PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 21 ISSUE 3 (2023), Page 171 – 182

A COASTAL EROSION DERIVATION FORMULA FOR VALUING THE COASTAL LAND VALUES IN MALAYSIA

Hamdi Abdul Hamid[1*], Norhadija Darwin[2], Masfaliza Mohsen[3], Norhidayah Md. Yunus[4], Azizah Ismail[5], Mohd Farid Mohd Ariff[6], Zulkepli Majid[7]

[1,2,4,5,6,7]*Faculty of the Built Environment and Surveying,*
UNIVERSITI TEKNOLOGI MALAYSIA
[3]*Faculty of Technology Management and Business,*
Department of Real Estate Management,
UNIVERSITI TUN HUSSEIN ONN MALAYSIA

Abstract

The coastal area hosts significant economic activity with some of the highest property values, which the government and private investors aim to maintain and secure their interests. Yet, this area presented a growing risk to coastal properties' value because the land and structural attributes are vulnerable to erosion. Few empirical studies have included erosion rate besides the land attribute and reclamation in analysing its impact on the value of coastal land, especially in Malaysia. Hence, this study aims to derive a coastal erosion formula for valuing the coastal land values in Malaysia. Taman Alai Perdana (Crystal Bay), Melaka, was selected as a case study area for investigating formula derivation. Based on the formula derivation, the findings have determined that significant property values were affected by erosion in the study area. Using property One (1) in Crystal Bay Alai, Melaka, as an example, with a land area of 632m^2, it was valued at RM163286.26 or RM236.81/m^2 before formula application. Then, by applying the formula for the same property, considering the identified area erosion rate of -1.41m required a reclamation width of 2.5m to rectify the erosion. So, a value of RM163,286.26 with a difference of RM13,625.00 was determined. Hence, the study has determined reclamation and erosion rate should be included in the coastal land valuation.

***Keywords**:* derivation formula, land value, coastline, coastal erosion

[1] Student. Email: hamdi4@graduate.utm.my

INTRODUCTION

The coastal area hosts significant economic activity as an area of recreation, tourism, picnics, cultivation, fishery, ports, petroleum, oil, and gas, including some of the highest residential property values contributing to a country's economy. By referring to various researchers, there are several definitions regarding coastline. A coastline is the physical interface of land and water (Alesheikh, Ghorbanali, and Nouri, 2007; Dolan, Hayden, May, and May, 1980). Another definition by Nayak (2002) described coastline as the land and sea line of interaction between the terrestrial and tidal processes. A coastline is a transitional region between the terrestrial and marine environment with features (Ong, Gong, and Chan, 2001). However, in practice, it is challenging to determine coastlines zone due to some conditions or environments regarding the impact of waves, wind, tides, and coastal geomorphology. Generally, coastline position changes after a short or long time depending on the cross-shore and alongshore sediment movement in the littoral zone and prone area because of the natural factors of water levels such as waves, tides, groundwater, storm, and wind at the coastlines or coastal boundary.

Because of a combination of geographic, economic, and historical factors that attract people and encourage various migration processes, the majority of the world's megacities are now located along the coastline (Barragán and de Andrés, 2015; Brown, Keath, and Wong, 2009; Seto, Fragkias, Güneralp, and Reilly, 2011). In most countries, coastal population growth outpaces non-coastal growth. According to Small and Nicholls (2003), approximately one-fifth of the world's 1.2 billion people reside within 100 kilometres of the coast. By 2030, this figure will have risen to half of the world's population. Around 6 billion people are predicted to reside within 200 kilometres of the coast by 2025, indicating the potential for fast growth in coastal areas (Creel, 2003).

However, these coastal regions are threatened by erosion as many world coastlines experience this situation (Pilkey and Cooper, 2014; Zhu, Linham, and Nicholls, 2010). Coastal erosion occurred due to climate change, such as increased temperature and rising sea levels. It is expected that future erosion could be uncontrollable magnitudes for humanity (Jones and Phillips, 2009; Shi, Xu, Ye, Yang, Liu, Fang, Liu, Li, and Wang, 2015). The value of the economic activity and natural resources of the coastline zone can be seen in two components; namely, the current market value of all goods and services that are produced directly and indirectly from coastal resources and coast-related activities (which is equivalent to the gross national product-originating in the coastal zone) whilst the other components is on the intangible value such as recreation and other activities and resources that people enjoy but did not directly pay (Luger, 1991).

