

# Evaluation of coastal squeeze and beach reduction and its consequences for the Caribbean island Martinique

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## Abstract

Based on a spatial model, the Martinique beaches and coastal wetlands are examined to identify the risks of coastal squeeze. In many cases coastal development prevents coasts from adapting by shifting landward. Also tourism infrastructure augments the vulnerability of beach reduction and mangrove squeeze. More than 70% of all Martinique beaches and 29% of mangrove forests are highly endangered by coastal squeeze if sea level rises.

The majority of coastal constructions and especially tourist hotels are built at heights between 1 and 10 m above the present sea level and therefore also within the zone at risk to flooding and erosion. Spatial analysis based on a conducted GIS model is carried out that evaluates the tourist destinations most vulnerable to the impacts of sea level rise. If sea level rises and beach reduction becomes an increasing problem the attractiveness of Martinique beaches as tourist destination is likely to decline.

*Keywords: Coastal Squeeze, Spatial Analysis, Caribbean, Sea Level Rise, GIS Modelling*

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## **1. Introduction**

### *1.1. Sea level rise in the Caribbean*

Relative sea level in the Caribbean has risen of about 20 cm within the last century [1]. Regional projections state a rise in sea level of additionally 10 to 50 cm by 2025 [1,2], respectively approximately 65 cm by 2100 [3]. Scarce data availability within the Caribbean and high spatial variability among the islands makes concrete relative sea level rise estimates for each single island region problematic. Besides a rise in sea level further projections for the Caribbean region [2] expect an increasing frequency and intensity of hurricanes and tropical storms that coincide with coastal flooding and high erosion rates at the shores, also as a cause of rising sea level.

### *1.2. Martinique*

Martinique is an island of the Lesser Antilles in the Caribbean region. It is a French Department and EU „ultra-peripheral region“. The economy is largely based on the export of agricultural goods (bananas, sugarcane, pineapples) and tourism as major income sources. Nearly one million visitors annually arrive on the island that is inhabited by approximately 390.000 people [4,5].

Because the topography of the island is characterised by steep mountains, the majority of the settlements and about 77% of the population are situated along the coast below the 20 m contour line. Today, most of the Martinique population is concentrated in the extending urbanized zone of the cities Fort-de-France and Schœlcher, where houses are built almost at the level of the sea.

### *1.3. Beaches and mangroves on Martinique*

Martinique has approximately 120 beaches, which make up 13% or 57 km of the entire coastline. The beaches on the North and South coasts of Martinique are made of fine sands. The Northern beaches are situated between the foothills of the Mt. Pelée and the sea. They

mainly consist of black sand that originates from the erosion of the volcanic massive. In general they are of small extensions. The Southern beaches consist of white sands that originate from the abrasion of bordering coral reefs along the Atlantic. They are of special importance for touristic purposes.

The main endangerment for beaches is erosion. Currently eroding beaches and barriers are expected to erode further as the climate changes and sea level rises [6].

Along the Martinique coastline there are about 79 km (18%) of mangrove forests, which total approximately 1.850 ha of mangrove area or 6% of the total island surface. Mangroves are mainly found inside the bays of the South and South-Eastern coast of the island (650 ha), as well as in extensive formations in Fort-de-France Bay (1.200 ha). On Martinique one can distinguish two mangrove types (after Delbond et al. [7]): First of all there are mangrove littorals or submerged forests with *Rhizophora*. This type is situated inside the bays, mainly at Fort-de-France Bay, Francois, Robert, and Marin. Secondly, there are mangroves bordering the river mouths. This type can only be found at Trinité and grows on terrestrial sediments. Figure 1 shows the distribution of beaches and mangroves on the Martinique coastline.

Mangroves serve as main nursery areas to commercially important fish stocks. They are also home for a large variety of birds, reptiles and mammals. The wetlands at Fort-de-France Bay are internationally important for migratory birds [12], and the Martinique mangroves are rich in molluscs and crabs.

Despite its biological value, Martinique mangrove swamps are often regarded as marginal land and are therefore systematically degraded and destroyed [13]. Often they have been selected as dump sites or for housing or other urban structures to accommodate coastal development [14]. In the past, mangroves have been cleared especially for the construction of tourism and residential developments, due to urbanisation pressure, unsustainable wood use, or industrial pollution.

Gabrie et al. [13] report that about 30% of the mangroves on Martinique were lost between 1972 and 1992. Even though there are now measures to prevent mangrove destruction which also include the construction of purification plants and the treatment of industrial sewage at an European norm, most of the mangroves still suffer from degradation (see also Figure 2).

#### *1.4. Mangrove response to climate change and sea level rise in the Caribbean*

Several studies about likely wetland responses to sea level changes have been conducted (e.g. [6,16,17,18]). However, there is still much controversy about this subject. Scenario studies of mangrove responses to sea level rise vary from little adverse impact to collapse. General statements should be treated with caution and some authors demand site-specific analyses [19]. The conclusions from these studies can be summarised as follows:

The health of mangrove forests is mainly influenced by sediment supply/flux, suitable substrate, stand composition and status, tidal range and migration opportunities [18]. For this reason, the impact of sea level rise on coastal ecosystems will vary regionally and will depend on erosion processes from the sea and depositional processes from land [6].

