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Erosion and tourism infrastructure in the coastal zone: Problems, consequences and management

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Abstract

The importance of coastal zones to the tourism industry and the need to protect such resources is not only vital to the economy of nations but presents a growing dilemma for many localities and regions. Beaches have become synonymous with tourism and with current predictions of climate change and sea-level rise; they are under significant threat of erosion worldwide. From an assessment of the effects of erosion, including evaluation of impacts on coastal destinations and tourism development, the consequences for global tourism business are projected. An analysis of hard and soft engineering responses showed that coastal protection measures should be linked to physical processes whilst management strategies included a case study proposal for beach nourishment, in response to the erosion of a tourist beach. Integrated Coastal Zone Management is justified as a tool for managing coastal resources and accommodating increasing pressures from tourism whilst strategies are recommended to ameliorate projected impacts.

Keywords: Destination; Beach nourishment; Dive tourism

1. Introduction: making waves, erosion and tourist beaches

A major current environmental debate concerns climate change together with predictions of causes and effects (Christy, 2001; Croner, 2001; Environmental Scientist, 1999; Matthews, 2003; Nature, 2002). Some of these predictions, especially with respect to sea-level rise, could have significant consequences for future management of the coastal zone (Granja & Carvalho, 2000; Jensen, Bender, & Blasi, 2001; Leatherman, 1991; Rivis, Ratas, & Kont, 2002; Vilibic, Leder, & Smircic, 2000). Beach erosion poses a threat to all stakeholders, especially tourism which, according to the World Tourism Organisation (2001), is the world's largest industry. Houston (2002) reported that travel and tourism was the United States largest industry, employer and earner of foreign exchange and that beaches were the major factor in this tourism market. He further identified beach erosion as the number one concern of Americans who visit beaches. With 33,000 km of eroding shoreline and 4300 km of critically eroding shoreline, the US Army Corps of Engineers (1994) considered it a serious threat to tourism and therefore a major threat to the national economy. Gable (1997) argued that tourism was the most important source of external revenue in the Caribbean and that all tourism development was located in the coastal zone, whilst a study by Dharmaratne and Braithwaite (1998), valued beaches along the Barbados coastline at $13 million to the local economy. Clearly, beaches are vital to tourism-based economies and these could be adversely affected by erosion resulting from sea-level rise. Effects may be worsened by storms and the reduction of sediment supply associated with global warming and anthropogenic modification of rivers and coastlines (van der Weide, Vroeg, & Sanyang, 2001), whilst management will be complicated by concerns over hard engineering sea defences (Basco, 1999; Gillie, 1997; Weerakkody, 1997; Wiegel, 2002). Furthermore, a world-wide tendency to coastal erosion (Cipriani, Wetzel, Aminti, & Pranzini, 2004) has been locally aggravated by some of

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the very strategies implemented to reverse the pattern (Gillie, 1997; Weerakkody, 1997).

If as stated by Povh (2000), three-quarters of the world's population will be living within 60 km of the shoreline by 2020, there will be an increase in demand for coastal leisure and tourism facilities. Whilst coastlines are often viewed as stable permanent assets, in reality they tend to be dynamic, responding to natural processes and human activities. Ketchum (1972) identified six major spheres of human activity in the coastal zone: residency and recreation; industrial and commercial; waste disposal; agricultural, aquaculture and fishing; conservation; military and strategic, and these still hold true. However, they are increasingly in conflict with one another as well as with longer-term natural processes. For example, in the Philippines, tourism is growing in importance with activities such as dive tourism and whale-watching whilst traditional fishing is in decline (Christie, 2005). Consequently, the point at issue is how to protect and manage our coastal resources whilst accommodating growing pressures for tourism development. Therefore, this paper will consider causes and effects of erosion, effectiveness of hard and soft engineering responses and advocate strategies, exemplified by a case study, for effective and sustainable management of tourism infrastructure in the coastal zone.