Subsequently, the coastal region hosts significant economic activity and is located with some of the highest property values in many countries and is vital to be protected and sustained. According to Catma (2021), local governments, businesses, and people are concerned about lost commercial activity and lower tax income as a result of coastal erosion's detrimental impacts on the tourism and hospitality industries. Furthermore, the loss of coastline due to erosion posed a hazard to surrounding properties because it served as a buffer zone against storm surges. In addition, the problem of coastal erosion worsens because the shoreline is a place where people focus on diverse activities and product development (Barragán and de Andrés, 2015). As a result, this phenomenon may affect property value, both favourably and negatively. Hence, research on determining the influence of coastal erosion on a property to maintain its value is called for.

RESEARCH BACKGROUND

The coastal area is delicate and vulnerable to various threats such as erosion that can affect the community's socioeconomic, environment and ecosystem. It is widely believed that erosion occurs continuously along the coastline due to natural and human factors. These include wearing away of land and removal of beach or dune sediments by tidal currents or rise in sea level (Bruun, 1988, 1989; Douglas, Kearney, and Leatherman, 2000; Kefu and Tegu, 2009; Nicholls and Tol, 2006; Schwartz, 1967; Teh and Voon, 1992) wave currents (Kearney, 2001; Silvester and Hsu, 1997) or climate changes (Adger, Hughes, Folke, Carpenter, and Rockström, 2005; Feagin, Sherman, and Grant, 2005; Zhang, Douglas, and Leatherman, 2004). Additionally, waves generated by storms and winds may take the form of long-term losses of sediment and rocks or merely the temporary redistribution of coastal sediments that could also cause erosion (Adger et al., 2005; Barnier, 1988; Feagin et al., 2005; Kearney, 2001; Kefu and Tegu, 2009; Silvester and Hsu, 1997; Zhang et al., 2004). Moreover, human interference such as dredging in a bay, construction of structures on the coastal beach which could disturb the movement of the sediments, coastal reclamation and other factors can also cause coastal erosion (Barnier, 1988; Leatherman, Zhang, and Douglas, 2000; Zhang et al., 2004). Also, the coastal erosion problem becomes much more significant, as coastlines are ideal for human concentrations and the development of different productive activities (Barragán and de Andrés, 2015).

Subsequently, the property values near the coast can be affected by environmental characteristics such as coastal erosion in ways similar to structural characteristics (Freeman, 1979; McNamara, Gopalakrishnan, Smith, and Murray, 2015). Currently, some studies have been conducted on the impact of coastal erosion on property value. For example, Jin, Hoagland, Au, and Qiu (2015) have identified that residences close to the ocean reduce the property value of RM1176 a year due to an annual erosion rate (1m) at Marshfield, Duxbury, and Plymouth,

Massachusetts. Another study by McNamara et al. (2015) also identified that erosion could affect property value in North Carolina and New Jersey by nearly 17% and 34% (as erosion from rising sea level reaches 4 m/yr) for high and low property value regions, respectively. However, there is a lack of study, especially in Malaysia, on property price valuation due to the impact of coastal erosion.

Generally, the main focus of the valuation is to address and justify the concept of economic value. Then, a Valuer must first estimate the highest and best use, or the most probable use of an asset to estimate market value which is the basis of value. By referring to the Board of Valuers, Appraisers, Estate Agents & Property Managers, market value is "*the estimated amount for which an asset or liability should exchange on the valuation date between a willing buyer and a willing seller in an arm's length transaction after proper marketing and where the parties had each acted knowledgeably, prudently and without compulsion"*. The International Valuation Standards Council (IVSC) and most of the world's major valuation standard setters refer to only three approaches to valuation: the Market/Comparison Approach, the Cost Approach and the Income Approach with valuation subsets, namely the Investment Method, the Residual Method, the Discounted Cash Flow Method and the Profits Method are used for estimating the market value of the property (Baum, Mackmin, and Nunnington, 2017; Board of Valuers, 2019; Colborne and Hall, 1993; French, 2004; Maliene, 2000; Skarzyński, 2006). Modern and advanced methods, like Artificial Neural Networks (ANNs), hedonic pricing, spatial analysis, fuzzy logic and Autoregressive Integrated Moving Average (ARIMA) (Arslan and Aydin, 2009; Jackson, 2008; Pagourtzi, Assimakopoulos, Hatzichristos, and French, 2003; Urbanavičiene, Kaklauskas, Zavadskas, and Seniut, 2009), as well as multiple criteria methods (Maliene, 2001; Peldschus, 2009; Zavadskas, Kaklauskas, and Maliene, 1997) becoming accepted progressively.

