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Developing a building policy for the erosion zone Solutions to some key (Dutch) questions

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Abstract

In those coastal communities where the most seaward strip of mainland consists of dunes, these dunes often serve as a flexible sea defence. In addition, this strip offers large potential for housing and commercial enterprises. Unfortunately, due to severe storm surges part of this strip (the erosion zone) is subject to erosion, and as a result of which any buildings or infrastructure located here, are destroyed. Therefore, as we will illustrate in this paper, a building policy for this zone should reflect a compromise between two opposite interests: exploitation of the existing potential and, prevention of an unacceptable high risk due to erosion. Accordingly, the authors have developed a framework for such a building policy on the basis of which the desirability of various different types of investments and the location within the erosion zone of such investments can be determined. The examples that are used to illustrate this framework in this paper are limited to experiences in The Netherlands as relevant data and experiences are available and relatively easy accessible here. Nevertheless, the approach as is described is generic and applicable worldwide suggesting that the discovered unused potential for exploitation is not just limited to The Netherlands.

Keywords: Coastal zone management; Severe storm surges; Damage due to storm surges; Building policy; Spatial planning; Investment decision

1. Introduction

Sand dunes are part of the coastal zone in The Netherlands along most of its coast. The most seaward sections of these dunes have three distinctive functions: sea defence for the inland areas that lie below sea level (main function), living environment and natural habitat.

During storms and increased hydraulic conditions the function as a sea defence can be clearly witnessed, as the dunes will erode at relatively high rates. Probabilistic calculation methods have been developed (CUR/TAW, 1989/1984; Van de Graaff, 1986) to assess the expected erosion rate of the dunes during storms. In the event that the hydraulic circumstances occur for which the sea defence is designed, a width of roughly 80 m of the dunes will erode. (The Dutch design conditions require that the frequency of exceedance of a breach of the dunes is smaller than 1/100,000 per year. This is required for those dunes that protect the most important and populated parts of The Netherlands; in other regions the design frequencies of exceedance are slightly larger.) The section of the dunes that is sensitive to these erosion processes during (Dutch) design conditions is called the *erosion zone* in this paper.

Although from a sea defence management point of view it seems attractive to keep the entire erosion zone free from infrastructure and buildings, this is, however, not realistic. Part of this erosion zone is actually very suitable and popular for building purposes, as is the case in so-called coastal villages at present. For those responsible for the development of a building policy for the erosion zone, the combination of the commercial potential of buildings and the chance of erosion in this zone offers a coastal management dilemma, because when storm

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surges erode away the dunes, they will also destroy the buildings that have been constructed on them. Nevertheless, as we will demonstrate in this paper, the associated risk of destruction of buildings in the erosion zone can be financially justified to a certain extent as a result of the mostly very high commercial potential.

The building policy should therefore reflect a compromise between two interests: exploitation of the existing potential and, prevention of an unacceptable high risk due to erosion.

In this paper we will illustrate our view on how to develop such a building policy for the erosion zone by answering four key questions that most coastal zone managers will have to face:

1. What buildings and structures should be allowed at which locations in the erosion zone at this time and why?
2. Regarding the situation in the future; how should we deal with the effects of future sea level rise (and climate change) in the erosion zone?
3. How should we deal with the responsibility of damage?
4. How should the present development be managed in the near future?

In the next section a detailed illustration is given of the relations between the relevant aspects within the erosion zone and from there we will explore the different key questions in the subsequent sections.

Coastal zone managers also have to combat structural erosion (relatively slow erosion because of the occurring morphological processes). Adequate coastal protection schemes are then often needed. Apart from ‘hard’ structures such as groynes or detached breakwaters, ‘soft’ methods such as regular artificial beach nourishments or shoreface nourishments prove to be very suitable solutions. In The Netherlands these nourishments help to keep the beach and dunes at the same heights and locations, as the Dutch official policy requires. In this paper we will not consider structural erosion but only the erosion that results from a severe storm surge (relatively fast erosion, which is unpredictable both in magnitude as in time). This type of erosion is the only real risk of erosion in our approach.

2. Relations between the relevant aspects within the erosion zone

2.1. Hydraulic forces; dune profile; chance of erosion

In case the hydraulic forces within the coastal zone remain unchanged, the dune profile will also not change. Some kind of an equilibrium profile develops; the shape of this profile depends on the fall velocity and diameter of the sand particles, and the characteristics of the wave climate (e.g. Vellinga, 1986). In this situation the transport of sediments in onshore and offshore direction is equal, seen over a longer period of time (e.g. a year).

In case of a sea level rise, a well-known model relating the resulting shoreline retreat is proposed by Bruun (1962; 1988). The process is illustrated in Fig. 1 where the new equilibrium can be seen as a result of the sea level rise.

In case of a storm however, the hydraulic conditions change temporarily; higher waves, longer wave periods, higher wind velocities, higher sea levels or a combination of these will occur. This will lead to a relative fast retreat of the upper part of a cross-shore profile and dune erosion occurs during the storm. The seaward transport of sediment is temporarily much higher than the landward transport.

The most important variables that represent the forces during storms that contribute to erosion are the significant wave height (H_s), wave period (T_p), the water level (h_w) and the duration of the storm (D).

$$\text{Forces} \approx \varepsilon\left(H_s, T_p, h_w, D\right) \tag{1}$$

The rate of retreat (Δx) of the dunes during a specific storm depends on the volume of sand (and the specific diameter of the sand particles) in the cross-shore profile. Research done in The Netherlands in the eighties on dune erosion, has resulted in the development of a method to calculate the safety of the dunes as sea defence (CUR/TAW, 1989/1984). This research has shown that the rate of erosion depends on a large number of variables (7). The preferred calculation method was based on a probabilistic approach, which used a predefined chance of failure of the dunes.

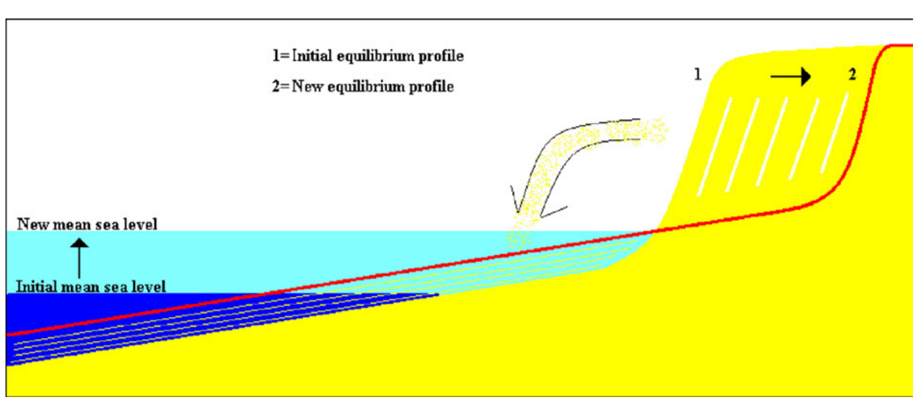

Fig. 1. Profile change caused by sea level rise (“Bruun rule”).