2. Climatic changes and associated erosion

Climate change could contribute significantly to beach erosion because of the predicted increase of storm activity and/or intensity, sea-level rise and the interaction of both consequences. Jensen et al. (2001) reported that since about 1960, there had been an increase in frequency and duration of storm floods along the German North Sea coastline, whilst Vilibic et al. (2000) predicted an increase in storm surges in the Adriatic Sea. These will cause considerable damage to coastal infrastructure and such events will be exacerbated by current predictions of global warming and sea-level rise. In this context, work by Crawford and Thomson (1999) along the Canadian British Columbia coastline, reported estimates of sea-level rise of between 3 and 9 mm/year for the next 80 years, whilst Douglas (2001) quoted average rates of 2–3 mm/year in the United States with up to 6 mm/year or more in some specific areas. Vilibic et al. (2000) stated that there had been a mean rise of 180 mm over the last century and that it was expected to be about 500 mm in the 21st century, whilst Weihaupt and Stuart (2000) logically argued from implications of ancient maps, that the mass reduction of the ancient Antarctic ice sheet could lead to the equivalent of a 4 m rise in sea level. Although the time-scale for this change is not given, it would have severe implications for the low-lying coastal environments of the world and existing developments constructed at or near sea level will be at significant risk.

Sand beaches, low-lying atolls and reef islands of the Pacific will potentially experience severe consequences resulting from accelerated sea-level rise (Richmond, Mieremet, & Reiss, 1997), whilst according to Durand, Vernette, and Augris (1997), global warming will cause higher sea levels and perhaps a larger number of great hurricanes in the Caribbean. As recognised by Titus, Leatherman, Everts, and Kriebel (1985), although hurricanes depend on many factors, an ocean temperature of 27 °C is one such requirement (Wendland, 1977). Therefore, global warming may extend the hurricane season or result in their formation at higher latitudes and the hurricane events experienced by New Orleans and Texas in 2005, may be indications of this trend.

One of the major physical impacts of sea-level rise is erosion of beaches, particularly along the open coast and this would leave coastal infrastructure more vulnerable to storm waves (Titus et al., 1985). This in turn will have significant consequences for tourism. Bruun (1962) long ago proposed that long-termed erosion of sandy beaches was a consequence of sea-level rise. His model predicts that beaches will erode by 50–200 times the rate of increase of sea level (Douglas, 2001). Along most US beaches, a 0.3 m rise in sea level would cause an estimated 30 m erosion although the actual amount depends on wave climate and beach profile (Titus et al., 1985). This relationship of sea-level rise to erosion has become known as the Bruun Rule (Leatherman, 2001). It does not suggest that sea-level rise actually causes erosion; rather, increased sea level enables high-energy, short-period storm waves to attack further up the beach and transport sand offshore. Furthermore, da Silva and Duck (2001) determined that in the Ria de Aveiro, Portugal, a 0.1 m increase in mean sea level would contribute to an increase in speed of tidal propagation with up to a 22% increase in volume of the tidal prism.

Beach erosion in the eastern Caribbean islands' averaged 0.3 m/year and Cambers (1997) emphasised the vulnerability of both the islands' coastal zone and tourism-based economies. In Mauritius, beach erosion threatens coastal roads and tourist hotels and according to Ragoonaden (1997), this will be compounded by accelerated sea-level rise resulting from global warming. Sri Lanka is directly affected by sea-level rise and beach erosion and many coastal protection schemes have resulted in the loss of the recreational beach (Weerakkody, 1997). This will be of particular concern for small island economies that often rely on tourism (Brown, Tomkins, & Adger, 2002) and the catastrophic economic impacts, inferred from work in Barbados by Dharmaratne and Braithwaite (1998), are major consequences. Thus sea-level rise, coupled with storm surges and high tides, will ultimately pose severe problems for beach managers, coastal engineers and tourism business. Obviously, policy and implementation will be influenced by the available techniques for defending the coastline with due consideration being given to their cost and sustainability. The Environmental Scientist (2000) reported that strengthening coastal and river flood defences to withstand climate change could cost £1.2 billion over the next half century in England and Wales, with buildings and infrastructure identified as areas most likely to be affected.

