

How far does tourism stress coral reef environment in island states: case studies of Indian Ocean and Caribbean islands

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Abstract

This contribution will expose and discuss the environmental impacts of tourism on the coral reef environment through the analysis of case studies of Indian Ocean and Caribbean Island Developing States. The objective is to demonstrate that the situation of islands and archipelagos is complex and diverse as numerous factors influence both the nature and extent of tourism environmental impacts and as tourism development produces contradictory impacts on the coastal environment. As a consequence, diagnosis must be moderate and gross generalization avoided. The first part of this paper will expose the major physical constraints that such countries have to face in order to achieve economic growth, as the reduction of these constraints largely determines the adverse environmental impacts of coastal development. Secondly, we will present the most common negative impacts of tourism-related projects and tourism activities on the coral reef environment. Then, we will demonstrate that tourism development has often played a major role in the setting up of coastal planning and environment preservation in various ways. Finally, we will sum up the main drivers of tourism environmental impacts.

Keywords: tourism environmental impacts, coral reef environment, Small Island Developing States, environmental degradation.

1 Introduction

The sustainability of tourist island states both depends, on the one hand, on their physical and human development capacities, and on the other hand, on the ability of human societies to maintain the viability of development projects through a



subtle equilibrium between economic development and environment preservation. In Small Island Developing States (SIDS) of the intertropical zone, the negative impacts of tourism on the coral reef environment are generally significant, due to low national capacities and high ecosystem vulnerability. The question of tourism environmental impacts is important for comprehending the sustainability of such countries because tourism, which is the main economic sector, highly depends on environmental assets that are threatened by the impacts of coastal development projects and by those of climate change, like coral bleaching and beach erosion. Among all ecosystems, the coral reef environment is at the same time the most attractive and the most vulnerable to all kinds of pressures. As it also provides food to human communities, it plays a central role in SIDS sustainability and in island viability.

In this paper, we will firstly present the specific constraints that island states have to face for achieving economic development as we argue that the environmental impacts of tourism are largely determined by island states' capacities. The second part of this contribution will expose and discuss the common adverse environmental impacts of tourism development. The objectives will be to draw up a review of these impacts and to analyse whether they are specifically due to tourism development or not. Then, we will demonstrate that tourism development and tourism-related projects can support environmental preservation in various ways. Thus, regarding tourism environmental impacts, diagnosis must be moderate as positive effects of tourism development can counterbalance its negative impacts, and even, in certain circumstances, support the implementation of sustainable development policies. As a conclusion, we will emphasize the drivers of tourism environmental impacts in SIDS.

2 Development constraints in Small Island Developing States

SIDS have to face diverse physical and human constraints which constitute limiting factors for economic growth and produce specific difficulties for controlling the impacts of both coastal engineering works and tourism-related projects. As island states present a high diversity of situations, the level of constraints varies a lot. Here, we will expose the major constraints and their variations from one island type to another.

2.1 Physical constraints

The physical constraints that SIDS have to address have already been listed in previous works [1–4]. They are mainly due to the remoteness of such territories, to limited flat land or island area, to the scarcity of terrestrial resources and to the dissemination of islands in the case of archipelagos.

2.1.1 Remoteness

In remote oceanic areas, islands have become more accessible since runways and international airports were built, which occurred either during World War II when foreign countries exploited their strategic location as for Saint-Marteen and Saint-Thomas in the Lesser Antilles, or at the time of their political



independence for those that were colonies of northern countries like Mauritius, Maldives and Seychelles.

Moreover, most island states of the intertropical zone are distant from the most developed areas of the world. Their peripheral location limits economic opportunities. On the contrary, island states that are under the influence of the most developed countries do benefit both financial and commercial opportunities that support their economic growth. This situation is that of many Caribbean islands, favoured by their location between America and Western Europe.

2.1.2 Territorial fragmentation of archipelagos

Archipelagos are generally composed of scattered islands separated by hundreds of kilometres of ocean surface. As a consequence, they have to face, on the one hand, the “outer” distance separating them from neighbouring countries, and on the other hand, the “inner” distance between islands. For example, the 25 Maldivian atolls and patch reefs stretch out on 820 km from North to South and 130 km from East to West. This physical distance is reinforced by the fact that strong currents circulate in the deep channels separating reef structures.

