Climate Change Risk Premium for Residential Coastal Real Estate

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Abstract

Problem/Purpose: The changing climate and specifically the rising sea level presents a risk to the future benefits of residential coastal real estate. The purpose of this paper is to propose a model property valuers can employ to derive a risk premium for properties at-risk of being permanently inundated due to the rising sea level.

Design/methodology/approach: A mixed methods approach employing a two stage sequential exploratory design was applied to investigate property valuer's lived experience regarding the changing climate and the rising sea level.

Findings: The findings indicate that property valuers pay no attention to the risk posed by the rising sea level and this can have far-reaching consequences for the coastal real estate market and the economies of coastal towns in South Africa.

Research limitations/implications: The research is restricted to residential coastal real estate on the Southern Cape Coast of South Africa. The proposed model reflects the researchers attempt to determine a risk premium and could be subject to a different interpretation by another researcher. As the first study of its nature on the risk posed by rising sea levels on property market values, the research lacks external validity. Further research may be required validate the findings.

Takeaway for practice: The model provides property valuers with an uncomplicated approach to identify at-risk residential coastal real estate and an objective methodology to derive a premium based on the risk of rising sea levels.

Originality/value: This research was the first to explore the effect of the rising sea level on the market value of residential coastal real estate in South Africa. It is also the first to provide property valuers with a model they can apply to quantify the rising sea level risk for a specific at-risk property.

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Introduction

Global warming and climate change is a reality with 2016 globally the warmest year yet recorded since 1880 (NASA, 2017, p. 1). According to (NASA, 2017) the sea level has globally risen with 88,2mm since 1993. It is therefore important that property valuers consider the rising sea level risk and uncertainty when they develop opinions of value for coastal residential real estate.

The market value of real estate is affected by present-day and future uncertainties (Adair and Hutchison, 2005). While French (2007) advocates that uncertainties are present when property valuers develop an opinion of value. Adair and Hutchison (2005, p. 254) further argues that '… risk and uncertainty is inherent in the valuation process.'

Uncertainty is defined by Byrne (2002, p. 8) as '… anything that is not known about the outcome of a venture at the time when the decision is made.' and risk as '… the measurement of a loss identified as a possible outcome of the decision'.

While Al-Marwani (2014) postulate that risk is an element present in any investment in real estate. This is similar to Wight and Ghyoot's (2005, p. 137) argument that since the real estate environment change over time it result in '*environmental (location) risk*'. They further suggest that due to environmental risk's connection to a specific location it is unmanageable and can have a substantial impact on an investment in real estate (Wight & Ghyoot, 2005). Frew and Wilson (2002, p. 1) also emphasised the importance of location when they maintains that '*Location has always been an important determinant of a property's value*.' The value of real estate is thus influenced by the immobility of its location according to (Zabel, 2004). The risk in real estate investments can be reduced if prime locations are chosen Nitsch (2006)

The effect of the changing climate and the rising sea level was researched in a study conducted in Sedgefield, South Africa. Sedgefield was identified as one of the area's most vulnerable to the changing climate and rising sea level along the South African coastline (Hughes, 1992). A mixed methods study was conducted in which property valuer's knowledge, behaviour and attitudes were explored. The results of the research culminated in the development of the model presented in this paper.

Literature review

The assessment of risk and uncertainty has long been at the centre of the debate regarding investment in real estate according to Lorenz, Trück and Lützkendorf (2006), Adair and Hutchison (2005), French and Gabrielli (2004) and Mallison and French (2000). D'Alpaos and Canesi (2014) have highlighted the lack of a specific methodology to assess risk in real estate investment. They ascribe this to the difference in risk assessment between financial investments and investment in real estate (D'Alpaos & Canesi, 2014).

According to Koubkov (2015), there are many uncertainties in real estate investments. Sea-level rise risk is one such new uncertainty and risk, which has not yet been addressed in property valuation literature.

In the current literature, researchers rely on historic data to predict what will happen in a specific real estate market in the near future. The emerging nature of climate change and the promulgation of the National Environmental Management: Integrated Coastal Management Act (ICM Act) to adapt to and mitigate for the rising sea level, raised the question to what extent and how well established valuation processes and procedures will be affected by the changing climate and rising sea levels.