Many other factors also contribute to erosion, and this further complicates the development of appropriate management strategies. According to Anfuso et al. (2000), different values of disturbance depth have been recorded in beaches exhibiting a broadly similar wave height. Disturbance depth therefore, depends on a combination of factors including prevailing weather and climatic conditions and coastal infrastructure. Concerns were also highlighted that offshore marine aggregate dredging, was contributing to erosion in the near-shore zone. The causes and effects of erosion can also vary temporally with natural changes in coastal processes. For example, SBCEG (Swansea Bay Coastal Engineering Group) (1999) reported that beach levels at Penarth, South Wales dropped to a critical level during 1997/98, causing the undermining of a section of the large vertical promenade. This agreed with Phillips (1999) who documented a fall in beach level resulting in an average loss of beach material of 50 kg/m^2 between September 1997 and April 1998. However, following a survey in September 1998, beach levels had risen with an average gain of beach material of 165 kg/m^2. This example demonstrates the difficulties faced by coastal managers when deciding on appropriate responses to erosion and decisions are further complicated because some methods of coastal defence themselves cause erosion (Gillie, 1997). In Gower, UK, significant beach erosion, allegedly due to offshore dredging, has raised concerns regarding detrimental impacts on an Area of Outstanding Natural Beauty and therefore, its appeal as a major 'seaside' tourism destination. The impact on newly developing tourism markets, including specialist and lucrative surfing markets, has also been raised as a major concern (Collis, 2003; Turner, 2003).

3. Holding back the tide: protecting beach assets

3.1. Utilising traditional methods

Hard engineering structures such as seawalls, groynes, piers, etc. have traditionally been used to manage storms and tides for the protection of developments within the coastal zone. These structures are expensive and tend to promote erosion, possibly by the formation of rip currents. In Porthcawl, South Wales, the Esplanade seawall of 1887 was replaced in 1906 and again in 1934 as erosion continually undermined the previous constructions. Beach levels continued to fall and in 1984 the beach was paved with bitumen macadam. Although not aesthetically pleasing, the project was successful in preventing further erosion and tourism was unaffected due to alternative nearby beaches. According to Bullen (1993), the Institute of Oceanographic Sciences concluded that human intervention, including port developments and seawall construction, had been the main erosion mechanism along the beaches in South Wales. Following port developments at Marina di Massa, Tuscany, Cipriani, Pelliccia, and Pranzini (1999) reported similar findings on the downdrift beaches. Indeed, they highlighted that in order to protect the seaside resort, each kilometre of coastline was protected by 1.4 km of hard structures. Later work identified 2.2 km of hard structures protecting every kilometre at Marina di Pisa, Tuscany (Cipriani et al., 2004). However, Basco (1999) believed there are many misconceptions that seawalls increase erosion and destroy the beach. Wiegel (2002) considered that they cause erosion in special circumstances where they prevent erosion of an upland source of sand for a beach downdrift, whilst van der Weide et al. (2001) recognised that engineering works along the coast often cause erosion and accretion. Indeed, Gillie (1997) cited seawall construction in the Pacific islands, as an example of a costly measure that often aggravated the problem.

It can be argued on socio-economic grounds, however, that hard engineering will still be necessary. If human activity and global change mean losses in the coastal zone, then risk assessments will have to be undertaken to consider overall consequences. These will include costs for defending buildings and infrastructure, environmental issues, and associated socio-economic benefits. Stakeholders would be unwilling to allow areas of high value real estate to be abandoned to the will of the sea unless cost benefit analysis and more importantly, political will prove otherwise. Controversial decisions of this nature are, however, already being made, with clear economic priorities being chosen such as at Porlock Beach, Somerset. A conscious decision by public bodies in the late 1990s to withdraw coastal defence expenditure has led to a sustained breach of sea wall defences with consequent flooding of low-lying areas beyond the beach. The result in terms of negative and positive benefit has been ambiguous since flooding resulted in the loss of valuable grazing farmland but also the creation of an inland salt marsh wetland. The latter has provided a new recreational resource with opportunities for bird watching and has become an asset for the local tourism industry.

