Establishing Fees for Beach Protection: Paying for a Public Good

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Costs of controlling shoreline erosion are not allocated equitably. Using estimates from Seabrook Island, South Carolina, we provide a method to set fees based on proximity to the beach. Equitable fees will encourage efficient beach protection policy. This method is also applicable to other areas that require beach maintenance.

Keywords beach nourishment fee, hedonic model, public good

Much of the East and Gulf coast of the United States is protected from the brunt of storms and their resultant destruction by narrow strips of sand and wetlands known as barrier islands. The 2,700 miles of barrier islands stretching along the coastline also buffer the mainland from the normal scour of waves and currents. Despite the obvious risks of damage to life and property from storms and flooding, the development of these islands is proceeding at a rapid pace.

Coastal barrier islands are especially vulnerable to shoreline erosion, since they follow a process that geologists refer to as island migration. These islands roll over themselves as sand, carried by storm waves during frequent floodings, is taken from the beach and offshore areas and is redistributed across the island. Serious erosion of beaches endangers oceanfront property and, in extreme cases, leads to houses toppling into the ocean. Wider beaches provide protection from flooding during storms and high tides to oceanfront property as well as to homes and lots farther removed from the beach. Additionally, wider beachers also enhance the value of recreational activities such as strolling on the beach, sunbathing, and picnicking. Therefore, the expectation is that a wider beach increases the market price of property, since property values capture the flood control and recreational gains associated with a wider beach.

However, since beach width is a nonmarket good, the actual value of a wider beach is difficult to measure. Also, because beaches are public goods, it is difficult to determine the value of the beach to individual property owners. We use an hedonic model to

Received 25 March 1998; accepted 1 October 1998.

We thank the Francis Marion University Faculty Research Committee for partial funding of the project, the South Carolina Office of Ocean Coastal Resource Management for providing data on beach width, and the Charleston Trident Association of Realtors for assistance with property data. We would like to thank three anonymous reviewers whose comments significantly improved the article.

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Coastal Management, 27:57–67, 1999

0892-0753/99 $12.00 + .00

estimate the effect of beach width on developed and undeveloped property values on Seabrook Island, South Carolina. Based on our calculations of the value of beach width, we provide some guidelines for setting fees to pay for beach protection.

The Problem of Shoreline Erosion

Seabrook Island, South Carolina, is a beach ridge barrier island located approximately 20 miles south of Charleston, South Carolina. The island consists of 2,200 acres of land, 3.5 miles of private beach, and is bordered by three rivers—the North Edisto, Bohicket, and Kiawah—and the Atlantic Ocean. The island is a privately developed residential community with entrance to the island limited to property owners, their guests, and renters. Seabrook has approximately 2,350 separate, privately owned properties consisting of 495 single-family homes, 1,003 villas, and 852 undeveloped lots. The community includes two golf courses, numerous tennis courts, and a variety of lakes, lagoons, marshes, and creeks. The island has a noncommercial atmosphere and exhibits forests of live oaks, palmetto palms, pines, and magnolias. Commercial establishments such as grocery stores, banks, gasoline stations, and department stores are located outside the entrance gates.

Seabrook Island has experienced significant beach erosion over the years, and since development began in the 1970s, both hard and soft engineering projects have been implemented in an attempt to control some of the most serious problems. Between 1975 and 1982, several different projects, involving sandbag revetments, groins, concrete sheetpile walls, and riprap stones, were undertaken at a cost of $3 million. In addition to these hard engineering techniques, three major soft engineering projects were completed.

In 1983, at a cost of $300,000, Captain Sam's Inlet, an unstable inlet bordering Seabrook on the northeast, was relocated northward in an attempt to encourage water currents to move sand to the beach area. In 1990 a beach nourishment project at Middle Beach that cost $1.5 million added 700,000 cubic yards of sand. Even so, storms in 1994 seriously eroded portions of the beach and other projects have followed. In the spring of 1996 Captain Sam's Inlet was again relocated northward at a cost of $500,000, since it had migrated back to its 1983 position. Similar projects will undoubtedly be necessary in the future if the beach is preserved in its present condition (Kana, 1984).

Since Seabrook is a private development with no beach access for the general public, the property owners on the island do not receive federal or state financial assistance. Therefore, property owners on the island must pay for all costs of beach protection. Accordingly, property owners on Seabrook pay an annual fee for beach protection.

