INTEGRATION OF RISK AND ASSET MANAGEMENT FOR SUSTAINABLE MANAGEMENT OF EUROPEAN COASTAL ZONES

Ruud Raaijmakers[(1)], Jörg Krywkow[(2)], Anne van der Veen[(3)]

[(1)]Department of Infrastructure and Environment, Grontmij, De Holle Bilt 22, 3732HM De Bilt, the Netherlands, phone: +31 30 220 7443; fax: +31 30 220 5084; e-mail: ruud.raaijmakers@grontmij.nl
[(2)]Department of Civil Engineering, University of Twente, Postbus 217, 7500 AE Enschede, the Netherlands, phone: + 31 53 489 4038; fax: + 31 53 489 5377; e-mail: j.krywkow@ctw.utwente.nl
[(3)]Department of Civil Engineering, University of Twente, Postbus 217, 7500 AE Enschede, the Netherlands, phone: + 31 53 489 3213; fax: + 31 53 489 5377; e-mail: a.vanderveen@ctw.utwente.nl

ABSTRACT

Increasing risk of climate change and human induced coastal erosion requires a sophisticated and flexible risk management. The search for effective management methods is illustrated in projects such as Integrated Coastal Zone Management (IZBM) and EUROSION. Research within both projects revealed that holding the responsibility for risk management merely in the hands of responsible authorities is neither effective nor efficient enough anymore. In our approach we seek to combine asset management with risk management of coastal zones. Hereby, it is important to include not only the value of properties, but also the life cycle, tangible and intangible values and social demand in the analysis. On the risk management side we assume a Bayesian approach employing perspectives of risk based upon individual interpretations of risk acceptance. Both risk and benefit can be outweighed in a Spatial Multi-criteria Analysis. This way a stakeholder-based diversification of risk can enter a calculation that provides decision makers with a number of plausible management alternatives. As a result both an increased responsibility among stakeholders, and an increased knowledge base for decision makers can be achieved.

Keywords: asset management, flood risk, coastal zones, risk perception, integrated assessment, spatial multi-criteria analysis

1 INTRODUCTION

Generally, coastal zones are divided into a terrestrial and a marine part. According to the definition of the European Environmental Agency (EEA) the landward area of the coastal zone extends up to ten kilometers from the coastline. The seaward area of the coastal zone extends ten kilometers seaward. The coastal strip is the area where interaction between sea and land takes place under normal circumstances (Agency, 2006). In Europe the pressure imposed onto the terrestrial part of the coastal zone is continuously increasing. There is a growing demand for residential areas, recreational facilities, industrial on-shore and off-shore development, shipping and fishing activities in coastal zones all over Europe. This demand for assets, causes conflicting spatial developments, especially between tangible asset developments and valuable natural functions (Commision, 2001). The main pressure from the sea side is the risk of flooding and coastal erosion. Coastal erosion and flooding cause losses of functions with economical and ecological value and damages to natural and artificial coastal defenses. A considerable part of coastal erosion is human induced. For example, dams constructed in upper courses of rivers trap sediment. This results in a shortage of sediment deposition in the delta. As a result an

imbalance toward coastal erosion and subsidence of the delta occurs (see for example (Ibànez et al., 1997)). Next to this asset developments on land extensions and artificial islands contribute to coastal erosion. Large asset developments in the marine area can be responsible for unacceptable deterioration of the coastal zone and coastal defenses elsewhere. Hence, flood and coastal erosion risk for the coastal zone is not only directly increased by asset development within the coastal zone, but also indirectly. Therefore, it might be useful to effectively and efficiently coordinate risk and asset management.

In the last decade Integrated Coastal Zone Management (IZBM) has been incorporated into European Coastal zone strategies (Commision, 2001). IZBM promotes sustainable and integrated coastal zone management strategies. This leads to the following main principles:

1. Coastal zone management should be problem-based, and therefore administrative and disciplinary boundaries must be crossed;

2. Stakeholders should be involved as much as possible in coastal zone management;

3. Management of coastal zones is adapted to local circumstances (Green et al., 2000);

4. Coastal zone management is based upon adaptive management principles (Walters, 1997). As a starting point adaptive management assumes that natural systems are predictable only for a small part of the entire system, and therefor management of those systems cannot be done by a management plan based that does not adapt to those changing circumstances. Management of coastal zones can be seen as a learning process, and has to be continuously adapted to changing natural conditions and new learning insights (Sendzimir et al., 1999).

