021)). House prices are comparatively higher relative to their rents (this is when the price-to-rent ratio is low) and changes in real rents tend to be larger than usual and changes in real prices tend to be smaller than usual (Gallin, 2004). Pancak (2017) reveals that the price-to-rent ratio can vary significantly across local markets, influenced by factors such as property tax rates, household income, and age. Studies in China have revealed that Price to rent ratios tend to be higher for low-end properties (Chen & Ni, 2011) and are generally higher than the rational levels for both subsidized housing as well as free-market housing (Chen, 1996). A study in England found that more desirable properties or affluent areas generally tend to have lower rent/price ratios (Stephen Clark & N. Lomax, 2019).

The School Equity Index (EQI) in New Zealand has been a topic of discussion and research, and the recent changes in the Government policies in New Zealand aimed at addressing the educational disparities. Recent studies have thoroughly assessed the EQI's impact on the student outcomes, school practices and expenditure decisions, resources designed to address socioeconomic barriers, and perceptions of the community (Alansari, Turner-Adams, & Li, 2023). Earlier research highlighted the importance of school culture as a community in encouraging equity and valuing diversity in the growing multi-ethnic populations (Robertson & Miller, 2007). Historical analysis of the school zoning reformations identified a shift from balancing the school needs to promoting the parental rights, potentially endangering the schools which are disadvantaged (McCulloch, 1991). Historical data also suggests that New Zealand's educational restructuring uniquely included goals of social equity as well as cultural inclusiveness, where local school boards had an important role in implementing these policies (Middleton, 1992). These studies collectively demonstrate the ongoing efforts as well as challenges in acquiring the educational equity in New Zealand, focusing on the need for culturally responsive practices and community engagement in the schools in New Zealand.

The Socioeconomic Deprivation Index (NZDep) is an area-based method for measuring socioeconomic deprivation New Zealand. It determines the level of deprivation of the inhabitants in each area, which is mainly based on nine Census variables (Environmental Health Intelligence NZ, 2023). This index has been implemented in different research and analysis contexts, policy contexts, including needs analysis and allocation of resources. Meshblocks (smallest geographical zone as specified by Statistics New Zealand) have designated deciles, where- 1 indicates the least-deprived areas, and 10 indicates the most deprived areas. This population-based deprivation is measured with a weighted-average of these deprivation index at the meshblock-level (Ministry of Business, Innovation and Employment [MBIE], n.d.). The dimensions which are considered in the Census variables for Socioeconomic Deprivation Index (NZDep) are- communication, income, employment, qualifications, home ownership, support, living space and dwelling condition (Stats NZ, 2025).

The risks associated with climate change and natural hazards are immense. Climate change can impact the environment in various ways, such as - rising the temperatures, sea level rise, flood, drought, earthquakes, volcanic eruptions etc. and these natural events affect those things which we rely on and value, such as- human health, wildlife, ecosystem, energy, water, agriculture and so on (National Oceanic and Atmospheric Administration [NOAA], n.d.). These risks are quite comprehensive and complex in nature, that requires multidimensional collaboration to address the knowledge gaps and uncertainties (Rising, Tedesco, Piontek, & Stainforth, 2022). To minimize and adapt to climate change risks, and to support the research and analysis, we must recognize and comprehend the climate change risks and their impacts on our ecosystems, people, and economy (Auckland Council, n.d.). Throughout the world, climate change has increased the acuteness and the length of wildfire by at least 30% on average during the last three decades and the harm caused by extreme wildfires goes well beyond the direct loss of life (Organization for Economic Co-operation and Development [OECD], n.d.). A latest Climate Crowd report, based on an assessment of more than 3,000 key-informant interviews conducted in the communities who live close to biodiversity hotspots, revealed that a fourth of all interviews identifies human-wildlife conflict as an impact of climate change (World Wildlife Fund, n.d.).

### **2.3 Research on Climate Risk and Property Markets**

Climate change is causing increasing concern worldwide, and the construction industry is encountering uncertainty about the ways the forecasted climate changes will affect the performance of the buildings around the world (De Wilde & Coley, 2012). Environmental incidents are now quite known – valuable assets are continuously exposed to the severe weather incidents quite often, however, the upward trend in the severe environmental incidents is causing much wider financial penalties which are becoming the liability of the by insurers, occupiers, owners, as well as governments (Clayton, Devaney, Sayce, & Van de Wetering, 2021). Thompson, Wilby, Hillier, Connell, and Saville (2023) discusses that evidence on physical environmental incidents such as flood, coastal erosion, wildfires etc. affect the housing prices, and climate change scenarios indicate towards more recurrent and extreme physical environmental incidents in the coming time, which will also be happening at the same time when population is also increasing. Environmental hazards cause a decline in the house ownership levels of incoming migrants in the second year after the occurrence of the disaster (Sheldon & Zhan, 2019). A latest global meta-analysis on whether flood vulnerabilities is capitalized in the housing prices revealed an average discount of 4.6 percent for the locations located in a 100-year floodplain (Beltrán, Maddison, & Elliott, 2018).

Climate change and natural hazard risks impact the real estate housing markets quite significantly and increase the financial risks. Whenever a hurricane takes place in a year or the previous year, it reduces the availability of affordable rental housing, especially for areas with higher percentages of renters and people of color (Best, He, Reilly, Tran, & Niemeier, 2023). Fuerst and Zhu (2023) demonstrated that Real Estate Investment Trusts (REITs) with increased exposure to environmental hazards experience enhanced risk of equity, attributed to the increased cost of debts and decreased rental income. Extreme flooding results in a substantial increase in rents for low-income renters, whereas federal disaster rental assistance shows no association with post-disaster rent changes (Brennan, Srin, & Steil, 2024). Bin, Kruse, and Landry (2008) investigated the effects of differential flood risks on property prices in the coastal housing market of Carteret County, North Carolina, between the years of 2000 and 2004, and their results revealed that

location within a flood prone zone decreases the property value. Price differentials due to flood risk and the capitalized cost of flood insurance premiums are approximately equivalent- both exhibit a nonlinear relationship in flood probability.

Bernstein, Gustafson, and Lewis (2017) identified that houses which are prone to sea level rise (SLR) sell for approximately 7% lower than apparently equivalent unexposed houses equidistant from the beach. This discount has increased with the flow of time and is propelled by the sophisticated buyers and communities concerned about the growing global warming. Consistent with the causal classification of long-horizon SLR costs, they found no relation between SLR exposure and rental rates and a 4% discount among the housing properties not forecasted to be flooded for almost a century. Their findings contributed to the literature on the pricing of the longer-term risky cash flows and delivered insights into the optimal climate change policy. Surprisingly, they suggested that the SLR exposure discount is broadly driven by properties which are not supposed to be affected by SLR for more than fifty years, demonstrating that house buyers and potential real estate investors are already pricing in the long-term consequences of climate change.

Keenan, Hill, and Gumber (2018) illustrated that properties situated at the higher elevated locations faced a decreased risk of coastal flooding and had quicker price increases when compared to properties at or nearer to sea level in Miami-Dade. They discovered positive relationships between the rate of price appreciation and property elevation, pointing towards consumer preference for locations with more climate-resilient characteristics. Likewise, Taylor and Aalbers (2022) evidenced that property market investors hedging against property price stagnation or depreciation along the Greater Miami flood-prone coastline by purchasing those properties which are at higher elevations. This indicates an effort by investors to exploit altering rent gaps in the face of growing risks and opportunities (Taylor and Aalbers 2022).

However, neither Keenan, Hill, and Gumber (2018) nor Bernstein, Gustafson, and Lewis (2017) considered the impacts of historical flood incidents or whether housing properties had been harmed by coastal flooding. Preliminary research recommends that property prices might be more sensitive to the history of flooding incidents rather than simply to the current exposure to the physical hazard (Beltran, Maddison, and Elliott 2019). Hirsch

and Hahn (2018) investigated the relationship between 100-year flood risk versus residential rental and property prices in Regensburg, Germany, between the years of 2012 and 2015. They revealed that the buying price of living space was Euro 299 lower per square meter for those properties in this highly vulnerable flood zone.

McAlpine and Porter (2018) looked at the flood risk in Miami and the way it is changing due to the SLR. They identified a minor but statistically significant impact on the property prices. However, in the Miami case, there was little scope that these properties will be abandoned because of their significant prices, and at least according to law, they would be able to uninterruptedly remain insured through the U.S. National Flood Insurance Program (NFIP). Hidano, Hoshino, and Sugiura (2015) discovered that the unit prices of residential properties in low-risk seismic zones are between 13,970 and 17,380 JPY higher than those in the highly vulnerable zones, depending on the category of the seismic hazard risk. Walsh, Griffiths, Guignet, & Klemick, (2015) focused on the property value of protection from SLR in Chesapeake Bay in the United States. They found a significant and consistent loss in value associated with SLR risk, using a similar method to Hidano, Hoshino, and Sugiura (2015). Previous findings also indicate that any discount related to the proximity of the ocean and SLR is not quite uniform, and they differ with the location and owners' understanding about the climate change, demonstrating the importance of micro-level research.

Although, there are several research done to assess and identify how much the natural disasters and climate change risks impacts the real estate housing prices, however, not much research has been done to identify if property rent is also similarly impacted the way property prices are impacted. This reveals a gap in the existing research and further research should be done to help assess the impacts of climatic risks on the property rents as well. Brennan, Srini and Steil (2024) investigated the impact of flooding disasters on rental markets, finding that severe floods led to significant rent increases for low-income households but not for middle or high-income renters. This indicates that the overall increase in the rent is affecting only the lower-earning group of people, while middle and upper earners are not affected, indicating a minimal increase in rent and suggests the rent does not change the same way the housing prices change significantly.

Therefore, although almost all existing research suggests that Natural hazards and climate change risks affect real estate property prices, more research is needed to address how they impact specifically the price-to-rent ratio and how they affect the property rents.

#### **2.4 Local Research on Environmental Hazards and Housing in New Zealand**

Quyên Nguyen, Diaz-Rainey, I., Moore, A., Thorsnes, P., Cox, S., & Stirk-Wang, L. (2019) revealed that the properties in Greater South Dunedin encounter a negative price effect of 3.1% to 5.9% because of the flooding risks, with potential inundation impacting up to 39% of properties under severe conditions. Cheung and Yiu (2022) highlighted that people's perception of flood risks is affected by both affect and availability heuristics, with instant negative impacts on the property prices right after the severe flooding events. Montz (1992) examined three communities in New Zealand, discovering that while early impacts of flooding incidents on property prices vary, longer-term differences between the flooded and non-flooded real estate properties reduce. Hirsch and Hahn (2017) demonstrated that the flood vulnerability decreases the property prices and rents significantly in Germany, indicating similar patterns can exist in New Zealand, stressing on the requirements for policy action and awareness regarding the climate change risks.

As per the preliminary research from NIWA, there are 125,600 buildings and \$38 billion replacement costs within 0-1m of sea level rise, and it is almost certain that the sea will rise a further 0.2m to 0.3m in the span of next 20 years. Therefore, sea level rises keep on increasing the risks from storms and coastal inundation, as well as the enhanced vulnerabilities of ever higher water tables and sunny day flooding (Insurance Council of New Zealand, 2018). Fleming, Noy, Pástor-Paz and Owen (2018) discovered that Northland and the Bay of Plenty in New Zealand are those regions which have the highest proportions of people and real estate properties affected by the weather events in the North Island of New Zealand. And in the South Island, the Nelson and Tasman regions are the most affected regions. Cheung and Yiu (2022) empirically observed that people pay price "premia" for the residential real estate properties with high flooding risks along the coastlines in New Zealand.

Although, there are existing research available in New Zealand in terms of how the climate change vulnerabilities affect the Insurance premiums and risk premiums, consumer buying behavior, policy and governance, there is lack of research on the impacts of climate change risks on Price to Rent ratio, which is an effective and important tool to assess whether purchasing or renting a property in a given location is cheaper and ensures the best value for money. Following the 2010 and 2011 earthquakes and the aftershocks in Canterbury, New Zealand, extensive research was carried out on the rockfall hazard to residential real estate buildings on Christchurch's Port Hills to identify which dwellings encountered an unacceptable risk to life safety, the recommendation was made to adopt a tolerable threshold for individual risk of 1/10,000 p.a. (10<sup>-4</sup> p.a.) (Enright, 2015). Insurers AMI, State, and NZI have released survey findings demonstrating that climate change vulnerabilities are increasingly driving house-buying decisions in New Zealand and the study revealed that 86% of participants consider climate change and natural hazard significant factors when purchasing a home, compared to just 55% two years ago- hence, it is no surprise that Weather and natural disaster risks now rank second only to pricing among housing considerations, ahead of crime rates, school zones, and public transportation (Libatique, 2024).

According to a report released by the Helen Clark Foundation and environmental consultancy WSP, an approximate 10,000 coastal properties in Dunedin, Christchurch, Wellington and Auckland face the threat of becoming uninsurable in the span of the next 25 years (Trethewey, 2025). The Government in New Zealand is considering residential insurance issues, including the role of insurance in climate change adaptation (The Treasury [New Zealand], 2024). Climate change and natural hazards critically impact buildings, including enhanced flooding and overheating, and these vulnerabilities need to be minimized by formulating and implementing effective adaptation strategies (Camilleri, Jaques, & Isaacs, 2001). Levy, Naish and Allen (2023) revealed that even a relatively small rise in the sea levels- around 40 centimeters along the Auckland coast - can result in rare flooding events which currently happen once every hundred years to become annual occurrences. This significant increase in flood frequency showcase how sensitive coastal areas is to sea-level changes and dynamics. Forecasting with accuracy about when these critical thresholds will be reached, is critical for the purpose of planning and

implementing effective adaptation strategies to handle the unavoidable impacts of sea-level rise.

## **2.5 Extended Determinants of the Price-to-Rent Ratio: Climate Risk and Beyond**

The price-to-rent ratio suggests the capitalized value of the upcoming income from rentals, and it also indicates the housing market valuation in a clearer and concise way. The ratio is especially subtle to longstanding risks, such as the risks caused by natural events and climate change. This is especially because the interaction between property costs (which exhibit long-term expectancies) and rental costs (which are fueled by shorter term needs for housing) are captured by this ratio.

The value of an asset is the current value of the future returns from it, discounted by risks and vulnerabilities. With the increase of natural hazard and climate change risks, customers look for more risk premiums, decreasing the current cost they would like to pay. This often causes a decrease in the real estate property prices in the highly risky areas. In contrast, rental costs tend to stay stable and do not deviate much, since tenants are not highly exposed to longer-term asset risks and often take their decisions depending on the short-term availability, affordability and location. So, the time duration of the risks plays a crucial part of the role here.

Furthermore, investors as well as the owners tend to incorporate natural hazard and climate-related concerns i.e. future resale price, mortgage access, and insurability, while making their decision. In contrast, tenants are quite less concerned about the longer-term exposure to climate risks and natural hazards, causing a divergence between the price and rent adjustments. The outcome is usually a decline in the price/rent ratio in the areas exposed to high risks, even when the rental costs remain static.

Urban economics supports this further, highlighting that the tenant category and owner-occupier category operate in segmented markets. Financial institutions also support this trend since lending and insurance requirements are frequently more stringent in climate-exposed areas, which drives down costs with no immediate effect on rental markets.

This difference is evident from empirical research, which shows that whereas climate risk may have a negligible impact on rentals, it frequently results in quantifiable drops in real

estate values. Because of this, the price/rent ratio is a particularly good way to see how hazards and climate risks are being capitalized in real estate markets, particularly in the geographical area like Auckland.