As the sea level rises, the surface of a coastal wetland shows increased vertical accretion due to increased sediment and organic matter input [20]. Therefore wetlands show a dynamic and non-linear response to sea level rise. Studies of the UNEP [17] expect mangrove forests to tolerate the anticipated sea level rise in rainfed humid areas. But the mangroves may be overstepped and abandoned in more arid areas particularly if inland retreat is not possible [17]. Fringe mangroves, the main mangrove type on Martinique, are expected to decrease in area on mountainous islands, and to migrate inland on low lying islands [19]. River mangroves are projected to be able to migrate inland. But, in many cases on Martinique, coastal development prevents wetlands from adapting by shifting landward. Where wetlands are bounded by elevations, as is the case in many of the Caribbean islands, it is unlikely that they will shift landward as the sea level rises [17,21].

Accretion studies of Ellison [16] show that mangroves of low islands are at risk from the rates of sea level rise predicted for the next 50 years. They are expected to suffer from erosion and inundation stress. Studies for mountainous islands, such as Martinique, do not exist. One might assume that the accretion rates may be higher due to the larger sediment availability. But these sediments are often polluted and vegetation stocks are often stunted. Furthermore, gradual succession into the inland island as adaptation to sea level rise often is impossible because of the mountainous topography. Therefore, mangroves on high islands might be as well at risk if sea level rises to modelled rates.

### *1.5. Tourism on Martinique*

Tourism is, besides the export of agricultural goods, the most important income source on Martinique providing 6.4 % of the GDP.

Especially the beaches along the Martinique South coast are famous among tourists. Here the majority of tourist accommodation facilities, mainly bigger hotel complexes are situated because of the favourite climatic and coastal conditions. Every year thousands of tourists visit the island just to spend some time (14 days on average) on these beaches. Main tourist season is during the dry months between December and March.

Table 1 shows the development of tourist numbers over time on Martinique. From 1960 to 1998 the number of visitors has multiplied by about 50.

Most visitors come to Martinique for its “sun, sea, surf and sand” image. More than three quarters of the visitors are of French origin (2003: 79%), whereas most of them come from the Départements d’Outre-Mer - Territoires d’Outre-Mer (DOM-TOM) [4].

## **2. Methodology: evaluation of coastal squeeze and its consequences**

In summary, the likely responses of wetlands to sea level rise are: Loss of the total wetland area by coastal erosion and inundation, relocation/migration rather than overall loss, change in

the mangrove forest or beach structure, and mangrove increase or new beach accretion further inland.

On the basis of a GIS database, a current land-use map and spatial sensitivity analyses, the Martinique beaches, mangrove forests, deltaic and estuarine areas, as well as coastal swamps, are further examined with regard to the risk of coastal squeeze and area reduction. In addition to mangrove wetlands and beaches, about 11 km of other coastal wetlands are included in this assessment. These are for example muddy bays or non forested river mouths with alluvial sediments.

For that reason two categories are selected that reflect the sensitivity of beaches and coastal wetlands to coastal squeeze and area reduction: migration opportunities inland and sediment household.

There is lack of detailed information about currents, sediment loads and seaward accretion rates for Martinique. For that reason, data from studies that determine accretion rates for mangrove swamps on other Caribbean islands are used. Such rates seem to be similar on the islands. This makes it possible to utilise the data also for Martinique even if there is a high range of uncertainty because of its mountainous topography. For example, the accumulation rates from Bermuda, Tonga and Cayman average from 8 to 10.6 cm/century [16]. That is less than the rate of sea level rise of 14.3 cm/century over the last few centuries, and the average rate of expected sea level rise of 28 cm/century during this century.

Even if the hinterland is steep or developed there may be no wetland change at all due to high accretion rates. The reported hyper-sedimentation at Martinique led to enormous accretion rates inside the bays in the past. Measurements of the Direction Départementale de l'Équipement reveal that the river Lézarde deposits on average 100.000 m<sup>3</sup> of sediments into the Fort-de-France Bay every year, the river Monsieur 45.000m<sup>3</sup> and the river Salée 90.000 m<sup>3</sup> (cit. in Saffache [25]). The methodology of this assessment is described in Figure 3.

Beaches are the main tourist destinations on Martinique. And also the mangrove forests serve as visiting places for tourists giving them the imagination of an adventurous day trip into “untouched nature”. Spatial analysis based on a conducted GIS model is carried out that evaluates the tourist destinations most vulnerable to the impacts of sea level rise.

In a second step tourists who visit the island especially for the vulnerable coastal areas, namely the beaches, are selected and examined through statistical data and interviews from different sources [4,5,22,23,26,27,28,29,30]. The aim is to give a first overview of the impact problematic. For detailed analysis further studies are recommended. Ecotourism as an alternative to the mass-beach tourism as well as adaptation measures to protect the beaches from rising sea levels and to prevent mangroves from squeeze are also discussed.