A large number of examples show us that asset management for land extensions, marinas and artificial islands in European Coastal zones is not compatible to IZBM principles. An example the estuary of the river Llobregat (Spain) where the construction of an airport, industry and a harbor have had a severe impact on ecology (ICKRO, 2006).

EUROSION is a project commissioned by the General Directorate Environment of the European Commission focusing on coastal erosion and flooding. One of the main findings of the EUROSION project was that, the reduction of risk is mainly financed by local, regional and national authorities to date. Owners of assets at risk and those partly responsible for coastal erosion, are hardly ever financially responsible for an unacceptable flood and coastal erosion risk. In a number of cases stakeholders were consulted in a limited way, and in a very late stage of asset development (Commission, 2004). Therefore, asset managers must be given more responsibly for negative impacts of such projects on coastal zones. Moreover, coastal asset management processes should include instruments for continuous monitoring and maintenance of acceptable levels of risk and sustainable development of land use throughout the whole asset management process.

In this article we elaborate on the integration of knowledge from the disciplines asset management and risk management for coastal zones, in order to support sustainable management strategies for asset development in European coastal zones. In this context the risk-perception-based trade-off between risk and benefit represents a crucial part of such a strategy. In section two we describe our view on asset management. Section three summarizes the approach to risk management that we have developed in Raaijmakers (2006) as a guideline to sustainable and integrated land use policy in coastal zones. This approach is applied in this article. Hereby, risk

for a coastal zone, benefits generated in a coastal zone and risk perception are seen as guiding principles for the spatial development within coastal zones. The consequences for asset management and risk management are presented in in section four.

2 ASSET MANAGEMENT

Asset management can be defined as the management for the whole life cycle of any property with tangible and intangible value in order to meet a societal demand (latcovich, 2003; Systematics, 2004). This definition includes four important elements: ”property”, ”tangible and intangible value”, ”life cycle” and ”societal demand”, which can be explained accordingly:

- **property:** Implies someone is responsible for the asset, who manages the asset. The asset manager is not necessarily considered to be an individual, but can be seen as the stakeholder groups owning and operating assets within a spatial domain;
- **life cycle:** The life cycle for an asset begins, when the need is identified for an asset and ends when the asset is being disposed of. Intermediate processes are investing, creating, operating and maintaining the asset;
- **tangible and intangible value:** Commonly asset management is aimed at managing assets with a monetary value, referred to as tangible assets. For coastal zone management we want to expand the discipline of asset management to assets of intangible value. Assets of intangible value are not tradeable on a market (Messner et al., 2006), as for example biodiversity, aesthetic aspects of nature or cultural value. Nevertheless, neglecting intangible assets may result in a reduction of valuable services and resources, which can increase to economic costs (Fromm, 2000). An example is the loss of visual amenity of a landscape, which causes touristic activity to decrease;
- **societal demand:** Asset management is not an objective by itself. However, it is a means to meet a demand, or accomplish a goal. A societal demand can be translated into a policy demand, but does not necessarily have to occur. Asset management can be aimed to increase company or community benefits. Additionally, a society demands that acceptable risks are imposed on assets. When constructing in the marine area of a coastal zone, this also can imply a risk is imposed by the asset, as erosion is caused elsewhere. Thus, next to the demand for an acceptable risk for the assets themselves, an additional demand exists for risks imposed on assets elsewhere. Those demands are constantly changing, therefore asset management should be an adaptive process.

Asset management is a very broad and complex discipline. It covers the management of financial assets, real estate and intangible assets such as nature. In this paper we want to focus on land use management, and spatial development projects. We are aware of the complexity of asset management, and have aggregated it into a very generalized representation. Therefor this paper should be seen as a first step in integrating asset, flood and coastal erosion risk management.

