Artificial Beach Nourishment: Lessons learned from field experiments

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In Germany, the first artificial beach nourishment on a large scale has been carried out on the East Frisian islands (Norderney, Southern North Sea) almost sixty years ago. These barrier islands shelter the low laying mainland against the Sea. They are part of the coastal defence system against flooding and land losses. The islands are developed for tourism and health care. According to the demands of coastal defence and of tourism, the technique of beach nourishment is frequently applied on the islands nowadays The paper explains why and how the beach nourishment has been integrated into the historically developed coastal defence systems. It provides information on field experiments, discusses benefits and limitations for different applications, deals with conflicts within the coastal society. The focus is rather on technical aspects associated with the artificial beach nourishment, than on its use as a tool to cope with conflicting demands for an integrated coastal protection management.

Introduction

The seven East Frisian Islands are located in the western area of the German North Sea coast. They belong to a system of barrier islands which extend from the Netherlands to Denmark. The islands protect the tidal flats and the mainland coast against the Sea.

The “chain” of the seven East Frisian islands is cut by tidal inlets and is separated from the mainland by a tidal basin system (Wadden Sea). The semi-diurnal impact of tides and waves generate a net littoral drift from West to East. The sandy islands experience both, erosion and accretion according to the hydrological and morphological conditions, the supply of material and the process of sediment transport. The morphological development of the East Frisian islands is well recorded since 1650 (Homeier, 1962).

The natural processes at the spits of the islands are governed by strong currents in the tidal inlets and by their interaction with the sediment transport in the ebb delta shoals and the tidal basin. Migrating inlets let to erosion of the spits and forced man since the middle of the nineteenth century to implement coastal protection systems by combining groynes and sea walls.

Coastal protection and artificial beach nourishment

The solid coastal protection system stopped the migration of inlets, but it was not able to defend beach erosion (Kunz, 1997a). Therefore artificial beach nourishment has been implemented around the western spit of Norderney island in 1950/51 by filling up the eroded groyne fields sufficiently high, to protect the constructions against failure during storm floods.

In the meantime, the technique of artificial nourishment is applied on almost all of the East Frisian islands. In the beginning, the sand fills were restricted to those beach areas which are stabilised by groynes and sea walls. Nowadays, the artificial sand supply is

performed on shore face, beaches and dunes (Kunz, Stephan, 2001). Remark: On the North Frisian islands (north-eastern part of the German North Sea) beach fills started on Sylt island in 1972, followed by numerous extended beach restoration projects, which are remarkable, even from an European point of view.

At first, the sand has been gained (dredged) from the Wadden Sea or from ebb delta shoals This was the cheapest solution from the economic point of view, but not favourable (tolerable) from an integrated judgement that takes into account the negative impacts on morphology and ecology. Nowadays, sand is borrowed from deeper parts of the Sea; relatively small volumes of sand are taken from accreting beach areas.

Main targets of the artificial sand supply on the East Frisian islands are both, “active” and “passive” protection measures. The “active” measures are directed towards the destructive impacts of storm surges and deal with the reinforcement of the defence constructions. “Passive” protection means include the widening and raise of beaches, the stabilization and feeding of beach profiles by shore face nourishment and a support of the natural processes towards accretion. Hence, nourishment techniques are primarily performed to compensate for sand losses or to prevent erosion of the shore line.

In Germany, flood defence is legally defined as a national target carried out under the competence of the respective State (e.g. Lower Saxony). On condition that the project is primarily related to the defence target, seventy percent of the funding comes from the Federal budget and the rest is given by the State.

The recreational sector generally benefits from the flood defence projects. Only a relatively small part of the beach nourishment on the East Frisian islands is solely carried out to provide high and wide beaches according to recreational demands.

Case Studies

The paper is restricted to a few information on the case studies (East Frisian islands) by addressing some selected aspects which will be lectured in more detail.

Norderney Island

Especially on Norderney island, different nourishment techniques have been applied. From the beginning, they were accompanied by special interdisciplinary research programmes, which primarily concentrated on an optimization of the restored beach profile (e.g. shape, volume, placement, material) aiming to minimize costs (Kunz, 1991, 1999).

After sand has been placed on a beach, the initial beach profile will be converted by waves and currents into slopes which are adapted to the specific natural conditions. This “naturalised” profile can significantly differ from the restored profile, leading to “visible” losses of sand which are often misinterpreted as final “losses” out of the

defined “control volume”. However, during this initial phase, a significant amount of sand is only transported into lower parts of the “active” profile where it invisibly supports the vulnerable part of the beach.

A reliable calculation of the sand volume which is washed out of a nourished area (“losses”) is essential, especially if decisions shall be based on long term cost benefit. The term “losses” asks for an adequate definition for the boundaries of the calculation area (defined “control volume”) which fits to the specific side and to the targets of the respective project. This requires knowledge about the related “equilibrium profile” and the extension of the “active” beach profile. Remark: For the East Frisian coast it is possible, that he “active” part of a beach reaches below the side specific “closure depth” (Kunz, 2003). Based on field data from several beach nourishment projects, the question has been investigated, how the “final” losses of sand from a nourished beach can minimized (Kunz, 1993a).