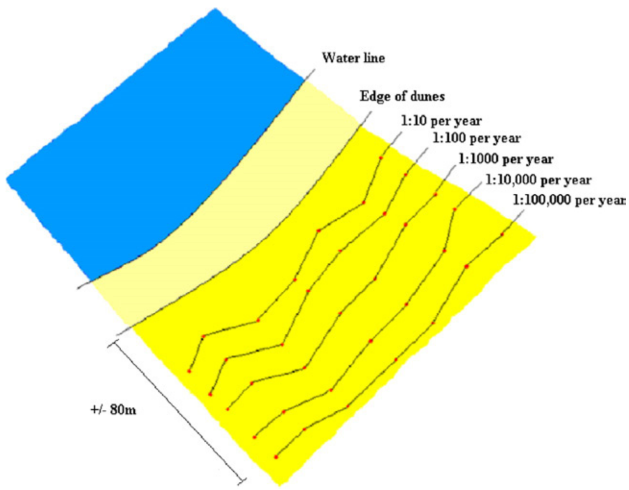

Fig. 2. Example of erosion contour lines.

[Recently the method has been modified. Based on large-scale flume tests in the so-called Delta Flume of Delft Hydraulics the effect of the peak period of the wave spectrum on the rate of dune erosion has now been included in the design method. See e.g. Van Gent et al., 2006 and in *preparation*.]

Such a calculation method can also be used to determine the frequency of exceedance of erosion for a certain point in a cross-shore profile. Once a point with a certain frequency of exceedance is calculated in a cross-shore profile, then a similar point with the same frequency of exceedance in a different cross-shore profile can be calculated. When these points are known they can be connected to form an erosion contour line. In Fig. 2 an example of a plot of these erosion contour lines is given.

In general the distance between the edge of the dunes and the landward boundary of the erosion zone (the erosion contour line with a frequency of exceedance of $1*10^{-5}$ per year) is approximately 80 m under Dutch conditions.

In many countries with coastlines like The Netherlands (i.e. where sand dunes and beaches are present) governments have put effort into defining the risk of erosion along the coast. In The Netherlands however, the dunes also have to protect the lower, heavy populated inland areas from flooding so a lot of effort has been put into really understanding the risk of erosion. The Dutch government keeps track of all the dunes along the coast as a matter of survival, so there are few countries like The Netherlands that need to have such a good understanding of the risk of erosion of its coastline. This understanding will become an essential asset for all inhabited coastal areas as their populations are rapidly increasing.

2.2. Stakeholders; commercial potential; development

The group of direct stakeholders in the erosion zone is rather large, and therefore the stakeholders are divided into three (more) specific groups:

- The stakeholder group of “house owners”.
- The stakeholder group of “business owners”, who own hotels, restaurants and bars.
- The “general public” consisting of tourists and inhabitants of possible flood areas behind the dunes.

The commercial potential of a possible investment in the erosion zone that these stakeholder groups finance, depends on the position in the erosion zone. We should not only differentiate for the position within the erosion zone, but also for each type of investment.

In general the commercial potential of a certain building plot, building or business, represents the attractiveness for a potential investor to invest in and depends on a number of criteria. These criteria can be divided into financial and social (preference) criteria. One of the most influential criteria in the coastal areas is whether the property has a sea view or not. This criterion alone can in certain areas and situations increase the market value of a property with 100%. An overview of these criteria is illustrated in Fig. 3.

For each stakeholder group the set of criteria is slightly different, because not all criteria are relevant for each type of investment. Because the building space in the erosion zone is limited, and in most coastal communities has run out, the effort stakeholders make to ensure they exploit the available commercial potential leads to conflicts between them. The building policy in this case should be a combination of rules and regulations that leads to the desired compromises between all stakeholders.

After considering the commercial potential and the possibilities within the building policy the different stakeholders in the erosion zone will decide to invest in specific plots or buildings etc. The result is the actual spatial layout of buildings and structures, or simply development, as it will be referred to in this paper.

2.3. Chance of erosion; development; risk

Any development in the erosion zone is subject to the chance of destruction because of erosion during a severe storm surge.

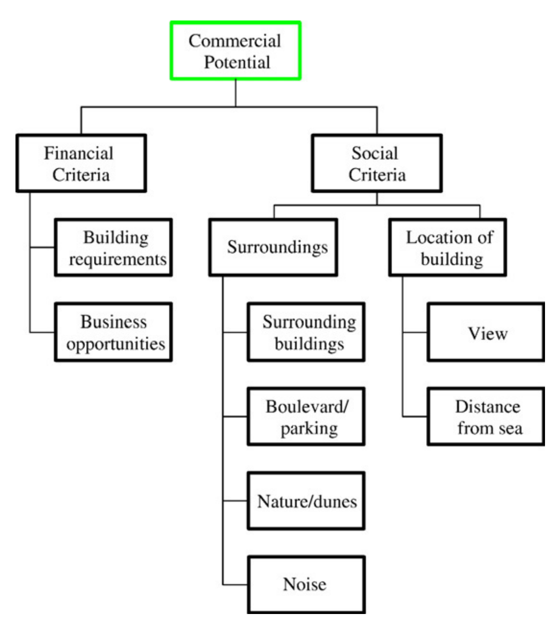

Fig. 3. Overview criteria of commercial potential.

The common (scientific) definition of risk is a combination of the probability that a hazard will occur and the (usually negative) consequences of that hazard. In essence it comes down to the following expression:

$$R = P_f * C_f \quad (2)$$

Where:

R: Risk [Euro per year]
P_f: Probability of the hazard occurring [per year]
C_f: Consequence of the hazard [Euro]

The definition of risk can be applied to different values in the erosion zone and to different hazards. The hazard in this case is, logically, the dune erosion during a severe storm surge and the consequences range from the loss of objective to subjective values.

To assess the actual expected damage of a building depends on the actual erosion processes around the building in case of a disaster, and the strength of the building. At the moment there is still a lot of uncertainty regarding the actual influence of buildings on the erosion processes. The assumption made here is that when a building is situated along a specific erosion contour line, with the seaside of the building on the contour line, the building will be totally destroyed when a disaster occurs with the frequency of exceedance of the specific erosion contour line.

The actual risk perception will always differ per individual, because the perception of the probabilities and consequences will differ per individual. For this investigation we have therefore tried to minimize some of the biases in risk perception by dividing risk into financial and social risk aspects.

The total risk involved is calculated with the probability of the disaster and the loss of all types of value. These losses of values are then divided into financial and social values. Financial loss occurs after a disaster when a house owner loses his property and thus his investment, or when a business owner is unable to generate income. Also the costs of reclamation works that could be needed to speed up the recovery of lost land might be considered as (part of the) financial loss. Besides financial loss, social or emotional loss can be a result of a disaster, which occurs when people lose value, which is irreplaceable. An example of this would be the loss of a historical building, or the loss of a given safety perception. The loss of safety perception works like this: in case disasters have not occurred in the recent past, the safety perception will in general be that the situation is safe (as is the case at present). People are confident and only the oldest generations have a recollection of a disaster in the past. In case of a disaster this perception will change into an unsafe perception, resulting in an immediate devaluation of property, affecting the whole erosion zone. In Fig. 4 an overview of the risk criteria is illustrated.

(Starr, 1969, identified that society reaches equilibrium in its judgment of risks. However, the low frequencies with which erosion disasters occur in The Netherlands presently result in an unrealistic positive safety perception, because of the lack of awareness of risk.)