2.1.3 Limited land area

The smallest countries (covering less than 300 square kilometres) are all the most constrained by limited land area as it is scattered between many islands. In Maldives (1169 islands), the average island size is only 0,2 square kilometres. So small surface areas question the viability of development projects. Moreover, many islands can hardly be reached by sea as they have formed in the inner part of extended reef flats. As a consequence, each island is difficult to reach and connections between islands are uneasy. In addition, some islands are not suitable for human settlement because of their morphological instability due to sediment movement and severe impacts of storms.

Mountainous islands, such as those of Seychelles, British and US Virgin Islands, have limited flat land areas, which is a serious limit to infrastructure building and economic development. In most cases, the flat land area is scattered between numerous small coastal plains, which reduces even more development opportunities.

2.1.4 Limited resources

The diversity and amount of natural resources is proportional with the land area and higher in mountainous islands than in coral ones. Whereas marine resources are quite abundant in small island states, terrestrial resources are very limited, in particular in low-lying islands where fresh water, wood for construction and cooking, and building material are scarce. Underground aquifers are small and exposed to salinity and pollution. Building material is limited to coral and sand that can only be exploited where they are easily accessible to human communities.

2.2 Limited human capacities

Various human factors limit the capacities of SIDS and threaten their sustainability.



2.2.1 Weakness of legislation

As a result of various colonial heritages and of economic backwardness, many island states still have a limited and inconsistent legislative framework regarding environmental protection. Moreover, the enforcement of the law is often limited by the lack of human capacities. In addition, as the national priority is given to economic growth, which is generally based upon foreign investments, international tourism companies are very powerful, which limits national initiatives aiming at strengthening environment protection and enforcing law and regulations. For example, setback distances are generally much lower than in developed countries (5 metres in Maldives, 15 m in Seychelles and Mauritius until their recent increase) and environmental impact assessment procedures are both recent and still badly implemented. In some cases, corruption also reduces the enforcement of the law [5].

2.2.2 Issues concerning land property

The question of land property is important as it determines the applicability and therefore the level of enforcement of the law. Over the past decades, whereas public actors of developed countries have strengthened their control on coastal development through land acquisition (see actions of *Conservatoire du Littoral* in France and of *National Trust* in United Kingdom), coastal land is still widely controlled by private actors in SIDS. Long-term leases and private property do limit the enforcement of law and regulations as well as the implementation of environmental policies. In Mauritius, for instance, speculation is important to a point that the Government can hardly determine who are the tenants of coastal leases.

2.2.3 Limited scientific and technical capacities

Scientific capacities and more globally national skills in environment management are generally limited by the absence of universities and training centres. Where universities exist, like in Mauritius and US Virgin Islands, they were recently created and they still don't offer training in all fields.

On another hand, technical capacities of many SIDS are limited as a result of reduced financial means and remoteness that limits the benefits of regional cooperation. As a consequence, external dependence is high in financial, technical and scientific terms. So, progress is generally chaotic.

3 Adverse impacts of tourism development on the coral reef environment

The main objective of this section is to distinguish the impacts that are directly due to the tourism sector from those that are more globally due to the development process and to the reduction of physical constraints.

3.1 Impacts of reclamation works

In many mountainous islands, shallow reef flats were reclaimed for increasing flat land area [6, 7]. Thus, over the past four decades, on the north-eastern coast



of Mahe (Seychelles), more than 700 hectares of fringing reefs were reclaimed for the needs of infrastructure development (international airport of Pointe Larue, four-lane road, rubbish dump), industry and housing [8]. In some places, massive reclamation works destroyed swamps and lagoons, like at Saint-Martin in the Lesser Antilles where the international airports of Juliana and Grand Case were built on ponds [9]. Such works are very destructive for coral reefs both in dredged and reclaimed areas that are directly affected by mechanical destruction and in peripheral areas that are degraded by high turbidity and fine particles deposition. As a result, coral mortality affects large areas.

In low-lying islands, dredging and reclamation works are operated so as to increase island size and accessibility [4, 10]. Dredging of reef flats is generally operated on the leeward side of islands so as to create sheltered harbours. Dredging material is also used for nourishing artificial sand beaches. In addition, navigation channels are dug into reef flats. These works modify current patterns and, as a consequence, they disrupt sediment transport and have an influence on shoreline evolution. Coastal erosion issues are often due to or aggravated by such morphological changes and hydrological disturbances.