For the School Equity Index (EQI), since January 2023, the Ministry of Education in New Zealand has removed the school decile system as to measure the distributing of funding. They replaced the School Decile System with the School Equity Index (EQI) as a means of Equity funding. The Equity Index (EQI) estimates the extent to which the youth encounter socio-economic challenges in order to achieve their education (Ministry of Education, 2023). Alansari, Turner-Adams, and Li (2023) found that the schools already engage themselves in a wide range of equity-centered initiatives and practices, which include access to resources that are funded by different sources (i.e., not just through equity funding). While this is reassuring, schools also expressed how stretched they felt when they try to provide for those students who encounter socioeconomic challenges on top of the grappling with policy changes (e.g., NCEA Change Programme, changes to school planning and reporting processes), and increased demands for mental health and wellbeing support for students. Beracha & Hardin (2018) are evidently the first to look at the impact of the school quality on prices versus rents. They used a standard hedonic regression model to compare the Florida Department of Education's A-F school ratings to premiums for buying versus renting. Like Black (1999), they use a border discontinuity approach to compare homes that lie on opposite sides of school assignment lines. Their results revealed a price premium of 4.3% and a rent premium of 2.6% generated by a one Florida letter rating increase. This indicated that schools are generally capitalized in the house prices more than rents. They also revealed that schools have a larger effect on price-rent ratios in houses with family-oriented characteristics, suggesting that buyers with children place a higher premium for living near good schools compared to renters with children. Therefore, research suggests that School Equity Index (EQI) also has impacts in the Price-to-Rent ratio.

The New Zealand deprivation index is an index of socioeconomic deprivation based on census information. Meshblocks (the smallest geographic area defined by Statistics New Zealand) are assigned to deciles, with 1 representing least-deprived areas, and 10

representing most deprived areas. The population-weighted deprivation is calculated by a weighted-average of the meshblock-level deprivation index (Ministry of Business, Innovation and Employment [MBIE], 2023). Poorer-quality housing is more common in areas with higher socioeconomic deprivation (Goodyear, Bentley, White, Bretherton, MacGregor, Jaques, Dowdell, Butler, Fabian, & Dickson, 2021). The dimensions considered to measure the Socioeconomic Deprivation Index are- Communication, Income, Employment, Qualifications, Owned home, Support, Living space and Living condition (Atkinson, Salmond, Crampton, Viggers, & Lacey, 2024). Grimes and Aitken (2010) found that lower socio-economic areas face higher rental yields even after controlling non-socio-economic factors than do high socio-economic areas. They revealed that rental yields are higher in lower socio-economic areas than in more advantaged areas. People living in more deprived areas tend to pay a relatively high level of rent as a ratio of local house prices. Lauren Bauer, Eloise Burtis, Wendy Edelberg, Sofoklis Goulas, Noadia Steinmetz-Silber, and Sarah Yu Wang (2024) researched the Rental housing in the United States and they found that The share of households that rent and that are headed by someone who does not have a college degree, who has lower income, or who is Black has consistently exceeded the overall share of renting households. While there are differences in rates of renting by education level, there are more striking differences both by income and by race or ethnicity. Those in the bottom fifth of the income distribution (first income quintile) are much more likely to rent than those in higher income groups; in 2022, 53 percent of those with the lowest incomes rented, which was four times more than households in the top income quintile. Black individuals, who generally tend to have lower levels of income and wealth, are the most likely to rent (Derenoncourt et al. 2022). Specifically, in 2022, 56 percent of households with a Black head of household were renters compared to 27 percent of households with a White head of household. These studies suggest that Socioeconomic Deprivation factors play an active role in affecting the price to rent ratio.

Another crucial factor that influences the price to rent ratio is the distance to the Central Business District (CBD). Barfoot and Thompson (2017) analyzed their rental data to examine the relationship between distance from the city and the average rent of an area. They observed an inverse relationship between the distance to the CBD from an area

and the average rent for a three-bedroom property in that area. The greater the distance from the CBD, the lower the rent. The west shows consistently lower rentals than the other focus areas within similar distances. The city center fringe areas, along with beach-side suburbs in east Auckland and the North Shore, tend to have lower rental yields, and these geographic variations remained relatively constant over time – i.e. the areas with the lowest indicative rental yields in 2001 tended to also have the lowest yields in 2013 (Nunns, Hitchins, & Owen, 2015). Living close to CBD is one of the key requirements for many people due to obvious reasons. Demand for Auckland CBD rental properties has skyrocketed by 900% over the past six months, one property management company says (Bell, 2023). Just over a decade ago, only 20,000 people called the city center home. Since then, the number has skyrocketed to 45,000, growing six times faster than the Auckland population as a whole (Heart of the City Incorporated, 2018). Research conducted by NielsenIQ for Auckland Council (NielsenIQ, 2023) found that almost two-thirds of respondents (63%) stated that access to shops and restaurants was a main reason, as well as the city center being close to their place of work (56%) and time saved not being in traffic (50%). These studies indicate that living close to CBD is a priority for many people and it affects the real estate housing prices and rental costs.

Another important factor that influences the Price to rent ratio is the Proximity to Tertiary Institutes. Location is a crucial factor when it comes to rent prices in NZ. Properties situated in prime locations, and proximity to schools, universities, employment hubs and recreational facilities can also impact rental costs (The Rent Shop, 2024). Cortes (2004) investigates whether neighborhood proximity to a public or private urban university is associated with systematic, significant impacts on average monthly rental payments and average owner-occupied housing unit value and If so, do these impacts vary between these university types. The study found that the characteristics of neighborhoods abutting universities are significantly different from neighborhoods citywide. Moreover, neighborhood adjacency to both the public and private institutions was associated with statistically significant effects, albeit dissimilar. As a preliminary analysis, we analyzed the effective distance range to which the presence of a university affects home prices and rent. Table 19 shows the correlations between home price/rent and distance from the nearest university based on different maximum distances. Although all such correlations

are very weak, we observed slightly higher correlations for both home price and rent among homes within two miles of a university. Rivas, Patil, Hristidis, Barr and Srinivasan (2019) analyzed the effective distance range to which the presence of a university affects home prices and rent, and their analysis table showed the correlations between home price/rent and distance from the nearest university based on different maximum distances. Although all such correlations are very weak, we observed slightly higher correlations for both home price and rent among homes within two miles of a university. From these studies, it is apparent that proximity to Tertiary Institutes is also an important factor that influences both real estate housing prices and rental costs.

An important macroeconomic factor affecting Price-to-Rent ratio is the Official cash rate (OCR). Fluctuations in the OCR have broader ramifications on rental markets, affecting supply and investor sentiment, which in turn drives rental prices upward (Harcourts New Zealand, n.d.). When the Reserve Bank of New Zealand raises the OCR, commercial banks face higher borrowing costs, prompting them to adjust their lending rates accordingly. As a result, mortgage rates for homeowners and property investors tend to rise. This, in turn, has a direct impact on homeowners' monthly mortgage repayments, potentially making property ownership less affordable for some (Harcourts New Zealand, n.d.). The Reserve Bank of New Zealand sets the Official Cash Rate (OCR) which impacts the mortgage rates that banks charge. The lower interest rates are, the lower the cost of borrowing to pay for a house is (Reserve Bank of New Zealand, n.d.). OCR influences mortgage rates. A low OCR often leads to lower mortgage rates, stimulating housing demand and potentially raising house prices. Conversely, a high OCR can lead to higher mortgage rates, potentially (MoneyHub, n.d.). Higher borrowing costs may reduce buyer demand, potentially slowing property value growth, and Lower borrowing costs can stimulate demand, driving property prices higher (NG Property Management Ltd., 2025). Tighter lending conditions may prevent buyers from entering the housing market, leading to higher rental demand, and Easier access to home loans may reduce the pool of renters, potentially impacting rental income (NG Property Management Ltd., 2025).

GDP per capita reflects the overall economic performance of a country. A growing GDP usually means a healthy economy with more disposable income, higher consumer confidence, and increased property investments. When the economy is booming, more people are likely to buy homes, increasing property listings. New Zealand's GDP growth trends are a valuable indicator, as they offer insights into broader economic health and potential shifts in the property market (The Rent Shop, 2024). GDP per Capita is the main driver of real estate prices and rents, real estate investments provide a direct way to participate in the strong growth of these economies (Asia Green Real Estate, n.d.). The direction of GDP rates has historically been an excellent predictor of the direction of housing prices, but on its own, it is less useful for explaining the size of the change in housing prices. Other factors, such as interest rates, population, housing supply and foreign investment all interact with the strength of the economy to create swings in housing prices that tend to be more volatile than what GDP exhibits (Hawkeye Wealth Ltd., 2024). GDP can act as reasonable estimator for the progression of residential and commercial real estate markets (Asia Green Real Estate, n.d.).

Inflation reduces the purchasing power of money, meaning more money is required to buy the same goods and services as before. Because of this, landlords increase rent to offset the higher costs associated with property maintenance, taxes, insurance, and other expenses that rise with inflation (Oxygen Ltd., 2024). One of the reasons investors favor real estate is due to its ability to weather the pressures of rising inflation and emerge with its values intact, even improved. However, recent rising inflation is having differing impacts on the New Zealand real estate sector. It's tough to enter the property market, agents are having a harder time finding buyers, and renters are struggling to find affordable options. Conversely, landlords unburdened by rising borrowing costs are riding the storm comfortably (Lindsay, 2023). Generally, rent has kept pace with inflation, while home prices have risen faster than inflation. Housing is a highly regional market, so some areas see price changes much more rapidly or to a greater extent. Home prices also tend to rise faster than incomes, meaning homes have become less affordable (Nguyen, 2023). Based on Barfoot & Thompson data, the average rent for a 3-bedroom home in Auckland in October was \$658. This is a 4% increase over the past 12 months and comes

against a backdrop of an inflation increase across the same period of 3.2% (Thompson, 2023).

## **2.6 Synthesis and Identification of Research Gaps**

The review of both the international and local literature exhibits that climate change risks and natural hazard vulnerabilities are increasingly growing concerns that significantly affect the property market dynamics and how it reacts to these, and this is applicable for local and international contexts. Significant amount of research has been conducted which apparently and continuously reveals an opposite relationship between the real estate property prices and the climatic vulnerabilities – especially flooding, coastal erosion and inundation and sea-level rise. Research performed in varied geographic landscapes, from the coastal areas of United States to the flood-prone regions in Germany, United Kingdom and Japan, demonstrates strong experiential evidence that exposure to the climate change risks and environmental vulnerabilities decreases the real estate housing prices, where several kinds of discounts are often included in the property market transactions via various streams of risk capitalization. Not only that, some of those studies (e.g., Bernstein, Gustafson, & Lewis, 2017; Brennan, Srini, & Steil, 2024) point out the disproportionateness between the impact of environmental vulnerabilities on property costs and their frequently different impact on rental values.

The observations from the local research in New Zealand also reveal the same results where it is apparent that exposure to climate change vulnerabilities increases the property prices. Research from Quyen Nguyen et al. (2019) and the Insurance Council of New Zealand (2018) affirms that real estate property values in natural hazard-prone regions- especially in the flood-prone coastal areas - are at risk of climate-change impacted devaluation of their prices. The international research also showcases quite enhanced consumer consciousness of climate change vulnerabilities, which is influencing the house-purchasing behavior. In addition to this, the literature describes organizational and policy responses, such as adjustments in insurance markets, government's adaptation strategies, and increasing public discussion on property-level climate resistance. However, the New Zealand based literature mostly concentrated on the buyer experiences, insurance access and premiums, macro-level policies and guidance on

climate adaptation, and risk disclosure frameworks. While these perspectives are important, they do not represent the facts on how climate related vulnerabilities are managed within the property market, especially when analyzing market metrics which are crucial to investment decision-making, like the price-to-rent ratio.

Although various previous research studies (e.g., Fuerst & Warren-Myers, 2021; Bellaver et al., 2025) indicate to the reasonable steadiness of rental values against the declining property prices, this remains under-explored, especially considering the growing urban vulnerabilities caused by climate change. While rental prices have been studied, such as in the study by Brennan, Srini, and Steil (2024), the concentration was broadly on the shorter-term rental change encountered by the low-income households followed by the disaster, rather than on the longer period connections among housing prices, rental prices, and climate change vulnerability status. This skewed concentration highlights a broader theoretical and empirical gap - there is inadequate incorporation of rental market dynamics into climate risk valuation models and how they react when faced by a natural disaster and climate change incident in comparison to the housing prices.

Furthermore, although the increasing attention is in the growing policy interest for climate adaptation and real estate resilience in New Zealand, empirical studies that quantitatively analyze the relationship between environmental risk and the price-to-rent ratio are apparently lacking. Price-to-rent ratio is a highly important method and tool for assessing the housing market proficiency, asset overestimation, and investment sustainability; however, this remains largely overlooked in climate change related risk assessments. This is specifically problematic in a context like Auckland, where population increase over time, housing availability and affordability, and climatic vulnerability interact in a complex way. The absence of such research hinders the capability of the residents, investors and policymakers, to reach an informed decision when assessing between purchasing and owning a property and renting the same property.

Furthermore, existing local studies in New Zealand mostly focuses on property-ownership markets and tend to consider rental housing as a residual category instead of a fundamental constituent of the real estate housing market. Nonetheless, rental housing markets are not only a significant chunk of urban housing but are also likely to be

disproportionately impacted by the climate-related risks - either because of the shortage of adaptive infrastructure or decreased insurance coverage. The scarcity of disaggregated data on the rent fluctuations and dynamics in hazard-prone suburbs further increases the challenge, making it difficult to methodically assess how environmental vulnerability translates into rental volatility or long-term affordability. Overall, although several studies have been conducted to understand how real estate housing prices react in the event of natural disasters and climate change risks, several gaps are still there which require further research. The gaps are:

1. Lack of integration and focus on the Price-to-Rent Ratio to assess the climate change impacts: majority of the existing studies concentrate exclusively on property prices, avoiding the very important dimension of rental dynamics and their combined effect on the price-to-rent ratio.
2. Under-Representation of Rental Market Dynamics in Climate Risk Research: There is lack of investigations about how natural hazard risks impact rent over time, and fewer studies explore how these effects vary by income group, tenure, or region.
3. Lack of Integration of Climate Risk into Housing Market Efficiency Models: Tools such as the price-to-rent ratio are underutilized in climate risk measurements, despite their possibility to signal market volatilities induced by environmental hazards.
4. Lack of the Local Empirical Studies linking the Climate Risks to Rental Patterns in New Zealand: While the international literature provides valuable insights, there is an absence of specific research in New Zealand that experiments the relationship between environmental hazard risks and rental market outcomes – especially in the suburbs in Auckland.
5. Existing studies have also not adequately analyzed on how the factors such as the School Equity Index (EQI), Socioeconomic Deprivation Index, distance to the Central Business District (CBD), proximity to tertiary institutes as well as Macroeconomic factors such as Official cash rate (OCR), GDP per Capita,

Inflation- influence the price-to-rent ratio. From the literature review, it is evident that these are important determinants affecting both real estate house prices and rents, yet their interactions with price to rent ratio and how they impact the ratio, remain underexplored.

Addressing these gaps in research is crucial for creating a more inclusive understanding of how climate change risks and natural hazard vulnerabilities are reshaping the housing markets, not only for the asset values, but also for the market effectiveness, tenure options, availability and affordability. The current study contributes to this effort by concentrating specifically on the price-to-rent ratio as a holistic indicator which highlights both purchase and rental market responses to natural hazard vulnerabilities, thereby proposing wider insight into housing market dynamics in the face of climate change – especially within the context of Auckland, New Zealand.

## **2.7 Conclusion**

This review of the literature has examined the growing amount of local and international research that links environmental risks and climate change to variations in the residential real estate markets. Across several regions, it is evident that environmental vulnerabilities - particularly flooding, rising sea levels, and extreme weather events - are driving up real estate housing costs. Property prices in exposed places experience price reductions as market players absorb the costs of possible risks, according to several empirical studies showing that these exposures have a negative capital impact. Urban planners, insurers, and legislators tasked with reducing long-term climate impacts are all significantly impacted, in addition to investors and homeowners.