Currently, most coastal properties use hedonic pricing in valuing those coastal land or property. However, Chau and Chin (2003) identified a major empirical issue about the hedonic price model as the choice of the functional form. They stated that several basic functional forms could be applied to the hedonic price model, such as linear, semi-log, and log-log forms. Subsequently, Blomquist and Worley (1981) and Goodman (1978) stated that inconsistent housing price estimates might occur if the functional form is incorrectly used. Consequently, this study aims to derive a coastal erosion model for estimating Malaysia's coastal property values.

RESEARCH METHODOLOGY

This study begins with collecting data and information from relevant articles, reports, websites, and seminar papers on the influence of coastal erosion on property value, including data on sales transactions received from the State of

Melaka's Department of Valuation and Property Services (JPPH). Subsequently, secondary data collection involves data on residential sales transactions in the study area over four years (2014-2018). Although several residential developments are located on the West Coast (Malacca Strait) of Penisular Malaysia, this study's scope focused mainly on the Taman Alai Perdana (Crystal Bay) due to this residential scheme facing erosion problems, as shown in Figure 1. This residential scheme is situated in the Melaka Tengah district of the State of Malacca, which has a total coastline of 120.5 km, with 3.1% or 3.7 km being eroded. However, generally, the 73-km-long Malacca coast has a rhythmic form. The northern portion comprises headlands alternating with bays to form an offset coast. The southern part includes a series of shallowly scalloped bays with protrusions spaced at about 4.5 km.

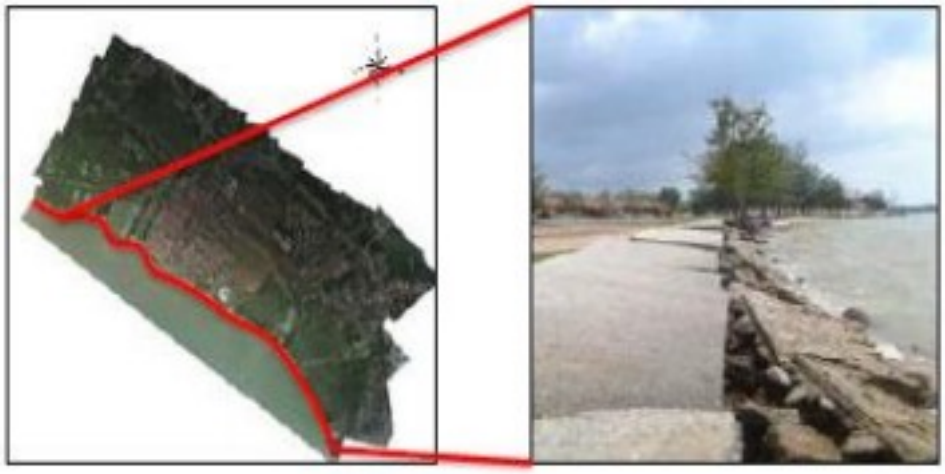
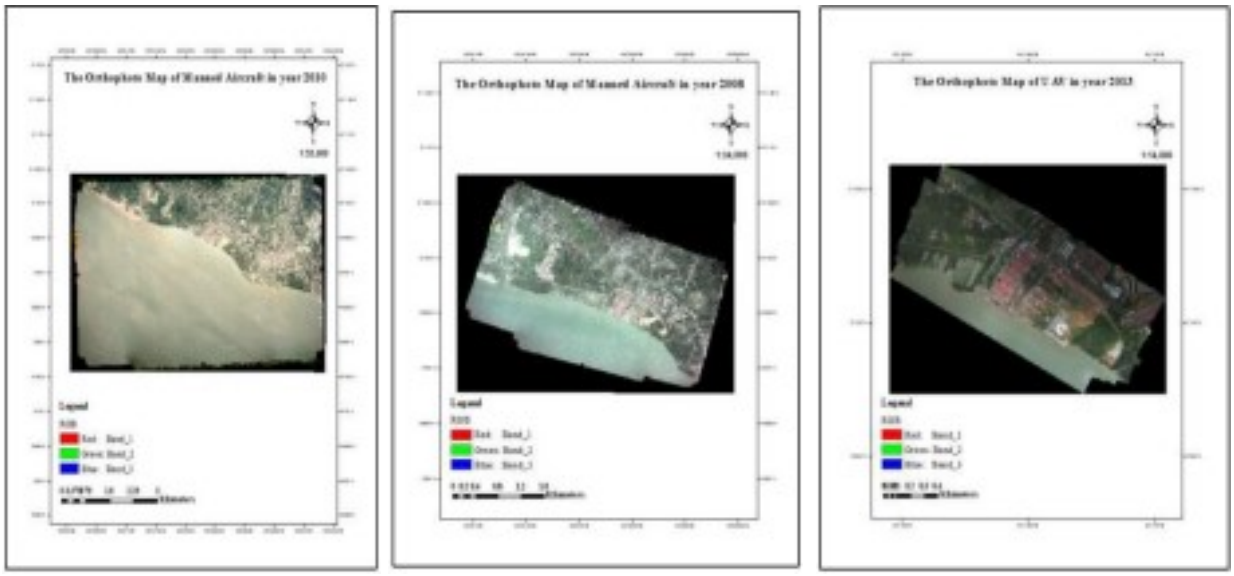