Beach nourishment projects on beaches that allow public access receive public funding. For example, a $60 million sand replenishment project along the shoreline of Myrtle Beach, South Carolina, that began in 1997 was funded by federal, state, and local tax dollars. The federal government underwrote $45 million of the cost, and the state and local community contributed $15 million.

The beach profile on Seabrook Island varies widely according to location and date. The average high tide beach width is 228 feet, and the average low tide beach width is 419 feet. In 1994, beaches at different locations varied from 16 to 1,357 feet at low tide. The Seabrook beach is very dynamic, changing dramatically from year to year sometimes as the result of beach nourishment projects but more often due to the natural dynamics of sand, wind, currents, waves, and tides. Portions of Seabrook erode an average of 5 feet per year, compared to Myrtle Beach, which erodes at less than a foot per year (Lennon et al., 1996, 80, 112). At a particular spot, the beach width at low tide varied from 30 feet in 1989 to 193 feet in 1990 (the result of beach nourishment) to 57 feet in 1994. We expect that property owners are aware of beach width conditions and variations and are influenced by such factors in negotiating a purchase price.

Some studies have focused on the effects of shoreline erosion on property values. Armstrong and Denuyl (1977) considered the value of alternative protection structures, such as groins or sea walls, to lakeshore property. They found that a wooden sea wall would provide a net benefit of $98 per frontage foot for lakeside property. Kern, Byrne, and Hobbs (1980) used historical erosion rates to evaluate the impact of coastal erosion on shoreline property along the Chesapeake Bay. They found that the value of a dwelling decreases by $0.24 for each square foot of shoreline lost and by $8.24 per foot of distance lost. Terich and Gabriel (1987) found that erosion has little effect on land values near Walapa Bay, Washington. They suggested that factors specific to their study explain this unexpected finding. Since coastal properties in this area are priced much lower than in other regions of the country, and since most properties are modest vacation homes, owners suffer little economic loss due to erosion.

Kriesel et al. (1993) estimated a hedonic model to determine the benefits of erosion control devices along Lake Erie. They constructed a variable (GEOTIME) measuring the expected number of years for a shoreline to erode away given the property's historical erosion rate. This variable is used to estimate the welfare gain to an individual if GEOTIME is increased (i.e., more years of protection) with an erosion control device. They found that for a property with 1 year of GEOTIME, a device that creates 8 additional years of protection is worth $34,540 and one that provides 20 years of additional protection is worth $48,710.

Black, Donnelley, and Settle (1990), using the judgment of realtors, estimated the value of beachfront houses to be $60,000 greater with a nourishment project for South Bethany, Delaware, beaches that increases beach width by 165 feet. Pompe and Rinehart (1995) found that an additional foot of beach for two coastal communities in South Carolina increases the value of developed and undeveloped oceanfront lots by $554 and $754, respectively. For developed and undeveloped property one-half mile from the beach, market value increased by $254 and $165, respectively.[1]

Model and Data Set for Seabrook Island, South Carolina

The empirical analysis is based on data collected on developed property and vacant lots on Seabrook Island. We estimate two hedonic price models to determine the value of beaches to property owners. Two hundred thirty-eight developed properties and 297 vacant lots that were sold between January 1989 and July 1994 comprise the sample. The following hedonic price model is estimated (Freeman, 1993):

$$P_i = P(S_i, N_i, Q_i)$$

The price of the *i*th house or *i*th vacant lot is a function of a vector of structural characteristics (S_i), a vector of neighborhood characteristics (N_i), and a vector of environmental quality characteristics (Q_i). Variable definitions and descriptive statistics for developed property and vacant lot models are listed in Tables 1 and 2, respectively.