In the model presented below the researcher, demonstrate how property valuers may address the uncertainty and risk created by the rising sea level. The model consists of two sections. In the first section, the elements, which affect at-risk real estate, will be identified and a qualitative rating scale proposed. The second section of the model will introduce a sea-level rise risk equation that property valuers can apply when they conduct valuations of residential coastal real estate.

The problem property valuers are faced with is that the rising sea level will diminish the future benefits of at-risk residential coastal real estate to zero. Domain, Wolf and Yang (2015) postulate that residential real estate is in general the most frequently possessed asset. While Du Preez, Balcilar, Razak, Koch and Gupta (2016) argues that 29,4% of South Africans assets are located in residential real estate. According to the Appraisal Institute a decision to invest in real estate is based on the principal of anticipation "*... value is created by the anticipation of benefits to be derived in the future."* (Appraisal Institute, 2014, p. 27). Brown and Klingenberg (2015) argues that investors are motivated by the anticipation of a future return that is higher than the current value, when they invest in real estate. Although it is not yet visible in the market, the rising sea level and the promulgation of the Integrated Coastal Management Act affect the future expectations for at-risk properties in the residential coastal real estate market in South Africa.

The ICM Act was promulgated in 2008 and amended in 2014, it has not been implemented yet and it may be one of the reasons why coastal real estate market has not responded to the sea-level rise risk (South Africa, 2014).

The ICM Act requires that a coastal protection zone must be implemented along the entire South African coastline. The coastal protection zone reaches 100m inland from the high-water mark in urban areas and a 1 000m inland in rural areas. The coastal protection zone further includes all land that will be inundated during a 1/50 year flood, caused by a storm event (South Africa, 2009). The height above mean sea level and the distance of a property from the high-water mark will consequently have an influence on the risk such property is exposed to.

None of the property valuers with whom interviews were conducted indicated that they consider the impact the rising sea level or the implementation of the ICM Act when they develop an opinion of value. Fitchett, Grant and Hoogendoorn (2016) found a similar attitude in a study they conducted in two small towns on the Eastern Cape coast of South Africa.

The examination of the sales data in Sedgefield did not provide any indication that purchasers and sellers of residential real estate in the study area, Sedgefield are concerned about the implications of the rising sea level or the promulgation of the ICM Act.

The slow onset nature of the rising sea level will have to be taken into account when property valuers develop an opinion of value for residential coastal real estate. This raises the question of how property valuers should deal with rising sea-level risk.

Influences of rising sea-level risk

Residential coastal real estate's exposure to the rising sea level will be affected by a properties height above mean sea level, the distance from the high-water mark and time.

The three influences height above sea level, distance from the high-water mark and time will be incorporated in the rising sea-level risk model considered below. These influences are normally not explicitly considered in the valuation process.

Height above sea level. The impact of flood plain location on value is well researched, Bélanger and Bourdeau-Brien (2016), Lamond, Proverbs and Hammond (2009) and Hallstrom and Smith (2005) among others.

The influence of the height above sea level by itself on value has not been researched. The height above sea level is of special importance to this study area as it is on average not more than 5m above mean sea level and partly surrounded by the Swartvlei estuary.

The probability that properties, which are situated closer to mean sea level, will be permanently inundated is greater than those, which are situated higher up. The height above mean sea level will therefore be one of the elements of the rising sea level, which can have a negative impact on property values and should be taken into account by property investors.

Distance from the high-water mark. A number of researchers examined the influence of the distance from the water to a water view, Jim and Chen (2009), Bin, Crawford, Kruse and Landry (2008), Samarasinghe and Sharp (2008), Bourassa, Hoesli and Sun (2005) and Benson, Hansen, Schwartz and Smersh (1998) amongst other.

The ICM Act do not allow any development within a 100m from the high-water mark indicate that properties situated closer to the high-water mark. Properties situated close to the water and just above the current mean sea level will have a higher risk while those more than five metre, above mean sea level, and further than 100 metres from the high - water mark will have a smaller risk of being inundated. Height above mean sea level and the distance from the high-water mark should therefore be included in any risk equation.