Massive reclamation works are necessary for extending flat areas and they are neither specifically due to tourism development, nor limited to tourist areas. Indeed, many islands were equipped with runways during WWII or the cold war, and airports were also built for national needs in islands states that are not economically oriented towards tourism. In Maldives, reef reclamation was operated both in the inhabited islands, as a result of population growth, and in the resort islands. It can be estimated that about 40% of the 87 island resorts were extended by reef reclamation [4]. In both cases, such works have reduced wave refraction and thus aggravated both marine submersion and coastal erosion.

In the Caribbean, the development of cruise ship and boating tourism has led to the construction of harbours and marinas in many bays, such as in the Virgin Islands. Such dredging works have affected marine fauna and current patterns, and fragile ecosystems such as mangrove swamps and coral reefs were partly destroyed. But on the whole, harbour construction is mainly due to the fact that islands have to import most goods because of their limited resources and reduced production capacity. Tourism has generally led to the increase of imports as a result of high tourist consumption, agriculture recession, increase of life standards and generalization of the northern hemisphere's consumption model [11].

3.2 Impacts of hotel construction

The main impacts of tourism development on coastal ecosystems are due to the construction of tourism facilities.

The coastal topography has been significantly modified where hotels and tourist residences were built. The increase of building material needs resulting from population growth, upgrading of local habitat and tourism development, often led to sand and/or coral mining. Some dunes and beaches have been severely affected by sand extraction, as in Mauritius and Seychelles [8, 12]. But



such practices are not limited to tourist islands. In Comoros, many beaches have disappeared as a result of sand extraction for local habitat construction. Thus, tourism development has to be considered not as a cause, but as an aggravating factor of sand and coral mining. In the Maldives, it was estimated in the 1980's that about one third of extraction was due to tourism development [13]. Sand and coral mining operated in coastal dunes and shallow waters modify coastal topography and bathymetry. Sand dune extraction has lowered coastal areas and therefore aggravated the risk of marine submersion. In foreshore areas, coral extraction has augmented the depth of coastal waters and reduced wave refraction, which has aggravated both marine submersion and erosion risks.

As setback distances are low, coastal dunes and berms have often been planned off for hotel construction and ponds filled in. Consequently, inundation risks were aggravated. In some places, reef flats were dredged in front of hotels for creating bathing areas, such as at Bel Ombre on the southern coast of Mauritius.

Because they have affected current patterns, sediment transport and deposition, and thus aggravated beach erosion and coastal plain submersion, the modifications of topography and bathymetry have often led to coastal protection works. Engineering structures such as seawalls, groins, concrete revetments, breakwaters and ripraps were built for protecting both land and buildings. Massive coastal defences have often destabilized sediment cells, accelerated beach loss and spoilt the landscape. Some hotels were built on eroding and high-energy coasts, which were rapidly affected by shoreline receding after their construction.

In Maldives, massive environmental degradation has led to the closing of some resort islands that were no longer attractive for tourists, which shows that non-sustainable development projects can finally be counterproductive.

3.3 Aggravation of pollution

Pollution is one of the main environmental problems of developing island states. As tourism has led to a significant increase of wastewater and waste production, it contributes significantly to an aggravation of the previous situation. The frequent accumulation of waste in uncontrolled rubbish dumps aggravates the pollution and degradation of ponds and coastal waters.

Cruise ship tourism and boating also contribute to ocean and coastal pollution because wastewater and waste are generally unloaded in the open sea, as in the US Virgin Islands [14]. In some countries like Barbados, beach cleaning has become an important issue as waves bring waste back on coasts [15].

Desalination plants are often necessary for providing hotels with fresh water. Such equipments that often use fuel oil are an additional source of pollution.

3.4 Impacts of tourism activities

Various activities have had adverse impacts on coral reef environment. Boat anchoring has devastated large surfaces of corals on the outer slopes of fringing reefs and on patch reefs. Diving has also led to the breaking of fragile corals



where divers are numerous, unskilled and unaware of the ecosystem vulnerability, as in various Caribbean islands as emphasized by marine biologists in the 1980's [16, 17]. At Vihamanaafushi Island in Maldives, coral destruction due to diving represents 7% of the total reef value [18].