Figure 1: The Coastline of Taman Alai (Crystal Bay), Malacca

In this research, the formula will be derived based on modeling coastal erosion using the regression model analysis. The data used to estimate the value of market valuation is from the year 2018 until the year 2021, and its factors are influenced primarily by natural factors. The updated orthophoto from aerial images of Crystal Bay, Alai Melaka, were collected in 2021, as shown in Figure 2.

There are various properties, such as vacant land, residential, commercial and industry. Table 1 shows examples of vacant land property transactions from 2014 to 2018 for Alai Melaka. Hence, two hypotheses are indicated in this research, specifically (1) the coastal erosion valuation model derived is inefficient, and (2) the derived coastal erosion valuation model can value coastal land and sustain the value of capital.



(a) Orthophoto in year 2008 (b) Orthophoto in year 2010 (c) Orthophoto in year 2021

Figure 2: The Orthophoto of Taman Alai (Crystal Bay), Malacca from 2008, 2010 and 2021

Table 1: Transaction Data for Alai Melaka

No.	Date of Transaction	Land Size (sq. m)	Lot	Title	Category	Price Transaction (RM)	RM per m2
1	21-Jul-14	632	2670	Pajakan Negeri	Perdagangan	149,661.00	236.81
2	27-Jun-14	884	2665	Pajakan Negeri	Perdagangan	252,152.00	285.24
3	21-Jul-14	1182	2655	Pajakan Negeri	Perdagangan	292,000.00	247.04
4	18-Dec-15	773	2651	Pajakan Negeri	Kediaman	220,480.00	285.23
5	18-Dec-15	595	2641	Pajakan Negeri	Perdagangan	115,200.00	193.61
6	12-Jan-15	595	2639	Pajakan Negeri	Perdagangan	121,600.00	204.37
7	14-Dec-18	595	2633	Pajakan Negeri	Perdagangan	128,080.00	215.26

RESULT AND ANALYSIS

To derive a coastal erosion model for estimating Malaysia's coastal property values, the concept of coastal land valuation is based on erosion and reclamation as shown in Figure 3.

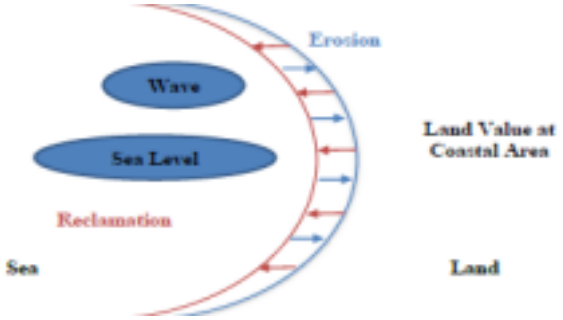


Figure 3: Concept of Coastal Land Valuation Based on Erosion and Reclamation

Figure 3 above shows the concept of determining the coastal land value based on the land attribute, erosion, and reclamation width. The red colour in the figure represents the prevention of the value, but it depends on the types of hard and soft defence structures used for maintaining the coastal line. Meanwhile, the blue represents the reduced coastal land value due to land depreciation. Subsequently, it is demonstrated that wave and sea levels influence the erosion rate, while reclamation mitigates erosion of the coastal area. Thus, based on the figure, the formula for calculating coastal land using the linear model formula is derived as shown below.