Selling price, location, and structural characteristics such as square footage, number of bedrooms, and age of structure were obtained from the Charleston Trident Associa-

Table 1
Variable definitions, symbols, and descriptive statistics of developed property (N = 238)

Variable definitions	Symbol	Mean	Std. dev.
Selling price of structure (deflated)	SP	137800.00	91434.00
Age of structure (years)	AGE	9.07	4.71
Size of structure (square feet)	SQFT	1613.20	700.96
Number of bathrooms	BATH	2.35	0.69
Number of bedrooms	BED	2.46	0.85
Dummy variable (1 = structure detached)	DET	0.60	0.49
Dummy variable (1 = located on golf course)	GOLF	0.27	0.45
Dummy variable (1 = located on creek or marsh)	CRK	0.20	0.45
Dummy variable (1 = view of ocean)	OCNV	0.11	0.32
Width of beach at high tide (feet)	WBHT	228.34	224.39
Road distance to nearest beach (feet)	DBCH	5888.70	4137.50
Length of time on market (months)	LT	11.21	10.68
Dummy variable (1 = sold in 1989)	Y89	0.07	0.26
Dummy variable (1 = sold in 1990)	Y90	0.03	0.18
Dummy variable (1 = sold in 1991)	Y91	0.12	0.32
Dummy variable (1 = sold in 1992)	Y92	0.30	0.46
Dummy variable (1 = sold in 1993)	Y93	0.31	0.36
Dummy variable (1 = sold in 1994)	Y94	0.15	0.36

tion of Realtors. Numerous visits to the island were conducted to obtain and verify information requiring actual sight. Variables such as view of a golf course, ocean, marsh, or creek were determined from detailed area maps and visits to the island. Distance variables were derived from various area maps. Prices of developed property and vacant lots were adjusted to 1989 dollars with the Boeckh Housing Index, a regional cost of building index. A variable for the year when the property was sold (Y89 to Y94) and a variable measuring the length of time the property was on the market (LT) are also included. Because the area for this study is homogeneous with regard to accessibility of public services, inclusion of these factors is unnecessary. We use distance traveled to the beach by road, rather than "as the crow flies," because the roads wind through the development and any travel to the beach must be by these roads.

Environmental quality characteristics are represented by two variables that capture the influence of beach width on property value—the width of beach at high tide, WBHT, and an interaction variable, DBHT, created by multiplying distance to the nearest beach (DBCH) by beach width (WBHT). Edwards (1989) showed that property farther from a beach will be less valued, so that the DBCH variable will capture the recreational value of being near the beach. Since using only DBCH would not capture the full impact of beach width, we use the interaction variable, DBHT, to adjust for the benefits from wider beaches. We expect wider beaches to increase property value since wider beaches provide flood protection value and increased recreational benefits associated with less congestion.[2]

Table 2
Variable definitions, symbols, and descriptive statistics of vacant lots (N = 297)

Variable definitions	Symbol	Mean	Std. dev.
Selling price of lot (deflated)	BDSP	53441.00	60544.00
Size of lot (square feet)	SQFT	25993.00	12273.00
Dummy variable (1 = located on golf course)	GOLF	0.28	0.45
Dummy variable (1 = located on creek or marsh)	CRK	0.26	0.56
Dummy variable (1 = view of ocean)	OCNV	0.06	0.23
Road distance to nearest beach (feet)	DBCH	7751.30	3667.30
Width of beach at high tide (feet)	WBHT	324.70	129.16
Length of time on market (months)	LT	11.83	10.99
Dummy variable (1 = sold in 1989)	Y89	0.11	0.32
Dummy variable (1 = sold in 1990)	Y90	0.08	0.27
Dummy variable (1 = sold in 1991)	Y91	0.13	0.35
Dummy variable (1 = sold in 1992)	Y92	0.21	0.41
Dummy variable (1 = sold in 1993)	Y93	0.26	0.44
Dummy variable (1 = sold in 1994)	Y94	0.21	0.41

A series of 11 survey markers spaced strategically along the shoreline provide the beach width measurements. The survey marker readings are monitored by South Carolina Ocean and Coastal Resource Management, a state agency. Readings are made approximately every six months and provide critical data for state coastal policies. The nearest survey marker to a particular property indicates the width of beach for that property. The marker readings are matched with the dates of sale for the property. For example, for a house or lot sold in February 1990, the reading from the nearest marker for February 1990 is used.

Several alternative measures of beach width are considered. High and low tide beach widths are examined. Also, an average of beach width for the five-year period of the study is examined. An average of beach width may be appropriate, because an individual purchases beach width over time, not at a particular date. However, if a prospective buyer knows of the beach management policy of the community, he or she may discount fluctuations over time. Finally, we consider the effect of the beach width of Middle Beach on property values, since Middle Beach is the most popular beach area on Seabrook.[3]

Empirical Results

The ordinary least squares estimates of the two hedonic price models (one each for developed property and vacant lots) are listed in Table 3, along with their *t* values. We use the Box-Cox transformation process to examine three standard functional forms—linear, semilogarithmic, and log-log (Box & Cox, 1964). Based on this method, we choose the log-log model. The adjusted R^2 is .89 for developed property and .73 for vacant lots. Most variables are significant and have the expected sign.