The collection of living marine organisms such as shells and corals by tourists has led to a significant rarefaction of some species and to the diminution of biodiversity in tourist areas. Moreover, the growing demand of tourists from the northern hemisphere for turtle shells and aquarium fish has considerably aggravated the state of reefs in the most accessible areas. For instance, in Maldives fish collection started in 1979 and rapidly developed until the 1990's. Although it has decreased with the adoption of conservation measures, it still affects 120 species and 175 800 fish per year [19].

4 Positive effects of tourism development on the coral reef environment

Tourism development has also had positive effects on environmental conservation and even more globally on national development policies through various ways.

4.1 Land use planning and creation of nature reserves

In SIDS, tourism development has played a major role in the setting up of national planning and conservation policies [5].

Since their political independence, most small island states have elaborated development plans defining guidelines for achieving economic growth and social progress. In most cases, land use plans were set up in a second period as a result of tourism take off in a renewed context of competition for coastal land. In parallel, the elaboration of tourism master plans and site development schemes has completed this operation. Planning has significantly improved coastal management and ecosystems protection.

On another hand, tourism development has favoured the creation of nature reserves that have promoted the environmental assets of island states on the international market, and thus supported the establishment of current conservation policies. In Seychelles, the conservation policy of the Government has played a major role in the elaboration and consolidation of the country's environment-friendly image [20]. The national ordinance on national parks was adopted in 1969 as the reef flat of Pointe Larue was reclaimed for the construction of the international airport, which opened in 1971, and Sainte-Anne national park was created in 1973 in front of this reclaimed area. In the 1980's, the designation of the Vallée de Mai in Praslin (1981) and atoll of Aldabra (1982) as World Heritage Areas (UNESCO) has reinforced the nature image of the country. Nature reserves and biodiversity are major elements of tourism promotion policies in island states of the intertropical zone.

The increase of human pressure on coastal environments has often led to the carrying out of biodiversity inventories and vulnerability assessments. Tourism



has played a significant role in the launching of such studies both because its rapid development has had adverse impacts on coral reefs and beaches, and because natural assets play a major role in the attractiveness of such tourism destinations.

4.2 Nature-based tourism

Some tourism projects are based upon the promotion of biodiversity, as those that are developed on most of peripheral islets in Seychelles and Mauritius. Whereas some islets offer accommodation facilities, others are only open to visitors coming within the framework of guided tours organized by tour operators or conservation NGOs. The main points of interest of these islets are fauna (seabirds at Aride, Cousin and North islands, Seychelles; tortoises at Curieuse island, Seychelles), flora (Aigrettes islands, Mauritius) as well as cultural heritage (old settlements, fortresses, lighthouses...). Fees paid by visitors often support scientific research programmes contributing to environmental preservation. Some sand-cays are also destined for high standard ecotourism based upon marine biodiversity. Here, the main attractions are seabirds, turtles and coral reefs. As an example, the private coral island of Bird (Seychelles) was pioneer in ecotourism development in the early 1970's. Sooty terns (*Sterna fuscata*) and turtles (*Eretmochelys imbricata* and *Chelonia mydas*) are its main attractions. The restoration of the sooty terns habitat has supported the reconstitution of the bird colony which increased from 67 000 couples in 1967 to more than 700 000 couples in 2004. Here, ecological tours and turtle monitoring programmes play a major role in the development of environmental awareness. The sustainability of Bird island tourism is based on a wise balance between economic goals (limited bed capacity), environmental conservation and promotion of socio-cultural values [21].

4.3 Ecological islands

Resort islands offering environment-friendly facilities (regarding energy production, wastewater and solid waste treatment, in particular) and conducting ecosystem restoration projects with the support of scientific expertise belong to the category of "ecological" or "green" islands, such as Ihuru in North Male atoll in Maldives [4]. Such islands play a major role in the experimentation of environment-friendly techniques for solving environmental issues. At Ihuru, an innovative restoration project aims at strengthening the resilience of corals that were severely degraded by the increase of ocean surface temperature during the ENSO event 1997-1998. Moreover, diving is strictly supervised and it contributes to environmental preservation through education and training programmes designed for tourists. Over the past years, Ihuru obtained several awards as a result of its ecological performances.

The high level of fragmentation of archipelagos is favourable to the carrying out of innovative conservation projects and to field experimentations as resort managers have an important room to manoeuvre in island management.