Though the effects on real estate prices are well-established and becoming more widely recognized, the same is not the case for the rental markets. Only a fragmented picture of how climate-related hazards impact rental values is provided by the literature currently in publication. While some studies indicate little to no change in rent levels despite falling property values, other studies demonstrate post-disaster rent hikes only for vulnerable renter groups. Rents might not accurately reflect environmental concerns in the same way that prices do, according to this discrepancy, which points to an understudied contradiction in housing market responses. As a result, the price-to-rent ratio - a crucial

indicator of market efficiency, investment appeal, and housing affordability - has evolved into a potentially illuminating but mainly underutilized instrument in climate risk assessments.

Scholarly and institutional interest in the New Zealand context has increased recently, particularly regarding the consequences for insurance, consumer attitudes, and government policy responses to climate hazards. Significant pricing effects in flood-prone areas like South Dunedin have been documented by research, which has also brought attention to the difficulties with future insurability in coastal zones. Research connecting these climate-induced vulnerabilities to rental market dynamics and, more crucially, to the price-to-rent ratio's combined study of property prices and rents is still noticeably lacking, though. In cities like Auckland, where there is a high demand for housing and a high danger of flooding from rainwater, sea level rise, and other climate hazards, this is especially important.

Academic research on how climate change is affecting the ratio of owning to renting is still lacking, despite a growing policy discussion about climate adaptation and housing affordability. Whether and how price-to-rent ratios vary among climate risk zones, as well as how these changes impact various income groups and tenure systems, have not been thoroughly examined in many, if any, studies conducted in New Zealand. A crucial layer of market knowledge is absent without this study, especially at a time when the financial and physical hazards associated with climate change are increasing.

This analysis thus emphasizes the urgent need for studies that quantify the distinct impacts of climate threats on rents and property values while also examining the ways in which these factors interact to influence more general market conditions. The current study fills this gap by examining the ways in which natural hazard and climate change threats affect Auckland's price-to-rent ratio. It provides a distinctive and comprehensive viewpoint that is supported by both theoretical frameworks and empirical research. In doing so, it advances evidence-based planning and investment strategies that are sensitive to socioeconomic realities and environmental concerns, and it advances a more nuanced understanding of housing market efficiency in the era of climate uncertainty.

Overall, even though the academic community has made great strides in determining the financial impacts of climate risk in housing markets, more comprehensive metrics like the price-to-rent ratio must be included to overcome price-centric models. The purpose of this study is to close that knowledge gap and provide fresh perspectives on how climate vulnerabilities might alter urban housing markets, impact affordability, and influence future residential choices in the face of climate change risks.

## Chapter 3: Materials and Methods

### 3.1 Data Sources

#### 3.1.1 Property Sales Price, Rental Price and Price to Rent Ratio

I have obtained the property sales prices and rent prices for the suburbs in Auckland from the renowned Real Estate Company in New Zealand- Barfoot & Thompson's Suburb level Monthly property report. I have collected the property sales price and rental price data from 2019 to 2025 for 5 types of room configurations such as- 1-bedroom, 2-bedrooms, 3-bedrooms, 4-bedrooms and 5-bedrooms residential properties from this source, since it provides detailed information on property sales and rental values at the suburb level across Auckland. And, utilizing the average sale prices and weekly rents from this report, I have calculated the price-to-rent ratio for each suburb for each year.

**The formula I used to calculate the Price-to-Rent Ratio (P to R) is as follows:**

**$$\text{P to R Ratio} = \frac{\text{Average Property Sale Price}}{\text{Annual Rent}} = \frac{\text{Average Property Sale Price}}{(\text{Average Weekly Rent} * 52)}$$**

Here,

- **Average Property Sale Price** is the mean price of selling for residential properties in each suburb.
- **Average Weekly Rent** is the mean rent price per week for residential properties in the same suburb.
- The multiplier 52 converts rent per week into annual rent to match the price's annual valuation scale.

#### 3.1.2 Natural Hazard and Climate Change Risk

I have collected and extracted natural hazard and climate risk data from the GeoMaps and Auckland ArcGIS Experience tool. These are developed and published by Auckland Council and from these, I have identified the natural hazard and climate risks for each suburb based on their risk status as flood zones, coastal hazard areas, and as per other

environmental risk layers. This allowed me to determine whether properties in each suburb are exposed to climate-related hazards. I focused on these sources because they are maintained by official authorities and could provide the most up-to-date and accurate spatial information.

### **3.1.3 School Equity Index (EQI)**

I have accessed and collected the School Equity Index (EQI) data from the New Zealand Ministry of Education website and the government's school zone and equity funding pages. These sources provided information on how it is different from the previous decile system, what the current EQI system is about, how it is calculated and how schools are now categorized in terms of providing government funding. I have collected the indexes and assigned the average school equity scores of each suburb.

### **3.1.4 Socioeconomic Deprivation Index**

In terms of the socioeconomic deprivation index data, I have obtained the NZDep/NZiDep index which have been published and provided by the University of Otago and from the 2023 Index of Socioeconomic Deprivation published by Stats NZ. These sources provide information about the relative socioeconomic conditions of neighborhoods, including income, employment, and housing quality. I linked each property to a deprivation score by using these indexes.

### **3.1.5 Distance to Central Business District (CBD)**

I have measured the distance from each suburb to the Auckland Central Business District (CBD) using the Google Earth Pro and I have assessed how proximity to the city center affects property values and rental rates, by mapping each property and calculating the respective distances to the CBD from each suburb.

### **3.1.6 Proximity to Tertiary Institutes**

I also measured the distance from each suburb to the nearest tertiary institute through the Google Earth Pro. I identified the closest major universities or colleges and calculating the distance from each property. In this way, I examined the influence of educational institutions on local property demand.

### **3.1.7 Official Cash Rate (OCR)**

For the Official Cash Rate (OCR) data, I have collected them from the Reserve Bank of New Zealand website. The data I received, delivers important information about the monetary policy decisions taken by the Reserve Bank in New Zealand over time. It includes the interest rates over time. The changes in the OCR impact on the borrowing costs, mortgage rates, and overall housing affordability and therefore, by linking the OCR data to the period of my property data, I accounted for one of the key factors in the macroeconomic market.

### **3.1.8 GDP per Capita**

I obtained GDP per capita data for Auckland from Infometrics. This source provides regional economic indicators, including output per person, which reflects the economic activity as well as the wealth of the area. I have assessed how regional economic performance influences the housing market, including both property prices and rental values.

### **3.1.9 Inflation**

And, I have acquired the inflation data from the Reserve Bank of New Zealand website. The Inflation data provides information on the changes in price levels over a period which impacts on the real value of money as well as the cost of living. I have used the collected official inflation statistics and included the national data against each of the suburbs.

## **3.2 Methodology**

### **3.2.1 Software and Tool**

I have undertaken all the statistical analyses using the R software's latest version- 4.5.1, as it provides extensive features such as statistical libraries, data handling efficiency, and reproducibility. I have used R coding and imported datasets on property prices, rents, socioeconomic indicators, and environmental hazards, and prepared them for analysis through the R Software.

### **3.2.2 Variables**

Price to Rent Ratio is the main dependent variable, Property Sales Price and Rental Price are 2 secondary dependent variables (to check the impact of Natural Hazard Risks only) and Natural Hazard Risk, Distance to CBD, Proximity to Tertiary Institutes, School Equity Index, Socioeconomic Deprivation Index, Official Cash Rate, GDP per Capita, and Inflation are the independent variables.

### **3.2.3 Descriptive Statistics**

I calculated descriptive statistics with R coding to explore the characteristics of my dataset. I assessed measures such as mean, standard deviation, minimum, maximum, skewness, and kurtosis for each variable, including Price-to-Rent Ratio (PRR), Natural Hazard Risk, School Equity Index (EQI), Socioeconomic Deprivation Index, Distance to CBD, Proximity to Tertiary Institutes, Official Cash Rate, GDP per Capita, and Inflation. This step provided a clear understanding of the distributions and variability within the data.

### **3.2.4 Stationarity Tests**

I tested the stationarity of time-series variables using R coding by applying Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. For the variables that were non-stationary, I transformed them through first differencing, and the tests were repeated to ensure all variables met stationarity requirements, allowing for reliable regression modeling.

### **3.2.5 Multicollinearity Assessment**

Multicollinearity among predictors was evaluated through correlation matrices calculations using R coding. This assessment helped me verify that no independent variables were excessively correlated, ensuring the regression coefficients would remain interpretable and unbiased.

### **3.2.6 Univariate Regression Model**

For modeling, I implemented a univariate regression model first to identify the individual impact of each independent variable on the main dependent variable Price-to-Rent ratio.

I also used this model to identify the impact of the main independent variable- Natural Hazard Risks on Property Sales Prices and Rental Prices.

**Equation:**

$$P \text{ to } R_{it} = \beta_0 + \beta_1 \cdot [\text{IndependentVariable}]_{it} + \epsilon_{it}$$

### 3.2.7 Bivariate Regression Model

After the Univariate model, I implemented a bivariate regression model to show the combined effect of two closely related independent variables at a time on the dependent variable- Price-to-Rent ratio.

**Equation:**

$$P \text{ to } R_{it} = \beta_0 + \beta_1 \cdot [\text{IndependentVariable1}]_{it} + \beta_2 \cdot [\text{IndependentVariable2}]_{it} + \epsilon_{it}$$

### 3.2.8 Multiple Linear Regression Model (OLS)

After Bivariate Model, I implemented a consolidated Multiple Linear Regression Model using the Ordinary Least Squares (OLS) approach to identify the consolidated impact of all independent variables on the dependent variable Price to Rent Ratio and the impact of Natural Hazard Risks on log-transformed Property Sales Prices and log-transformed Rental prices while considering all other independent variables.

**Equation for multiple linear regression (OLS) – to identify the consolidated impact of all independent variables on the dependent variable Price to Rent Ratio:**

$$P \text{ to } R_{it} = \beta_0 + \beta_1 NHR_{it} + \beta_2 EQI_{it} + \beta_3 Deprivation_{it} + \beta_4 DistanceCBD_{it} + \beta_5 ProxTertiary_{it} + \beta_6 OCR_t + \beta_7 GDPpc_t + \beta_8 Inflation_t + \epsilon_{it}$$

Equation for multiple linear regression (OLS) - to identify the impact of Natural Hazard Risks on Property Sales Prices and Rental prices while considering all other independent variables:

$$\begin{aligned} \log(\text{Sales}_{it}) &= \beta_0 + \beta_1 \text{NHR}_{it} + \beta_2 \text{EQI}_{it} + \beta_3 \text{Deprivation}_{it} + \beta_4 \text{DistanceCBD}_{it} \\ &+ \beta_5 \text{ProxTertiary}_{it} + \beta_6 \text{OCR}_t + \beta_7 \text{GDPpc}_t + \beta_8 \text{Inflation}_t + \epsilon_{it} \end{aligned}$$

$$\begin{aligned} \log(\text{Rent}_{it}) &= \beta_0 + \beta_1 \text{NHR}_{it} + \beta_2 \text{EQI}_{it} + \beta_3 \text{Deprivation}_{it} + \beta_4 \text{DistanceCBD}_{it} \\ &+ \beta_5 \text{ProxTertiary}_{it} + \beta_6 \text{OCR}_t + \beta_7 \text{GDPpc}_t + \beta_8 \text{Inflation}_t + \epsilon_{it} \end{aligned}$$

### 3.2.9 Robustness Test

For robustness, the analysis used the yearly event-based measure of natural hazard risk, capturing whether a suburb experienced a hazard event each year. This approach allows assessment of whether the impact of natural hazards on the Average Price-to-Rent Ratio is held when considering actual events rather than the general risk classification.

### 3.2.10 Additional Analyses:

#### 3.2.10.1 Lagged Effects Analysis

To capture temporal dynamics of climate risk, I constructed lagged variables in R coding. I incorporated these into the analysis to examine potential delayed effects of environmental hazards on PRR.

Equation:

$$\begin{aligned} P \text{ to } R_{it} &= \beta_0 + \beta_1 \text{NHR}_{i,t-1} + \beta_2 \text{EQI}_{it} + \beta_3 \text{Deprivation}_{it} + \beta_4 \text{DistanceCBD}_{it} \\ &+ \beta_5 \text{ProxTertiary}_{it} + \beta_6 \text{OCR}_t + \beta_7 \text{GDPpc}_t + \beta_8 \text{Inflation}_t + \epsilon_{it} \end{aligned}$$

### 3.2.10.2 Heterogeneity Analysis

I also performed subgroup analysis for properties situated within natural hazard risk zones compared to those outside, enabling a focused examination of location-specific risk exposure.

**Equation:**

$$\begin{aligned} P \text{ to } R_{it} = & \beta_0 + \beta_1 NHR_{it} + \beta_2 SubgroupDummy_i \\ & + \beta_3 (NHR_{it} * SubgroupDummy_i) + \beta_4 EQI_{it} + \beta_5 Deprivation_{it} \\ & + \beta_6 DistanceCBD_{it} + \beta_7 ProxTertiary_{it} + \beta_8 OCR_t + \beta_9 GDPpc_t \\ & + \beta_{10} Inflation_t + \epsilon_{it} \end{aligned}$$

### 3.2.10.3 Mechanisms Analysis

Finally, I investigated mechanisms through which climate risk could influence PRR by including variables such as insurance premiums, days to sell, and repair costs in the regression framework. Using R coding, I integrated these mechanisms to study their separate contributions and how they could mediate the relationship between environmental risk and property values.

**Equation:**

$$\begin{aligned} P \text{ to } R_{it} = & \beta_0 + \beta_1 NHR_{it} + \beta_2 Insurance_{it} \\ & + \beta_3 DaysToSell_{it} + \beta_4 RepairCost_{it} + \beta_5 (NHR_{it} \times Insurance_{it}) \\ & + \beta_6 (NHR_{it} \times DaysToSell_{it}) + \beta_7 (NHR_{it} \times RepairCost_{it}) \\ & + \beta_8 EQI_{it} + \beta_9 Deprivation_{it} + \beta_{10} DistanceCBD_{it} + \beta_{11} ProxTertiary_{it} \\ & + \beta_{12} OCR_t + \beta_{13} GDPpc_t + \beta_{14} Inflation_t + \epsilon_{it} \end{aligned}$$

## Chapter 4: Results and Discussion

The descriptive statistics reveal some apparent patterns in the dataset. The average price-to-rent ratio (PRR) is 32.02, where most of the suburbs are between 28.72 and 35, while the maximum reaches 49.57, reflecting a moderate positive skew of 0.27 and kurtosis of 3.03, indicating the data is slightly concentrated around typical values with a few higher cases. Approximately 62 percent of suburbs lie within natural hazard zones, reflected in the mean value of 0.62 for the binary hazard risk variable. The School Equity Index (EQI) averages 422.9, ranging from 344 to 543, with modest spread and slight positive skew, meaning more schools fall below the mean than above. The socioeconomic deprivation index has a mean of 5.36 on the 1–10 scale, suggesting most suburbs fall in the middle to higher range of deprivation, with an even distribution. Geographically, suburbs are on average 18.54 kilometers from the central business district (CBD) in Auckland, though distances vary from under 10 to over 50 kilometers. Other contextual variables show similar patterns of concentration with some variation. Proximity to tertiary institutions averages 0.26, indicating only about a quarter of suburbs are near such facilities, explaining the skewness and kurtosis values. Macroeconomic variables—official cash rate (OCR), GDP per capita, and inflation—show stable distributions. The OCR averages 2.62 percent, ranging from 0.33 to 5.25 percent, with nearly normal distribution. GDP per capita averages \$86,561, with small variation and slight negative skew, while inflation averages 2.96 percent, ranging from 1.7 to 5.8 percent, with a mild positive skew reflecting occasional higher inflation. Average sale prices and rental prices have moderate variation, averaging \$1,116,580 and \$669, respectively, while insurance premiums, days to sell, and repair costs display wider dispersion, highlighting some suburbs with extreme values. Overall, these findings show that socioeconomic, geographic, and macroeconomic factors are balanced, while the PRR stands out as moderately skewed, underlining the importance of careful analysis in further statistical testing.