Table 3
Hedonic model for developed property and vacant lots

Symbol	Developed Coefficient (*t* value)		Vacant lots Coefficient (*t* value)	
One	5.556	(10.156)	10.775	(17.135)
AGE	–.063	(–3.125)	—	
SQFT	.953	(12.682)	.217	(3.911)
BATH	–0.023**	(–.290)	—	
BED	.289	(4.366)	—	
DET	0.093*	(2.214)	—	
GOLF	–.038**	(–1.140)	.340	(5.782)
CRK	.099	(2.943)	.782	(15.790)
OCNV	.377	(7.369)	.601	(4.586)
WBHT	.134	(5.495)	.304	(9.687)
DBHT	–.129	(–6.530)	–.318	(–14.373)
LT	–.010**	(–.690)	–.043**	(–1.464)
Y89	.211	(3.532)	.306	(3.471)
Y90	.090**	(1.115)	.270	(2.712)
Y91	.068**	(1.253)	.233	(2.565)
Y92	.065**	(1.533)	.250	(3.299)
Y93	–.027**	(–.649)	–.036**	(–.512)
	$N = 238$		$N = 297$	
	Adj. $R^2 = .885$		Adj. $R^2 = .731$	
	$F = 114.70$		$F = 68.16$	

Note: All variables are significant at 1% except for: *Significant at 10%, **Not significant. Dependent variable = natural logarithm of deflated selling price.

Nice views are important to property owners, as indicated by CRK and OCNV, which are significant and positive.[4] Location on a marsh or creek add about 10% and 119% to housing and vacant lot values. Ocean views add about 45% and 83% to housing and vacant lot values.[5] The golf location variable is positive for vacant lots, and negative, although insignificant, for developed property. Signs for the structural variables (SQFT, BD, DET) are positive as expected and significant at the 1% level. AG and LT are negative as expected, although only AC is significant.

Of particular interest in this study are the variables valuing the beach. The high tide width of the "nearest" beach at the date of purchase is the value used for beach width. This variable provides the highest adjusted R^2, although other measures (low tide and average beach width) provide similar results. As expected WBHT is positive and significant in both models, indicating that property buyers value wider beaches.

When the "good" beach (i.e., Middle Beach) is used as a proxy, the coefficient is insignificant in the model used here and in many other models as well. This suggests that property owners value wider beaches in general, not only at a particular beach, even if it is the principle recreational beach. This may be because property owners perceive some flood protection benefits from wider beaches. Also, since most property owners must travel to get to any beach, having to travel another block or so in any direction would not matter much.

Property owners value additional beach width differently, based on the state of development of the property, and the proximity to the beach.[6] The value of an additional foot of beach is $58.19 for vacant lots and $80.98 for developed lots. Price differentials exist for property at different locations. An additional foot of beach adds $194.09 and $310.84, respectively, to developed and undeveloped oceanfront property. For this data set, only 5 developed and 9 undeveloped observations are oceanfront. Therefore, these results should be viewed cautiously. For locations not on the oceanfront, but with an oceanview, an additional foot of beach adds $143.45 and $263.94, respectively, to developed and undeveloped property. For property not within view of the ocean, an additional foot of beach adds $74.42 and $44.41, respectively, for developed and undeveloped property.

The interaction variable, DBHT, is negative as expected and significant, indicating that proximity to the beach is also important, other factors being constant.[7] For developed property each additional foot closer to the beach adds $3.03 to value. For undeveloped property a foot closer to the beach adds $2.20.[8]

An Equitable Fee System

Residents of Seabrook pay an annual fee to cover costs of all beach maintenance. Under the current fee system, owners of developed property (villas/single-family homes) pay $100 and owners of unimproved lots pay $50 per year regardless of distance to the beach. The fees go into a joint beach and road maintenance fund that in the past has been split equally between the two. Additional fees for beach maintenance may be assessed periodically.