4.4 Role of hotel beaches for progress in beach erosion management

Due to limited financial, technical and scientific capacities, islands states often have significant difficulties for identifying and implementing sustainable practices for controlling beach erosion. As a consequence, public policies are largely based on hard engineering structures (breakwaters, groins, ripraps, seawalls, gabion baskets...) installed for fixing the coastline and protecting buildings and infrastructures. As exposed in previous works dealing with the same island states [10, 22, 23], these structures have spoiled the scenery, aggravated environmental degradation and accelerated beach loss. In such a context, tourism companies may play a major role in the introduction and experimentation of soft techniques. The high economic value of hotel beaches and the high financial capacity of tourism companies support the development of consultancy firms and of innovative environment-friendly experimentations. As a consequence, new techniques are, set up locally, or imported from abroad, experimented on hotel beaches and then replicated on other eroded beaches if they give good results. Where environment impact assessment procedures are obligatory for any project developed in the coastal zone (hotel construction, defence works, building of jetties...) and rigorously conducted by consultants, both knowledge and technical skills make significant progress. As few scientific studies are available in most SIDS, the studies that are carried out by consultants provide basic and valuable data in various fields (marine hydrology, topography, bathymetry...), as in Mauritius. These data present a main interest for all institutions and stakeholders as they are produced at the scale of sediment cells. Thus, site studies made by consultancy firms and experimentations implemented on hotel beaches strengthen the capacities of institutions and support the development of wise practices contributing to progress in beach management.

5 Conclusion

The environmental impacts of tourism development projects are highly variable both at national and local scales due to the high level of physical fragmentation of archipelagos, to the diversity of stakeholders who are involved in ecosystem management in a context of backwardness of law passing and enforcement. The level of physical constraints is a major driver of tourism impacts on coral reef environment as they make massive coastal works necessary for the development of tourism projects and for protecting buildings and infrastructures from wave destruction. The principal constraints are limited flat land area and accessibility and high exposure to natural hazards. As physical constraints are exacerbated in low-lying islands, they are much more vulnerable to environmental degradation than mountainous islands.

The environmental impacts of coastal tourism are also variable according to the level of economic development as it determines the financial, technical and scientific capacities of SIDS. Local expertise and technical skills strengthening and coastal planning and legislation setting up have allowed recent progress in environment management. Foreign aid and regional cooperation have often



played a positive role in the strengthening of island states capacities by providing financial support, external expertise and training programmes. Tourism revenues have also financially supported the strengthening of island states capacities.

The setting up and increase of the setback distance (from 15 to 35 metres in Seychelles and from 15 to 30 metres in Mauritius) and the adoption and enforcement of environmental impact assessment procedures have played a major role in reducing the adverse environmental impacts of tourism both on coral reefs and sandy beaches. The strengthening of the legislative framework has also played a major role in pollution and mining control.

Due to their small size, vulnerable coral reefs and sandy beaches, and rapid coastal changes related to the high influence of extreme events such as storms, low-lying islands and coastal plains of mountainous islands have limited environmental carrying capacities. The construction of massive hotels often leads to serious environmental degradation and to the destabilisation of ecosystems as the buffer zones that are necessary for their protection and resilience are not included in hotel plans. The density and dimensions of buildings are important parameters for preserving the dynamic and equilibrium of ecosystems. Thus, big hotels with high bed capacities and numerous facilities are very destructive. Small tourism establishments with limited bed capacities are much more adapted to ecosystems vulnerability than big resorts. Both the setback distance, conception of buildings, facilities provided to visitors play a major role in the degradation of coral reef environment.

Strategies of tourism operators are another main driver of tourism environmental impacts. They are largely determined by internal factors (legislative framework and regulations) as well as external factors such as financial opportunities and evolutions of the international market. The nationality of investors is also important as local actors develop long-term investment strategies whereas international groups are more subject to capital relocation. Generally, long-term strategies are most sustainable than short-term investments, and as local groups are more aware of physical constraints, they are more qualified than international companies to integrate them into their development strategies.

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References

- [1] Huetz de Lemp, A., *Le monde des atolls et des îles basses. Nature et Hommes dans les îles tropicales: réflexions et exemples*, CEGET-SEPANRIT, *Îles et Archipels*, **3**, pp. 93-106, 1984.
- [2] Liew, J., *Sustainable development and environment management of atolls*, UNDP, New York, 1986.