Time. The slow rate at which the sea level is rising should also be taken into account. Umvoto Africa (2010c) estimated a sea level rise of 0.75 m by 2050 and one metre by 2100 along the southern Cape coast. Umvoto Africa's estimates is based on the IPCC's sea level rise predictions for the 21st century, i.e. until 2100 (IPCC, 2013). The IPCC (2013), Lorbacher, Marsland, Church, Griffies and Stammer (2012) and (Rahmstrof, 2007) established that the sea level is rising at approximately 3,2mm per annum.

Church, et al. (2013) argues that higher sea levels will increase the intensity and frequency of storm surges. They postulate that the return period for storm surges will also become quicker (Church, et al., 2013).

The years 2050 and 2100 may seem far of however, if the average period of a bond, 20 to 30 years is taken into account 2050 is just 35 years ahead. Property valuers should therefore be attentive to the affect time will have on the remaining useful life of an at-risk property.

It is suggested that the probability of a 1/100 year flood be used, that is a 1% probability that a property may be flooded in any given year, to determine the influence of time.

At-risk value model

The aim of the model is to quantify the at-risk value of residential coastal real estate that are exposed to the rising sea level risk. The model is based on the valuation framework Jackson (2003) proposed for the valuation of environmental contaminated properties.

According to the Appraisal Institute (2014) there are three influences that affects the value of contaminated property namely, cost, use and risk influences. These influences are included in the following formula:

"Impaired value = Unimpaired value – cost effect – use effect – risk effect" (Jackson 2003, p. 314).

Jackson (2003) postulate that the unimpaired value is typically estimated by means of one of the traditional approaches, comparable sales, income capitalization or cost. However, he argues that in the case of an environmental contaminated property, the traditional approaches cannot be applied and an alternative approach must be followed due to limited data and other restraining factors (Jackson, 2003). Jackson (2003) maintains that the approach must still be grounded in appropriate market data.

When the influence of the rising sea level is considered, it is the lack of appropriate market data, which produce the problem for property valuers. The environmental risk imagined by the rising sea level is based on the predictions by natural scientists and the requirements of the ICM Act.

With reference to Jacksons' (2003) argument above the researcher, present the following risk model:

At-risk value (ARV) = market value (MV) – suggested risk premium

At-risk Value = market value (MV) – suggested risk premium at date of valuation, represented by f (MV, X_1, X_2, X_3) = MV x (X_1 + X_2 + X_3) / 3

X_1 = height above mean sea level, X_2 = distance from the high-water mark and X_3 = Time (or the rate of sea level rise).

A linear function was used as it is in line with the predictions made regarding the changing climate and the rising sea level are based on the results of linear models (Knutti & Rugenstein, 2015 and Vermeer & Rahmstrof, 2009).

The purpose of the model is to determine the at-risk value of a residential coastal property. To accomplish this the property valuer will commence by determining the market value of the subject property according to the market approach as defined by the IVS. The market approach "*... provides an indication of value by comparing the subject asset with identical or similar assets for which price information is available"* IVSC (2013, p. 5).

A property valuer will apply the comparable sales approach using appropriate market data of similar properties, to develop an opinion of value for the at-risk subject property without the rising sea-level risk. This is in agreement with the current practice of the property valuers in the study area. The next step would be to quantify the risk and deduct it from the market value.

A risk factor for each of the three predicted influences, which constitute rising sea-level risk namely, the height above sea level, the distance to the high-water mark and time, will be applied in the equation. The arithmetic mean of the influences will be determined and used as the risk premium.

The tables below provide a reference, which property valuers can use to obtain a risk factor to apply in the equation. Table 1 indicate the probability of the subject property being flooded in relationship with its height above mean sea level.