3.2. Utilising alternative methods

Because of the problems associated with hard engineering in the nearshore zone, not least cost and maintenance, alternative soft engineering techniques that work in conjunction with natural coastal processes are increasingly being used. These include the construction of submerged breakwaters that reduce effective depth offshore and consequently reduce wave power and erosion of the beach (Aminti, Cipriani, Iannotta, & Pranzini, 2002), and groyne field techniques, which promote sediment deposition and evolution of the shoreline (Kunz, 1999). A further method for protecting the shoreline is beach nourishment which is a soft engineering solution that has been used primarily for the benefit of the tourism industry. A good example is Miami Beach which, as a result of erosion, had virtually no beach by the mid-1970s. Consequently, visitor numbers declined and its facilities were run down. Following beach nourishment and infrastructure improvements in the late 1970s, Miami Beach was rejuvenated to such an extent that the current annual revenue from foreign tourists alone is $2.4 billion, about 50 times the $52 million cost of the 20-year project (Houston, 2002). Furthermore, foreign tourists who visit Miami Beach, pay more in Federal taxes than the Federal Government spends nationally on beach nourishment. Using the capitalised annual cost of the project, for every $1 that has been invested annually on the nourishment, Miami Beach has received almost $500 annually in foreign exchange (Houston, 2002).

Cipriani et al. (1999) reported that approximately 7 km of beaches at Marina di Massa, experienced severe erosion resulting from the construction of an industrial harbour in the early 1920s. This interfered with longshore sediment transport which induced a sediment deficit to downdrift beaches. Despite construction of different types of hard structures including seawalls, breakwaters and groynes, as well as a submerged breakwater, beach erosion continued and tourism suffered. A beach nourishment programme was introduced where offshore sand was dredged and dumped on the beach, the project being funded by bathing establishment owners and the local authority. The mean grain size of the borrow material was finer than the native beach sediment which resulted in approximately 66% of borrow material disappearing within 1 year. The beach quality also worsened due to the fine sediments making the beach dusty. Although financially successful in terms of tourist revenue, the process was unsustainable. This led to a loss of faith in a soft engineering solution by private owners, tourist operators and local authorities alike which may result in future construction of additional hard structures (Cipriani et al., 1999). However, had more money been spent initially and the project taken into consideration all prevailing conditions, coarse-grained sediment would have been imported and the nourishment would have been successful.

Micallef, Williams, and Cassar (2001) undertook environmental risk assessments on a proposed beach nourishment project for tourism at St George's Bay, Malta. Two different sized sediments, one fine grained and one coarse grained were modelled utilising potential volumes whilst considering positive and negative performance during both construction and post-construction phases. Findings showed a high probability (0.95) of a mild impact during the post-construction phase with fine-grained sediment as against a high probability (0.86) of a negligible impact with coarse-grained sediment. These predictions were in agreement with the nourishment problems identified at Marina di Massa.

The lesson to be learned is that beach nourishment can be a sustainable way to manage coastal erosion provided that coastal processes are appropriately considered. Following nourishment, the new wider beach serves as shore protection from the impacts of storms and increases recreational benefits with new tourism related opportunities (Benassai, Calabrese, & Uberti, 2001). For example, there currently exists a European sponsored project in the Lazio region of Italy to define technical, environmental and economic problems linked to the borrowing of marine sand for reconstruction and maintenance of littoral coasts under erosion. The main issues relate to the estimation of required sand volumes, search for sediments on the continental shelf, environmental compatibility, extraction technologies and projected costs (Lupino & Riccardi, 2001). In Italy approximately 20 million cubic metres of marine sands have been used for beach nourishment during the last 10 years (Cipriani et al., 2004) whilst 20 million tonnes was used in the same period to nourish Britain's beaches (Symes & Byrd, 2003). Furthermore, beach nourishment is the preferred alternative in response to erosion along the US coasts (Leatherman, 1997) and as argued by Symes and Byrd (2003), there is a natural symmetry to combating coastal erosion with ballast won from the sea.

3.3. Case study—Gower, South Wales, UK

The Gower Peninsula, South Wales, UK (Ordnance Survey Ref: SS460900), is located in the Bristol Channel which has the second highest tidal range in the world (mean 8.3 m spring tidal range at Gower—Fig. 1).