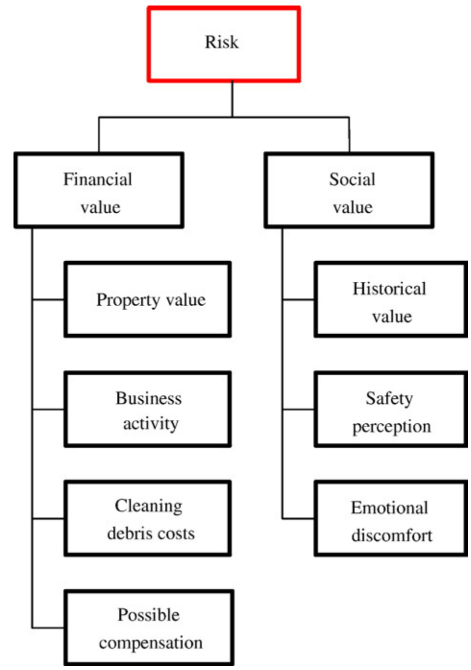

Fig. 4. Overview of risk criteria.

Obtaining the values of financial risk is relative straightforward; most of the values are available through the real estate and construction markets. Obtaining the value of the social risk is not so straightforward since it requires for instance that a value for the emotional loss is obtained, which will depend highly on the perception of the individual. (For this reason we have used the contingent valuation method, e.g. a survey, to assure that we obtain the correct perception of these individuals.)

2.4. Risk; stakeholders

The awareness of the stakeholders of the risk of erosion is essential, but unfortunately there is at present little knowledge on the actual risk amongst citizens, lower government authorities and beyond. This was, however, different in past centuries, when citizens used to be more aware of the danger of the sea. Over the last couple of decennia citizens have had great confidence in the erected (coastal) protection works, which are the result of powerful technical solutions.

In reality stakeholders should take into account the available commercial potential, the building policy and risk of erosion before being able to make any sound investment decision in the erosion zone.

2.5. Stakeholders; dune profile; development

Besides the building policy, the stakeholders have the possibility to directly alter two aspects within the erosion zone; they have the possibility to alter the shape of the present development and development plans as well as the shape of the dune profile. These possibilities also provide the opportunity to indirectly alter the value of risk and commercial potential. Two methods of reducing risk in the erosion zone can be identified:

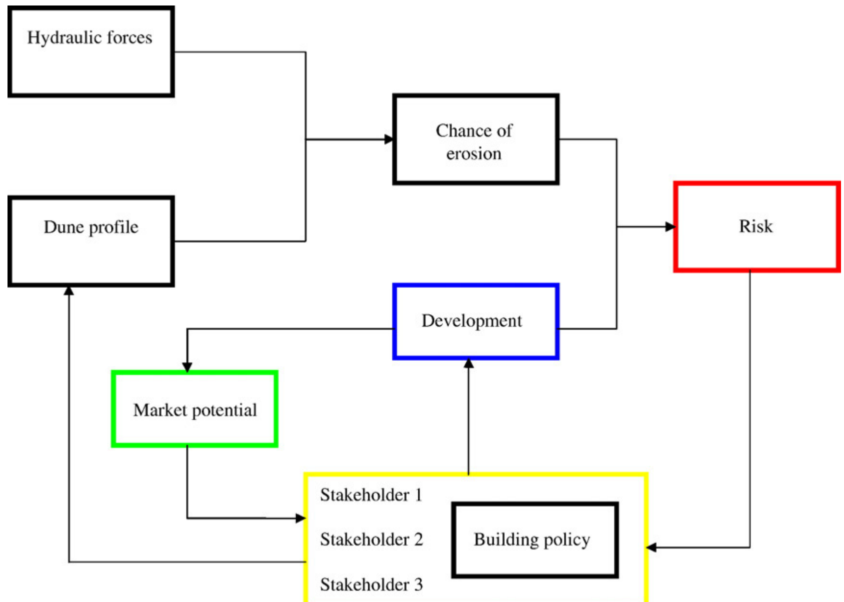

Fig. 5. Schematization of relevant relations in the erosion zone.

(1) reducing the value of the development can decrease the consequence of erosion and thus the risk and (2) increasing the strength of the dunes, or that of the buildings (foundations), can reduce the probability of the hazard, and thus the risk.

2.6. Overview of all relations

Fig. 5 illustrates all relations between the relevant aspects in the erosion zone, which have been discussed in this chapter.

3. Which buildings should be allowed in the erosion zone and where?

To answer this key question, we must investigate ways of dealing with the available commercial potential and risk in the erosion zone (Fig. 4).

A decision model was developed that uses both the value of the available commercial potential and risk (and both the financial and social aspects of these).

To be able to valuate the available commercial potential the hedonic regression method was used.[2] Similar investments inside and outside the erosion zone, but within the same urban coastal area, were compared regarding their respective commercial potential (Winckel, 2005). This enabled us to valuate the commercial potential of certain specific criteria, for instance the value of the availability of a sea view.

To valuate the risk the value of all financial and social aspects of the property were used together with the frequencies of exceedance of the specific erosion contour lines.

[2] In economics, the hedonic regression method, or more generally hedonic demand theory, is a widely used method of estimating demand or prices. It decomposes the item being researched into its constituent characteristics, and obtains estimates of the value of each characteristic. A good example of the use of this method is illustrated by Nelson, 1978.

3.1. Detailed description of the decision model

The Initial Value (IV) is considered to be the value of a specific type of investment outside the erosion zone (but within the coastal area), where there is no risk of erosion. Then the erosion zone is considered, where the difference in value of the exact same investment depends (should depend) on the difference in commercial potential and risk in the erosion zone.

Compared to the IV, the difference in value of the investment in the erosion zone due to the difference in commercial potential in the erosion zone (which value can be rather high) is called the Hedonic Value (HV), which is calculated with the hedonic regression method.

Besides this, the investment in the erosion zone is subject to risk. This risk contributes (should contribute) to devaluation of the investment. The value of this devaluation is here called Devaluation by Risk (DbR). By adding these values (IV+ HV+ DbR) the Total Value (TV) of the investment in the erosion zone is calculated; meaning the new calculated market price. This TV then represents the value of an investment in the erosion zone that was valued at the IV outside the erosion zone. In Fig. 6 an illustration of the calculation of the TV is given.

The different values in this diagram are different for each stakeholder group as the criteria of the commercial potential and risk are not completely the same for all stakeholders. Most importantly, the decision whether to invest can be made after all these aspects are properly valuated and then the key criterion for investing is that the HV of the building in the erosion zone is equal, or more than the (absolute value of) DbR. If the HV is less than the (abs.) DbR the return on the investment will be lower (or even negative) compared to the return on the same investment outside the erosion zone, which was our initial benchmark.

Besides for new investments, this criterion also holds for an existing property in the erosion zone that could be bought. In a

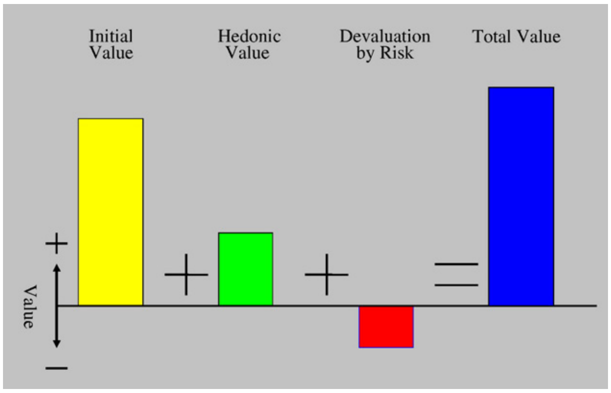

Fig. 6. Valuation diagram of investment.

transparent market the acquisition price (TV) of a building with a larger DbR than HV would be less than the value of a similar property outside the erosion zone (IV). In that case the unfortunate result would be that the required maintenance investments, which values are directly related to the IV and not to the (lower) TV cannot be financially justified in this case and the property value would eventually plummet due to dilapidation. This sounds drastic, but as we will see, in the case that the HV is less than the DbR the building will be situated close to the sea (within approximately 30 m). At these locations the chance of destruction (and thus DbR) increases drastically with every meter closer to the sea.