The stationarity of the variables was assessed using three complementary tests: the Augmented Dickey-Fuller (ADF) test, the Phillips-Perron (PP) test, and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. Stationarity refers to the property of a time series

whose statistical characteristics, such as mean and variance, remain constant over time, which is crucial for producing reliable regression results. The ADF test results indicate that, in their original levels, the price-to-rent ratio, average sales price, average rental price, natural hazard risk, school equity index (EQI), socioeconomic deprivation index, distance to the central business district (CBD), and proximity to tertiary institutes are stationary at the 5% significance level. In contrast, the official cash rate (OCR), GDP per capita, and inflation were non-stationary, indicating trends or persistent changes over time. First differencing these macroeconomic variables confirmed stationarity, making all variables suitable for analysis. The PP test largely mirrored the ADF findings: the price-to-rent ratio, average sales price, average rental price, natural hazard risk, EQI, socioeconomic deprivation index, distance to CBD, and proximity to tertiary institutes were stationary, while OCR, GDP per capita, and inflation were non-stationary at their original levels. After first differencing, the macroeconomic variables became stationary across all significance levels, confirming the reliability of the transformed dataset. The KPSS test, which assumes stationarity under the null, showed that the price-to-rent ratio, average sales price, average rental price, EQI, socioeconomic deprivation index, and distance to CBD are stationary at 5%, while natural hazard risk and proximity to tertiary institutes were non-stationary. OCR, GDP per capita, and inflation also exhibited non-stationarity. After first differencing of these variables, KPSS confirmed stationarity across all variables, aligning with the ADF and PP results.

The correlation matrix shows the relationships between all variables and helps assess multicollinearity. Most correlations are low to moderate, though OCR and GDP per capita exhibit a very strong positive correlation (0.911), indicating potential collinearity between these macroeconomic variables. Average sale price and average rental price are moderately correlated (0.665), while other variables remain largely independent. With respect to the price-to-rent ratio, there are moderate positive correlations with average sale price (0.798) and weaker positive correlations with proximity to tertiary institutes (0.110) and inflation (0.124), and moderate negative correlations with school equity index (-0.422), socioeconomic deprivation index (-0.282), natural hazard risk (-0.249), GDP per capita (-0.289), and OCR (-0.346), while distance to CBD shows negligible correlation (0.010). Overall, the results suggest that property market factors, particularly sale prices,

are most strongly linked to the price-to-rent ratio, and except for OCR and GDP per capita, no serious multicollinearity is present to distort regression estimates.

The univariate regressions examine the effect of each variable on the price-to-rent ratio individually. The results show that higher socioeconomic deprivation is associated with a lower price-to-rent ratio, with a significant coefficient of -0.53, indicating that areas with greater deprivation tend to have lower returns relative to property prices. Similarly, the school equity index has a negative relationship (-0.03), meaning that areas with better school equity slightly reduce the price-to-rent ratio. Natural hazard risk also shows a negative impact (-2.54), suggesting that properties in areas exposed to higher environmental risk tend to be less profitable in terms of rent relative to price. Distance from the central business district shows an essentially null effect (0.00), indicating that, in this dataset, distance from the CBD does not meaningfully affect the price-to-rent ratio. Proximity to tertiary institutes shows a positive effect (1.24), suggesting that properties near universities or colleges tend to have higher price-to-rent ratios. Among macroeconomic variables, the official cash rate has a significant negative effect (-0.88), GDP per capita has a negligible effect ( $\sim 0.00$ ), while inflation has a small positive effect (0.45). Overall, these univariate models highlight that local socioeconomic conditions, environmental risk, location-related factors, and certain macroeconomic variables can individually influence the price-to-rent ratio.

The bivariate regressions explore the combined effects of two variables simultaneously. When socioeconomic deprivation and school equity are included together, both remain significant, with coefficients of -0.40 and -0.02 respectively, indicating that each variable individually influences the price-to-rent ratio, though some shared influence exists. For distance to CBD and proximity to tertiary institutes, both variables show positive effects, with coefficients of 0.07 and 2.28, and are highly significant, suggesting that properties farther from the CBD but closer to tertiary institutes tend to have higher price-to-rent ratios. The combination of inflation and the official cash rate shows that OCR maintains a strong negative effect (-1.40), while inflation has a positive effect (1.48), both highly significant, implying that macroeconomic conditions jointly impact property returns. For natural hazard risk and GDP per capita, natural hazard risk has a negative effect (-2.33)

and GDP per capita a very small negative effect (0.00), both significant, confirming that environmental risk and local wealth jointly influence the price-to-rent ratio. Overall, these bivariate results indicate that the relationships observed in the univariate models largely persist, though the magnitude and significance of effects can change when variables are considered together.

The full regression model incorporates all independent variables simultaneously to assess their combined effects on the price-to-rent ratio. The results indicate that several factors significantly influence the ratio. Natural hazard risk (-1.11,  $p = 0.01$ ) and socioeconomic deprivation (-0.41,  $p = 0.00$ ) are negatively associated, suggesting that areas with higher environmental risks or greater deprivation tend to have lower price-to-rent ratios. School equity shows a marginally negative effect (-0.01,  $p = 0.09$ ), indicating a slight tendency for higher school equity to reduce the ratio, though this effect is not strongly significant. Distance to the CBD (0.05,  $p = 0.03$ ) and proximity to tertiary institutes (3.15,  $p = 0.00$ ) are positively associated, meaning that properties farther from the CBD or near universities/colleges generally have higher price-to-rent ratios. Among macroeconomic variables, GDP per capita has a small positive effect (0.00,  $p = 0.01$ ), while the official cash rate is not significant (0.34,  $p = 0.26$ ). Inflation could not be included due to near-perfect collinearity with GDP per capita, preventing its independent effect from being estimated. Overall, the full model highlights that local geographic, environmental, and socioeconomic factors are the strongest determinants of the price-to-rent ratio, whereas macroeconomic variables play a smaller or secondary role. These findings suggest that property investors and policymakers should carefully consider both local conditions and broader economic indicators when evaluating rental performance.

The full OLS regression results also indicate that natural hazard risk exerts a significant negative influence on property sales prices, with a coefficient of -43,070 ( $p = 0.03$ ). This demonstrates that properties situated in areas exposed to higher environmental risks, such as flooding, earthquakes, or storm surges, tend to sell for considerably lower amounts compared to properties in lower-risk areas. This reduction in sale price reflects the heightened caution of buyers, who factor in potential future costs, insurance implications, and the long-term risk of property damage. In contrast, natural hazard risk

does not exhibit a statistically significant effect on rental prices (1.96,  $p = 0.64$ ), suggesting that tenants are less influenced by these risks when deciding on rental properties. The lack of significant rental effect may be due to the shorter-term nature of rental agreements, where tenants are less exposed to long-term risk and can more easily adjust or relocate if hazards materialize. Overall, these results imply that environmental risks are a critical determinant in property purchasing decisions, while their influence on rental markets is limited.

The robustness test results show a negative and statistically significant effect of Natural Hazard Risks on the Average Price-to-Rent Ratio. This indicates that suburbs experiencing actual hazard events consistently tend to have lower price-to-rent ratios compared to those without events. The findings provide additional confidence that the negative relationship observed in the main analysis is not driven solely by general risk classifications but also holds when considering the occurrence of real hazard events over time. This reinforces the validity and reliability of the main results and highlights the tangible impact of natural hazards on property market outcomes.

The analysis of the lagged effect of climate risk on the price-to-rent ratio (PRR) indicates a measurable negative impact. Properties exposed to climate risk in the previous period (lag 1) have an average PRR of 31.67, compared to 33.66 for properties with no prior risk exposure (lag 0), resulting in a difference of -1.99, or a 5.90% decrease. This difference is statistically significant ( $p < 0.01$ ) with a Cohen's  $d$  of -0.41, reflecting a small to medium effect size. The 95% confidence interval for this effect ranges from -0.56 to -0.26, confirming that the reduction in PRR is unlikely to be due to random variation. These findings suggest that prior exposure to climate risk has a persistent, negative influence on property rental performance, emphasizing the importance of incorporating historical risk exposure into property market evaluations.

The comparison of price-to-rent ratios (PRR) between properties classified as at risk versus not at risk demonstrates a clear negative impact of climate risk. Properties identified as at risk have an average PRR of 31.05, compared to 33.60 for properties not at risk, resulting in a difference of -2.54, or a 7.57% decrease. This difference is statistically significant ( $p = 0.00$ ) with a medium effect size (Cohen's  $d = 0.53$ ), and the

95% confidence interval ranges from 0.39 to 0.67, indicating that the reduction in PRR for at-risk properties is unlikely to be due to chance. These findings suggest that exposure to natural hazard risk meaningfully lowers the price-to-rent ratio, highlighting the influence of local climate risk on property market performance.

The mechanisms analysis examined how climate change and natural hazard risks affect the price-to-rent ratio in properties exposed to risk by looking at three potential factors: insurance premiums, days to sell, and repair costs. For insurance premiums, the coefficient is 0.01 ( $p = 0.00$ ), indicating a positive and significant effect on price-to-rent ratio. This suggests that higher insurance costs in risk-exposed properties are linked to a measurable increase in the price-to-rent ratio, highlighting the role of insurance expenses in shaping price-to-rent ratio. In contrast, days to sell and repair costs did not show any significant effect on price-to-rent ratio in this analysis, meaning that these factors do not appear to contribute in a measurable way to variations in price-to-rent ratio for the properties studied. Overall, based on the available data and results, insurance premiums demonstrate a clear and quantifiable impact on price-to-rent ratio, indicating that higher insurance costs are an important factor influencing the increase in the price-to-rent ratio.

Overall, the analyses indicate that climate change and natural hazard risks have a clear and consistent negative effect on the price-to-rent ratio in Auckland, aligning with insights from the literature that environmental hazards can depress property market performance. Properties located in high-risk areas tend to sell for lower prices, reflecting buyers' awareness of potential damage, insurance costs, and future financial burdens, while rental prices are less sensitive, likely due to the shorter-term nature of tenancy agreements and the ability of tenants to relocate if risks materialize. In addition to environmental risks, local socioeconomic factors such as higher deprivation levels and variations in school quality, as well as geographic characteristics like distance from the central business district and proximity to tertiary institutions, meaningfully influence the price-to-rent ratio. Macroeconomic conditions, including GDP per capita and interest rates, have comparatively smaller or indirect effects on property returns. Mechanism analysis further highlights that higher insurance premiums in risk-exposed properties are a measurable pathway affecting the price-to-rent ratio, while days on market and repair

costs do not show a significant effect Overall, these results emphasize that both environmental risks and local social and geographic factors play critical roles in shaping property market outcomes, with natural hazard exposure consistently reducing the price-to-rent ratio and underscoring the importance of considering risk in property valuation and investment decisions.

## Chapter 5: Conclusion

This study has investigated the way climate change and natural hazard risks affect the housing market in Auckland. The analysis reveals that properties that are situated in hazard-prone areas consistently demonstrate lower price-to-rent ratios and reduced property prices compared with those in the lower-risk areas. This pattern reflects the way buyers adjust their purchase decisions in response to the obvious environmental risks, discounting potential long-term returns. However, rental prices remain comparatively stable due to the ongoing demand for rent. This difference between sales prices and rental prices indicates that climate change risks are not conceptual or future concerns, and rather they are actively impacting the housing outcomes in Auckland.

Suburbs in high-risk areas tend to experience slower growth in property sales prices, but the rental prices in these areas remain strong and often rise alongside the broader city pressures. This results in a measurable reduction in the price-to-rent ratio, confirming that buyers are more sensitive to and cautious about long-term risk exposure than the renters are. Renters' decisions are influenced by short-term factors such as location, availability, affordability etc. maintaining demand even in areas exposed to natural hazards. The difference between the renter behavior and buyer behavior displays a critical market dynamic. It entails that climate change risks affect the investment decisions in a stronger way than rental choices, revealing observable patterns in market performance.

These findings align with the evidence from literature review, where it was found that properties in hazard-prone areas sell at decreased prices while rents remain stable due to demand. In Auckland, this dynamic is strengthened by strong population growth, constrained housing supply, and persistent affordability pressures, which sustain high rental demand across the city. The study therefore contributes to the broader understanding of housing market adjustments by showing how environmental risk interacts with local demand-supply conditions, making the price-to-rent ratio a particularly useful measure for detecting and quantifying these effects.

The study also highlights the impact of local socioeconomic and geographic factors in shaping the property market in Auckland. Areas that have higher socioeconomic

deprivation and school equity indexes, have lower price-to-rent ratios and sale prices, which displays the impact of income constraints and financial conditions. Proximity to tertiary institutes also plays considerable roles, with properties near tertiary institutes showing distinct patterns in returns relative to price. For the macroeconomic factors such as the GDP per capita and official cash rate- these exhibit minor effects due to their data availability for larger geographic areas.

The implications of these findings are significant for housing policy, urban planning, and market regulation. The evidence that hazard-prone suburbs are underperforming in terms of price growth indicates that risk is already being internalized by buyers. This raises critical equity concerns: lower-income households may be concentrated in higher-risk areas because of lower purchase costs, increasing their exposure to environmental hazards and financial burdens, including higher insurance costs, repair obligations, and reduced resale value. Renters, meanwhile, face sustained affordability pressures, suggesting that climate and hazard risks do not alleviate housing stress but can exacerbate existing vulnerabilities. Therefore, policymakers and planners must treat environmental risk as an integral consideration, recognizing its interaction with social and economic conditions rather than approaching it solely as a technical or future-oriented challenge.

Financial institutions and insurers are also implicated. Buyers' responses to risks are taking place even before insurance premiums or lending policies fully adjust, indicating that market participants are anticipating potential losses. As climate change continues to develop, insurers and financial institutions will need to adopt their practices, which will in turn shape property values and rental conditions further. Understanding this interaction between the responses and household decision-making is important to anticipate how hazard exposure will influence housing market trajectories in the coming years.

It is important to acknowledge the limitations of this study. The analysis is centered on the Auckland and does not include other cities in New Zealand. Hence, despite the findings are mostly likely to be the same for other cities, however, different attributes may alter the outcomes for other cities in New Zealand. Moreover, this study examines the residential properties only and does not consider the commercial properties, which may have

different impacts due to climate and hazard risks due to their different investment objectives, usage patterns, and market dynamics.

Despite these limitations, the study provides a solid foundation for further research and extending the investigation to the other cities in New Zealand can investigate if similar patterns or findings are discovered under various demographic conditions and market situations. Further analysis of the impacts of environmental and natural hazard risks could explore whether vulnerable or lower-income households are the ones who bear the disproportionate burdens. Complementing quantitative results with more qualitative research, such as interviews with buyers, renters, and property market professionals, could also provide deeper insights into perceptions of environmental risks and their influence on decision-making.

The overarching conclusion of this research is that climate change and natural hazard risks affect the property outcomes in Auckland. Buyers adjust the prices to account for visible climate change risks, whereas the rental prices remain relatively stable due to strong demand conditions. The resulting divergence between the sales and rental markets, reflected in the price-to-rent ratio as well as the sales prices, provides clear evidence that environmental risk is a structural factor in housing markets rather than a secondary or future concern.

Auckland's housing market is already facing ongoing pressures such as limited supply of housing options, housing affordability etc. And this study shows that environmental risks compound these challenges. Factoring and addressing this while planning and policymaking is utterly important. If this is not done in a timely manner and with strong emphasis, this can significantly intensify both the housing level stress as well as vulnerability to environmental hazards. The findings highlight that addressing climate and hazard risks is not an optional consideration but a necessary component of creating resilient and sustainable housing systems. Findings from Auckland are also important beyond New Zealand, as they provide guidance for other urban centers in the world that are struggling with rapid growth, tight housing markets, and increasing exposure to climate change risks.