In 1995, property owners voted down a proposed beach nourishment project for Middle Beach that would have added 700,000 cubic feet of sand at a cost of $900,000. An additional fee of $375 would have been collected from each of the approximately 2,400 property owners, regardless of distance to the beach or state of development. It is safe to assume that the proposal was voted down, partially because many felt unfairly burdened, since benefits are clearly not equal for all property owners although the proposed fees were. A more equitable beach nourishment fee system for shared beach protection costs would encourage agreement among property owners on such proposals.

One theory of tax equity proposes that people should contribute to a service based on the amount that they benefit (Young, 1994). The difficulty with determining an equitable fee based on the benefit received is that a public good, such as a beach, is jointly consumed. A property owner is not likely to reveal the amount he or she would be willing to pay for a public good, since he or she would hope to "ride free" on another' s payment.

The results from this study indicate that some property owners benefit more from beach width than others. Shoreline erosion at some locations on Seabrook can be severe, even to the point of placing several oceanfront locations in imminent danger of destruction. A propsective buyer would undoubtedly choose to pay much less for a property that is at risk of collapsing into the ocean. Based on estimations from our model of the value that property owners place on wider beaches, it is possible to establish a more equitable fee system for financing beach nourishment projects. Using the results of the hedonic model, a system based on proximity to the beach can be devised.[9]

We suggest a system that sets fees for a limited number of zones, rather that a tax that would change foot by foot, because a foot-by-foot approach would produce so many different tax rates for property owners that it would likely be politically impossible to implement. Also, benefit differences between property owners within categories are relatively small, compared to benefit differences between different categories. We apply our model to the proposed 1995 project that was turned down by Seabrook property owners. Seabrook consists of approximately 2,400 separate properties. One hundred fifty are directly on the oceanfront, 200 are close enough for an oceanview, and the remaining 2,050 properties are not within sight of the ocean. No property on the island is more than 2 miles from the ocean.

The average high tide width of the beach to be nourished is 322 feet. The proposed nourishment project would have added approximately 150 feet of beach width, an increase of 47%. We use the average price of developed and undeveloped property and the width of beach coefficient (WBHT) to calculate the added value from the beach nourishment project for properties at different distances from the beach.[10] The values are presented in Table 4.[11] Beach nourishment adds significantly more to property on the ocean or within view of the ocean than to property inland. Also, value added to undeveloped property on the ocean or within view of the ocean is greater than the value added to developed property.

Owners of property with an oceanview have approximately 25% less benefit and nonoceanview property owners approximately 75% less benefit than oceanfront property owners from the nourishment project.[12] Therefore, the three categories would pay $112,500 (no oceanview), $337,500 (oceanview), and $450,000 (oceanfront) of total project costs. Since the 1995 beach nourishment project would have cost $900,000, fees of $55 (2,050 properties), $1,688 (200 properties), and $3,000 (150 properties) per property for the three categories should be assessed. Such a fee system would have property owners paying in proportion to benefits received. Annual fees collected for beach maintenance could be calculated in similar fashion.

This beach nourishment fee, decreasing as property is farther from the beach, would also reflect flood risks on Seabrook (Lennon et al., 1996, 112). Such a fee would be comparable to the present method used for setting flood insurance fees. Also, the fee system we propose would reflect the increased travel distance, and therefore the decreased value from beach maintenance, for property owners farther from the ocean.

Seabrook Island experiences a great deal of variation in beach width, unlike some coastal areas, where beaches are fairly stable. Because beach profiles and erosion levels vary widely from place to place, we expect that the benefits of wider beaches would vary as well.

Table 4

Value of wider beach for average property at different distances from beach for an increase in beach width from 322 feet to 472 feet (in 1989 dollars)

Location	Developed	Vacant
Oceanfront	$22,718	$36,373
Oceanview (not oceanfront)	$12,780	$33,016
Inland (no ocean view)	$8,081	$5,915

Conclusions

Our study provides additional data for estimating the value of wider beaches and has implications for beach-protection policies. To the authors' knowledge, this is the first attempt to set beach nourishment fees based on the benefits received by property owners, using an hedonic model. Because beaches are public goods, the value of beach protection to a property owner is not readily known. We estimate the increased property value from wider beaches on Seabrook Island and provide a strategy that would allocate the costs of beach protection in a more equitable manner. The problem of allocating costs for beach nourishment may be more tractable for Seabrook Island than for public beaches, since there is no public access for Seabrook beaches, thus allowing property owners to capture all the benefits. Although this study involves a private development on a coastal barrier island, the results are relevant for all coastal developments where shoreline erosion is a concern.