### **3. Results**

#### *3.1. Sensitivity of Martinique wetlands and beaches to coastal squeeze and erosion*

In many areas of Martinique, beaches, mangroves and other wetlands provide significant coastal protection. The ecosystems serve as natural shock absorbers and protect coastal infrastructure and land use against tropical storms and hurricanes. They also provide critical storage capacities for storm surges and flood waters. Beaches serve as attractions for tourists and are economically quite valuable. All together, in 2002 6.537 people were involved in the tourist business on Martinique, 4.534 of them are directly employed in hotels and restaurants, 1.390 indirectly through other services, agro-industry, agriculture or transport, for example [23].

Loss of these coastal systems would therefore have great impacts on human life on Martinique. The following analysis examines the adaptive capacity of wetlands and beaches to sea level rise on Martinique.

As shown in Figure 4, 78% of the mangroves, 98% of all Martinique beaches, and 86% of other coastal wetlands are at risk to erosion and inundation if sea level rises.

Often inland migration is impossible because of topography reasons but also because of urbanisation. Even if the majority of the coastline is natural space, 32% (916 ha) of the coastal zone, the so called “50 pas”, are urbanised.

Figure 5 visualises the sensitivity of coastal segments to area reduction and coastal squeeze for a sea level rise of 25cm.

About 45.6% of the coastline is very sensitive to coastal squeeze. The endangered segments are distributed all over the island, and especially the North-Western part of the island is at high risk. Here the anthropogenic developments are situated right between the sea and the steep slopes of Mt. Pelée. Without their high sedimentation rates bays at the Southern and Eastern coast and the Fort-de-France Bay would also have greater sensitivity indexes than determined. 28.8% (=124.6 km) have a medium squeeze index, only 0.8% (3.4 km) got the “low sensitivity” index. 24.8% (107.5 km) have not been included in the analysis because of their morphology (e.g. steep coast etc.).

### *3.2. Human impacts on mangrove squeeze and beach reduction*

On Martinique tourism infrastructure, road networks and major settlements are usually all located along the coast giving locals and visitors an easy access to the coastal and marine natural resources and hindering the wetlands to migrate further inland. The vulnerability of beach reduction is also augmented.

An evaluation of infrastructure and constructions situated within the impact zone reveals that settlements are seldom found below an elevation of 5m along the Southern coast whereas at the Northern coast they reach further down to sea level because here is often the only flat land available. On average, the majority of coastal constructions are built at heights between 5 and 10 m above the present sea level and therefore also within the zone at risk of flooding and erosion. Especially the tourist hotels are mainly found very close to the sea and below the 5m level. Additionally, many coastal communes in the South experienced massive population



increases during the last decade: Le Diamant + 40%, Trois Ilets +38%, Sainte-Luce +30%, Rivière-Salée +30%, and Saint-Joseph +25%, for example [31]. Figure 6 shows the communes with more than 50% coastal urbanisation as well as the population evolution per commune over time. Especially in the North-Western coastal part urbanisation rates are quite high because of the mountainous topography. But also Southern communes, at the moment considered as the most attractive living space, show high urbanisation rates.

Massive hotel construction programmes led also to a profound transformation of the coastal zone. In the past, the majority of tourism development has taken place without prior environmental assessments. As a result, hotels have been constructed in areas of valuable natural habitat. Latest trends have even led towards high-density, mass-market tourism sites close to the water's edge. But also smaller holiday and weekend homes are found along the South and South-Eastern coast mainly between Trois-Ilets and Trinité.

It is therefore a quite logical consequence that the majority of Southern communes experience mangrove degradation (see Figure 2). This may accentuate the Coastal squeeze and would give way to the sea to reach further inland than with land protecting mangrove forests. Also coastal pollution adversely affects the health of mangrove forests and its ability to keep pace with rising sea levels. A clear example is the Fort-de-France Bay where pollution is a severe problem [24,25] (s. also Figure 2).

### *3.3. Consequences of coastal squeeze and beach reduction for Martinique tourism*

Local inhabitants depend on the diverse system of coastal and marine resources.

The projected loss of beaches as a consequence of sea level rise may cause severe economic impacts on the tourism industry. A study on the beach-oriented island of Barbados showed that income from tourism is predicted to decline by 62% if the beach areas were significantly reduced [30]. During questionnaires tourists indicated a reduced probability of selecting the island destinations if climate change significantly altered features such as beach structure or

coral reef health [30]. The same may also happen on Martinique: about 85% of the beaches on Martinique are economically used for tourist recreation. That is a total length of nearly 42 km sandy beaches. Of these 27% are associated with a village, a sightseeing-road, or a harbour. The remaining majority are the lonely beaches that Martinique is famous for. Spatial analysis revealed that the additional supply of suitable beaches that are touristically unused till now is nearly exhausted. A total of 6 km of the beaches, especially along the Northern coast, are out of reach, the rest is not attractive for beach tourism.