3 RISK MANAGEMENT IN COASTAL ZONES

Risk management consists of three basic steps: (1) risk analysis, (2) risk assessment and (3) risk mitigation. In risk analysis two approaches can be distinguished: the classical (traditional engineering) approach and the Bayesian approach. Generally risk is defined as the product of

probability times negative consequence. In the classical approach the assumption is made that experts are able to estimate an 'objective' probability of occurrence of an event by subjecting it to a classical statistical analysis (Klinke and Renn, 2002; Aven and Kristensen, 2005). However, in the Bayesian way of thinking no true objective measurement of risk exists, and risk is a way of expressing uncertainty. Risk is treated as a collection of perceptions. It is considered to be a judgment rather than a fact (Aven and Kristensen, 2005). In this approach probability is an expression for the state of knowledge that depends on the information and the knowledge of the individual who assigns it. Hence, no universal and true probability exists.

"When an individual examines a risk or determines his or her favor toward it, he or she has three options: (1) accept the level of risk, (2) reduce the risk or (3) avoid it altogether." (Sharlin, 1989, p.262). When an investor decides to develop assets in the marine part of a coastal zone, one's investment is voluntarily exposed to the risk of coastal erosion and flooding. Hence, one can say, in a marine area the risk of damage to assets, or even loss of life, is taken on a voluntary basis. When an individual voluntarily decides to expose him or herself to a risk, the individual is assumed to have the choice to avoid this risk. Hence, there must be some motivation to take the risk. We assume that individuals weigh the perceived risk against the perceived benefit of an activity. The larger the perceived benefit of an activity the larger the accepted perceived risk (Fischhoff et al., 1978; Starr and Whipple, 1980; Vlek and Stallen, 1981).

Not only the risks, but also the benefits of hazardous events can be perceived differently by individuals, for example, in the case of smoking. A risk can be accepted in two cases. Firstly when the risk is of such a small magnitude, that it becomes acceptable. A society handles risks with the maintenance, adaptation or even emergence of applicable norms of acceptable risk. Secondly, when a risk is generally perceived as unacceptable, but the perceived benefit for the activity outweighs the risk, as, for example, is the case for extreme sports activities. Reducing a risk typically leads to a reduction of benefits, which poses many dilemmas for a society. In other words a society has to make the trade-off between risk and benefit (Fischhoff et al., 1978). Within this trade-off, the way society perceives a risk will determine the preference toward the reduction of risk, or the conservation of benefits. In this way risk perception can be a misguidance, as individuals are not always aware of the risk that they are exposed to. Moreover, when people are aware of a risk, they may or may not worry about it. The more people worry about or even fear the risk, the larger the demand from society is to reduce the risk. There is a large willingness-to-pay to reduce risks which is worried about and pathways to solutions are known (Savage, 1993). Awareness and worry, may lead to a society which is prepared for a possible event. Over a longer time span, this may lead to a decreasing worry and awareness, which is often the case for long-term or episodic events (Arthurton, 1998). Thus, awareness, worry and preparedness are indicators for the way risk is perceived, and as a consequence the preference within the risk benefit trade-off. Important criticism toward public risk perception is its possible misguidance, but we have to consider that expert risk perception can be misguiding as well (Pidgeon, 1998). Moreover, public can be a valuable addition to the policy process, as local stakeholders often have valuable information about handling the risk. Secondly, knowledge of perception and misperception of risk, leads to more effective risk communication (Slovic, 1993). Slovic (1998, p.76) argues "...that whoever controls the definition of risk, controls the solution to the problem at hand". For example, a policy maker may choose the safest or most cost-efficient solution, while lay people may accept risks by voluntary agreement.