TABLE 1: Probability of inundation risk

Height above mean sea level	1/50-years		1/100-years	
	Percentage	Risk factor	Percentage	Risk factor
0m	100	1	100	1
1m	80	0.80	99	0.99

2m	60	0.60	98	0.98
3m	40	0.40	97	0.97
4m	20	0.20	96	0.96
5m	1	0.01	95	0.95
6m			94	0.94
7m			93	0.93
8m			92	0.92
9m			91	0.91
10m			90	0.90
Source: Researcher's calculations				

Height above sea level. Table 1 provide the percentage as well as the risk factor, which should be used in the model. The 1/50 and 1/100 year flood lines indicate the probability that a specific property will be flooded once in 50 or once in a 100 years. The flood lines are closely linked with the height above mean sea level in that the 1/50 year flood line is represented by the five meter above mean sea level contour. The 1/100 year flood line is represented by the 10 meter above mean sea level contour. The table indicate that an at-risk property located one metre above mean sea level has an eighty present probability of being flooded within the next 50 years. While the same property has a 99% probability of being flooded in the next 100 years. The probabilities are also expressed as risk factors that will be applied in the proposed model. The broad parameters, 1/50 and 1/100 years, afford a property valuer flexibility to decide on the level of risk he/she assume once they have familiarised themselves with the physical situation regarding the subject property.

It is anticipated that property valuers will initially tend to be conservative in their estimation of the risk and apply the risk factors for a 1/100 year flood. However, as the effect of the rising sea level become more visible they may revert to the less conservative 1/50 year flood risk.

Distance to high-water mark. Either a one or a zero indicates the distance to the high-water mark. If a subject property is within a 100m or less from the high-water mark, a one is awarded and if it is further than 100m a zero is awarded in the proposed model.

Time. The IPCC predicts that the sea level is rising at approximately 3,2mm per annum while Umvoto Africa (2010c) considered a sea level rise of 0.75 m by 2050 and two metre by 2100.

According to the IVSC (2017, p. 82), property valuers are responsible to identify any "… *actual or potential environmental risks* …" during their investigation in the valuation process. It is argued that property valuers should not only identify the risk but also pay attention to the affect time will have on the remaining useful life of an at-risk property.

If the principles underlying the 1/100 year flood line is applied, there is a 1% probability that an at-risk property may be flooded once in 100 years. Every year the at-risk property is not flooded increase the probability of being flooded with 1%. This suggest that the risk of being flooded increase over time. Although it is at present a very small risk, the risk will increase over time. As the risk increases, the future benefits that can be derived from the at-risk property will diminish. Table 2 at the back provide the risk factors in a linear format until 2100 and expected 100% inundation of an at-risk property.

The risk factors indicated in Table 2 assume that an at-risk property will be permanently inundated due to the rising sea level by 2100. The risk factor is further based on the premise that the likelihood of inundation increases as time goes by.

The problem created by the rising sea-level risk is that there is currently no relevant market data property valuers can count on to inform their opinion of value. The repeat sales data collected and analysed in the study area indicated that flooding events did not have a negative impact on property prices. The trend indicated a positive increase in property prices.

The suggested at-risk value model utilizes data, other than market data, namely the height above mean sea level, distance to the high-water mark and time, to quantify the rising sea level risk. The model provide property valuers with an objective framework to determine a risk premium for residential coastal properties that are at risk of being inundated.

Valuation framework for rising sea-level risk

The aim of the at-risk value model is to provide property valuers with a framework they can use to bring the three risk factors together into one risk premium. Property valuers who work along the southern Cape coast indicated that they do not consider climate change and the rising sea level risk because they have nothing to compare with or anchor it. The three potential risk factors, height above sea level, distance to the high-water mark and time, provide them with a framework within which they can operate, when they develop on opinion of value of at-risk properties

The first step in the framework would be to develop and opinion of the market value of the subject property (an at-risk property) on the date of valuation based on relevant market data. The appropriate approach is the sales comparison approach. During the investigation, the property valuers should identify actual or potential environmental risks by consulting Table 3. The average risk as indicated in Table 3 provide an indication of the level of the average risk, very low, low, moderate, high or very high and also provide secondary information the property valuer can use as a starting point to make a decision regarding the level of risk. The average risk is derived from sea level rise induced erosion and inundation, ground water contamination and extreme events (Umvoto Africa, 2010c).