The final investment decision should therefore depend on the criterion:

$$\text{Hedonic Value} \geq \text{Devaluation by Risk} \quad (3)$$

West et al., 2001 also identified this fundamental balance between exploiting the available commercial potential and averting too much risk. They are, however, more concerned with the effect of sea level rise on investments. Here we will go in much more detail on what specific locations in the (present) erosion zone are suitable for specific investments.

We will answer the key question of this section now by using this decision model for three different types of building investments. Three types of buildings have been chosen that are considered to be good examples of the majority of buildings (structures) in the erosion zone and represent all the stakeholder groups, viz.: (1) an investment in a house; (2) an investment in a hotel and (3) an investment in a boulevard.

These three examples will be discussed here using data obtained from the investigation areas Noordwijk aan Zee and Katwijk aan Zee (coastal villages) in The Netherlands.

3.2. Using the decision model for an investment in a house

The IV of the house consists of the value of the building itself (Building Value, BV) and the value of the plot, which is situated in a specific coastal area, but outside the erosion zone ("in landward direction") and is valued using the market price method. The market determines this value and all future costs and benefits that are related specifically to this type of house, including general maintenance costs, taxes and benefits that derive from it, will be represented in this value.

The HV represents the additional increase in market value of a (reasonably) similar house that is now situated within the erosion zone of the same specific coastal area (so that the possible influence of differences between regional house markets are excluded). By similar we mean a building and plot of the same design, materials and sizes. This increase in market value is the result of an increase in commercial potential in the erosion zone. To calculate this HV, the hedonic price method can be used along with information provided by real estate specialists. The hedonic value (HV) can then be expressed as a percentage of the initial value (IV).

By using the results of a survey done amongst homeowners in the investigation areas and several interviews with real estate brokers, it was concluded that the additional commercial potential in the erosion zone solely depends on two criteria: the proximity of the sea and the possibility of sea view from the house. With the help of an extensive database of market prices of apartments both in and out of the erosion zone the HV's relating to these two most important market criteria, location near the sea and view of the sea, were obtained. These respective HV's in the (investigated) coastal villages in The Netherlands have an average value of 50% and 100% of the IV. We will refer to these as being factors of the HV of respectively 0.5 and 1 times the IV. This means that the value of a house with a sea view is twice the value of a similar house outside the erosion zone, without any sea view. This is in fact quite remarkable as these two houses could be located only a couple of hundred metres apart.

The actual costs of this HV for the investor depends on the method that is used to finance the investment. In this paper one option is considered: the investment is financed with capital from the investor. The yearly cost for the investor of the HV can then be expressed as:

$$\text{Yearly cost of HV} = r * \Delta * \text{IV}(\text{Euro/year}) \quad (4)$$

Where:

HV:	Hedonic Value [Euro]
r:	real rate of interest [per year]
Δ:	factor of Hedonic Value [–]
IV:	Initial Value [Euro]

It is considered appropriate to use a safe assumption for the real rate of interest, and therefore a real rate of interest of 2% is used.

The risk of the investment is calculated using the chance of destruction of the house per year and the resulting loss of value. This loss depends on both financial and social criteria (see Fig. 3). The financial loss consists firstly of the loss of property value, which in the case of this risk assessment is considered to be valued most appropriately by the replacement cost of the building (the plot will be reclaimed by the government, as this is part of the sea defence, or by natural restoring sediment transport processes). Furthermore, the loss consists of the value of assets within the house (i.e. furniture, jewellery etc), the cleaning costs of the debris and a possible (partial) compensation by an institution such as the government.

After investigation the emotional discomfort proved to be the most important social loss criteria. (The criteria of safety perception can only result in a significant devaluation of the property in case the frequency of damage is of the same magnitude as the frequency with which the property ownership changes. In short, this has to do with the capacity to pass on the awareness of natural disasters and tragedy across different generations.)

To come to a conclusion we will have to quantify the different values and this has been done for our specific investigation areas.

The replacement costs of the building were quantified with the help of estimates of real estate brokers and these were calculated as a factor α (α=0.65) of the building value (the building value BV is the IV minus the value of the plot).

The cleaning costs of the plot have been obtained through estimates of demolition specialists and are calculated by multiplying the IV of the property with a factor β (β=0.015). The government will pay the cost of the reclamation works of the plot, as the plot is part of the sea defence. The sea defence must be reconstructed to provide the necessary safety for the inland areas and therefore these reclamation costs are excluded in the valuation.

The value of furniture and other assets inside the building is rather significant. From insurance policies it can be concluded that the value of assets in houses, like furniture and electric appliances etc. can also be related to the initial value and are expressed as a factor λ of IV (λ=0.29).

The social risk, consisting of emotional discomfort, is somewhat more difficult to quantify. Here the emotional discomfort has been quantified with the contingent valuation method by relating this value to the specific financial loss. (This tool has also been used by Polomé et al., 2005, amongst other valuation tools, for quantifying social values in coastal areas.) About 60% of the owners valued the emotional discomfort in the range of 40–60% of the financial risk, 30% valued this lower and 10% higher. The emotional discomfort has therefore been taken at an average of 50% of the financial risk. The risk of the emotional discomfort is calculated as a factor γ of the total financial risk (γ=0.5).

Because present legislation states that all risk in the erosion zone is the responsibility of the owner/investor, compensation in this valuation is zero. For illustrational purposes this compensation is included in the valuation and expressed as a factor δ of the resulted financial damage.

The total yearly risk is then the sum of the yearly financial risk and the risk of emotional discomfort, minus the possible compensation. Combining the different aspects of the annual risk [DbR] in one equation gives:

$$\mathrm{DbR} = P_f((\mathrm{BV}^*\alpha) + \mathrm{IV}^*(\beta+\lambda))^*(1+\lambda)^*(1-\delta)(\mathrm{Euro/year}) \tag{5}$$

Where:

P_f: chance of destruction [per year]
BV: Building Value [Euro]
α: factor of replacement cost [–]
IV: Initial Value [Euro]
β: factor of cleaning debris cost [–]
λ: factor of assets value [–]
γ: factor of emotional discomfort [–]
δ: factor of possible compensation [–]

Remark:

The fact that apparently no risk is taken into account in the present market prices in The Netherlands has serious financial consequences, which will certainly be encountered when a disaster occurs. DbR is in fact not considered at all at the moment, and so the TV is at present IV +HV. (At the moment this is, however, very helpful in valuing the HV.)

The most important criterion remains: whether the HV is higher than the DbR, which means, as far as the housing market is concerned, that the yearly cost of capital to acquire the HV (r ∗ HV) must exceed the yearly cost of risk.

When r∗HV and the yearly cost of risk are equal, this means that the willingness to pay for living in the erosion zone is equal to the risk. The market value (TV) of such an investment is equal (should be equal) to that outside of the erosion zone because these two values cancel each other out. With regard to the erosion contour lines, it can be concluded that a maximum frequency of destruction, because of erosion due to a storm surge is found, and the distance between the sea and the location of this house cannot (should not) decrease any further.