## References

Alansari, M., Turner-Adams, H., & Li, M. (2023). *Assessing how schools are responding to the Equity Index*. New Zealand Council for Educational Research (NZCER).

Retrieved from <https://www.nzcer.org.nz/research/publications/assessing-how-schools-are-responding-equity-index>

Asia Green Real Estate. (n.d.). *The link between GDP growth and the real estate market*. Retrieved July 19, 2025, from <https://www.asiagreen.com/en/news-insights/the-link-between-gdp-growth-and-the-real-estate-market>

Atkinson, J., Salmond, C., Crampton, P., Viggers, H., & Lacey, K. (2024, October 31). *NZDep2023 index of socioeconomic deprivation: User's manual* (Department of Public Health Research Report). University of Otago.

[https://www.otago.ac.nz/\\_data/assets/pdf\\_file/0026/593135/NZDep2023-Research-Report-31-October-2024.pdf](https://www.otago.ac.nz/_data/assets/pdf_file/0026/593135/NZDep2023-Research-Report-31-October-2024.pdf)

Auckland Council. (n.d.). *Homes and places explained*. Retrieved July 6, 2025, from <https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/auckland-plan/homes-places/Pages/homes-and-places-explained.aspx>

Auckland Council. (n.d.). *GeoMaps: Auckland Council's GIS viewer*. Retrieved July 7, 2025, from <https://www.aucklandcouncil.govt.nz/geospatial/geomaps/Pages/default.aspx>

Auckland Council. (2023). *Auckland's key challenges*. Retrieved July 7, 2025, from <https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/auckland-plan/about-the-auckland-plan/Pages/aucklands-key-challenges.aspx>

Auckland Council. (n.d.). *The potential risks to Auckland*. Retrieved July 8, 2025, from <https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/topic-based-plans-strategies/environmental-plans-strategies/aucklands-climate-plan/preparing/Pages/potential-risks-to-auckland.aspx>

Bell, M. (2023, September 12). Huge spike in Auckland CBD rental demand. *Stuff.co.nz*. <https://www.stuff.co.nz/business/property/132914554/huge-spike-in-auckland-cbd-rental-demand>

Bellaver, A., Costantini, L., Fosch, A., Monticelli, A., Scala, D., & Pangallo, M. (2025). *Floods do not sink prices, historical memory does: How flood risk impacts the Italian housing market*. arXiv. <https://arxiv.org/abs/2502.12116>

Beltrán, A., Maddison, D., & Elliott, R. J. R. (2018). *Is flood risk capitalised into property values?* [Accepted manuscript]. University of Birmingham Research Archive. [https://pure-oai.bham.ac.uk/ws/portalfiles/portal/58883966/JEEM\\_Paper\\_Revised\\_19\\_12\\_2018\\_AB\\_RE.pdf](https://pure-oai.bham.ac.uk/ws/portalfiles/portal/58883966/JEEM_Paper_Revised_19_12_2018_AB_RE.pdf)

Beltrán, A., Maddison, D., & Elliott, R. J. R. (2018). Is flood risk capitalised into property values? *Ecological Economics*, 146, 668–685. <https://doi.org/10.1016/j.ecolecon.2017.12.015>

Beltrán, R., Maddison, D., & Elliott, J. R. (2019). The impact of flooding on property prices: A repeat-sales approach. *Journal of Environmental Economics and Management*, 95, 62–86. <https://doi.org/10.1016/j.jeem.2019.02.006>

Beracha, E., & Hardin, W. G. III. (2018). The capitalization of school quality into renter and owner housing. *Real Estate Economics*, 46(1), 85–119. <https://doi.org/10.1111/1540-6229.12195>

Bernstein, A., Gustafson, M. T., & Lewis, R. (2019). *Disaster on the horizon: The price effect of sea level rise*. *Journal of Financial Economics*, 134(2), 253–272. <https://doi.org/10.1016/j.jfineco.2019.03.013>

Bernstein, A., Gustafson, M. T., & Lewis, R. (2019). *Disaster on the horizon: The price effect of sea level rise*. *Journal of Financial Economics*, 134(2), 253–272. <https://doi.org/10.1016/j.jfineco.2019.03.013>

Best, K. B., He, Q., Reilly, A., Tran, N., & Niemeier, D. (2023). Rent affordability after hurricanes: Longitudinal evidence from US coastal states. *Risk Analysis*. <https://doi.org/10.1111/risa.14224>

- Black, S. E. (1999). Do better schools matter? Parental valuation of elementary education. *Quarterly Journal of Economics*, 114(2), 577–599. <https://doi.org/10.1162/003355399556070>
- Bin, O., Kruse, J. B., & Landry, C. E. (2008). Flood hazards, insurance rates, and amenities: Evidence from the coastal housing market. *Journal of Risk & Insurance*, 75(1), 63–82. <https://doi.org/10.1111/j.1539-6975.2007.00248.x>
- 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. <https://doi.org/10.1016/j.jeem.2012.12.002>
- Boustan, L. P., Kahn, M. E., Rhode, P. W., & Yanguas, M. L. (2020). The effect of natural disasters on economic activity in US counties: A century of data. *Journal of Urban Economics*, 118, 103257. <https://doi.org/10.1016/j.jue.2020.103257>
- Brennan, M., Srini, T., & Steil, J. (2024). *High and dry: Rental markets after flooding disasters*. Urban Affairs Review. MIT Department of Urban Studies and Planning. <https://dusp.mit.edu/news/understanding-impacts-floods-rental-markets>
- Brennan, M., Srini, T., & Steil, J. (2024). *High and Dry: Rental Markets After Flooding Disasters* [Working paper]. MIT & Rutgers. <https://doi.org/10.2139/ssrn.5282307>
- Brennan, M., Srini, T., & Steil, J. (2024). High and dry: Rental markets after flooding disasters. *Urban Affairs Review*. <https://doi.org/10.1177/10780874241243355>
- Camilleri, M., Jaques, R., & Isaacs, N. (2001). *Impacts of climate change on building performance in New Zealand*. *Building Research & Information*, 29(6), 440–450. <https://doi.org/10.1080/09613210110083636>
- Chen, J. (1996). *China's urban housing reform: Price-rent ratio and market equilibrium*. *Urban Studies*, 33(7), 1077–1092. <https://journals.sagepub.com/doi/abs/10.1080/00420989650011519>
- Chen, J., & Ni, S. (2011). Estimating estate-specific price-to-rent ratios in Shanghai and Shenzhen: A Bayesian approach. *International Real Estate Review*, 14(2), 208–239. Retrieved from <https://ideas.repec.org/a/ire/issued/v14n022011p208-239.html>

- Cheung, K. S. W., & Yiu, C. C. Y. (2022). *Public perception of flood hazards in the housing market: A revealed preference study of affect heuristics and availability heuristics*. *International Journal of Disaster Risk Reduction*, 75, 102977. <https://doi.org/10.1016/j.ijdrr.2022.102977>
- Clark, S., & Lomax, N. (2020). *Rent/price ratio for English housing sub-markets using matched sales and rental data*. *Area*, 52(1), 136–147. Retrieved from White Rose Research Online: <https://eprints.whiterose.ac.uk/id/eprint/146325/>
- Clayton, J., Devaney, S., Sayce, S., & Van de Wetering, J. (2021). *Climate risk and commercial property values: A review and analysis of the literature*. United Nations Environment Programme Finance Initiative. <https://www.unepfi.org/publications/climate-risk-and-commercial-property-values/>
- Climate X. (n.d.). *How risk impacts property value*. <https://www.climate-x.com/articles/industry/how-risk-impacts-property-value>
- Cortes, A. (2004). Estimating the impacts of urban universities on neighborhood housing markets: An empirical analysis. *Urban Affairs Review*, 39(3), 342–375. <https://doi.org/10.1177/1078087403255654>
- 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. <https://doi.org/10.1016/j.ecolecon.2009.08.018>
- De Wilde, P., & Coley, D. (2012). The implications of a changing climate for buildings. *Building and Environment*, 56, 1–7. <https://doi.org/10.1016/j.buildenv.2012.03.014>
- Del Barrio Castro, T., Rodrigues, P. M. M., & Taylor, A. M. R. (2015). On the behaviour of Phillips–Perron tests in the presence of persistent cycles. *Oxford Bulletin of Economics and Statistics*, 77(4), 495–511. <https://doi.org/10.1111/obes.12091>
- Enright, P. A. (2015). Is there a tolerable level of risk from natural hazards in New Zealand? *Natural Hazards*, 76(1), 1–8. <https://doi.org/10.1080/17499518.2014.1000341>

Environmental Health Intelligence NZ. (2023). *Socioeconomic deprivation profile*. Retrieved from <https://www.ehinz.ac.nz/indicators/population-vulnerability/socioeconomic-deprivation-profile/>

Fleming, D., Noy, I., Pástor-Paz, J., & Owen, S. (2018). *Public insurance and climate change (Part One): Past trends in weather-related insurance in New Zealand* (Working paper). Motu Economic and Public Policy Research Trust; Victoria University of Wellington. [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3477038](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3477038)

Folger, J. (2024, August 10). *Real estate valuation: What you should know*. Investopedia. <https://www.investopedia.com/articles/realestate/12/real-estate-valuation.asp>

Fuerst, F., & Warren-Myers, G. (2021). Pricing climate risk: Are flooding and sea level rise risk capitalised in Australian residential property? *Climate Risk Management*, 34, 100361. <https://www.sciencedirect.com/science/article/pii/S2212096321000905?via%3Dihub>

Fuerst, F., & Zhu, B. (2023). *Natural hazard exposure and REIT equity risk* [Working paper]. European Real Estate Society (ERES). Retrieved from [https://eres.architecture.net/system/files/P\\_20230130140215\\_7366.pdf](https://eres.architecture.net/system/files/P_20230130140215_7366.pdf)

Gallin, J. H. (2004). *The Long-Run Relationship between House Prices and Rents*. Federal Reserve, Finance and Economics Discussion Series 2004–50. Retrieved from <https://www.federalreserve.gov/pubs/feds/2004/200450/200450pap.pdf>

Global Property Guide. (2025, July). *Price/Rent Ratio in New Zealand compared to Pacific*. Retrieved from <https://www.globalpropertyguide.com/pacific/new-zealand/price-rent-ratio>

Gourevitch, J., Porter, J., & Hsiang, S. M. (2023). Unpriced climate risk and the potential consequences of mispricing in the housing market. *Nature Climate Change*, 13(5), 373–380. <https://doi.org/10.1038/s41558-023-01594-8>

Guo, Z. (2023). Research on the augmented Dickey-Fuller test for predicting stock prices and returns. *Advances in Economics Management and Political Sciences*, 44(1), 101–106. <https://doi.org/10.54254/2754-1169/44/20232198>

Harcourts (New Zealand). (n.d.). *The surprising influence of cash rate on rental rates: Unraveling the connection*. Retrieved July 19, 2025, from <https://harcourts.net/nz/office/accommodation-centre/people/rosa-ellis/resources/investors-and-tenants/the-surprising-influence-of-cash-rate-on-rental-rates-unraveling-the-connection>

Hashida, Y., & Dundas, S. J. (2024). *Barriers to Coastal Managed Retreat: Evidence from New Jersey's Blue Acres Program*. *Marine Resource Economics*, 39(3), 179–205. <https://doi.org/10.1086/729868>

Hawkeye Wealth Ltd. (2024, December 21). *The impact of GDP on housing prices: Insights for 2025*. Retrieved July 19, 2025, from <https://www.hawkeyewealth.com/the-impact-of-gdp-on-housing-prices-insights-for-2025/>

Goodyear, R., Bentley, A., White, V., Bretherton, C., MacGregor, C., Jaques, R., Dowdell, D., Butler, J., Fabian, A., & Dickson, C. (2021). *Housing in Aotearoa, 2020*. Stats NZ. <https://www.stats.govt.nz/assets/Uploads/Reports/Housing-in-Aotearoa-2020/Download-data/housing-in-aotearoa-2020.pdf>

Grimes, A., & Aitken, A. (2007, March). *House prices and rents: Socio-economic impacts and prospects* (Motu Working Paper No. 07-01). Motu Economic and Public Policy Research. [https://motu-www.motu.org.nz/wpapers/07\\_01.pdf](https://motu-www.motu.org.nz/wpapers/07_01.pdf)

Heart of the City Incorporated. (2018, April 18). *Auckland's city centre: a place to call home*. Hotcity. <https://www.hotcity.co.nz/latest-updates/aucklands-city-centre-place-call-home>

Hidano, N., Hoshino, T., & Sugiura, A. (2015). The effect of seismic hazard risk information on property prices: Evidence from a spatial regression discontinuity design. *Regional Science and Urban Economics*, 53, 113–122. <https://doi.org/10.1016/j.regsciurbeco.2015.05.005>

Hirsch, J., & Hahn, J. (2018). How flood risk impacts residential rents and property prices: Empirical analysis of a German property market. *Journal of Property Investment & Finance*, 36(1), 50–67. <https://doi.org/10.1108/JPIF-11-2016-0088>

- Ihaka, R. (n.d.). *The R Project*. Department of Statistics, University of Auckland. Retrieved August 12, 2025, from <https://www.stat.auckland.ac.nz/~ihaka/downloads/the-r-project.pdf>
- Infometrics. (2024). Migration surge follows a familiar pattern. <https://www.infometrics.co.nz/article/2024-08-migration-surge-follows-a-familiar-pattern>
- Insurance Council of New Zealand. (2018, December 13). *Insurers pay \$226M to support recovery from extreme weather*. <https://www.icnz.org.nz/industry/media-releases/insurers-pay-226m-to-support-recovery-from-extreme-weather/>
- Keenan, J. M., Hill, T., & Gumber, A. (2018). Climate gentrification: From theory to empiricism in Miami-Dade County, Florida. *Environmental Research Letters*, 13(5), 054001. <https://doi.org/10.1088/1748-9326/aabb32>
- Levy, R., Naish, T., & Allen, J. (2023, April 6). *Climate change: What are the risks to real estate?* REINZ. [https://www.reinz.co.nz/Web/Web/News/News-Articles/Interest/climate change risks to real estate.aspx](https://www.reinz.co.nz/Web/Web/News/News-Articles/Interest/climate%20change%20risks%20to%20real%20estate.aspx)
- Libatique, R. (2024, May 10). Climate risks influence New Zealand housing decisions. *Insurance Business New Zealand*. <https://www.insurancebusinessmag.com/nz/news/property/climate-risks-influence-new-zealand-housing-decisions-488671.aspx>
- Lindsay, S. (2023, September 1). *Inflation and its effect on property*. NZ Property Investor. Retrieved July 19, 2025, from <https://www.nzpropertyinvestor.co.nz/inflation-and-its-effect-on-property>
- Lo, D., McCord, M. J., McCord, J., Davis, P. T., & Haran, M. (2021). *Rent or buy, what are the odds? Analysing the price-to-rent ratio for housing types within the Northern Ireland housing market*. *International Journal of Housing Markets and Analysis*, 14(5), 1062–1091. <https://doi.org/10.1108/IJHMA-08-2020-0103>
- Lo, D., McCord, M., McCord, J., Davis, P. T., & Haran, M. (2021). *Rent or buy, what are the odds?: Analysing the price-to-rent ratio for housing types within the Northern Ireland housing market*. *International Journal of Housing Markets and Analysis*. Retrieved from:

<https://www.researchgate.net/publication/350769132> Rent or buy what are the odds  
[Analysing the price-to-rent ratio for housing types within the Northern Ireland housing market](#)