As soon as the property valuer has established that the subject property is at-risk, they can apply the proposed at-risk value model to measure the impact of the rising sea-level risk on the subject property.

Risk factors for the height above sea level and time can be acquired from Tables 1 and 2 respectively. While the risk factor for distance from the high-water mark is either one or zero, one if it is 100 metre or less from the high-water mark and zero if it is further than 100 metre from the high-water mark.

The model will typically be applied in the following settings:

Setting one: A property valuer establish that the market value of the subject property is R1 000 000,00 according to the market approach. During his or her investigation the property valuer, find that the subject property is at-risk of being inundated in future and the risk is high, as per the average risk indicated in Table 3. The property valuer also confirm that the subject property is situated one meter above sea level and within 100 meters from the high water mark. The property valuer are of the opinion that the subject property will be inundated by 2100. The property valuer apply the model with the information provided above:

At-risk value (ARV) = MV – risk premium

The suggested risk premium f (MV, X_1, X_2, X_3) = MV x (X_1 + X_2 + X_3)/ 3

For example if the market value is R1 000 000.00 – MV x (1m + 100m + 2017) / 3

= R1 000 000.00 - 1 000 000.00 x (0.80 + 1 + 0.18) / 3

= R1 000 000.00 - 1 000 000.00 x (1.98/3)

= R1 000 000.00 – 1 000 000.00 x 0.66

= R1 000 000.00 – R660 000.00

= R340 000.00

The at-risk value of the subject property is thus R340 000.00 at the date of valuation.

Setting two: A property valuer establish that the market value of the subject property is R1 000 000,00 according to the market approach. During his or her investigation the property valuer, find that there is a moderate risk that the subject property will be inundated in future, as per the average risk indicated in Table 3. The property valuer also confirm that the subject property is situated two metre above sea level and 300 metre from the high water mark. The property valuer are of the opinion that the subject property will be inundated by 2100. The property valuer apply the model with the information provided above:

At-risk value (ARV) = MV – risk premium

The suggested risk premium f (MV, X_1, X_2, X_3) = MV x (X_1 + X_2 + X_3) / 3

For example if the market value is R1 000 000.00 – MV x (2m + 300m + 2017) / 3

= R1 000 000.00 - 1 000 000.00 x (0.60 + 0 + 0. 18) / 3

= R1 000 000.00 - 1 000 000.00 x (0.78/3)

= R1 000 000.00 – 1 000 000.00 x 0. 26

= R1 000 000.00 – R313 333.33

= R740 000.00

The at-risk value of the subject property is thus R740 000.00 at the date of valuation.

Conclusion

Risk and uncertainty was discussed and the property valuer's predicament concerning sea level rise risk and uncertainty in the valuation process highlighted. The use of different models to quantify both positive and negative environmental influences on property was examined and the use of such models to quantify sea-level rise risk argued. The assessment of risk and uncertainty and the lack of a specific methodology to assess sea level rise risk in real estate was emphasised. The use of Umvoto Africa's (2010c) risk rating in 'Table 3: Summary of coastal zone management unit hazard risk scores, highest to lowest risk' was recommended to property valuers as a point of reference to identify at-risk real estate along the southern Cape coast.

The findings indicate that property valuers pay no attention to the risk posed by the rising sea level and this can have far-reaching consequences for the coastal real estate market and the economies of coastal towns in South Africa. The research is restricted to residential coastal real estate on the Southern Cape Coast of South Africa. The proposed model reflects the researchers attempt to determine a risk premium and could be subject to a different interpretation by another researcher. As the first study of this nature on the risk posed by rising sea levels on property market values, the research lacks external validity. Further research may be required validate the application of the model. The proposed model provides property valuers with an uncomplicated approach to identify at-risk residential coastal real estate and an objective methodology to derive a premium based on the risk of rising sea levels. This research was the first to explore the effect of the rising sea level on the market value of residential coastal real estate in South Africa. It is also the first to propose a model property valuers can apply to quantify the rising sea level risk for a specific at-risk property.