Using Eqs. (4) and (5) for the yearly cost of HV and risk, the following equation can be derived where the maximum acceptable chance of destruction (P_{face}) is found:

$$P_{f\,\mathrm{acc}} = \frac{r^*\Delta^*\mathrm{IV}}{((\mathrm{BV}^*\alpha)+\mathrm{IV}^*(\beta+\lambda))^*(1+\gamma)^*(1+\delta)}\,(\text{per year}) \tag{6}$$

With the use of the values obtained from the investigation areas, the maximum acceptable chances of destruction can now be calculated. The calculations have been made for a house near the sea, without sea view and a house with sea view. [r=0.02; Δ=0.5 or 1; BV=0.72∗IV; α=0.65; β=0.015; λ=0.29; γ=0.5; δ=0].

With regard to the erosion contour lines, the locations suitable for building houses without sea view have a maximum acceptable frequency of erosion of ≈1/120 per year and houses with sea view ≈1/60 per year. In the investigation areas these frequencies correspond to locations within 25 to 20 m from the edge of the dunes (where the dunes and beach meet). In Fig. 6 an illustration is given of the values of the HV and the (capitalized) risk as function of the location, or distance to the sea. The TV of the investment can be calculated by adding the IV, HV and DbR (negative) for a specific location and investment. Locations A and B in Fig. 7 then represent the minimum acceptable distances to the sea/edge of the dunes, respectively for houses with sea view and houses without sea view. [In an entirely transparent market the TV of a house (sea view) at location A and the TV of a house (without sea view) at location B should be equal to IV.]

From Eq. (6) it can be concluded that changes in time of the IV (and BV) have no influence on the outcome of the maximum

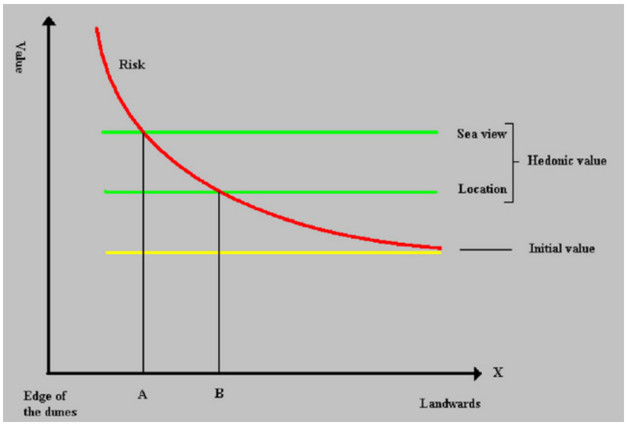

Fig. 7. HV and risk as a function of the location (not to scale).

acceptable chances of destruction. However, changes in time of the values of the real rate of interest and the factors Δ, α, β, λ, γ and δ will result in different maximum acceptable chances of destruction in time. In the event that a valuable prognosis of the future values of these factors becomes available, the maximum acceptable chance of destruction can then be calculated by discounting all costs (DbR and $r*$HV) during the expected investment duration back to the year of the investment decision ($t=0$) by using the corresponding rates of interest and factors from the prognosis. In this paper the changes of these values in time are considered to be nil, assuming we are able to obtain useful averaged values (from long term data sets) for the real rate of interest and the different factors that need to be imputed.

3.3. Using the decision model for an investment in a hotel

The valuation of a business such as a hotel is obviously very different from that of a house, but nevertheless the same valuation diagram as in Fig. 5 is applicable. The basic underlying idea used in this valuation, is to calculate the possible increase in net profit that the commercial potential of locations in the erosion zone provides (HV) in relation to those locations, without this commercial potential, outside the erosion zone. The criterion of a financially justifiable investment in the erosion zone is whether the net increase of profit (HV) exceeds the cost of risk.

The Initial rate of Return On an Investment (Initial ROI) in a hotel is introduced as the ratio of the yearly net profit and the Replacement Cost (RC) of the hotel building outside of the erosion zone. The RC of the building is used because a reliable market value is very difficult to obtain for a hotel.

$$\text{Initial ROI} = \frac{\text{Net profit}}{\text{RC}}(\text{per year}) \quad (7)$$

The Hedonic rate of Return On Investment (Hedonic ROI) is the ratio of the potential increase of net profit of a hotel situated in the erosion zone, compared to a similar hotel situated outside the erosion zone, and the RC of the building.

$$\text{Hedonic ROI} = \frac{\text{Potential increase in net profit}}{\text{RC}}(\text{per year}) \quad (8)$$

The potential increase in yearly net profit of a hotel in the erosion zone depends on the criteria of the commercial potential. For a business owner the same criteria for the commercial potential are important, as are for the house owner, only some additional criteria need to be added. The business opportunities, together with some extra maintenance costs in the erosion zone, are important. To calculate this hedonic value, the expert judgement of the business owners and the hedonic price method can be used, supplemented with differences in prices of, for instance, hotel rooms. The results that were obtained from a market research, a survey and several interviews, show many similarities, and lead to the conclusion (for the investigated area) that a hotel close to the sea with sea view can increase the sales price of rooms with an average of at least 15%, in comparison to a hotel outside the erosion zone, or not close to the sea.

Furthermore, a distinction must be made between rooms with or without sea view. Rooms with sea view can have an estimated average price increase of 20%, and without sea view 10% in comparison to hotels outside the erosion zone.

To obtain the resulting net profit of the hotel because of the increased sale prices and maintenance costs, it is essential to use the profit/loss statement of the specific business. The increased values are simply imported in the profit/loss statement, to obtain the resulting profit.

The risk is introduced in a similar way; a ratio will be used of the Total Risk and RC of the building. This will be called the Risk Ratio:

$$\text{Risk Ratio} = \frac{\text{Total Risk}}{\text{RC}}(\text{per year}) \quad (9)$$

The financial risk is calculated with the chance of destruction and the value of the objects (building and assets; $\lambda=0.17$ in case of a hotel) and the cleaning costs ($\beta=0.01$).

Besides this, a disaster will result in a loss of business, as no revenues can be expected without a hotel building. The duration and amount of this loss is quantified using the expertise of business owners. The duration is estimated at 4 years and the yearly loss is estimated to be equal to the yearly operational costs (YOC).

The social risk, or emotional discomfort (the safety perception, as in the example of the house, is disregarded), depends largely on the amount of invested capital of the specific investor, and on the emotional attachment to the business. The risk of the emotional discomfort is calculated as a factor γ, of the total financial risk and is quantified using the opinions and expertise of the business owners ($\gamma=0.3$).

In this example the possible compensation is nil, but will be illustrated in the equation. This compensation is given as a factor δ, of the resulted financial damage.