Therefore, in our methodology (see Raaijmakers (2006)) we compare the risk of flooding

and coastal erosion to the benefits that various types of land use offer, in order to find the best alternative configuration of land use. Here for we use a methodology based on spatial multi-criteria analysis (SMCA) as described by van Herwijnen (1999). In this multi-criteria analysis we take several scenarios as alternatives and judge them on the basis of the criteria (1) tangible and intangible 'benefits of land use' and (2) 'risk of flooding and coastal erosion'. These scenarios are a combination of land use scenarios, flooding and coastal erosion scenarios which assume particular environmental conditions (sea level, storm conditions, etc). Land use data are represented either as a raster (usually equally sized square cells) or polygons (areas with homogeneous information are outlined). For each land unit the effect score (p_{ji}) of alternative I is determined on the basis of criterion J. After spatial aggregation SMCA transforms into a regular multi-criteria analysis (MCA). By standardizing the aggregated effect scores, the dimensionless effect score $v_j(p_{ji})$ is determined. In this SMCA risk perception is represented as a weight (w_j), which balances the preference of society toward the reduction of flood risk or maintenance or even expansion of the current number of assets (benefits). The higher a risk is perceived, for example, the more it is worried about and the larger the willingness-to-pay is, the more the preference of society will balance toward risk reduction. The land use alternatives are ranked using a multi-criteria methodology for ranking, as for example weighted summation (see equation 1).

$$V(P_i) = \sum_{j=1}^{J} w_j * v_j(p_{ji}) \tag{1}$$

The result of this spatial MCA is an order of preference of a number of land use alternatives on the basis of risk, benefit and risk perception. This does not mean the conducted policy should be the same as the one that was selected by the SMCA procedure. However, the methodology should be able to aid an asset manager or policy maker to have insight into the societal basis for a particular land use policy.

4 INTEGRATION OF RISK AND ASSET MANAGEMENT FOR COASTAL ZONES

Integrated Assessment (IA) is the scientific approach which aims at building bridges between a number of scientific disciplines. IA integrates both scientific and participatory knowledge, and provides these multi-disciplinary insights as input for decision making processes (Hisschemöller et al., 2001; Pahl-Wostl, 2002). In this article we will apply the IA paradigm in order to integrate knowledge of asset and risk management.

In larger asset development projects on European coastal zones an impact analysis for coastal erosion and flooding is included in an Environmental Impact Assessment (EIA). However, such an analysis is often excluded from small and medium scale projects, while the cumulative impact onto the coastal zone of those projects can be significant (Commission, 2004). An EIA is often combined with a Social Impact Assessment (SIA) and a Cost Benefit Analysis (CBA) or Economic Impact Assessment, of which results can be combined to a Multi-Criteria Analysis. An Impact Assessment is most often initiated within the early stages of a project and is hardly ever used to base upon the strategic decision for the final design of a project (Janssen, 2001).

Environmental, economic and social conditions of an asset development project are continuously changing. Coastal zones all over the world become more vulnerable due to both sea level rise and population growth (Nicholls et al., 1999), but the magnitude growth in vulnerability remains uncertain. However, sea level rise seems to be inevitable as globally ice sheets

are rapidly melting (Overpeck et al., 2006). Therefore, mitigation policies of flood risk may be inevitable (Parry et al., 1998), but with a rapidly growing demand for asset development in coastal zones this may well be unrealistic. However, it is clear that a higher responsibility has to be taken by asset developers in coastal zones. Comparing sustainable risk management for coastal zones and asset management, their similarity lies within the adaptability of management over a long time period. Additional to an initial impact assessment, similar assessments in less extensive form conducted during the life cycle of such a project. Preferably, this should be laid down in a contract between government and asset manager. Hereby the asset manager takes responsibility for measures, when unacceptable risk of flooding or coastal erosion is created for his own asset or for other assets elsewhere in the coastal zone.

With our SMCA methodology, an asset manager can optimize risk benefit decisions for land use development. The advantage of this methodology is, that it can be used at any point within the life cycle of an spatial development. Because risks, benefits and risk perception are rapidly changing within a coastal zone, the methodology may be an effective decision support tool for adapting land use to these changes. When the threat due to hazard increases for his assets, an asset manager will have to reduce the vulnerability to maintain acceptable exposure to risk, or the owner of the asset will have to accept higher levels of risk, and take the economic consequence of a flooding for granted. This means a large part of the management of risk is left to the market. This gives way to:

- **Private Financed Initiatives (PFI):** when developing an asset in the marine area of the coastal zone, coastal protection can be regarded as a shared responsibility of both the the asset manager and authorities. The sharing of interests and responsibility between the public and private sector is defined as a public-private partnership. Mostly, a private consortium is responsible for the financing, development, operation and maintenance of an asset. As an example this could imply that a bank, project developer and dredging company perform management of an asset in the marine area of a coastal zone under supervision of authorities. The dredging company will not only be responsible for creating the extension of land, but also for maintaining the surrounding shoreline. This maintenance is taken into account in the development phase of the project and can be financed by profits out of operation of the asset. An example of a PFI of a dredging company, that can be regarded as successful, is the Pevensey Sea Defenses Project (Boskalis, 2006);

- **Accepting higher monetary risks:** When the probability of a hazard for an asset increases, in a way that the risk becomes unacceptable, one of the options that an asset manager has, is to accept higher levels of risk. This could be acceptable for the monetary consequences of a flooding, but generally not for health risks. When the risks are purely monetary the asset manager has to make the trade-off between taking the higher risk of flooding, or mitigating the risk an thus losing benefit;

- **Communication of risks:** an asset manager can both merit or lose from a public (mis) perception on flood risk. When the public is unaware of its exposure, it may be involuntarily exposed to a risk, as an asset manager could neglect to invest into risk management. In the contrary, when the public overestimates a risk, it could demand the asset manager to invest into more risk management measures than necessary. However, risk communication can be effective, as ignoring risk perceptions can lead to societal discontent and financial consequences for the asset manager as as a result of social amplification of risk

(see (Pidgeon, 2000)). Therefore, it is wise to foresee a risk communication plan already in early stages of a asset development, where attention is given to awareness, worry and preparedness.

- **Land use planning adaptive to risk:** When risk is unacceptable, an asset manager must be prepared to mitigate the risk by reducing the vulnerability of his assets. This has to be planned strategically over a long period of time (Arthurton, 1998). Assets as well as people using these assets, have to have a low susceptibility to flooding (Messner and Meyer, 2005). This means the economic, social and environmental functions must not be sensitive to a flooding, and cope well during, and recover fast after an event. Assets should be accommodated to different circumstances of flooding. In some cases this might mean the asset manager has to choose a type of land use that is less vulnerable to tangible damage the original land use. This might imply a planned retreat of tangible assets.

In this case, we suggest that our SMCA methodology can function as the basis of a first as well as an additional Impact Assessment. In our experience, making risk management a shared responsibility of authorities and market parties is a sensitive approach. Trust in the market is low as authorities see maximizing profit is the main goal of the market which would create a lack of responsibility for safety. However, a broad active involvement of stakeholders risk management is allows for innovative, more legitimate risk solutions (Slovic, 1998). The quality of such solutions can be improved as the problem now is approached from a multi-stakeholder perspective. Moreover, investments for these solutions, can be divided under stakeholders, where the risk solution is financed by its source and not by its receptors.

5 CONCLUSION

Currently, the responsibility for risk management in coastal zones lies too much in the hands of authorities. All involved parties should take responsibility to an appropriate extent. This can best be achieved due to an intense communication and participation prior to a decision. The introduction of risk perspectives in risk management can support both a democratic and responsible participatory process as well as the elicitation of valuable knowledge that is otherwise not available for a policy process. The integration of risk management and asset management can help to outweigh risk and benefit of investments. This, however, can provide decision makers with guidelines in how to manage and maintain coastal zones appropriately and sustainable.

REFERENCES

Agency, E. E. (2006). The changing faces of Europe's coastal areas. Technical report, European Environmental Agency.

Arthurton, R. (1998). Marine-related physical natural hazards affecting coastal megacities of the Asia-Pacific region-awareness and mitigation. *Ocean and Coastal management*, 40:65–85.

Aven, T. and Kristensen, V. (2005). Perspectives on risk: review and discussion of the basis for establishing a unified and holistic approach. *Reliability Engineering and Systems Safety*, 90:1–14.

Boskalis (2006). www.boskalis.nl.

Commision, E. (2001). EU focus on coastal zones. Technical report, Directorate-General Environment, Nuclear Safety and Civil Protection.

Commission, E. (2004). Living with coastal erosion in europe: Sediment and space for sustainability. Technical report, Directorate-General Environment, Nuclear Safety and Civil Protection.