Lo, D., McCord, M., Davis, P. T., Haran, M., & McGreal, S. (2022). Causal relationships between the price-to-rent ratio and macroeconomic factors: A UK perspective. *Journal of Property Investment & Finance*. Retrieved from <https://www.emerald.com/insight/content/doi/10.1108/jpif-08-2021-0068/full/html>

McAlpine, S. A., & Porter, J. R. (2018). Estimating recent local impacts of sea-level rise on current real-estate losses: A housing market case study in Miami-Dade, Florida. *Population Research and Policy Review*, 37(6), 871–895. <https://doi.org/10.1007/s11113-018-9473-5>

McCulloch, G. (1991). *School zoning, equity and freedom: The case of New Zealand*. *Journal of Education Policy*, 6(2), 155–168. Retrieved from <https://www.tandfonline.com/doi/abs/10.1080/0268093910060204>

Middleton, S. (1992). Equity, equality, and biculturalism in the restructuring of New Zealand schools: A life-history approach. *Harvard Educational Review*, 62(3), 301–323. Retrieved from <https://meridian.allenpress.com/her/article-abstract/62/3/301/31589/Equity-Equality-and-Biculturalism-in-the?redirectedFrom=fulltext>

Ministry of Business, Innovation and Employment. (n.d.). *Deprivation index in New Zealand* [Interactive map]. Retrieved July 8, 2025, from <https://webrear.mbie.govt.nz/theme/deprivation-index/map/timeseries/2023/new-zealand?right-transform=absolute>

Ministry of Business, Innovation and Employment. (2023). *New Zealand Deprivation Index – Time series map*. WeRear. <https://webrear.mbie.govt.nz/theme/deprivation-index/map/timeseries/2023/new-zealand?right-transform=absolute>

Ministry of Education. (2023). *Equity Index*. <https://www.education.govt.nz/our-work/changes-in-education/equity-index>

MoneyHub. (n.d.). *What is the OCR?* Retrieved July 19, 2025, from <https://www.moneyhub.co.nz/what-is-the-ocr.html>

Montz, B. E. (1992). The effects of flooding on residential property values in three New Zealand communities. *Disasters*, 16(4), 283–298. <https://doi.org/10.1111/j.1467-7717.1992.tb00411.x>

National Oceanic and Atmospheric Administration. (n.d.). *Climate change impacts*. Retrieved July 8, 2025, from <https://www.noaa.gov/education/resource-collections/climate/climate-change-impacts>

NG Property Management Ltd. (2025, January 7). *Understanding the Official Cash Rate (OCR) and its impact on landlords*. Retrieved July 19, 2025, from <https://ngpm.co.nz/ocr-impact-on-landlords-nz/>

Nguyen, Q., Diaz-Rainey, I., Moore, A., Thorsnes, P., Cox, S., McKenzie, L., & Stirk-Wang, L. (2019). *Risk to residential property values from climate change-related flooding hazards: A mixed-methods approach* [Working paper]. University of Otago. <https://doi.org/10.13140/RG.2.2.33845.01769>

Nguyen, J. (2023, November 22). *Is there a correlation between inflation and home prices?* Investopedia. <https://www.investopedia.com/ask/answers/correlation-inflation-houses.asp>

NielsenIQ (2023). *Perceptions of living in Auckland's city centre: 2022 survey of residents*. Prepared by NielsenIQ for Auckland Council. <https://www.knowledgeauckland.org.nz/media/2552/perceptions-of-living-in-auckland-s-city-centre-2022-survey-of-residents-nielseniq-jan-2023.pdf>

Nunns, P., Hitchins, H., & Owen, P. (2015). *To buy or not to buy? A spatial analysis of house prices and rents in Auckland, 2001–2013* (Auckland Council Technical Report, TR2015/002). Auckland Council. <https://knowledgeauckland.org.nz/media/1311/tr2015-002-to-buy-or-not-to-buy-a-spatial-analysis-of-house-prices-and-rents-in-auckland-2001-2013.pdf>

Organization for Economic Co-operation and Development (OECD). (n.d.). *Housing prices*. OECD Data. Retrieved July 8, 2025, from <https://www.oecd.org/en/data/indicators/housing-prices.html>

Organization for Economic Co-operation and Development (OECD). (n.d.). *Climate risks and disasters*. Retrieved July 8, 2025, from <https://www.oecd.org/en/topics/climate-risks-and-disasters.html>

Oxygen Ltd. (2024, May). *Inflation and rental prices: What you need to know*. Retrieved July 19, 2025, from <https://oxygen.co.nz/news/how-does-inflation-impact-rental-prices/>

Pancak, K. A. (2017). Variation in local house price–rent ratios. *Journal of Housing Research*, 26(1), 79–94.

<https://www.tandfonline.com/doi/abs/10.1080/10835547.2017.12092129>

Parra, M. I., Sanjuán, E. L., Robustillo, M. C., & Pizarro, M. M. (2023). Using R for teaching and research. *arXiv*. <https://doi.org/10.48550/arXiv.2306.12200>

Rathburn, D. (2009, July 16). *Price-to-rent ratio: Determining if it's better to buy or rent*. Investopedia. <https://www.investopedia.com/terms/p/price-to-rent-ratio.asp>

Reserve Bank of New Zealand. (n.d.). *The role of house prices in our mandate*. Retrieved July 19, 2025, from <https://www.rbnz.govt.nz/monetary-policy/about-monetary-policy/the-role-of-house-prices-in-our-mandate>

Rising, J., Tedesco, M., Piontek, F., & Stainforth, D. A. (2022). *The missing risks of climate change*. *Nature*, 610(7933), 643–651. Retrieved from

<https://www.nature.com/articles/s41586-022-05243-6>

Rivas, R., Patil, D., Hristidis, V., Barr, J. R., & Srinivasan, N. (2019). The impact of colleges and hospitals to local real estate markets. *Journal of Big Data*, 6, Article 7.

<https://doi.org/10.1186/s40537-019-0174-7>

Robertson, J., & Miller, T. (2007). *School leadership and equity: the case of New Zealand*. *School Leadership & Management*. Retrieved from ResearchGate:

[https://www.researchgate.net/publication/233562524\\_School\\_leadership\\_and\\_equity\\_The\\_case\\_of\\_New\\_Zealand](https://www.researchgate.net/publication/233562524_School_leadership_and_equity_The_case_of_New_Zealand)

Statistics How To. (n.d.). *KPSS test: Definition and interpretation*. Retrieved August 12, 2025, from <https://www.statisticshowto.com/kpss-test/>

Stats NZ. (2025). *New Zealand index of socioeconomic deprivation: 2023 Census*. Retrieved from <https://www.stats.govt.nz/information-releases/new-zealand-index-of-socioeconomic-deprivation-2023-census/>

Sheldon, T. L., & Zhan, C. (2019). The impact of natural disasters on US home ownership. *Journal of the Association of Environmental and Resource Economists*, 6(6), 1169–1203. <https://doi.org/10.1086/705398>

Taylor, Z., & Aalbers, M. (2022). Climate gentrification: Risk, rent, and restructuring in Greater Miami. *Annals of the American Association of Geographers*, 112(6), 1685–1701. <https://doi.org/10.1080/24694452.2021.2000358>

The New York Times. (2025, July 7). *Texas floods live updates*. <https://www.nytimes.com/live/2025/07/07/us/texas-floods>

The Rent Shop. (2024, February 20). *Which factors influence New Zealand's rent prices?* <https://www.therentshop.co.nz/post/which-factors-influence-new-zealands-rent-prices>

The Rent Shop. (2024, July 10). *Understanding the impact of economic factors on property listings*. Retrieved July 19, 2025, from <https://www.therentshop.co.nz/post/understanding-the-impact-of-economic-factors-on-property-listings>

The Treasury. (2024, July 8). *Residential insurance and climate-related hazards*. The Treasury New Zealand. <https://www.treasury.govt.nz/news-and-events/reviews-consultation/residential-insurance-and-climate-related-hazards>

Thompson, J. J., Wilby, R. L., Hillier, J. K., Connell, R., & Saville, G. R. (2023). Climate gentrification: Valuing perceived climate risks in property prices. *Annals of the American Association of Geographers*, 113(5), 1092–1111. <https://doi.org/10.1080/24694452.2022.2156318>

Thompson, P. (2023, November 29). *Delving into the drivers causing rent and house price rises*. Westpac REDnews. <https://www.westpac.co.nz/rednews/opinion-delving-into-the-drivers-causing-rent-and-house-price-rises/>

Trethewey, V. (2025, March 5). *Insurance and climate change: What you need to know*. AA Directions. <https://www.aa.co.nz/membership/aa-directions/home-living/how-climate-change-impacts-insurance/>

Walsh, P., Griffiths, C., Guignet, D., & Klemick, H. (2015). Adaptation, sea level rise, and property prices in the Chesapeake Bay Watershed. *U.S. Environmental Protection Agency, National Center for Environmental Economics*.  
<https://www.epa.gov/sites/default/files/2016-03/documents/2015-02.pdf>

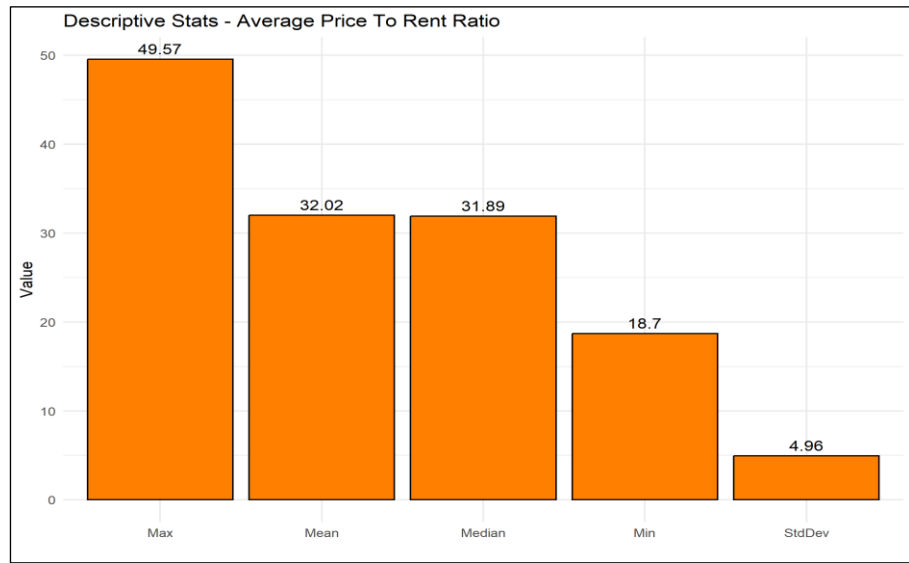
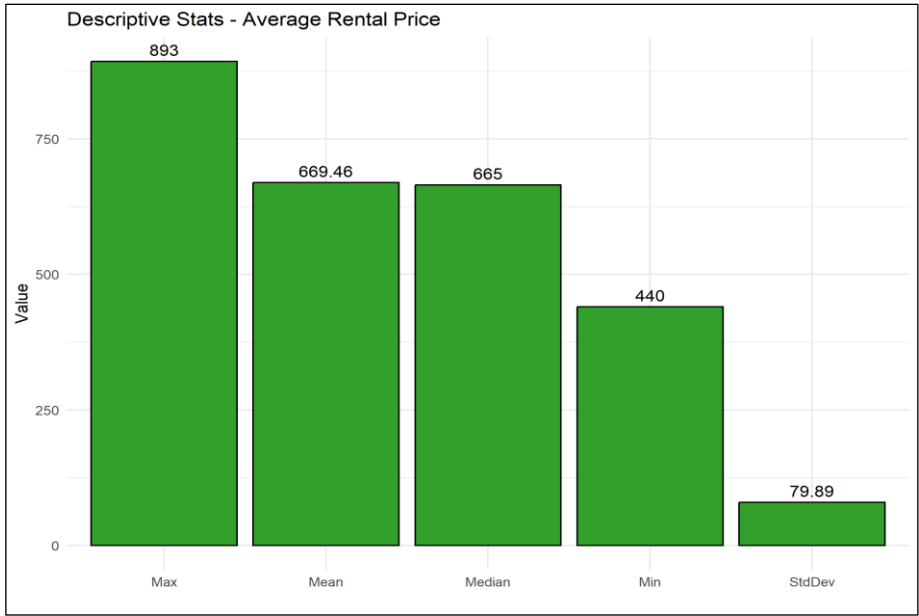
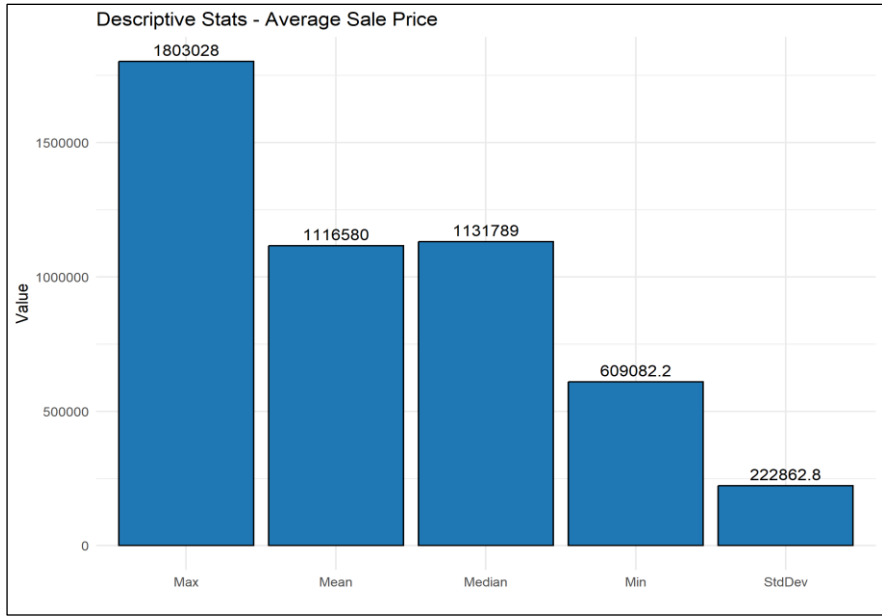
World Wildlife Fund. (n.d.). *Effects of climate change*. Retrieved July 8, 2025, from <https://www.worldwildlife.org/threats/effects-of-climate-change>

## Appendices

**Table 1: Descriptive Statistics**

The findings from the Descriptive Statistics are shown in the table below:

<b>Descriptive Statistics Analysis</b>										
<b>Variable</b>	<b>N</b>	<b>Mean</b>	<b>Std_Dev</b>	<b>Min</b>	<b>Q1</b>	<b>Median</b>	<b>Q3</b>	<b>Max</b>	<b>Skewness</b>	<b>Kurtosis</b>
<b>Natural Hazard Risk</b>	847	0.62	0.49	0	0	1	1	1	-0.49	1.24
<b>School Equity Index EQI</b>	363	422.9	57.29	344	374	407	472	543	0.54	1.97
<b>Socioeconomic Dep. Index</b>	847	5.36	2.63	1	4	5	7	10	0.2	1.99
<b>Distance to CBD (km)</b>	847	18.54	10.37	0	9.66	18.37	27.02	51.21	0.23	2.46
<b>Proximity to Tertiary Ins.</b>	847	0.26	0.44	0	0	0	1	1	1.07	2.14
<b>Official Cash Rate OCR</b>	847	2.62	1.95	0.33	0.33	2.25	5.18	5.25	0.19	1.47
<b>GDP per Capita</b>	847	86,561.43	2,516.35	83,416	83,639	87,916	88,878	89,177	-0.24	1.14
<b>Inflation</b>	847	2.96	1.36	1.7	1.7	2.5	3.9	5.8	1.1	3
<b>Average Sale Price</b>	847	1,116,580	222,862.8	609,082.2	956,816.8	1,131,789	1,240,714	1,803,028	0.12	3.13
<b>Average Rental Price</b>	847	669.46	79.89	440	607	665	728	893	0.23	2.44
<b>Average Price To Rent Ratio</b>	847	32.02	4.96	18.7	28.72	31.89	35	49.57	0.27	3.03
<b>Insurance Premium</b>	847	814.46	660.83	0	0	1350	1350	1350	-0.42	1.18
<b>Days To Sell</b>	847	52.07	9.79	40	40	60	60	60	-0.42	1.18
<b>Repair Cost</b>	847	9,049.59	7,342.51	0	0	15,000	15,000	15,000	-0.42	1.18