- [3] Doumenge, F., Quelques contraintes du milieu insulaire. *Îles tropicales: insularité, insularisme*. CRET-CEGET, *Îles et Archipels*, **8**, pp. 67-86, 1987.
- [4] Cazes-Duvat, V., Le poids des contraintes physiques dans le développement des atolls: l'exemple de l'archipel des Maldives. *Les Cahiers d'Outre-Mer*, **213**, pp. 3-25, 2001.
- [5] Duvat, V., Mondialisation touristique et environnement dans les petites îles tropicales. *Les Cahiers d'Outre-Mer*, **236**, pp. 513-539, 2006.
- [6] Salvat, B., Dredging in coral reefs. In: Salvat, B., Ed. – *Human impacts on coral reefs: facts and recommendations*, Antenne EPHE, Polynésie Française, Papeete, pp. 165-184, 1987.
- [7] Solomon S.M. & Forbes, D.L., Coastal hazards and associated management issues on South Pacific islands. *Ocean and Coastal Management*, **11**, pp. 231-248, 1999.
- [8] Cazes-Duvat, V., *Les littoraux des Îles Seychelles*, L'Harmattan: Paris, 1999.
- [9] Cazes-Duvat, V., Le système du risque dans l'île de Saint-Martin (Petites Antilles). *Développement Durable et Territoire, Dossier 11, Catastrophes et territoires*, 2008, mis en ligne le 6 November 2008 URL: <http://developpementdurable.revues.org/sommaire6753.html>
- [10] Duvat, V., *Les littoraux coralliens des petites îles de l'ouest de l'océan Indien. Aménagement et gestion*, 2ème Partie, *Oceanis*, **31 (3-4)**, Institut Océanographique: Paris, 2007.
- [11] Giacottino, J.-Cl., Problématiques et perspectives du développement des petits pays insulaires tropicaux. *Îles tropicales: insularité, insularisme*. CRET-CEGET, *Îles et Archipels*, **8**, pp. 167-191, 1987.
- [12] Cazes-Duvat, V. & Paskoff, R., *Les littoraux des Mascareignes entre nature et aménagement*, L'Harmattan: Paris, 2004.
- [13] Brown, B.E. & Dunne R.B., *The impacts of coral mining on coral reefs in the Maldives. An assessment and recommendations*. Technical report, 1986.
- [14] Pesme, J.-O., Tourisme et développement durable à Saint-Thomas (Îles Vierges Américaines). *Îles et Archipels*, **24**, CRET: Talence, 1995.
- [15] Government of Barbados, *National Strategic Plan of Barbados*, 2005.
- [16] Marion, J.L. & Rogers, C.S., The applicability of terrestrial visitor impact management strategies to the protection of coral reefs. *Ocean and Coastal Management*, **22**, pp. 153-163, 1994.
- [17] Rogers, C.S., McLain, L., Zullo, E., Damage to coral reefs in Virgin islands national park and biosphere reserve from recreational activities. *Proc. of the 6th International Coral Reef Symposium*, **2**, pp. 405-410, 1988.
- [18] Allison, W.R., Snorkeler damage to reef corals in the Maldives. *Coral Reefs*, **15**, pp. 215-218, 1998.
- [19] Saleem, M.R. & Waheed, Z., A review of the Maldivian aquarium fishery. *Proc. of the 10th International Coral Reef Symposium*, 2004.
- [20] Gay, J.-Ch., Tourisme, politique et environnement aux Seychelles. *Tiers-Monde*, t. XLV, **178**, pp. 319-339, 2004.



- [21] Cazes-Duvat, V. & Magnan, A., *L'île de Bird aux Seychelles: un exemple de développement durable?* L'Harmattan: Paris, 2004.
- [22] Cazes-Duvat, V., Les archipels de l'océan Indien face à l'érosion côtière, *Annales de Géographie*, **644**, pp. 6-25, 2005.
- [23] Duvat, V., Beach erosion management in Small Island Developing States: Indian Ocean case studies. *Proceedings of the 1st International Conference on Physical Coastal Processes, Management and Engineering*, 16-18 September 2009, Malta, WIT Press, Southampton, pp. 149-160, 2009.