The total risk is then the sum of the financial risk and the risk of emotional discomfort, minus the possible compensation. Combining the different aspects of risk in one equation then results in:

$$\text{Total risk} = P_f(\text{RC}*(1+\beta+\lambda)+\text{YOC}*D_{\text{loss}}) *(1+\gamma)*(1+\delta)(\text{Euro/year}) \quad (10)$$

Where:

P_f: the chance of destruction [per year]
RC: the replacement cost of the building [Euro]
β: the factor of cleaning costs [–]
λ: the factor of assets value [–]
YOC: yearly operational costs [Euro/year]
D_{loss}: duration of loss [years]
γ: factor of emotional discomfort [–]
δ: factor of possible compensation [–]

In the situation that the Hedonic ROI and the Risk Ratio are equal, it can be concluded that the increase of net profit in the erosion zone is equal to the extra cost of the risk involved. The result is that the net profit of this hotel at this location in the erosion zone is equal to that of a similar hotel outside of the erosion zone. The chance of destruction of this location is then the maximum acceptable chance of destruction, P_{facc}, and is reached when:

$$\text{Hedonic ROI} = \text{Risk Ratio} \quad (11)$$

Filling in the different equations and rewriting leads to:

$$P_{f\text{acc}} = \frac{\text{Hedonic ROI*RC}}{(\text{RC*}(1+\beta+\lambda)+\text{YOC*}D_{\text{loss}})\text{*}(1+\gamma)\text{*}(1-\delta)} \text{(per year)} \quad (12)$$

With the use of values obtained from the investigation areas, the maximum acceptable chances of destruction can now be calculated. In the present example the following data (assuming a moderate hotel and based on some expert estimates) have been used: RC=Euro 1,500,000; β=0.01; λ=0.17; YOC= Euro 1,000,000; D_{loss}=4 years; γ=0.30; δ=0. Filling in this data gives the following relation:

$$P_{f\text{acc}} = 0.20\text{*Hedonic ROI(per year)} \quad (13)$$

Winckel (2005) compared different hotels and calculated Hedonic ROI's for the situation where the hotel is situated near the sea without sea view (0.06 per year), and for the situation where the hotel has sea view (0.12 per year). These figures mean that the yearly additional profit due to the favourable location of the hotel is 6%, and 12% of the replacement costs of the hotel.

The maximum acceptable chances of destruction can next be calculated with Equation (13). For the hotel without sea view a chance of ≈1/85 per year is found, and for the hotel with sea view a chance of ≈1/42 per year.

For the hotel the same can be said as for the houses: the resulting maximum acceptable chances of destruction for hotels with and without sea view are in reality related to locations very close to the beach and rather close to one another. (The distance between the erosion contour lines with frequencies of exceedance of 1/42 and 1/85 per year, is in fact only a few metres.)

3.4. Using the decision model for an investment in a boulevard

Boulevards come in many sizes, shapes and are always built to serve a specific local purpose. Unlike the investments in a house or hotel the investment decision in a boulevard is mostly made at a communal or national level, because of the shared benefits that are obtained throughout the community or nation and because of the large cost involved. To make the example of the boulevard worthwhile we will first have to make a distinction between at least two totally different types of boulevards.

1) The most common boulevard type is that of a 'hard' structure located close to the beach and parallel to the shore, consisting of an almost vertical section (seawall) and a horizontal section. The horizontal section may be used for easy walking and driving, and for hosting kiosks at the boulevard itself. On the landward side of the boulevard, houses, hotels restaurants and bars are assumed to be present. The vertical section of the boulevard then forms a clear and stable transition between beach and mainland. If, in such a case, the boulevard is well designed and well constructed, the boulevard structure might prevent erosion of the mainland due to storm surges to a certain extent.

A boulevard that must be stable under the most severe conditions will become very costly, but boulevards that are designed to prevent erosion due to storms with an intensity that is exceeded up to frequencies of say 1/300 per year, are easier to build. Such a boulevard is apparently able to adequately protect houses and hotels that are presently located above this limit as calculated in the previous paragraphs (frequencies of exceedance ≈1/40 to 1/150 per year).

2) A boulevard without a (strong) vertical section is in fact a sea-route; at the seaward side of the boulevard some primary dunes will be present. Such a boulevard does not offer serious 'protection' to the structures at the landward side of the boulevard.

If, with the construction of the boulevard also coastal protection issues are involved as in type 1), then the central government has a role, but generally this is mostly the responsibility of the local government. Since it is difficult (and often even impossible) to transfer individual benefits to governmental investments, the valuation process of an investment of a boulevard of type 1) is often done at a higher level of aggregation. A cost/benefit analysis might be used, in which the benefits for the whole society are taken into account. This cost/benefit analysis will not be detailed further in this paper, but by using even a rough (partial) estimate of the benefits, it becomes clear that boulevards can contribute significantly to the increase in value of the most seaward houses and hotels.

[Consider e.g. a boulevard of 1 km that protects 40 houses. The houses at first had an average DbR of 0.02* IV per year (maximum DbR for sea view house, which is equal to the annual cost of HV), but because of the presence of the boulevard the chance of destruction is decreased from 1/75 per year to 1/300 per year and therefore the DbR decreases to 0.0054* IV. Presuming that the IV is on an average Euro 350,000, a contribution to the total benefits of these 40 houses is already Euro 210,000 per year.]

Only the boulevard type 2) will be discussed in this paper because investing in a type 1) boulevard is often an attempt to increase the HV of the erosion zone and simultaneously decrease the risk, and this requires a somewhat different evaluation. Moreover, in this chapter we are discussing what are suitable locations in the erosion zone for different types of (new) investments. A boulevard of type 1) will mostly be considered in regions where previous investments (i.e. houses, hotels etc.) are situated at locations in the erosion zone where their DbR is higher than their HV. The boulevard is then one of the options that can be used to "save" these investments (i.e. increase the value to at least the IV).

Because the decision to build a boulevard of type 2) and the provision of the necessary construction funds, are (at least in The Netherlands) governmental responsibilities the investor is now not an individual as before but consists of a large group of investors all with different values. This unfortunately introduces more complexity into the decision model.

Nevertheless we can still use the decision model if we are able to obtain correct values for the IV, HV and DbR as we have done previously. Similar to a house or a hotel in the erosion zone, a boulevard along the sea has to some extent a hedonic value HV. This is especially true for a boulevard of type 2); a sea-route in the erosion zone might be easily compared to a route outside the erosion zone (farther from the sea). [For a boulevard of type 1) a realistic counterpart outside the erosion zone does not exist.]

The financial involvement of the local community of inhabitants, homeowners and business owners in the construction costs of the boulevard is now somewhat indirect; e.g. via taxes.

To continue this boulevard example, it is considered most appropriate to use a specific case. For this reason the existing boulevard in Noordwijk aan Zee in The Netherlands has been chosen. In this example sewage, gas and electric infrastructure is included in the boulevard (constructed under the pavement) and is considered in the costs.

The IV of the boulevard is considered best represented by the replacement costs, for similar reasons as for the hotel example. The IV includes the replacement costs of the sewage, gas and electric infrastructure, which are in most cases constructed underneath the boulevard. The IV of the existing boulevard in Noordwijk aan Zee (length: 2 km) is estimated at Euro 6,800,000.

Although there is no doubt that the HV of a boulevard along the edge of the dunes is significant, it is rather difficult to quantify this value, seeing that all stakeholders have to be included in this valuation.

To value the HV of a boulevard along the edge of the dunes, the following method is chosen: the HV is assumed to be equal to the "willingness to pay" (WTP) of the stakeholders to pay extra for protecting the boulevard against destruction caused by erosion. (See also Polomé et al., 2005, for more practical applications of this tool in the coastal area.) All three stakeholder groups are involved in this case.

This WTP method is considered useful because of the large group of stakeholders and the absence of any market prices from which the actual HV could be derived. This WTP is quantified with the help of a survey done by Winckel (2005), which includes all stakeholders. It must be kept in mind that the survey results are also partly based on answers concerning a risk (of erosion) of which the stakeholders are mostly unaware.

The results per stakeholder group were different and were related to their specific relation with the boulevard. The total amount of HV for the whole community was around Euro 50,000 per year, which seems as a rather small amount given the 500 housing units within the erosion zone (10,000 housing units in the whole community of Noordwijk aan Zee) and about 30 businesses within the erosion zone.