**Table 2: Stationarity Assessments via Unit Root Tests**Before first difference:

Variable	N	ADF	PP	KPSS
Average Price to Rent Ratio	847	-7.222*** (0.016)	-5.255*** (0.022)	1.367*** (CV)
Average Sale Price	847	-6.45*** (0.015)	-5.935*** (0.016)	1.059*** (CV)
Average Rental Price	847	-4.691*** (0.01)	-5.42*** (0.009)	5.078*** (CV)
Natural Hazard Risk	847	-28.592*** (0.034)	-21.949*** (0.045)	0.167 (CV)
School Equity Index EQI	363	-13.048*** (0.049)	-8.845*** (0.073)	0.462* (CV)
Socioeconomic Deprivation Index	847	-19.611*** (0.032)	-13.467*** (0.046)	0.1 (CV)
Distance to CBD	847	-9.296*** (0.02)	-11.512*** (0.016)	0.119 (CV)
Proximity to Tertiary Institutes	847	-8.85*** (0.019)	-7.401*** (0.023)	0.186 (CV)
Official Cash Rate OCR	847	-0.992 (0.002)	-0.928 (0.003)	8.942*** (CV)
GDP per Capita	847	-0.807 (0.002)	-1.323 (0.001)	10.363*** (CV)
Inflation	847	-1.899* (0.005)	-1.333 (0.007)	2.761*** (CV)

*Note: CV = Critical Value.*

**Stationarity Table (Yes = Blue, No = Grey)**

Socioeconomic Deprivation Index	Yes	Yes	Yes
School Equity Index EQI	Yes	Yes	Yes
Proximity to Tertiary Institutes	Yes	Yes	Yes
Official Cash Rate OCR	No	No	No
Natural Hazard Risk	Yes	Yes	Yes
Inflation	No	No	No
GDP per Capita	No	No	No
Distance to CBD	Yes	Yes	Yes
Average Sale Price	Yes	Yes	Yes
Average Rental Price	Yes	Yes	Yes
Average Price To Rent Ratio	Yes	Yes	Yes
	ADF	PP	KPSS

*Note: First differencing has been done after this to ensure 100% stationarity.*

**Table 3: Multicollinearity Assessment via Correlation Matrix**

**Pearson Correlation Test**

The findings from the Pearson Correlation test are shown in the table below:

	N	Natural Hazard Risk	School Equity Index EQI	Socio. Dep. Index	Distance to CBD	Prox. to Ter. Ins.	Official Cash Rate OCR	GDP per Capita	Inflation	Avg Sale Price	Avg Rental Price	Avg Price To Rent Ratio
<b>Natural Hazard Risk</b>	847	<b>1</b>	<b>0.288</b>	<b>0.35</b>	<b>0.023</b>	-0.047	0.073	0.075	0.063	<b>-0.237</b>	<b>-0.08</b>	<b>-0.249</b>
<b>School Equity Index EQI</b>	363	<b>0.288</b>	<b>1</b>	<b>0.797</b>	<b>0.189</b>	<b>-0.266</b>	0.011	0.013	0.013	<b>-0.501</b>	<b>-0.5</b>	<b>-0.422</b>
<b>Socio. Dep. Index</b>	847	<b>0.35</b>	<b>0.797</b>	<b>1</b>	<b>0.117</b>	<b>-0.147</b>	0	0	0	<b>-0.439</b>	<b>-0.39</b>	<b>-0.282</b>
<b>Distance to CBD</b>	847	<b>0.023</b>	<b>0.189</b>	<b>0.117</b>	<b>1</b>	<b>-0.651</b>	0	0	0	<b>-0.32</b>	<b>-0.539</b>	0.01
<b>Prox. to Ter. Ins.</b>	847	-0.047	<b>-0.266</b>	<b>-0.147</b>	<b>-0.651</b>	<b>1</b>	0	0	0	<b>0.462</b>	<b>0.621</b>	<b>0.11</b>
<b>Official Cash Rate OCR</b>	847	0.073	0.011	0	0	0	<b>1</b>	<b>0.911</b>	<b>0.509</b>	0.014	<b>0.459</b>	<b>-0.346</b>
<b>GDP per Capita</b>	847	0.075	0.013	0	0	0	<b>0.911</b>	<b>1</b>	<b>0.381</b>	0.066	<b>0.482</b>	<b>-0.289</b>
<b>Inflation</b>	847	0.063	0.013	0	0	0	<b>0.509</b>	<b>0.381</b>	<b>1</b>	<b>0.208</b>	<b>0.208</b>	<b>0.124</b>
<b>Avg Sale Price</b>	847	<b>-0.237</b>	<b>-0.501</b>	<b>-0.439</b>	<b>-0.32</b>	<b>0.462</b>	0.014	0.066	<b>0.208</b>	<b>1</b>	<b>0.665</b>	<b>0.798</b>
<b>Avg Rental Price</b>	847	<b>-0.08</b>	<b>-0.5</b>	<b>-0.39</b>	<b>-0.539</b>	<b>0.621</b>	<b>0.459</b>	<b>0.482</b>	<b>0.208</b>	<b>0.665</b>	<b>1</b>	<b>0.091</b>
<b>Avg Price To Rent Ratio</b>	847	<b>-0.249</b>	<b>-0.422</b>	<b>-0.282</b>	0.01	<b>0.11</b>	<b>-0.346</b>	<b>-0.289</b>	<b>0.124</b>	<b>0.798</b>	<b>0.091</b>	<b>1</b>

*Note: Bolded values indicate correlations significant at the 5% level.*

**Table 4: Univariate and Multivariate Regression Models showing impact on Current Price to Rent Ratio**

Variables	(1) (Univar.)	(1) (N)	(2-1) (Prog. Multivar.)	(2-1) (N)	(2-2) (Prog. Multivar.)	(2-2) (N)	(2-3) (Prog. Multivar.)	(2-3) (N)	(2-4) (Prog. Multivar.)	(2-4) (N)	(2-5) (Prog. Multivar.)	(2-5) (N)	(2-6) (Prog. Multivar.)	(2-6) (N)
<b>Natural Hazard Risk</b>	-2.54*** (0.34)	847	-1.25*** (0.45)	847	-1.00** (0.45)	847	-1.01** (0.45)	847	-0.99** (0.43)	847	-0.94** (0.43)	847	-1.11** (0.43)	847
<b>School Equity Index (EQI)</b>		363	-0.03*** (0.00)	363	-0.016*** (0.00)	363	-0.015** (0.00)	363	-0.009 (0.00)	363	-0.009 (0.00)	363	-0.01* (0.01)	363
<b>Soc. Dep. Index</b>		847		847	-0.35*** (0.13)	847	-0.36*** (0.13)	847	-0.42*** (0.12)	847	-0.42*** (0.12)	847	-0.41*** (0.12)	847
<b>Distance to CBD</b>		847		847		847	-0.03 (0.02)	847	0.05** (0.024)	847	0.05** (0.02)	847	0.05** (0.02)	847
<b>Prox. to Ter. Ins.</b>		847		847		847		847	3.17*** (0.59)	847	3.16*** (0.58)	847	3.15*** (0.58)	847
<b>Official Cash Rate (OCR)</b>		847		847		847		847		847	0.78*** (0.25)	847	0.34 (0.3)	847
<b>GDP per Capita</b>		847		847		847		847		847		847	4.51*** (1.68)	847
<b>Inflation</b>		847		847		847		847		847		847	NA (NA)	847
<b>R<sup>2</sup></b>	0.062		0.196		0.212		0.218		0.276		0.295		0.309	

*Notes:*

- I. Inflation was excluded from the model due to high linear dependency with other variables.*
- II. Values include coefficients, standard errors are in parenthesis, \*\*\*, \*\* and \* refer to 1%, 5% and 10% significance level.*

**Table 5: Univariate and Multivariate Regression Models showing impact on Lagged Price to Rent Ratio**

<b>Variables</b>	(1) (Univar.)	(1) (N)	(2-1) (Prog. Multivar.)	(2-1) (N)	(2-2) (Prog. Multivar.)	(2-2) (N)	(2-3) (Prog. Multivar.)	(2-3) (N)	(2-4) (Prog. Multivar.)	(2-4) (N)	(2-5) (Prog. Multivar.)	(2-5) (N)	(2-6) (Prog. Multivar.)	(2-6) (N)
<b>Natural Hazard Risk_lag</b>	-1.85*** (0.35)	846	-1.32*** (0.42)	846	-1.21*** (0.42)	846	-1.16*** (0.42)	846	-0.90** (0.41)	846	-0.99** (0.41)	846	-0.99* (0.41)	846
<b>School Equity Index (EQI)</b>		362	-0.03*** (0.00)	362	-0.02*** (0.01)	362	-0.02*** (0.01)	362	-0.01 (0.01)	362	-0.01* (0.01)	362	-0.01* (0.01)	362
<b>Soc. Dep. Index</b>		846		846	-0.39*** (0.13)	846	-0.40*** (0.13)	846	-0.47*** (0.12)	846	-0.46*** (0.12)	846	-0.41*** (0.12)	846
<b>Distance to CBD</b>		846		846		846	-0.03 (0.02)	846	0.05** (0.02)	846	0.05** (0.02)	846	0.05** (0.02)	846
<b>Prox. to Ter. Ins.</b>		846		846		846		846	3.09*** (0.59)	846	3.06*** (0.58)	846	3.15*** (0.58)	846
<b>Official Cash Rate (OCR)</b>		846		846		846		846		846	0.30 (0.30)	846	0.34 (0.3)	846
<b>GDP per Capita</b>		846		846		846		846		846		846	8.19*** (1.55)	846
<b>Inflation</b>		846		846		846		846		846		846	NA (NA)	846
<b>R<sup>2</sup></b>	0.033		0.202		0.223		0.229		0.284		0.314		0.309	

*Notes:*

- I. *Inflation was excluded from the model due to high linear dependency with other variables.*
- II. *Values include coefficients, standard errors are in parenthesis, \*\*\*, \*\* and \* refer to 1%, 5% and 10% significance level.*

**Table 6: OLS Regression Table showing the Impact of Current and Lagged Natural Hazard Risks and other variables on - Log-transformed Average Property Sales Price Per Bedroom and Log-transformed Average Rental price Per Bedroom:**

Variables	For Current Natural Hazard Risk (t)		For Lagged Natural Hazard Risk (t-1)			
	N	Value (For Property Sales Price Per Bedroom_log)	Value (For Property Rental Price Per Bedroom_log)	N	Value (For Property Sales Price Per Bedroom_log)	Value (For Property Rental Price Per Bedroom_log)
<b>(Intercept)</b>		21.375*** (4.561)	18.021*** (1.886)		21.039*** (4.547)	17.716*** (1.881)
<b>Natural Hazard Risk</b>	847	-0.008 (0.014)	0.003 (0.006)			
<b>Natural Hazard Risk_lag</b>				846	0.016 (0.014)	0.004 (0.006)
<b>School Equity (EQI)</b>	363	-0.001*** (0.00)	0.00*** (0.00)	362	-0.001*** (0.00)	0.00*** (0.00)
<b>Soc. Dep. Index</b>	847	-0.016*** (0.004)	-0.01*** (0.002)	846	-0.017*** (0.004)	-0.01*** (0.002)
<b>Distance to CBD</b>	847	-0.006*** (0.001)	-0.002*** (0.00)	846	-0.006*** (0.001)	-0.002*** (0.00)
<b>Prox. to Ter. Ins.</b>	847	0.084*** (0.018)	0.102*** (0.008)	846	0.084*** (0.018)	0.102*** (0.008)
<b>OCR</b>	847	0.01 (0.009)	-0.003 (0.004)	846	0.009 (0.009)	-0.004 (0.004)
<b>GDP per Capita</b>	847	-0.091* (0.052)	-0.127*** (0.021)	846	-0.088* (0.051)	-0.123*** (0.021)
<b>Inflation</b>	847	NA (NA)	NA (NA)	846	NA (NA)	NA (NA)
<b>R<sup>2</sup></b>		0.577	0.743		0.578	0.743

*Notes:*

- I. Inflation was excluded from the model due to high linear dependency with other variables.*
- II. Values include coefficients, standard errors are in parenthesis, \*\*\*, \*\* and \* refer to 1%, 5% and 10% significance level.*

**Table 7: Robustness Test**

<b>Variables</b>	(1) (Univar.)	(1) (N)	(2-1) (Prog. Multivar)	(2- 1) (N)	(2-2) (Prog. Multivar)	(2-2) (N)	(2-3) (Prog. Multivar)	(2-3) (N)	(2-4) (Prog. Multivar)	(2-4) (N)	(2-5) (Prog. Multivar)	(2-5) (N)	(2-6) (Prog. Multivar)	(2-6) (N)
<b>(Intercept)</b>	32.81*** (0.27)		43.33*** (1.54)		39.35*** (1.98)		39.36*** (1.97)		34.77*** (2.08)		31.14*** (2.36)		-295.78** (141.04)	
<b>Natural Hazard Risk</b>	-1.3*** (0.35)	847	-0.22 (0.44)	847	0.06 (0.44)	847	0.09 (0.44)	847	-0.04 (0.43)	847	-0.04 (0.42)	847	-0.04 (0.42)	847
<b>School Equity Index EQI</b>		363	-0.03*** (0)	363	-0.02*** (0.01)	363	-0.02*** (0.01)	363	-0.01 (0.01)	363	-0.01* (0.01)	363	-0.01* (0.01)	363
<b>Socioeconomic Deprivation Index</b>		847		847	-0.41*** (0.13)	847	-0.42*** (0.13)	847	-0.48*** (0.12)	847	-0.47*** (0.12)	847	-0.47*** (0.12)	847
<b>Distance to CBD</b>		847		847		847	-0.03 (0.02)	847	0.05** (0.02)	847	0.05** (0.02)	847	0.05** (0.02)	847
<b>Proximity to Tertiary Institutes</b>		847		847		847		847	3.18*** (0.59)	847	3.17*** (0.59)	847	3.17*** (0.58)	847
<b>Official Cash Rate OCR</b>		847		847		847		847		847	0.8*** (0.26)	847	0.43 (0.3)	847
<b>GDP per Capita</b>		847		847		847		847		847		847	3.69** (1.59)	847
<b>Inflation</b>		847		847		847		847		847		847	NA (NA)	847
<b>R<sup>2</sup></b>	0.017		0.179		0.201		0.207		0.266		0.285		0.296	

Notes:

- I. Inflation was excluded from the model due to high linear dependency with other variables.
- II. Values include coefficients, standard errors are in parenthesis, \*\*\*, \*\* and \* refer to 1%, 5% and 10% significance level.