ß = ά1 x ά2 + ((– m1 + m2) x ϒx Ø) x €
Where,
ß = Land Value,
ά1 = Land Size
ά2 = Price per meter square (after applying the valuation method)
m1 = Erosion
m2 = Reclamation (width)
ϒ = Coastal Length
Ø = Coastal Depth
€ = Price of Reclamation

The analysis and results of landed commercial property transactions data from 2014 to 2018 before and after the formula used are shown in Table 2. The table shows the property details such as the date of transaction, land size, title, category and transaction price.

Table 2: Analysis and Result before and after Formula

No.	Date of Transaction	Land Size (m^2)	Lot	Title	Category	Erosion (m)	Reclamation (width) (m)	Depth (m)	Coastal Length (m)	Transaction Price (RM)	Formula Price (RM)	RM per m^2 (Before)	RM per m^2 (After)
1	21-Jul 14	632	2670	*Pajakan Negeri*	*Perdagangan*	-1.41	2.5	2.5	100	149,657.60	163,286.26	236.81	291.56
2	27-Jun 14	595	2665	*Pajakan Negeri*	*Perdagangan*	-1.41	2.5	2.5	100	130,001.55	143,626.55	218.49	241.39
3	21-Jul 14	1028	2655	*Pajakan Negeri*	*Perdagangan*	-1.41	2.5	2.5	100	265,563.24	276,463.24	258.33	268.93
4	18-Dec-15	595	2651	*Pajakan Negeri*	*Perdagangan*	-1.41	2.5	2.5	100	160,001.45	187,251.45	268.91	314.71
5	18-Dec-15	595	2641	*Pajakan Negeri*	*Perdagangan*	-1.41	2.5	2.5	100	160,001.45	170,901.45	268.91	287.23
6	12-Jan 15	595	2639	*Pajakan Negeri*	*Perdagangan*	-1.41	2.5	2.5	100	160,001.45	170,901.45	268.91	287.23
7	14-Dec-18	884	2633	*Pajakan Negeri*	*Perdagangan*	-1.41	2.5	2.5	100	252,152.16	263,052.16	285.24	297.57
8	14-Dec-18	773	2622	*Pajakan Negeri*	*Perdagangan*	-1.41	2.5	2.5	100	220,482.79	231,382.79	285.23	299.33

The table above shows differences in land value compared to data transactions using the derived formula. As an example, item number 1, its erosion rate is -1.41m, followed by the reclamation width is 2.5m, the price per square meter is RM236.81 (before adjustment), land area (632m2), land value using the formula (RM163,286.26) and the transacted land value (RM149,661.00). From this calculation, although the coastal area is affected by erosion, the difference between transacted land value and the formula of item number 1 is RM13,625 which determines that the land value can be sustained or slightly increased due to reclamation.

The coastal land value derived from the Melaka formula was analysed using the statistical t-test. The t-test of the derived formula is a comparative test to assess the coastal land value between the results of using the formula and transacted land value. Based on the analysis, the formula's effectiveness was determined by the confidence level for the t-test is 95% (where α=0.05). The hypothesis of the test is:

H_o: $\mu_1 = \mu_2$: There are no differences in land value between the derived formula and transacted data

H_A: $\mu_1 \neq \mu_2$: There are differences in land value between the derived formula and transacted data

The null hypothesis, Ho (which indicates the tested method is not significant), will be rejected if the calculated t value is higher than the critical t value (predicted from the t-distribution table) with the selected level of significance (e.g.α = 0.05). The test method is statistically significant with the rejected Ho (accept H_A, alternative hypothesis). Below is the t-test result between land value derived from the formula and transacted data for three locations of the coastal area.

Table 3: T-test result between land value

	Land Value (Formula)	Land Value (Formula)
Mean	156241.6526	154223.3333
Variance	2625246971	2604326367
Observations	24	24
Pearson Correlation	0.999992885	
Hypothesized Mean Difference	0	
df	**23**	
t Stat	35.16636197	
P(T<=t) one-tail	8.43162E-22	
t Critical one-tail	1.713871528	
P(T<=t) two-tail	1.68632E-21	
t Critical two-tail	2.06865761	

CONCLUSION

Thus, it can be concluded that this study has provided empirical findings through the derivation of the formula coastal property valuation with the inclusion of erosion and reclamation factors. Also, several types of research can be considered for investigation in the future. Firstly, research can be extended to other coastal areas such as Terengganu, Kedah and Pahang. Secondly, research on applying this formula as a calculation system using programming software such as Matlab, C++ and others to facilitate the valuer in calculating the coastal land where this software can be integrated with other input files such as excel and text files. Thirdly, research on the value of coastal properties based on the scheme can be conducted to determine coastal property marketability for future development.