On the risk side only the financial risk criteria are considered in this valuation, as the social risk of infrastructure is considered insignificant. The most important financial criteria of the risk are the replacement cost and cleaning cost of the boulevard, and the resulting business loss for the businesses along it. The probability of a disaster occurring in the low tourist season (winter) is considerably higher than in the high season (summer). Nevertheless an amount of loss should be considered.

The total risk of the boulevard can thus be calculated:

$$\text{Total risk} = P_f((1+\beta)^*\text{RC} + \text{NOB}^*\text{NP}^*\chi^*D_{\text{loss}})(\text{Euro/year}) \tag{14}$$

Where:

P_f:	chance of destruction [per year]
β:	the factor of cleaning costs [–]
RC:	replacement costs [Euro]
NOB:	number of businesses affected [–]
NP:	normal profit of business [Euro]
χ:	factor of profit loss [–]
D_{loss}:	duration of loss [years]

The ultimate justified position of the boulevard can then be determined when the yearly HV is equal to the yearly risk. The relating chance of destruction is then the maximum acceptable limit, $P_{f\text{acc}}$. Rewriting the previous equation gives:

$$P_{f\,\text{acc}} = \frac{\text{WTP}}{(1+\beta)^*\text{RC} + \text{NOB}^*\text{NP}^*\chi^*D_{\text{loss}}}(\text{per year}) \tag{15}$$

Using the data that was obtained during the investigation a $P_{f\text{acc}}$ of $\approx 1/145$ per year was found. [WTP = Euro 50,000; β=0.01; RC = Euro 6,800,000; NOB = 30; NP = Euro 100,000 per year; χ = 0.5; D_{loss} = 0.25 year.]

Because of the awareness with which the stakeholders have quantified the HV, the results might be considered as a lower boundary.

3.5. Suitable locations

With these maximum acceptable chances of destruction and the erosion contour lines with similar chances of exceedance, it is possible to determine, per type of investment, the suitable building locations.

Even after taking all the most relevant factors into account, the resulting magnitude of the acceptable chances of damage allow for building locations rather close to the beach. (The erosion contour line with a frequency of exceedance of 1/100 per year is located approximately 20 m from the edge of the dunes in the investigation areas.)

Therefore there seems little ground for the present, very restrictive, building policy in The Netherlands.

The coastal zone management authorities, responsible for developing building policies for the erosion zone, should take these acceptable chances of destruction and erosion contour lines into account when developing an integral coastal zone management plan. Provided that the stakeholders are fully aware of the risk involved in the erosion zone, there is still much potential to be exploited!

4. How should the effects of a rising sea level be dealt with?

Global sea level rise (SLR) and climate changes are expected to occur simultaneously and both these phenomena affect the future position of the erosion contour lines. One of the starting points of the policy of the Dutch government is to keep the position of the coastline (at least) at a pre-described position. As a consequence that means that if any SLR occurs, at least the upper part of a cross-shore profile must be artificially nourished with a layer of sand with a thickness equal to the SLR.

The SLR will of course still reduce the relative height to the sea, of the parts of the profile that are not nourished. This will result in a slight increase in the risk of dune erosion compared to the situation without SLR (provided that the same storm surge intensity is considered). If also some climate changes occur besides the SLR, such as an increase in the storm surge intensity, this will also result in an increase of dune erosion and thus a landward shift of the erosion contour lines.

The influence of sea level rise and the increase of risk can be included in the valuation of the different investments. Two aspects are important in this respect: the planning timeframe of the building policy and the expected increase of the chances of damage.

For the first aspect a planning timeframe of 50 years is considered suitable, considering that the present lifetime cycles of building projects are approximately the same.

In 2001 the Intergovernmental Panel on Climate Change (IPCC, 2001) generated 35 possible future scenarios, which resulted in a wide range of values for the future sea level rise. The IPCC then estimated the most likely sea level rise (SLR) during the next century to be 50 cm. Recently the IPCC have communicated through the press that the latest figures could be as high as 89 cm. (The 4th IPCC Assessment report will be published at the end of 2007.) Nevertheless, an average (relative) sea level rise of 0.2 m per century has been observed for the last 200 years.

When developing the building policy these aspects should be taken into account and not only the most likely case should be considered. For our own example we will discuss a sea level rise of 0.2 m per century and one of 0.9 m per century to illustrate the range of results.

Part of the present Dutch policy is that the cross-shore profile is increased in height with the same rate of SLR. The maximum resulting landward movement of the erosion contour lines is then the result of the relative decrease of the dune height and the increase in storm intensities. For the investigation areas, Noordwijk aan Zee and Katwijk aan Zee (Alkyon, 2001), the resulting landward movement of the erosion contour line is then ≈ 5 m per century in case of a SLR of 0.2 m per century and ≈ 20 m per century in case of a SLR of 0.9 m per century. This yields a maximum landward rate of retreat of the erosion contour lines of 2.5 m and 10 m for the next 50 years for the two scenarios.

It has been explained in this paper how the maximum acceptable chance of destruction for a structure can be calculated and why it is essential for structures not to be situated in areas where the chance of destruction exceeds this maximum. Therefore the effect of the expected rate of retreat of the erosion contour lines should be accounted for in the building policy by adding an extra margin in landward direction, equivalent to the maximum expected landward retreat (of 2.5 m or 10 m, depending on the chosen SLR), to the zone where building is not allowed. When the unfortunate situation occurs where structures are situated seaward of their maximum acceptable erosion contour line, or will occur within the planning timeframe, a number of options are available to reduce the chance of destruction to acceptable levels again or even a further reduction, viz.:

- Strengthening of the dunes with either sand nourishments or sea defence structures (for instance a boulevard type 1), see Section 3).
- Strengthening of the structure with for instance an erosion-proof foundation.
- Remove the structures that are located in the areas where the chance of destruction exceeds their maximum acceptable chances.

The alternative that results in the highest increase in value (when taking all benefits and costs for the total timeframe per alternative into account) is considered the best option.

5. How to handle the aspect of responsibility of damage?

The aspect of responsibility of damage in the erosion zone is at present an important topic of discussion at governmental level. In the erosion zone the responsibility for damage of private property due to erosion is at present solely for the private owner of the specific property. At the same time most owners are unaware of the risk of erosion. In cases where they are aware of the risk, they are not informed on the specific level of risk involved.

This is a very undesirable situation, which needs to be dealt with. We will explore different solutions for this problem by contemplating different options of distributing the responsibility of risk amongst the stakeholders.

The values of the benefits and costs of any investment remain unchanged when the responsibility for these benefits and costs are varied amongst different stakeholders. However, differences in responsibility can result in quite different building policies as new possibilities to distribute the risk can give an individual investor the opportunity to invest in areas with different (higher) chances of damage. The influence that this aspect of responsibility has on the policy and on the stakeholders, is explained using three different scenarios:

- When the responsibility is for the owner.
- When the responsibility is transferred to an insurance company.
- When the government is responsible for (part of) the damage.

5.1. Responsibility for the owner

The following question should be asked in this scenario: how will the specific owner's financial situation be affected by a disaster? It is obvious that only the more financially capable owners will be able to avert serious financial problems after a disaster, considering for instance the significant value that a house represents in an average house owners' asset portfolio. On the other hand, in reality the investor will never actually pay the cost of the yearly risk when no disaster ever occurs. (In fact the investor then saves the required costs of the risk.) This can easily lead to negligence of (part of) the costs when valuating an investment in the erosion zone, and over-valuation might be the result. (This is also the case at present.) The outcome of this scenario therefore depends mainly on the competence of the individual investors to safeguard their own financial situation.