Gower's ragged outline comprises carboniferous limestone cliffs, sandy bays and green headlands. The geology and mild climate created diverse habitats and spectacular views leading to its designation in 1956, as the UK's first Area of Outstanding Natural Beauty (AONB). It has four National Nature Reserves (NNRs), 17 Local Nature Reserves (LNRs), an internationally important RAMSAR site, 27 Sites of Special Scientific Interest (SSSIs) and 55 ha of Heritage Coast (Bridges, 1997). In addition, a proportion of the south Gower coastline and offshore waters are within the candidate Carmarthen Bay Marine Special Area of Conservation (SAC). Although the Gower Peninsula is predominantly carboniferous limestone and is generally resistant to erosion, there are a number of beaches that overlie rock platforms and are subject to change. Some of these beaches are naturally volatile being exposed to the southwest and as such, the worst of the storm surges. Natural processes of sediment movement cause erosion and accretion along this coastline in a complex and sometimes unpredictable manner (Bullen, 1993). Gower is an important tourism resource due to its rich unspoiled scenery and is considered a competitive strength by Swansea City Council. However, over the last 6–8 years, there had been a dramatic loss of sand from many Gower beaches (Venables, 2001), especially Port Eynon and Horton, where the remains of ancient forests had become visible on the foreshore (Fig. 2).

The construction industry is also a major contributor to the economy of South Wales, and in 1996, accounted for 10% of Gross Domestic Product (GDP) (Clifton, 2000). The extraction of sand from the Severn Estuary and Bristol Channel has for a century been vital to the construction

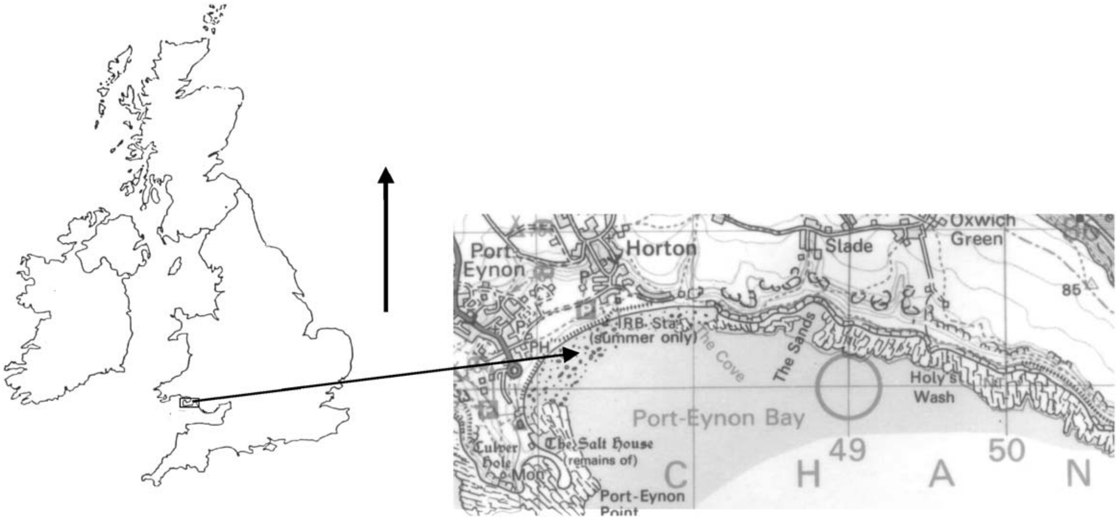

Fig. 1. Location map of Gower and Port Eynon Bay (reproduced by kind permission of Ordnance Survey, Crown Copyright. All rights reserved).