ACKNOWLEDGEMENTS

The authors would like to thank the National Real Property Research Coordinator (NAPREC), National Institute of Valuation (INSPEN), Valuation & Property Services Department (JPPH Malaysia) and the Ministry of Finance, Malaysia for funding the research project under the NAPREC grant no. (23/2021).

REFERENCES

Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., & Rockström, J. (2005). Social-ecological resilience to coastal disasters. *Science, 309*(5737), 1036- 1039.

Alesheikh, A. A., Ghorbanali, A., & Nouri, N. (2007). Coastline change detection using remote sensing. *International Journal of Environmental Science & Technology, 4*(1), 61-66.

Arslan, G., & Aydin, Ö. (2009). A new software development for fuzzy multicriteria decision-making. *Technological and Economic Development of Economy, 15*(2), 197-212.

Barnier, B. (1988). A numerical study on the influence of the Mid-Atlantic Ridge on nonlinear first-mode baroclinic Rossby waves generated by seasonal winds. *Journal of physical oceanography, 18*(3), 417-433.

Barragán, J. M., & de Andrés, M. (2015). Analysis and trends of the world's coastal cities and agglomerations. *Ocean & Coastal Management, 114*, 11-20. doi:https://doi.org/10.1016/j.ocecoaman.2015.06.004

Baum, A., Mackmin, D., & Nunnington, N. (2017). *The income approach to property valuation*: Routledge.

Blomquist, G., & Worley, L. (1981). Hedonic prices, demands for urban housing amenities, and benefit estimates. *Journal of Urban Economics, 9*(2), 212-221. Board of Valuers, A., Estate Agents & Property Managers. (2019). The Malaysian Valuation Standards (MVS). In.

Brown, R. R., Keath, N., & Wong, T. H. (2009). Urban water management in cities: historical, current and future regimes. *Water science and technology, 59*(5), 847-855.

Bruun, P. (1988). The Bruun rule of erosion by sea-level rise: a discussion on large scale

two-and three-dimensional usages. *Journal of Coastal Research*, 627- 648.
Bruun, P. (1989). Coastal engineering and use of the littoral zone. *Ocean and Shoreline Management, 12*(5-6), 495-516.
Catma, S. (2021). *The Price of Coastal Erosion and Flood Risk: A Hedonic Pricing Approach.* Paper presented at the Oceans.
Chau, K. W., & Chin, T. (2003). A critical review of literature on the hedonic price model. *International Journal for Housing Science and Its Applications, 27*(2), 145-165.
Colborne, A., & Hall, P. C. (1993). The profit method of valuation. *Journal of Property Valuation and Investment*.
Creel, L. (2003). *Ripple effects: population and coastal regions*: Population reference bureau Washington, DC.
Dolan, R., Hayden, B. P., May, P., & May, S. (1980). The reliability of shoreline change measurements from aerial photographs. *Shore and beach, 48*(4), 22-29. Douglas, B., Kearney, M. T., & Leatherman, S. P. (2000). Sea level rise: History and consequences.
Feagin, R. A., Sherman, D. J., & Grant, W. E. (2005). Coastal erosion, global sea-level rise, and the loss of sand dune plant habitats. *Frontiers in Ecology and the Environment, 3*(7), 359-364.
Freeman, A. M. (1979). *The benefits of environmental improvement: theory and practice*.
French, N. (2004). The valuation of specialised property: A review of valuation methods. *Journal of Property Investment & Finance*.
Goodman, A. C. (1978). Hedonic prices, price indices and housing markets. *Journal of Urban Economics, 5*(4), 471-484.
Jackson, L. A. (2008). An examination and application of current lodging valuation practices. *Journal of Retail & Leisure Property, 7*(3), 234-247.
Jin, D., Hoagland, P., Au, D. K., & Qiu, J. (2015). Shoreline change, seawalls, and coastal property values. *Ocean & Coastal Management, 114*, 185-193. Jones, A. L., & Phillips, M. R. (2009). *Disappearing destinations: Climate change and future challenges for coastal tourism*: Cabi.
Kearney, M. S. (2001). Late Holocene sea level variation. In *International Geophysics* (Vol. 75, pp. 13-36): Elsevier.
Kefu, Y., & Tegu, C. (2009). Beach sediments from northern South China Sea suggest high and oscillating sea levels during the late Holocene. *Earth Science Frontiers, 16*(6), 138-145.
Leatherman, S. P., Zhang, K., & Douglas, B. C. (2000). Sea level rise shown to drive coastal erosion. *Eos, Transactions American Geophysical Union, 81*(6), 55-57. Luger, M. I. (1991). The economic value of the coastal zone. *Journal of Environmental Systems, 21*(4), 279-301.
Maliene, V. (2000). Comparative value methods review: Bonner method. *Technological and Economical Development of Economy, 6*(1), 46-52.
Maliene, V. (2001). Valuation of commercial premises using a multiple criteria decision-making method. *Property Management, 5*(2), 87-98.
McNamara, D. E., Gopalakrishnan, S., Smith, M. D., & Murray, A. B. (2015). Climate adaptation and policy-induced inflation of coastal property value. *PloS one, 10*(3), e0121278.
Nayak, S. (2002). Use of satellite data in coastal mapping. *Indian Cartographer, 22*(147-