From tourist used beaches 83% are at risk to erosion and inundation. An interrogation [26] proved that in general the Martinique tourist looks for the classic beach environment combined with warm climate, sandy beaches, an exotic picture, as well as relaxation opportunities. Therefore 87% of the visitors come to the island to relax on the beach. After a questionnaire 50% of the visitors are quite satisfied with the beaches on Martinique. In 2002 53% of the visitors came to the island for the first time [26].

If sea level rises and beach reduction will become an increasing problem the attractiveness of Martinique beaches as tourist destination is likely to decline as might also the local production for tourists. Today, the total production for tourists represents 11% of the total market production for Martinique [23]. With rising sea levels the consequences might be similar to those of the Barbados example [30].

In addition to the consequences of beach reduction, infrastructure found up to 300 m landward of the beach and within an area below 5-10m along the coast is vulnerable to accelerated sea level rise. That is an area of about 11-14% of the total island surface, where more than 62% of the infrastructure and about 53% of the total population is situated.

#### **4. Discussion**

Spatial evaluation of the adaptive capacity of wetlands and beaches to sea level rise on Martinique shows that the regional wetland system is unlikely to collapse completely. Of the

79 km mangrove forests along the coast, only a total of 23 km is rated as highly sensitive to coastal squeeze, the majority of 55 km is of medium sensitivity, mainly due to high sedimentation rates.

Furthermore, besides the migration opportunities and sediment budget the state of the ecosystem (degraded, stressed or in good condition) also needs to be taken into consideration. The marine and coastal ecosystems are stressed by agricultural pollution, hyper-sedimentation of bays, urban and industrial pollution, especially due to sugar and rum production, as well as oil and petrol pollution [25]. Sedimentation and erosion processes are doing its stint for a healthy or degraded ecosystem. Studies about the coastal pollution of Martinique were conducted by [25,32,33]. Degraded and stressed ecosystems may not be able to adapt to sea level rise impacts even if coastal squeeze is not a problem. Degradation makes the ecosystems more vulnerable to extreme events. Many Martinique wetlands, particularly the mangrove forests are overexploited and polluted. Figure 2 shows the Martinique communes reporting coastal pollution and wetland degradation. Most of the Martinique communes are reporting severe coastal pollution. It is important to note that 6 communes at the South coast do not seem to have any pollution problems. These communes are the main beach tourist destinations. They depend on their untouched, natural image of white Caribbean beaches. Nevertheless, most of these tourist communes report high mangrove degradation. Nearly all communes with mangrove-stands report degradation, except for Le Robert and La Trinité, where the nature park of “Caravelle Peninsula” protects the remaining mangroves from human destruction.

Losses of wetlands impact many sectors and functions of coastal areas including food production (loss of nursery areas for fisheries), flood and storm protection (storm surges will penetrate further inland), waste treatment and nutrient cycling, and the capacity to serve as a habitat for wildlife [20]. The mangroves may be able to adapt to the changing conditions: *Rhizophora mangle*, the main mangrove species on Martinique, occurs in markedly different

geographic habitats, under brackish, marine, and hypersaline conditions, as well as in developed estuarine fringe forest down to lower scrub [19]. A problem is the coastal and marine pollution that threatens the mangrove habitats and makes them more vulnerable to sea level rise impacts.

In addition to the probable mangrove losses, 45% of other coastal wetlands and more than 70% (40 km out of 57 km total) of the beaches are highly sensitive to coastal squeeze. Especially the fine sands beaches along the Southern coast that serve as main tourist destinations are the most vulnerable to coastal erosion. Theoretically, shoreline migration will create new areas of economic benefit as new beaches are built, but because of the mountainous island character, steep shores, and anthropogenic constructions very close to the sea sedimentation processes that might lead to beach evolution are unrealistic on Martinique. Therefore, the protection, replenishment and stabilisation of existing beaches, at least until major existing tourist investments are amortised, represents a principal socioeconomic impact [17]. Against progressive coastal erosion it had become necessary for the regional council to work out defence strategies to protect the settlements and other infrastructure. Besides longitudinal and transversal buildings found along the coast at some settlements, breakwaters are built in front of Hotel Complexes in the South. But to beware the tourists of the unesthetic view they were not adequately set and just reduce the erosion partially. To manage and protect the coast permanent the protection buildings are not suitable [12], because the use of structural solutions interferes with sediment transport along the coastline and, with that, the shoreline stability of adjacent properties [34].

No additional considerations and strategies for a potential rise of sea level and its consequences do yet exist for Martinique beaches and wetlands.