Fig. 2. Remains of ancient forest, Port Eynon Beach.

industry and almost 90% of the sand supplied in South Wales, comes from marine sources (Bellamy, 1999). This sand is ideal for construction and there is a lack of viable alternatives and environmentally acceptable land-based deposits. There is, however, controversy regarding offshore marine aggregate dredging in the Severn Estuary/Bristol Channel, and specifically off the Helwick Bank (Walters, 2000). Bullen (1993) stated that the main ebb tidal current carries material down channel, which is distributed, along Gower beaches and onto the Helwick Bank. This sandbank is approximately 15 km long and up to 1.4 km wide and lies approximately 2 km offshore from Port Eynon and Horton beaches (Fig. 1), in Port Eynon Bay, on the southwest Gower coast. Links had been hypothesised between the erosion of South Wales beaches and the volume of material dredged and an Internet website was initiated to disseminate information for the "Save our Sands" campaign (www.gower-sos.org). There was dismay when the results of a government sponsored 4-year research programme, into links between dredging and sand loss from Gower beaches, were inconclusive (Walters, 2000).

According to Butt and Russell (2000), erosion and accretion of the shoreline, in response to dynamic wave conditions are functions of the overall sediment budget. ABP Research and Consultancy, and Posford Duvivier (2000) argue that net sediment transport is in response to the effects of wind and waves; to seasonal variation and long-term climatic trends, whilst DOE (Department of the Environment) (1995) recognised that sediment is linked by coastal processes to sediment sinks, for example, beaches and offshore sinks. Dredging may increase total wave energy, reduce wave dissipating forces and shelter to the coastline (Brampton & Evans, 1998) and according to the SBCEG (1999), Helwick Bank provides some shelter from storm waves during low flow periods.

Therefore, a possible solution to this problem would be beach nourishment in conjunction with submerged breakwaters. The submerged breakwaters would protect the beach from storm waves in a manner similar to the sandbank, whilst dredged sand from Helwick Bank, would provide the source of beach nourishment. Sand from Port Eynon beach is statistically similar in grading to that extracted from the Helwick Bank (Phillips & England, 2001; Phillips & Lees, 2003) and supports findings of ABP Research and Consultancy, and Posford Duvivier (2000) of a weak two-way link between the beach and the Bank. Therefore, the nourishment process would be sustainable as it avoids the problems identified by Cipriani et al. (1999) and complies with the findings of Micallef et al. (2001). The performance of a nourishment project is generally determined by the remaining volume to the volume used and this ratio depends on various wave, coast and material parameters (Karasu, Komurw, & Yuksek, 2004). With infrastructure costs, Phillips (2005) projected a 5-year gross nourishment cost of £28/m^2 of beach surface for another beach on the South Wales coast. Consequently, this soft engineering solution to protect both the natural environment and tourism infrastructure would be in line with sustainable management practices and could provide the ultimate irony in that dredging of the Helwick Bank, would be used to protect Gower beaches.

4. Integrated coastal zone management (ICZM): combining coastal conservation with tourism development

The factors which influence sustainability in coastal management span social, economic, institutional, bio-physical and legal conditions (Christie, 2005). However, as argued by Sorensen (1997), despite the growth in ICZM over the past 30 years, there is uncertainty and little information regarding successful strategies. The clear trends of continued human migration to the coast and major growth in coastal tourism, has resulted in escalating investment in coastal locations (JHCS (John Heinz III Centre for Science), 2000). Global warming and sea-level rise are coastal hazards difficult to quantify but indirect costs will include falling property values and loss or transfer of tourism revenues.

According to Williams and Morgan (1995), the primary responsibility of coastal managers is to conserve coastal scenery quality in its natural state as far as is possible and, to facilitate its enjoyment by the public via recreational activities in accordance with its primary aim. Granja (2001) highlighted that the lack of coastal zone management had irreversibly contributed to the gradual degradation of Portugal's natural heritage, including the landscape that is one of its key elements. She further argued that promoting conservation implied an understanding of geoforms, their generation and longevity and their relationship with the ecosystems dependent on them. Therefore, to ensure that recreational and tourism assets are protected, it is important to understand not only present day factors and processes, but also those that have been active in the recent geological past. This further validated Hall (1997) who argued that environmental scientists should to be more involved in tourism issues.