The proposed model is an attempt to enable property valuers to quantify sea-level rise risk and include a considered risk premium in their valuation reports. Property valuers who apply the model will be able to include a risk premium arrived at, with a degree of clarity and certainty and avoid any bias.

The proposed model may also provide purchasers, sellers, financial institutions and local authorities in the coastal real estate market with a transparent model to enable them to determine an unbiased sea-level rise risk premium for individual properties. However, the proposed model should by no means be seen as definitive but rather as the beginning of a debate, in the property valuation fraternity, regarding the impact of the rising sea level on the future benefits of residential coastal real estate.

TABLE 2: Risk factor years remaining

Current year	Year value zero	Years remaining until 2100	Risk factor
2000	2100	100	0.01
2001	2100	99	0.02
2002	2100	98	0.03
2003	2100	97	0.04
2004	2100	96	0.05
2005	2100	95	0.06
2006	2100	94	0.07
2007	2100	93	0.08
2008	2100	92	0.09
2009	2100	91	0.10
2010	2100	90	0.11
2011	2100	89	0.12
2012	2100	88	0.13
2013	2100	87	0.14
2014	2100	86	0.15
2015	2100	85	0.16
2016	2100	84	0.17
2017	2100	83	0.18
2018	2100	82	0.19
2019	2100	81	0.20
2020	2100	80	0.21
2021	2100	79	0.22
2022	2100	78	0.23
2023	2100	77	0.24
2024	2100	76	0.25
2025	2100	75	0.26
2026	2100	74	0.27
2027	2100	73	0.28
2028	2100	72	0.29

2029	2100	71	0.30
2030	2100	70	0.31
2031	2100	69	0.32
2032	2100	68	0.33
2033	2100	67	0.34
2034	2100	66	0.35
2035	2100	65	0.36
2036	2100	64	0.37
2037	2100	63	0.38
2038	2100	62	0.39
2039	2100	61	0.40
2040	2100	60	0.41
2041	2100	59	0.42
2042	2100	58	0.43
2043	2100	57	0.44
2044	2100	56	0.45
2045	2100	55	0.46
2046	2100	54	0.47
2047	2100	53	0.48
2048	2100	52	0.49
2049	2100	51	0.50
2050	2100	50	0.51
2051	2100	49	0.52
2052	2100	48	0.53
2053	2100	47	0.54
2054	2100	46	0.55
2055	2100	45	0.56
2056	2100	44	0.57
2057	2100	43	0.58
2058	2100	42	0.59
2059	2100	41	0.60
2060	2100	40	0.61
2061	2100	39	0.62
2062	2100	38	0.63
2063	2100	37	0.64
2064	2100	36	0.65
2065	2100	35	0.66
2066	2100	34	0.67
2067	2100	33	0.68
2068	2100	32	0.69
2069	2100	31	0.70
2070	2100	30	0.71
2071	2100	29	0.72
2072	2100	28	0.73
2073	2100	27	0.74
2074	2100	26	0.75

2075	2100	25	0.76
2076	2100	24	0.77
2077	2100	23	0.78
2078	2100	22	0.79
2079	2100	21	0.80
2080	2100	20	0.81
2081	2100	19	0.82
2082	2100	18	0.83
2083	2100	17	0.84
2084	2100	16	0.85
2085	2100	15	0.86
2086	2100	14	0.87
2087	2100	13	0.88
2088	2100	12	0.89
2090	2100	10	0.90
2091	2100	9	0.91
2092	2100	8	0.92
2093	2100	7	0.93
2094	2100	6	0.94
2095	2100	5	0.95
2096	2100	4	0.96
2097	2100	3	0.97
2098	2100	2	0.98
2099	2100	1	0.99
2100	2100	0	1.00

Source: Researcher's calculations

Table 3: Summary of coastal zone management unit hazard risk scores, highest to lowest risk