However, Martinique has more to offer to tourists than just sandy beaches: Since 1999 the island also promotes ecotourism as alternative to its «sea, sand, sun »-slogan. Ecotourism on the island includes nature and culture activities like mangrove excursions, bird watching,

museums, a garden route and rum circle that shall make the inland island and mangrove forests more attractive for tourists. Between 1990 and 1998 the frequentation of rural accommodations has doubled. In 1999 already 3% of the Martinique visitors have been categorised as ecotourists. About 1000 rural overnight accommodations have been counted in 1998 and future perspectives aim at 1800 rural accommodations in 2006 and 2800 accommodations in 2011 [35]. But the danger for the Martinique economy is still that the island may no longer be as attractive a destination as they is now and will lose visitors to competing destinations if environmental degradation, coastal squeeze, and beach reduction further continues as is projected here.

## **5. Conclusion**

This study showed that spatial analysis is quite useful to locate and evaluate coastal parts sensitive to coastal squeeze and area reduction. On the basis of several spatial datasets, Martinique beaches, mangrove forests, deltaic and estuarine areas, as well as coastal swamps, are examined with regard to the risk of coastal squeeze and area reduction. The spatial evaluation of the adaptive capacity of wetlands and beaches to sea level rise on Martinique revealed that the majority of the beaches are highly vulnerable to area reduction, whereas only 29% of the mangrove forests are rated as highly sensitive to coastal squeeze. The majority is of medium sensitivity, mainly due to high sedimentation rates. But many Martinique wetlands are also overexploited and polluted. The state of the ecosystem is a factor that affects coastal squeeze and should be included into the sensitivity modelling as soon as appropriate data are available not to underestimate the results.

This study also tried to address the correlation between human impacts and wetland reductions. Often not only topography prevents the wetlands to shift inland, but also anthropogenic infrastructure. Especially the tourism industry often occupies areas very close to the sea. On the other hand the same is also dependent on the existence of wide natural

beaches. The key aspects of the popularity of Martinique as a tourist destination are its fine sandy beaches, clear water and pristine habitats. If accelerated sea level rise further continues, Martinique is endangered to lose not only the majority of its famous beaches and its valuable mangrove habitats but also its prestige as beach tourist destination.

The data situation on Martinique is quite poor regarding coastal squeeze. It is therefore important to undertake more detailed studies to improve this littoral vulnerability assessment. Nevertheless, this study is a suitable attempt to emphasize that not only low lying islands are exposed to the consequences of accelerated sea level rise, but that also mountainous islands are very vulnerable.

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## **Figure Captions**

Figure 1: Distribution of beaches and mangroves on Martinique.

(Based on IGN [8,9,10]; Hinnewinkel & Petit [11])

Figure 2: Reported environmental problems of the coastal zone.

(Data adapted from Assaupamar [15])

Figure 3: Methodology of the squeeze assessment

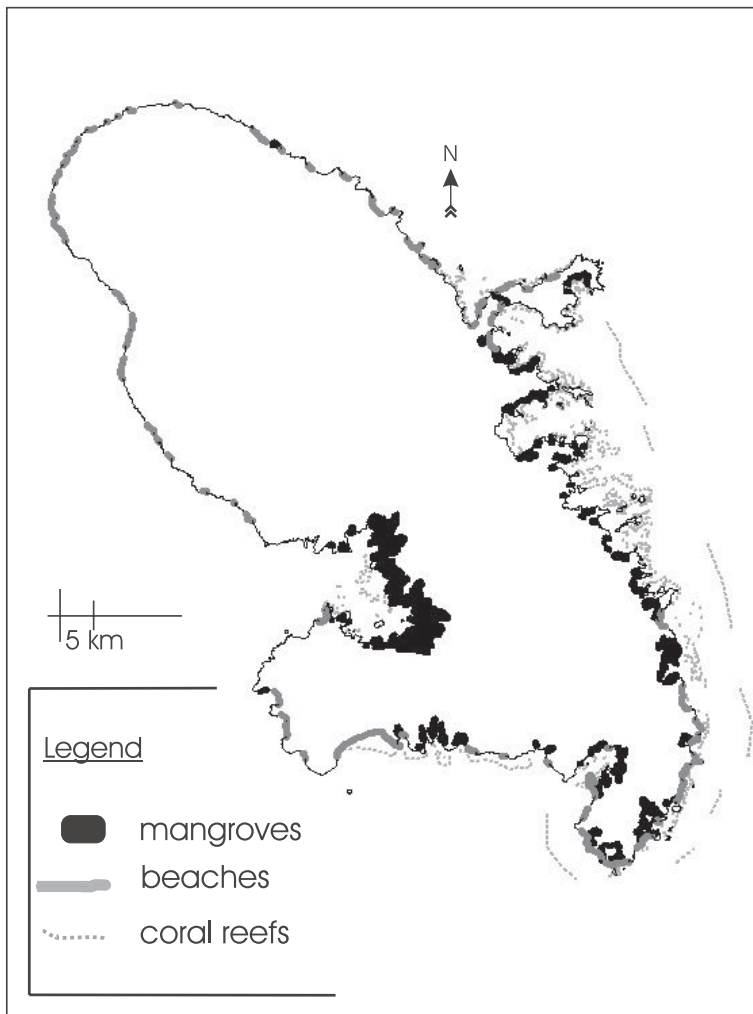
Figure 4: Sensitivity analysis of Martinique coastal types to flooding and erosion