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., and Combs, B. (1978). How safe is safe enough? a Psychmetric study toward technological risks and benefits. *Policy Sciences*, 9:127–152.

Fromm, O. (2000). Ecological structure and functions of biodiversity as elements of its total economic value. *Environmental and Resource Economics*, 16:303–328.

Green, C., Parker, D., and S.Turnstall (2000). Assessment of flood control and management options. Technical report, World Commission on Dams.

Hisschemöller, M., Tol, R., and Vellinga, P. (2001). The relevance of participatory approaches in integrated environmental assessment. *Integrated Assessment*, 20:57–72.

Ibànez, C., Canicio, A., Day, J., and Curcó, A. (1997). Morphologic development, relative sea level rise and sustainable management of the Ebro Delta, Spain. *Journal of Coastal Conservation*, 3:191–202.

ICKRO (2006). www.ikcro.nl.

Janssen, R. (2001). On the use of Multi-Criteria Analysis in Environmental Impact Assessment in The Netherlands. *Journal of Multi-Criteria Decision Analysis*, 10:101–109.

Klinke, A. and Renn, O. (2002). A new approach to risk evaluation and magagement: risk-based, precaution based and discourse based strategies. *Risk Analysis*, 22:1071–1094.

latcovich, J. (2003). what is asset management. In *Power generation asset management conference*.

Messner, F. and Meyer, V. (2005). Flood damage, vulnerability and risk perception-chalenges for flood damage research. unpublished.

Messner, F., Penning-Rowsell, E., Green, C., V.Meyer, Turnstall, S., and van der Veen, A. (2006). Guidelines for socio-economic flood damage evaluation. Technical report, European Community. Part of Floodsite project.

Nicholls, R., Hoozemans, F., and Marchand, M. (1999). Increasing flood risk and wetland losses due to global sea-level rise: regional and global analyses. *Global Environmental Change*, 9:S69–S87.

Overpeck, J., Otto-Bliesner, B., Miller, G., Muhs, D., Alley, R., and Kieh, J. (2006). Paleoclimatic evidence for future ice-sheet instability and rapid sea-level rise. *science*, 311:1747–1750.

Pahl-Wostl, C. (2002). Polycentric integrated assessment. *Integrated Assessment*, 2:220–232.

Parry, M., Arnell, N., Hulme, M., Nicholls, R., and Livermore, M. (1998). Adapting to the inevitable. *Nature*, 395:741.

Pidgeon, N. (1998). Risk assessment, risk values and the social science program: why do we need risk perception research? *Reliability Engeneering and Systems Safety*, 59:5–15.

Pidgeon, N. (2000). *Risk Communication and the Social Amplification of Risk.* Health and Safety Executive, London, 1st edition.

Raaijmakers, R. (2006). A spatial multi criteria analysis methodology for the development of sustainable flood risk management in the ebro delta.

Savage, I. (1993). An empirical investigation into the effect of psycological perceptions on the Willingness-to-Pay to Reduce Risk. *Journal of Risk and Uncertainty*, 6:75–90.

Sendzimir, J., Light, S., and Szymanowska, K. (1999). Adaptive understanding and management for floods. available online:www.adaptivemanagement.net/flooding.

Sharlin, H. (1989). Risk perception: changing the terms of debate. *Journal of Hazardous Materials*, 21:262–271.

Slovic, P. (1993). Perceived risk, trust and democracy. *Risk Analysis*, 13:675–682.

Slovic, P. (1998). The risk game. *Reliability Engeneering and Systems Safety*, 59:73–77.

Starr, C. and Whipple, C. (1980). Risks of risk decisions. *Science*, 208:1114–1119.

Systematics, C. (2004). Fhwa Asset Management Position Paper. Technical report, Camebridge Systematics Inc.

van Herwijnen, M. (1999). *Spatial Decision Support for Environmental Management*. PhD thesis, Vrije Universiteit.

Vlek, C. and Stallen, P. (1981). Judging risks and benefits in the small and the large. *Organizational behaviour and human performance*, 28:235–271.

Walters, C. (1997). Challenges in adaptive management of riparian and coastal ecosystems. *Conservation Ecology*, 1.