The coastal zone has evolved from many natural and anthropocentric factors and processes. In a dynamic perspective, it is logical that management concepts inherent to these factors should be integrated. van der Meulen, Misdorp, and Baarse (2001) suggested that ICZM was a cyclic process of problem recognition, planning, implementation and monitoring which can be used to ameliorate and manage conflict. Tourism development for instance, may on times be incompatible with conservation. This was illustrated by Pearce (1998), who argued that for compliance with standards necessary for European Blue Flag beach status, the beach and coastal waters may be modified at the expense of marine ecosystems and sand dunes. However, Granja and Carvalho (2000) had reservations regarding primary conservation and implied that it was unrealistic to believe all coastlines can be conserved from impending sea-level rise and subsequent coastal erosion. They suggested managed retreat and selective conservation of parts of the coast that are important to society and to use technological developments, where possible, to halt inland beach migration. Measures should be taken to attenuate or reduce the effects of erosion but where irreversible loss is evident, society must be persuaded to undertake a gradual and planned retreat from the waterfront. Therefore it is argued that when deciding the future of New Orleans, managed retreat should be the primary consideration for decision-makers.

Beach management and sea defences can generally be justified on socio-economic grounds for a particular region and community which depend on the beach, even though in some cases, these may cause accelerated erosion further along the coastline. Management strategies for the coastal zone are in line with those suggested for coping with the negative effects of climate change. They include prevention of loss, tolerance of loss and changing activities and location, whilst the mechanisms to achieve these strategies include institutional, legal, financial and technological aspects (Environmental Scientist, 1999). Although managing erosion is potentially damaging to conservation and tourism interests, it is not necessarily irreversible. Schroeder (2000) argued that erosion does not generally result in detrimental impacts to unmodified areas and in some instances can often provide a net benefit, as in the case of Porlock. As the coastal zone is naturally dynamic and with progress being made in sustainable management practices, there will be a tendency to adopt more soft engineering solutions to work alongside natural coastal processes. In Italy, gravel beaches have been constructed to protect coastal facilities and buildings (Cipriani et al., 2004). They have proved cost-effective and also provided increased recreational space. It must be remembered, however, that as advocated by van der Weide et al. (2001), to best design appropriate mitigating measures the causes of erosion should be properly analysed and the technical and economic feasibility of such mitigating measures should be evaluated. Furthermore, resort areas depend on facilities and infrastructure and as argued by JHCS (2000), if tourist perception is negatively affected, then the resorts themselves may be severely affected for many years. Consequently, the prospects for controlling costs and losses are not good.

The growing message is clear and was validated by Malvarez Garcia, Pollard, and Dominguez Rodriquez (2003) when reporting on their study of Southern Spain. They highlighted the critical importance of the coast as a landscape resource for both visitors and residents and considered the need for integrated management to ensure: erosion control, physical protection of the landscape and implementation of effective urban planning measures to ameliorate tourism pressures. It was suggested that this approach will ensure an attractive environment for visitors and ultimately assist in maintaining Spain's position as a major player in the global tourism market. Sorensen (1997) argued that it was necessary to determine and apply coastal management lessons derived from cross-national comparisons. Therefore, from a cross-national analysis of the problems and consequences of erosion, and management lessons learned, effective decisions can be made for the future protection of tourism infrastructure.

5. Conclusions

Beach erosion undoubtedly poses a significant threat to recreation and tourism and consequently the economy of many localities and regions. There is uncertainty regarding climate change and the validity of current predictions but general consensus amongst coastal scientists is that there will be an increased incidence of storm surges and a general rise in sea level. Coastal managers will therefore need to adopt techniques that work with the natural processes rather than simply implement traditional hard engineering responses. Beach nourishment is increasingly used as a soft engineering solution for the sustainable management of eroding beaches.

There is a need to think with long-term vision, as current practices, as well as medium-term local planning strategies, tend to concentrate on immediate socio-economic benefits and pay little attention to longer-term coastal management concerns. It is essential therefore that stakeholders and policymakers implement measures based on sound ICZM practice. Thereby, using a cyclic process of problem recognition, planning, implementation and monitoring, appropriate responses to coastal erosion can be developed. Such a strategy will ensure that any decisions made, remain appropriate to the sustainable management of the coastal zone which after all, is the raw material supporting the tourism industry.

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