Figure 5: Sensitivity of coastal segments to area reduction and coastal squeeze with accelerated sea level rise

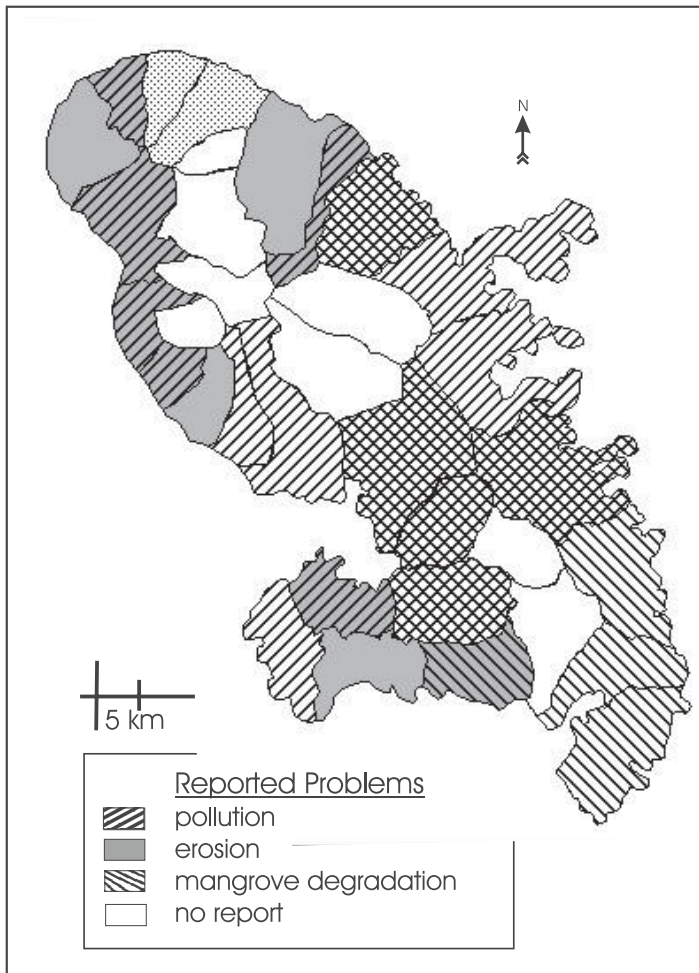
Figure 6: Evolution of commune population and coastal urbanisation rates.

(Sources: [28,31])

**Figure 1:** Distribution of beaches and mangroves on Martinique.  
(Based on IGN [8,9,10]; Hinnewinkel & Petit [11])



**Figure 2:** Reported environmental problems of the coastal zone.  
(Data adapted from Assaupamar [15])



**Figure 3**

**Sensitivity of coastal wetlands to coastal squeeze and area reduction**

Relative sea level rise scenarios

+

1. migration opportunities depending on morphology and development (**M**)

a. landward margin steep or coastline developed = **High**; migration impossible (**3**)

b. landward margin of reclaimed land = **Medium**; migration under restriction possible (**2**)

c. landward margin an adjoining wetland = **Low**; migration possible (**1**)

(adapted from Bacon 1994; altered)

+

2. sediment budget (**S**)

a. sedimentation < sea level rise = **High** (**3**)

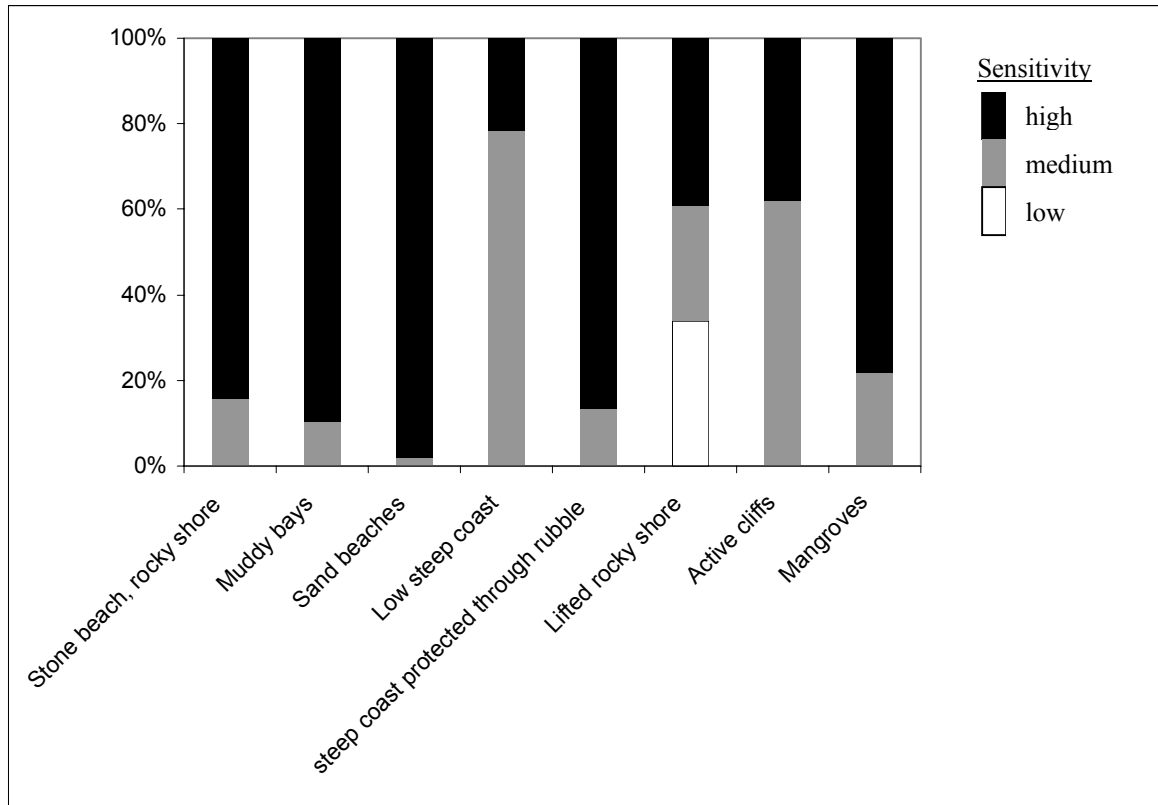
b. sedimentation and erosion offset = **Medium** (**2**)