CZMU Code	CZMU Name	SLR Induced Erosion and Inundation	Groundwater Contamination	Extreme Events	Average Risk
K1	Sedgefield-Swartvlei	6.4	9.5	9.5	8.5
G5	Wilderness East	8.3	6.5	9.2	8.0
G4	Wilderness West	8.3	6.5	9.2	8.0
K6	Knysna	6.7	7.5	9.5	7.9
B2	Plettenberg Bay	5.8	6.7	9.6	7.4
M5	Hartenbos	5.8	5.7	9.6	7.1
B3	Keurbooms-Bitou	5.8	5.7	9.6	7.1
B6	Nature's Valley	5.7	4.8	9.6	6.7
M6	Klein-Brakrivier	5.8	5.0	8.6	6.5
M7	Groot-Brakrivier	5.8	5.0	8.6	6.5
K3	Walker's Bay	4.8	4.8	9.6	6.4
M4	Mossel Bay	5.0	4.8	8.6	6.1
B4	Keurboomsstrand	4.3	4.3	6.7	5.1
M8	Outeniquastrand	5.0	3.6	6.7	5.1
H4	Stilbaai	3.3	5.2	6.7	5.1
K2	Goukamma	3.6	5.7	5.0	4.8
M2	Vleesbaai	4.2	4.2	5.7	4.7
G6	Kleinkrantz	4.3	3.6	5.8	4.6
K4	Buffelsbaai	3.6	4.3	5.0	4.3
G1	Herolds Bay	2.9	3.6	5.8	4.1
G3	Victoria Bay	2.9	3.6	5.8	4.1
H1	Witsand	3.3	2.8	5.8	4.0
M1	Visbaai	2.9	4.2	3.8	3.6
G2	George	2.4	5.0	3.0	3.5
K7	Noetzie	2.4	3.6	4.2	3.4
M3	Pinnacle Point	2.9	3.6	3.6	3.3
B5	De Vasselot	2.9	3.6	3.6	3.3
B7	Bloukrans	2.9	3.6	3.6	3.3
H6	Gouritsmond	2.6	3.6	3.3	3.2
H5	Ystervark	1.9	5.2	2.2	3.1
H3	Jongensfontein	2.2	3.3	3.3	3.0
B1	Sinclair-Robberg	2.4	3.0	3.0	2.8
G7	Gerickes Point	2.4	2.4	3.3	2.7
H2	Duiwenhoks	1.9	2.8	3.2	2.6
K5	Brenton-On-Sea	1.9	3.0	2.4	2.4
M9	Maalgate	1.9	2.4	2.4	2.2

Source: *Umvoto Africa, 2010:17*

References

Adair, A., & Hutchison, N. (2005). The reporting of risk in real estate appraisal property risk scoring. *Journal of Property Investment & Finance, 23*(3), 254-268.

Al-Marwani, H. (2014). *An approach to Modeling and Forecasting Real Estate Residential Property Market (Unpublished thesis).* Brunel University.

Bélanger, P., & Bourdeau-Brien, M. (2016). The impact of flood risk on the price of residential properties: The case of England. Regensburg, Bavaria/Germany: European Real Estate Society.

Benson, E. H. (1998). Pricing residential amenities: The value of a view. *Journal of Real Estate Finance & Economics*, 55-73.

Bin, O., Crawford, T., Kruse, J., & Landry, C. (2008). Viewscapes and flood hazards: Coastal housing market response to amenities and risk. *Land Economics, 84*(3), 434-448.

Bourassa, S., Hoesli, M., & Sun, J. (2005). The price of aesthetic externalities. *Journal of Real Estate Literature* , 167-187.

Brown, R., & Klingenberg, B. (2015). Real estate risk: heavy tail modeling using Excel. *Journal of Property Investment & Finance*, 393-407.

Byrne, P. (2002). *Risk, Uncertainty and Decision making in property Development.* London.

Church, J., Clark, P., Cazenave, A., Gregory, J., Jevrejeva, S., Levermann, A., . . . Unnikrishna, A. (2013). *Sea Level Change. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

D'Alpaos, C., & Canesi, R. (2014). Risks Assessment in Real Estate Investments in Times of Global Crisis. *WSEAS TRANSACTIONS on BUSINESS and ECONOMICS*, 369-379.