On Seabrook Island, property owners pay for all beach maintenance costs. Beach nourishment is currently the best alternative in many cases. However, the costs of public beach nourishment projects are financed by federal, state, and local governments. Recently the Clinton administration announced that the federal government's share of beach protection costs (currently 65%) would be reduced for most projects (National Research Council, 1995, 44). If federal funding is decreased or is no longer available, determining how the costs should be distributed will become more important.

Maintaining coastal beaches is an expensive and continuing process, whether private or public funding is used. Since 1950, the federal government has spent $1.5 billion (1993 dollars) on beach nourishment and is committed for an additional $1.3 billion for future nourishment projects (Sudar et al., 1995). Information on the marginal benefits and how they are distributed among beach nourishment beneficiaries is presently insufficient for good decision making. The results of our study suggest that property owners near the beach benefit greatly from nourishment projects, and therefore, should be expected to bear a significant portion of the burden. Our study offers a method to measure the benefits that property owners near the beach receive. For public beaches, beneficiaries of beach protection other than property owners (e.g., day users) would also be expected to bear some of the burden. Many day users would pay via rents on hotels and condominiums, which in turn would be taxed to pay for beach maintenance.

Current population projections indicate that we can expect increasing development in coastal areas where property may be at risk from storm and flood damage. Wider beaches reduce the risk of damage, but they continually move and require periodic maintenance. An equitable system of beach maintenance cost sharing, whether on public or private beaches, will encourage wise and more efficient land use. When property owners do not have to pay for beach protection, they are more likely to choose riskier (i.e., erosive) locations. Requiring residents to pay for their share of beach maintenance will induce more rational decision making about where to locate and how best to mitigate the risk of property loss.

We expect that further study of beaches will provide more accurate estimates of aggregate benefits from wider beaches, how benefits are distributed, and how fees should be assigned.

Notes

1. Other studies that use proximity to beach as a measure of beach-related benefits include Milon, Gressel, and Mulkey (1984), Edwards and Anderson (1986), Parsons and Wu (1991), and Smith and Palmquist (1994). The studies do not measure the value of beach width.

2. We do not include a variable for the presence of protective devices, which would be capitalized into property values. Less than a dozen oceanfront properties are protected by a structure on Seabrook Island, and only 2 of those properties are in our database.

3. Middle Beach varies over time from a minimum of 189 feet to a maximum of 496 feet.

4. We also tried a dummy variable indicating ocean frontage, but because frontage was strongly correlated with ocean view, we used only ocean view.

5. When the dependent variable is in the log form, the estimated coefficient of the dummy variable must be transformed by using the formula: 100 ($e^{(B1)}$ – 1)%, where B1 is the coefficient of the dummy variable (Kennedy, 1981).

6. We use the mean values of the variables and the implicit function theorem to calculate marginal benefits: P/W (Bw) where P is the price of the property, W is the beach width, and Bw is the coefficient of beach width.

7. We use mean values of variables and the implicit function theorem to calculate marginal distance: P/DBHT (Bdbht) where P is the price of the property, DBHT is the interaction variable, and Bdbht is the coefficient of the interaction variable.

8. In both the linear and semilog models the order of marginal valuation between the three categories of properties is the same.

9. We use the model from our study, although in our analysis, proximity to Middle Beach did not have a significant impact on property value. We do so for illustrative purposes. This may be a concern of using this approach, since various site-specific conditions may determine the value of wider beaches.

10. The average value of developed property is $363,430, $204,440, and $129,270, respectively, for oceanfront, oceanview, and inland property. The average value of undeveloped property is $256,840, $235,140, and $41,768.

11. We use only the beach width variable and not the interaction variable in the calculations. When the interaction variable is included, properties inland increase very little in value from the nourishment project. However, a zero fee would not be practical or reasonable, since it likely that some benefit is received from wider beaches even for properties not directly on the oceanfront.

12. We average together developed and undeveloped properties, although percentage differences between the two categories vary somewhat. We simplify the results in order to facilitate implementation.

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