c. sedimentation > sea level rise = **Low Sensitivity** (**1**)

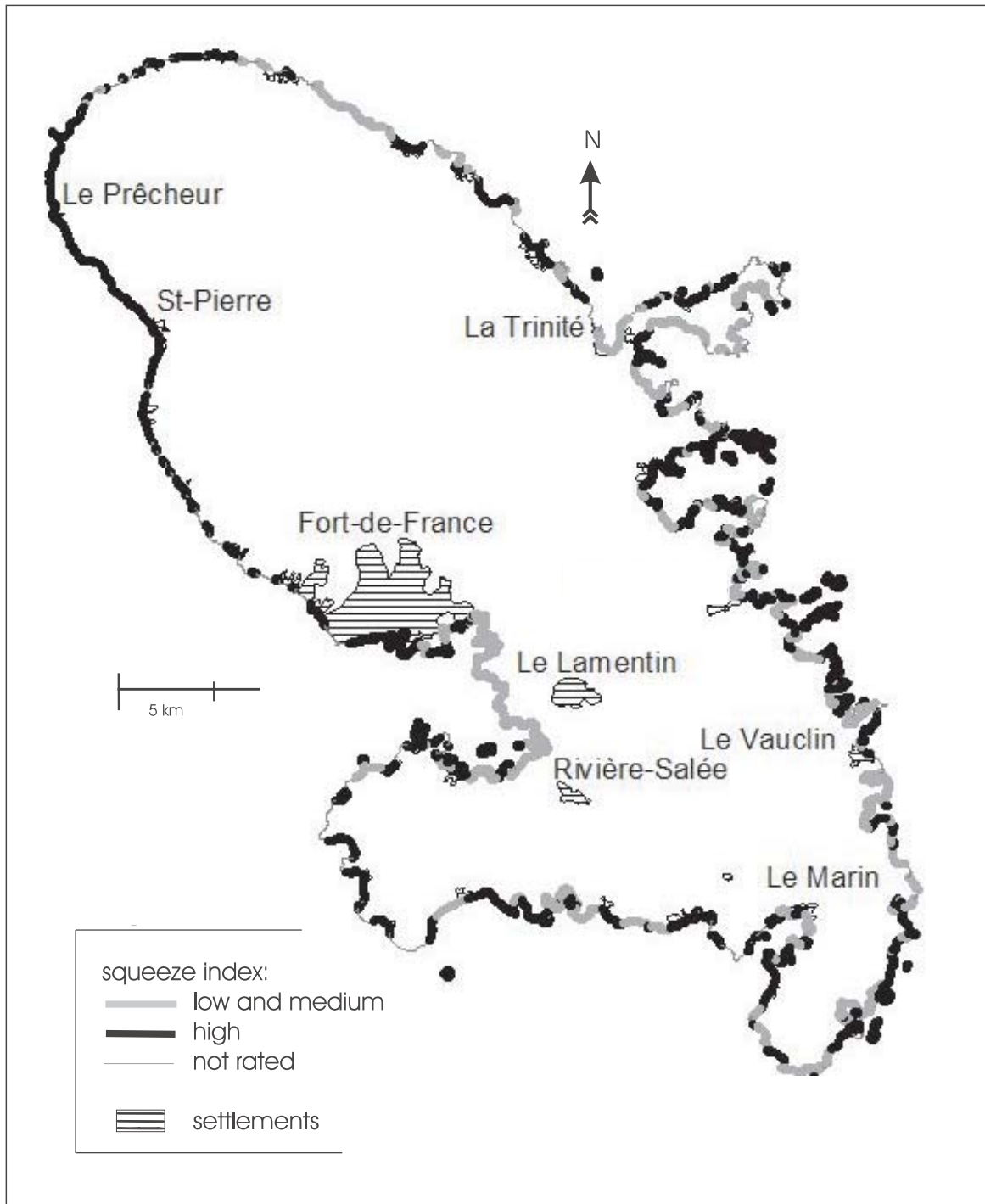
based on historical coastline changes and sensitivity map to flooding and erosion