157), 1.

Nicholls, R. J., & Tol, R. S. (2006). Impacts and responses to sea-level rise: a global analysis of the SRES scenarios over the twenty-first century. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 364*(1841), 1073-1095.

Ong, J., Gong, W., & Chan, H. (2001). *Governments of developing countries grossly undervalue their mangroves.* Paper presented at the Proc. International Symposium on Protection and Management of Coastal Marine Ecosystems.

Pagourtzi, E., Assimakopoulos, V., Hatzichristos, T., & French, N. (2003). Real estate appraisal: a review of valuation methods. *Journal of Property Investment & Finance*.

Peldschus, F. (2009). The analysis of the quality of the results obtained with the methods of multi-criteria decisions. *Technological and Economic Development of Economy, 15*(4), 580-592.

Pilkey, O. H., & Cooper, J. A. G. (2014). *The last beach*: Duke University Press. Schwartz, M. L. (1967). The Bruun theory of sea-level rise as a cause of shore erosion. *The journal of Geology, 75*(1), 76-92.

Seto, K. C., Fragkias, M., Güneralp, B., & Reilly, M. K. (2011). A meta-analysis of global urban land expansion. *PloS one, 6*(8), e23777.

Shi, P., Xu, W., Ye, T., Yang, S., Liu, L., Fang, W., Liu, K., Li, N., & Wang, M. (2015). World atlas of natural disaster risk. In *World Atlas of natural disaster risk* (pp. 309-323): Springer.

Silvester, R., & Hsu, J. R. (1997). *Coastal stabilisation* (Vol. 14): World Scientific Singapore.

Skarzyński, A. (2006). Residual method of property valuation. *Technological and Economic Development of Economy, 12*(3), 253-256.

Small, C., & Nicholls, R. J. (2003). A global analysis of human settlement in coastal zones. *Journal of coastal research*, 584-599.

Teh, T., & Voon, P. (1992). Impact of sea level rise on the coastal zone of Malaysia. *Background Paper, Malaysian National Conservation Strategy 1992, WWF Malaysia Resource Library Economic Planning Unit, kuala Lumpur 100*.

Urbanavičiene, V., Kaklauskas, A., Zavadskas, E. K., & Seniut, M. (2009). The web– based real estate multiple criteria negotiation decision support system: A new generation of decision support systems. *International Journal of Strategic Property Management, 13*(3), 267-286.

Zavadskas, E., Kaklauskas, A., & Maliene, V. (1997). Real estate price evaluation by means of multicriteria project assessment methods. *Real estate valuation and investment in central and eastern Europe during the transition to free market economy. Vilnius: Technika*, 156-170.

Zhang, K., Douglas, B. C., & Leatherman, S. P. (2004). Global warming and coastal erosion. *Climatic change, 64*(1), 41-58.

Zhu, X., Linham, M. M., & Nicholls, R. J. (2010). Technologies for climate change adaptation. Coastal erosion and flooding.

Received: 19th December 2022. Accepted: 19th June 2023