Du Preez, M., Balcilar, M., Razak, A., Koch, S., & Gupta, R. (2016). House values and proximity ro a landfill in South Africa. *Journal of Real Estate Literature*, 133-150.

Fitchett, J., Grant, B., & Hoogendoorn, G. (2016). Climate change threats to two low-lying South african coastal towns. *South African Journal of Science*, 1-9.

French, N. (2007). Valuation uncertainty: Common professional standards and methods. Fremantle, Western Australia: 13th Pacific-Rim Real Estate Society Conference.

French, N. G. (2004). The uncertainty of valuation. *Journal of Property Investment & Finance*, 484-500.

French, N., & Gabrielli, L. (1994). *Discounting cash flow: Accounting for uncertainty.* London: RICS.

Frew, J., & Wilson, B. (2002). Estimating the Connection between Location and Property Value. *Journal of Real Estate Practice and Education*, 17-25.

Hallstrom, D., & Smith, K. (2005). Market responses to hurricanes. *Journal of Environmental Economics and Management*(50), 541-561.

Hughes, P. (1992). *The Impacts of Sea Level Rise on The South African Coastal Environment* (Unpublished PhD Thesis ed.). Cape Town: University of Cape Town.

IPCC. (2013). Sea Level Change. In T. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. Allen, J. Boschung, . . . P. Midgley (Eds.), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1137-1216).

Cambridge, United Kingdom and New York, NY, USA.: Cambridge University Press.

IVSC. (2017). *International Valuation Standards.* London: International Valuation Standards Council.

Jackson, T. (2003). Methods and Techniques for Contaminated Property Valuation. *The Appraisal Journal*, 311-320.

Jim, C., & Chen, W. (2009). Value of scenic views: Hedonic assessment of private housing in Hong Kong. *Landscape and Urban Planning*, 226-234.

Knutti, R., & Rugenstein, M. (2015). Feedbacks, climate sensitivity and the limits of linear models. *Philosophical Transactions of the Royal Society*.

Lamond, J., Proverbs, D., & Hammond, F. (2009). Flooding and Property Values - Findings in Built and Rural Environments. *FiBRE: Royal Institute of Chartered Surveyors*.

Lorbacher, K., Marsland, S., Church, J., Griffies, S., & Stammer, D. (2012). Rapid barotrophic sea-level rise from ice-sheet melting scenarios. *Journal of Geophysical Research, 117*.

Lorenz, D., Trück, S., & Lützkendorf, T. (2006). Addressing risk and uncertainty in property valuations: a viewpoint from Germany. *Journal of Property Investment & Finance, 24*(5), 400-433.

Mallison, M., & French, N. (2000). Uncertainty in Property Valuation: the nature and relevance of uncertainty and how it might be measured and reported. *Journal of property Investment & Finance*, 13-32.

NASA. (2017). *Global Climate Change: Vital Signs of the Planet: Sea Level*. Retrieved March 21, 2017, from https://climate.nasa.gov/vital-signs/sea-level/

Rahmstrof, S. (2007). A semi-empirical approach to projecting future sea-level rise. *Science, 315*(5810), 368-370.

Samarasinghe, O., & Sharp, B. (2008). Value of a view: A spatial hedonic analysis . *New Zealand Economic Papers*, 59-78.

South Africa. (2014). Act 24 of 2014: National Environmental Management: Integrated Coastal Management Act as amended. Pretoria: Government Printer.

Umvoto Africa (Pty) Ltd. (2010c). *Sea Level Rise and Flood Risk Assessment for a Select Disaster Prone Area Along the Western Cape Coast Phase 1 Report: Eden District Municipality Sea Level Rise and Flood Risk Literature Review.* Cape Town: Provincial Government of the Western Cape Department of Environmental Affairs and Development Planning: Strategic Environmental Management.

Vermeer, M., & Rahmstrof, S. (2009). Global sea level linked to global temperature. *PNAS*, 21527-21532.

Wight, A., & Ghyoot, V. (2005). *The Property Finance Business.* Pretoria: Unisa Press.

Zabel, J. (2004). The demand for housing services. *Journal of Housing Economics*, 16-35.