**M+S = squeeze index**      **2&3: low, 4&5: medium, 6: high sensitivity**

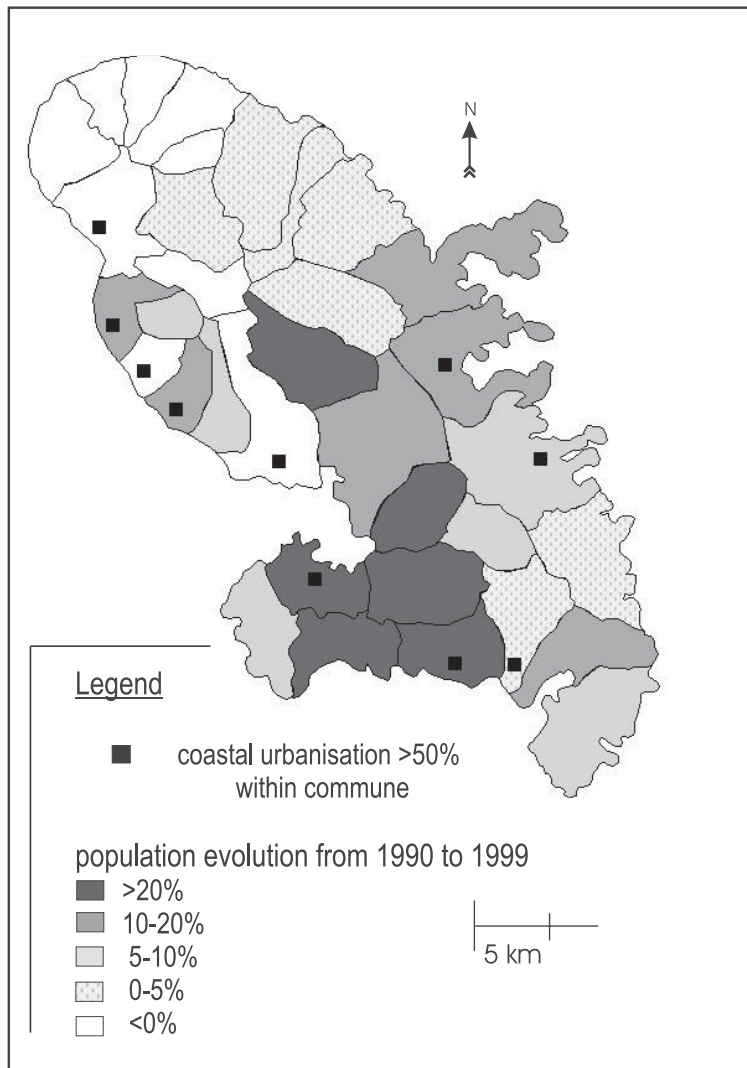
**Figure 4:** Sensitivity analysis of Martinique coastal types to flooding and erosion



**Figure 5:** Sensitivity of coastal segments to area reduction and coastal squeeze with accelerated sea level rise



**Figure 6:** Evolution of commune population and coastal urbanisation rates.  
(Sources: [28,31])



## Tables

Year	visitor numbers (stay <24h)	Tourist numbers (stay >24h)
1960	20.000	
1996	931.786	476.977
1997	942.432	513.231
1998	1.007.451	548.766
2000	928.737	
2001	755.660	460.000
2002	735.925	447.000
2003	785.700	453.000
2004	969.000	

Sources: [4,22,23,24]

Table 1: Evolution of Martinique tourist numbers over time.



## **Zusammenfassung**

Strände und Mangrovenwälder Martiniques wurden auf Basis eines GIS-Modells auf das Risiko einer Gebietsreduzierung untersucht. In vielen Fällen verhindern Relief und anthropogene Bauten eine Anpassung der Ökosysteme an steigende Meeresspiegel. Ein sukzessives Zurückweichen ins Hinterland ist somit unmöglich und auch flachere Küstengebiete für eine mögliche Neuansiedlung, bzw. Sedimentation sind oftmals verbaut, oftmals durch touristische Bauten. Mehr als 70% aller Strände auf Martinique und etwa 29% der Mangrovenwälder sind durch Gebietsreduzierung äußerst gefährdet, wenn der Meeresspiegel weiter ansteigt.

Neben touristischen Einrichtungen befindet sich ein Großteil der Infrastruktur Martiniques entlang der Küste unterhalb von 10 m und somit im Risikobereich für Erosion und Überschwemmung. Anhand einer räumlichen Analyse werden die gefährdeten Touristenziele identifiziert und mögliche Konsequenzen erörtert.