5.2. Possibility of insuring the property

The distress caused by the financial loss or potential financial problems is largely erased in this scenario, as this loss is compensated for. In case an insurance company sells responsibility for damage, it becomes essential for the company to know the exact chances of damage to be able to secure its future as an insurer. Policies will be made, priced accordingly and advertised. This will lead to increased transparency of the risk within the building market.

In the case of insuring objects within the erosion zone (the chances of damage to buildings are highly dependent on the position with respect to the edge of the dunes), the insurance company must take into account that if damage occurs, most likely a whole row of objects along the coast will be destroyed. This means that a lot of capital is possibly needed, which insurers in The Netherlands are likely to lack at this moment.

In many 'coastal erosion discussions' the so-called structural erosion (gradual year after year erosion) and the episodic erosion because of a severe storm surge are often mixed up. If, like in The Netherlands, the structural erosion is properly mitigated by governmental actions (e.g. artificial nourishments) a much better view on the remaining (episodic) risks is obtained.

[At the moment it is not possible to insure storm surge erosion damage (destruction) of objects situated in the erosion zone in The Netherlands. This is mainly because of the ignorance of the insurance companies with regard to the various aspects of this problem. An interesting market could be opened for insurance companies in the future.]

5.3. Responsibility for the government

In this scenario it is considered most plausible that the government will not be responsible for damage in all areas in the erosion zone. It is mostly likely that it will depend on the specific chances of damage (and public opinion). The erosion zone must then be divided into an area where the government is responsible, (most likely the landward part of the erosion zone, with the smallest chances on damage) and where the government is not. Unfortunately the (existing) building layout will most probably not permit an easy division of these areas.

Investors interested in the 'compensated' part of the erosion zone will acquire 'free' insurance for most of their risk. It is, however, very doubtful that the government will be able to exclude victims of compensation in case of a disaster, while others are included. Besides the costs of possible compensation, the costs of implementing the policy, controlling the specific zone and performing duties when citizens disobey the rules, also have to be taken into account.

In our opinion the scenario where the risk of damage due to storm surge can be insured offers the most potential out of the three scenarios discussed here. Not only will this scenario lead to more transparency of the market, it will also safeguard individuals from financial disaster. Moreover, this scenario has the best chances of leading to the desired situation where the available potential of the erosion zone is fully exploited and there is no over- or undervaluing of this potential.

In the USA the problem of erosion is also a serious issue. In fact, around 25% of homes and other structures within 500 ft of the shorelines will fall victim to the effects of erosion within the next 60 years if nothing is done. In the USA the FEMA has set up the National Flood Insurance Program, which moves the responsibility for damage due to storms, floods and erosion (cf. also structural erosion!) from the taxpayer to the owners using insurance policies and mandatory structural requirements for the houses (FEMA, 1994). Unfortunately the program has had financial trouble and has needed extra governmental funding on several occasions. When a disaster strikes and damage payments are due, large amounts of capital are often involved. This requires that the insurance providers are experts in the field of risk assessment to be able to survive.

6. How to manage the problems encountered in the present situation?

The present chances of destruction were investigated for the existing investments in the investigation areas (Noordwijk aan Zee and Katwijk aan Zee). No problems were identified here for the next 50 years, as the maximum acceptable chances of destruction will not be exceeded.

(At the same time unused potential was identified!)

When the approach as is outlined in this paper is applied to other coastal areas (of course with area specific parameter settings) it might occur that in a specific area the maximum chances are (seriously) exceeded for some structures. These structures are then situated too close to the sea.

If the owner is fully aware of this (new) insight, he will also be aware of the (unacceptable) low value of the property because of the unacceptable high risk involved and of the lack of (financial) benefit in maintaining the property. Several options are available in this case. The most probable are:

- Increasing the strength of the dunes with sand nourishments or sea defence structures.
- Reinforcing the structures.
- Removing the property.

For these options the following notes are important:

(1) Dune nourishments and sea defence structures (which are rather costly) are most likely only profitable for the respective properties when the risks involved are rather high.
(2) Preliminary (rough) calculations suggest that the decrease in risk (benefit), by using "erosion proof" foundations, can exceed the costs of the foundations.
(3) The option of removing the property can result in an increase of the HV of surrounding properties (by obtaining sea view and by the removal of devaluated properties) and results in a decrease of the total risk within the community.

It is considered unacceptable to do nothing in this situation, as the resulting devaluation, or loss of value of the property involved, and of the surrounding properties, will be much higher than the benefits (if any).

In case it becomes apparent that the future risk will exceed acceptable levels within the 50 years timeframe, the previous three options must also be assessed. It is then also important to calculate the most beneficial moment to implement any of these options.

7. Conclusions and recommendations

After identifying the relevant relations within the erosion zone, it was concluded that all stakeholders should take into account the available commercial potential and risk when making investment decisions for structures built within the erosion zone.

By comparing similar structures inside and outside of the erosion zone, suitable compromises concerning the available commercial potential and risk can be made. Due to the increased commercial potential within the erosion zone (compared to outside the erosion zone) an increase in value (hedonic value) for an investment can be realised. Within the erosion zone, however, investors also have to account for the chance of destruction due to erosion, which increases the closer the structure is located to the sea.

A decision model was developed which might be used to decide what locations are suitable for which structures in the erosion zone by calculating the maximum acceptable chance of destruction and locating the relating erosion contour lines. The maximum acceptable chance of destruction is located at that point in the erosion zone where the hedonic value of a structure equals the value of the risk. This is the closest to the sea that this structure should be built. The total value of this investment within the erosion zone is equal to a similar investment outside the erosion zone.

For house owners, for example, the maximum acceptable chances of destruction for their houses range from $\approx 1/60$ to $\approx 1/120$ per year. The coastal zone management authorities, responsible for developing the building policies for the erosion zone, should take these acceptable chances of destruction and erosion contour lines into account.

To take the effect of sea level rise and the resulting movement of the erosion contour lines into account in the building policy, two factors are important to quantify: the expected movement of the erosion contour lines and the timeframe for which the building policy is made. Within this timeframe the maximum acceptable chances of destruction should not be exceeded.

To decide who should be responsible for any damage to the structures in the erosion zone due to a disaster, three scenarios have been identified: (1) the owner is fully responsible (2) the responsibility can be transferred to an insurance company and (3) the government will take on (part of) the responsibility.

The scenario in which the owners are responsible is only suitable when they are fully aware of the situation and are able to decide on risk matters without getting into financial problems. If that is not the case the stakeholders will still depend on government aid (as is the case at present).

As the government is not likely to become responsible for all chances of damage, the scenario in which the government is responsible would lead to inequalities and high costs of executing such a policy.

The possibilities to fully exploit the potential of the erosion zone were considered the greatest when insurance for erosion damage due to a storm surge is available. Not only will this scenario lead to more transparency of the market, it will also safeguard individuals from financial disaster.

It is considered of the utmost importance that the responsibility for damage in the erosion zone is dealt with as soon as possible. At the moment investors are either unaware of the risk, or do not think they are liable for any possible damage. Only the commercial potential is included in the present investment decision while the risk is often entirely disregarded, and this is considered a large problem.

The reality is that the situation can now arise in which the market value of a property is overvalued by 100% or more, where this overvalued property is situated in a high risk location, while the actual capital providers (mostly banks) have no proper insight in this situation at all and should not count on any refund of the capital they provided in case of a disaster.

It is important to inform all stakeholders of the actual facts. All related problems that may derive from sharing this information are considered less troublesome than the problems that could develop in the present situation when a storm surge with serious damage occurs.

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