**Table 8: Heterogeneity Analysis**

term	N	Natural Hazard Risk (High vs Low)	Socioeconomic Dep. Index (High vs Low)	Distance to CBD (km) (Near vs Far)	School Equity EQI (High vs Low)
(Intercept)		-313.58** (155.74)	-462.94** (195.63)	-813.4*** (162.24)	-510.97*** (189.79)
		-358.04 (300.89)	-264.43 (193.9)	91.74 (218.05)	-202.74 (202.55)
Natural Hazard Risk	847	NA (NA)	-1.68** (0.71)	-0.96* (0.49)	-1.12* (0.66)
		NA (NA)	-0.98* (0.54)	-1.42** (0.69)	-1.03* (0.57)
School Equity Index EQI	363	-0.01** (0.01)	0.00 (0.01)	-0.02*** (0.01)	0.01 (0.01)
		0.00 (0.01)	-0.02*** (0.01)	0 (0.01)	-0.05*** (0.02)
Socioeconomic Deprivation Index	847	-0.34** (0.13)	-0.48* (0.28)	-0.5*** (0.13)	-0.53*** (0.16)
		-0.52* (0.26)	-0.66*** (0.23)	-0.16 (0.2)	-0.26 (0.19)
Distance to CBD	847	0.04* (0.03)	0.01 (0.04)	0.12*** (0.04)	0.05* (0.03)
		0.07 (0.06)	0.09*** (0.03)	0.09 (0.07)	0.09** (0.04)
Proximity to Tertiary Institutes	847	2.86*** (0.62)	4.82*** (0.92)	NANA (NA)	4.99*** (0.86)
		3.94*** (1.37)	2.81*** (0.75)	3.37*** (0.71)	2.38*** (0.82)

<b>Official Cash Rate OCR</b>	847	0.5	0.42	0.13	0.32
		(0.33)	(0.41)	(0.34)	(0.41)
		0.01	0.28	0.52	0.35
		(0.61)	(0.41)	(0.46)	(0.43)
<b>GDP per Capita</b>	847	-0.70***	-0.65***	-0.78***	6.73***
		(0.065)	(0.10)	(0.11)	(2.07)
		-0.57***	-0.51***	-0.36***	3.04*
		(0.064)	(0.08)	(0.07)	(2.02)

Notes:

1. Values include coefficients, standard errors are in parenthesis, \*\*\*, \*\* and \* refer to 1%, 5% and 10% significance level.

**Table 9: Mechanism Analysis**

<b>term</b>	<b>N</b>	<b>Insurance Premium</b>	<b>Days To Sell</b>	<b>Repair Cost</b>
<b>(Intercept)</b>		51013.94*** (15748.28)	795.76*** (233.31)	566821.55*** (174980.9)
<b>Natural Hazard Risk</b>	847	1065.85*** (47.97)	15.79*** (0.71)	11842.82*** (533.02)
<b>School Equity Index EQI</b>	363	0.61 (0.63)	0.01 (0.01)	6.76 (6.97)
<b>Socioeconomic Deprivation Index</b>	847	15.57 (13.57)	0.23 (0.2)	172.96 (150.83)
<b>Distance to CBD</b>	847	6.55** (2.67)	0.1** (0.04)	72.83** (29.68)
<b>Proximity to Tertiary Institutes</b>	847	116.46* (64.24)	1.73* (0.95)	1293.94* (713.8)
<b>Official Cash Rate OCR</b>	847	84.98** (33.41)	1.26** (0.49)	944.22** (371.19)
<b>GDP per Capita</b>	847	-0.58*** (0.18)	-0.01*** (0)	-6.47*** (1.98)
<b>R<sup>2</sup></b>		0.641	0.641	0.641

**Notes:**

- I. Values include coefficients, standard errors are in parenthesis, \*\*\*, \*\* and \* refer to 1%, 5% and 10% significance level.

**Table 10: Univariate and Multivariate Regression Models showing impact on Current Price to Rent Ratio (with Fixed Effects)**

<b>Variables</b>	(1) (Univar.)	(1) (N)	(2-1) (Prog. Multivar.)	(2-1) (N)	(2-2) (Prog. Multivar.)	(2-2) (N)	(2-3) (Prog. Multivar.)	(2-3) (N)	(2-4) (Prog. Multivar.)	(2-4) (N)	(2-5) (Prog. Multivar.)	(2-5) (N)	(2-6) (Prog. Multivar.)	(2-6) (N)
<b>Natural Hazard Risk</b>	-0.318 (0.297)	847	-0.325 (0.289)	363	-0.199 (0.301)	363	-0.192 (0.300)	363	-0.163 (0.304)	363	-0.163 (0.295)	363	-0.163 (0.290)	363
<b>School Equity Index (EQI)</b>		363	-0.004 (0.003)	363	0.000 (0.004)	363	0.001 (0.004)	363	0.000 (0.004)	363	0.000 (0.004)	363	-0.000 (0.004)	363
<b>Soc. Dep. Index</b>		847		363	-0.140 (0.095)	363	-0.151 (0.095)	363	-0.151 (0.095)	363	-0.145 (0.092)	363	-0.141 (0.091)	363
<b>Distance to CBD</b>		847		363		363	-0.049 (0.034)	363	-0.049 (0.034)	363	-0.049 (0.033)	363	-0.049 (0.032)	363
<b>Prox. to Ter. Ins.</b>		847		363		363		363	-0.402 (0.687)	363	-0.407 (0.667)	363	-0.410 (0.656)	363
<b>Official Cash Rate (OCR)</b>		847		363		363		363		363	0.792*** (0.166)	363	0.425** (0.193)	363
<b>GDP per Capita</b>		847		363		363		363		363		363	3.656*** (1.023)	363
<b>Inflation</b>		847		363		363		363		363		363	NA (NA)	363
<b>R<sup>2</sup></b>	0.346		0.683		0.684		0.686		0.687		0.706		0.716	
<b>Fixed Effects</b>	District		District		District		District		District		District		District	

Notes:

- I. Inflation was excluded from the model due to high linear dependency with other variables.
- II. Values include coefficients, standard errors are in parenthesis, \*\*\*, \*\* and \* refer to 1%, 5% and 10% significance level.

**Table 11: Univariate and Multivariate Regression Models showing impact on Lagged Price to Rent Ratio (with Fixed Effects)**

Variables	(1) (Univar.)	(1) (N)	(2-1) (Prog. Multivar.)	(2-1) (N)	(2-2) (Prog. Multivar.)	(2-2) (N)	(2-3) (Prog. Multivar.)	(2-3) (N)	(2-4) (Prog. Multivar.)	(2-4) (N)	(2-5) (Prog. Multivar.)	(2-5) (N)	(2-6) (Prog. Multivar.)	(2-6) (N)
<b>Natural Hazard Risk_lag</b>	-0.239 (0.320)	847	-0.192 (0.354)	363	-0.037 (0.369)	363	-0.029 (0.368)	363	0.008 (0.374)	363	0.009 (0.346)	363	0.010 (0.327)	363
<b>School Equity Index (EQI)</b>		363	-0.005 (0.004)	363	-0.000 (0.005)	363	0.001 (0.005)	363	0.001 (0.005)	363	-0.000 (0.005)	363	-0.001 (0.005)	363
<b>Soc. Dep. Index</b>		847		363	-0.171 (0.116)	363	-0.184 (0.116)	363	-0.184 (0.117)	363	-0.172 (0.108)	363	-0.165 (0.102)	363
<b>Distance to CBD</b>		847		363		363	-0.054 (0.041)	363	-0.055 (0.041)	363	0.054 (0.038)	363	0.054 (0.036)	363
<b>Prox. to Ter. Ins.</b>		847		363		363		363	-0.525 (0.844)	363	-0.534 (0.782)	363	-0.540 (0.739)	363
<b>Official Cash Rate (OCR)</b>		847		363		363		363		363	1.486*** (0.195)	363	0.725*** (0.217)	363
<b>GDP per Capita</b>		847		363		363		363		363		363	7.580*** (1.152)	363
<b>Inflation</b>		847		363		363		363		363		363	NA (NA)	363
<b>R<sup>2</sup></b>	0.331		0.443		0.446		0.449		0.450		0.529		0.581	
<b>Fixed Effects</b>	District		District		District		District		District		District		District	

*Notes:*

- I. *Inflation was excluded from the model due to high linear dependency with other variables.*
- II. *Values include coefficients, standard errors are in parenthesis, \*\*\*, \*\* and \* refer to 1%, 5% and 10% significance level.*

**Table 12: OLS Regression Table showing the Impact of Current and Lagged Natural Hazard Risks and other variables on - Log-transformed Average Property Sales Price Per Bedroom and Log-transformed Average Rental price Per Bedroom (with Fixed Effects):**

Variables	For Current Natural Hazard Risk (t)		For Lagged Natural Hazard Risk (t-1)			
	N	Value (For Property Sales Price Per Bedroom_log)	Value (For Property Rental Price Per Bedroom_log)	N	Value (For Property Sales Price Per Bedroom_log)	Value (For Property Rental Price Per Bedroom_log)
<b>(Intercept)</b>		21.375*** (4.561)	18.021*** (1.886)		21.039*** (4.547)	17.716*** (1.881)
<b>Natural Hazard Risk</b>	847	-0.004 (0.009)	0.003 (0.002)			
<b>Natural Hazard Risk_lag</b>				846	0.016 (0.014)	0.004 (0.006)
<b>School Equity (EQI)</b>	363	-0.000 (0.000)	-0.000 (0.000)	362	-0.001*** (0.000)	0.000*** (0.000)
<b>Soc. Dep. Index</b>	847	-0.007* (0.003)	-0.003*** (0.000)	846	-0.017*** (0.004)	-0.010*** (0.002)
<b>Distance to CBD</b>	847	-0.002* (0.001)	-0.000* (0.000)	846	-0.006*** (0.001)	-0.002*** (0.000)
<b>Prox. to Ter. Ins.</b>	847	-0.015 (0.019)	-0.005 (0.003)	846	0.084*** (0.018)	0.102*** (0.008)
<b>OCR</b>	847	0.008 (0.006)	-0.004*** (0.001)	846	0.009 (0.009)	-0.004 (0.004)
<b>GDP per Capita</b>	847	-0.103** (0.032)	-0.126*** (0.005)	846	-0.088* (0.051)	-0.123*** (0.021)
<b>Inflation</b>	847	NA (NA)	NA (NA)	846	NA (NA)	NA (NA)
<b>R<sup>2</sup></b>		0.831	0.983		0.578	0.743

*Notes:*

- I. Inflation was excluded from the model due to high linear dependency with other variables.*
- II. Values include coefficients, standard errors are in parenthesis, \*\*\*, \*\* and \* refer to 1%, 5% and 10% significance level.*

**Table 13: Robustness Test (with Fixed Effects):**

Variables	(1) (Univar.)	(1) (N)	(2-1) (Prog. Multivar)	(2- 1) (N)	(2-2) (Prog. Multivar)	(2-2) (N)	(2-3) (Prog. Multivar)	(2-3) (N)	(2-4) (Prog. Multivar)	(2-4) (N)	(2-5) (Prog. Multivar)	(2-5) (N)	(2-6) (Prog. Multivar)	(2-6) (N)
<b>(Intercept)</b>	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Natural Hazard Risk</b>	-0.318 (0.297)	847	-0.325 (0.289)	847	-0.199 (0.301)	847	-0.192 (0.300)	847	-0.163 (0.304)	847	-0.163 (0.295)	847	-0.163 (0.290)	847
<b>School Equity Index EQI</b>		363	-0.004 (0.003)	363	0.000 (0.004)	363	0.001 (0.004)	363	0.000 (0.004)	363	0.000 (0.004)	363	-0.000 (0.004)	363
<b>Socioeconomic Deprivation Index</b>		847		847	-0.140 (0.095)	847	-0.151 (0.095)	847	-0.151 (0.095)	847	-0.145 (0.092)	847	-0.141 (0.091)	847
<b>Distance to CBD</b>		847		847		847	-0.049 (0.034)	847	-0.049 (0.034)	847	-0.049 (0.033)	847	-0.049 (0.032)	847
<b>Proximity to Tertiary Institutes</b>		847		847		847		847	-0.402 (0.687)	847	-0.407 (0.667)	847	-0.410 (0.656)	847
<b>Official Cash Rate OCR</b>		847		847		847		847		847	0.792*** (0.166)	847	0.425** (0.193)	847
<b>GDP per Capita</b>		847		847		847		847		847		847	3.656*** (1.023)	847
<b>Inflation</b>		847		847		847		847		847		847	NA (NA)	847
<b>R<sup>2</sup></b>	0.346	-	0.683	-	0.684	-	0.686	-	0.687	-	0.706	-	0.716	-

Notes:

- I. Inflation was excluded from the model due to high linear dependency with other variables.
- II. Values include coefficients, standard errors are in parenthesis, \*\*\*, \*\* and \* refer to 1%, 5% and 10% significance level.

**Table 14: Heterogeneity Analysis (with Fixed Effects):**

term	N	Natural Hazard Risk (High vs Low)	Socioeconomic Dep. Index (High vs Low)	Distance to CBD (km) (Near vs Far)	School Equity EQI (High vs Low)
(Intercept)		-313.58** (155.74)	-462.94** (195.63)	-813.4*** (162.24)	-510.97*** (189.79)
		-358.04 (300.89)	-264.43 (193.90)	91.74 (218.05)	-202.74 (202.55)
Natural Hazard Risk	847	NA (NA)	-1.68** (0.71)	-0.96* (0.49)	-1.12* (0.66)
		NA (NA)	-0.98* (0.54)	-1.42** (0.69)	-1.03* (0.57)
School Equity Index EQI	363	-0.01** (0.01)	0.00 (0.01)	-0.02*** (0.01)	0.02 (0.01)
		0.00 (0.01)	-0.02*** (0.01)	0 (0.01)	-0.05*** (0.02)
Socioeconomic Deprivation Index	847	-0.34** (0.13)	-0.48* (0.28)	-0.50*** (0.13)	-0.53*** (0.16)
		-0.52* (0.26)	-0.66*** (0.23)	-0.16 (0.20)	-0.26 (0.19)
Distance to CBD	847	0.04* (0.03)	0.02 (0.04)	0.12*** (0.04)	0.05* (0.03)
		0.07 (0.06)	0.09*** (0.03)	0.09 (0.07)	0.09** (0.04)
Proximity to Tertiary Institutes	847	2.86*** (0.62)	4.82*** (0.92)	NA (NA)	3.37*** (0.71)
		3.94*** (1.37)	2.81*** (0.75)	NA (NA)	4.99*** (0.86)

<b>Official Cash Rate OCR</b>	847	0.5	0.42	0.13	0.32
		(0.33)	(0.41)	(0.34)	(0.41)
		0.01	0.28	0.52	0.35
		(0.61)	(0.41)	(0.46)	(0.43)
<b>GDP per Capita</b>	847	-0.70***	-0.65***	-0.78***	6.73***
		(0.065)	(0.10)	(0.11)	(2.07)
		-0.57***	-0.51***	-0.36***	3.04*
		(0.064)	(0.08)	(0.07)	(2.02)

*Notes:*

- 1. Values include coefficients, standard errors are in parenthesis, \*\*\*, \*\* and \* refer to 1%, 5% and 10% significance level.*

**Table 15: Mechanism Analysis (with Fixed Effects):**

term	N	Insurance Premium	Days To Sell	Repair Cost
(Intercept)		1051.51*** (49.33)	15.58*** (0.73)	11683.5*** (548.13)
Natural Hazard Risk	363	1065.85*** (47.97)	15.79*** (0.71)	11842.82*** (533.02)
School Equity Index EQI	363	28.14* (14.9)	0.42* (0.22)	13.37 (58.49)
Socioeconomic Deprivation Index	363	1.2 (5.26)	0.02 (0.08)	2137.66* (1191.58)
Distance to CBD	363	192.39* (107.24)	2.85* (1.59)	72.83** (29.68)
Proximity to Tertiary Institutes	363	83.99*** (31.92)	1.24*** (0.47)	933.23*** (354.7)
Official Cash Rate OCR	363	-0.57*** (0.17)	-0.01*** (0)	-6.37*** (1.89)
GDP per Capita	363	NA (NA)	NA (NA)	NA (NA)
R <sup>2</sup>		0.641	0.641	0.641

Notes:

1. Values include coefficients, standard errors are in parenthesis, \*\*\*, \*\* and \* refer to 1%, 5% and 10% significance level.