An extended German-Russian field experiment on sediment transport has been carried out in the near shore zone to study the dynamic processes which are induced by wave effects. The experiment focused on the recording of field data like currents, waves, suspension, bottom level (Kunz, Kos’yan, 1997). The data from the North Sea (“Norderney’94”) have been combined with data from the Black Sea (“Novomichailovska’93”) and from the Mediterranean Sea (“Ebrodelta’96”) to investigate the process which control the temporal variability of suspended sand concentration and the sand flux near the bottom (Kos’yan et al., 2001).

Langeoog Island

The Langeoog-case is an example how artificial sand nourishment is adapted to temporary changes of the morpological boundary conditions (Abels et al., 1999).

The artificial fill of beach- and trough- areas is only applied when the natural sand supply to the beach by migrating shoals is not sufficient and erosion endangers the shore line and the dunes.

Juist Island

The western spit of Juist experiences structural erosion. Up to now, it was not necessary to protect this area of the island. Hence it is still in an almost natural condition, highly valued and preserved as part of the National Park “Wadden Sea”.

The coastal community worries about land losses or even an breakthrough which would cut off the recent western spit and convert it into a small island. Consequently, solid coastal protection works are demanded. However, from history we can learn, that this would be the beginning of an irreversible development, principally comparable to “Norderney West,” where the coastal protection works had been forced by nature step by step.

Both, the hydrodynamic and morphological conditions as well as the environmental concerns, give reasons to resist and to protest against an “armouring” of the spit. This conflict asks for a political decision.

The results of studies on the long term morphological development(Ladage, Kunz, 2002) in combination with experiences of artificial nourishment projects provided the basis for an intermediate compromise: Special nourishment projects are performed and planned which shall ensure, that no substantial losses nor a breakthrough can occur.

Conclusions concerning public and political perception of artificial beach nourishment

The political valuation of a beach nourishment project is influenced by a balance between public demands, economical benefits and impacts on the environment.

Public and politicians are generally aware, that the technique of artificial beach nourishment can only solve problems temporary, as it usually has to be repeatedly carried out to compensate for sand losses. However, there is generally a lack of awareness concerning the cost-benefit-problems on a long term perspective which has to incorporate the whole range of impacts.

The limitations to apply the technique “artificial beach nourishment” are often not known, not realized, or not accepted. In many cases, like described for the East Frisian islands, it is inevitable to accept solid constructions. According to the specific situation, artificial nourishment projects have to be adapted and integrated, as far as reasonable. This applies also for the acceptance that the existing groyne-sea wall-systems which have been constructed on the western spit of several East Frisian islands during the last two centuries, can only be analysed and validated against the backdrop of its political, social, economical and technical history (Kunz, 2004).

The technique of beach nourishment is often judged as a tool which provides unlimited alternatives, helping to avoid conflicts within the society between economical and environmental arguments which are incompatible. This may lead to unreasonable political decisions and to disappointments concerning the long term benefit of a nourishment project, especially when the visible losses of sand out of the restored area are much larger than expected.

The knowledge how to design and perform a nourishment project has increased over the last decades. Usually there is not much preference to design a stable “initial” beach profile. From the field experiments we learned how easily nature adapts the dumped sand from an “obstacle” to a quasi “natural profile”. A prediction of the visible ”initial” losses of sand from the restored beach and its interpretation provides public awareness as well as acceptance.

Public Information and participation has widened the consciousness for problems on a long term perspective regarding advantages and limits of the nourishment technique and the lack of accessible sand sources.

A comprehensive knowledge of the natural processes is an indispensable assumption for a nourishment project. This aspect demands to accept limitations given by nature and agreement to minimize harmful impacts of a project on the morphology and the ecosystem.

Integrated Coastal Zone Management (ICZM) calls for political and public awareness by taking into account all relevant aspects. This implies: Restrict yourself to reasonable targets; create side specific technical solutions, take into account the demands of the coastal society as well as the natural conditions, consider properly possible impacts of the project, when calculating the cost-benefits for short and long term.

An acceleration of the relative sea level rise as well as more frequent and higher storm surges are a realistic prospective. This enhances recent conflicts about the question, which parts of the East Frisian islands definitely need to be protected against erosion (solid constructions; artificial beach nourishment) and where a dynamically managed retreat of the shoreline (integrated response) can be accepted.

Artificial sand nourishment has become an effective tool for the realization of a coastal zone management which incorporates “spatial coastal protection”. It can be integrated into a system perspective with multi sectoral approaches. Thus it allows flexible responses to meet opposing demands of the coastal society (Kunz,1993b, 2004, 2008).

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