Seminar: 63-052 Studienprojekt: Bahamas - Gesellschaftliche Anpassung an den Klimawandel

Final Field Study Report:

„Social response to climate change – Sea level rise on the Bahamas“

University of Hamburg
Institute of Geography
July 2016

Impressum:

Beate MW Ratter and Jan Petzold (2016): Final Field Study Report - „Social response to climate change – Sea level rise on the Bahamas“, University of Hamburg, Hamburg.
Based on the Seminar and Field Trip to the Bahamas: 63-052 Studienprojekt: Bahamas - Gesellschaftliche Anpassung an den Klimawandel, Winter Term 2015/2016.
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List of abbreviations

BEST Commission – Bahamas Environment Science and Technology Commission

BNT – Bahamas National Trust

CCI – Climate Change Initiative

CoB – College of the Bahamas

CRFM – The Caribbean Regional Fisheries Mechanism

CW – Consolidated Water limited

DMR – Department of Marine Resources

ENSO – El Niño Southern Oscillation

FAO – Food and Agriculture Organization of the United Nations

GDP – Gross Domestic Product

IPCC – Intergovernmental Panel on Climate Change

LDC – Least Developed Country

MPA – Marine Protected Area

NGO – Non-Governmental-Organization

NRW – Non –revenue water

OMZ – Oxygen Minimum Zones

RBDF – The Royal Bahamian Defense Forces

SIDS – Small Island Development State

UNEP – United Nations Environment Programme

UNFCCC – United Nations Framework Convention on Climate Change

USD – US Dollar (Currency of the United States)

VAT – Value-added tax

WMO – World Meteorological Organization

WSC – Water and Sewerage Corporation

1. Introduction

Coastal regions and small islands are particularly affected by the consequences of climate change, in particular by rising sea levels (cf. Nurse et al. 2014). Small Island Developing States (SIDS), such as the Bahamas, need to find sustainable adaptation solutions to future sea-level changes. The associated magnitudes and impacts on local communities are highly uncertain, and adaptation to climate change impact is not only a technical but a societal endeavour. Various stakeholders are involved in climate change adaptation – not only technical expertise is required, but also political decisions need to be taken and societal awareness for the upcoming challenges has to increase. Therefore, climate change adaptation strategies encompass policy-makers and scientists but also industry, non-governmental organisations (NGOs) and the local population at large.

This report summarises the findings from a field trip of the Institute of Geography of the University of Hamburg to New Providence, the capital island of the Bahamas. The project is part of the work of the Cluster of Excellence Integrated Climate System Analysis and Prediction (CliSAP) and addresses the issue of social responses to climate change, with a focus on impacts and adaptation to sea-level changes. Under the guidance of Dr. Jan Petzold and Prof. Beate Ratter, a two-week field trip with 15 students of Geography, Oceanography, Anthropology and Latin American Studies to New Providence in February 2016 provided the opportunity to collect empirical data on the spot. Here, we benefitted from the help and openness of the local population, authorities and the cooperation with the College of the Bahamas (COB).

Climate change, small islands and adaptation

Climate change is considered the 'most pressing' (United Nations 2014: 40) problem and 'greatest potential threat' (Byrne and Inniss 2002: 10) to small islands. In fact, UNEP's coastal vulnerability index lists all SIDS under moderate or high risk (UNEP 2005: 43). An increase in global sea level of 20 cm on average during the last century and a potential further increase of one metre until the end of this century imply serious problems especially for low-lying SIDS, such as the Maldives, Tuvalu, or the Bahamas.

Issues associated with sea-level changes include increased salt water intrusion, flooding of freshwater wetlands and valuable agricultural zones, higher peak tides and potentially increased impacts of storm surges and tropical cyclones (Byrne and Inniss 2002: 9; Walker and Bellingham 2011). Moreover, changes in regional rainfall patterns affect especially dry islands by increased water stress, which can have an impact on populations, agriculture and general vegetation (United Nations 2014: 41). SIDS are particularly affected due to directly or indirectly exacerbating challenges on their economic, environmental, geopolitical, societal and technological structures, causing SIDS to be more vulnerable than other Least Developed Countries (LDC) (Hay 2013).

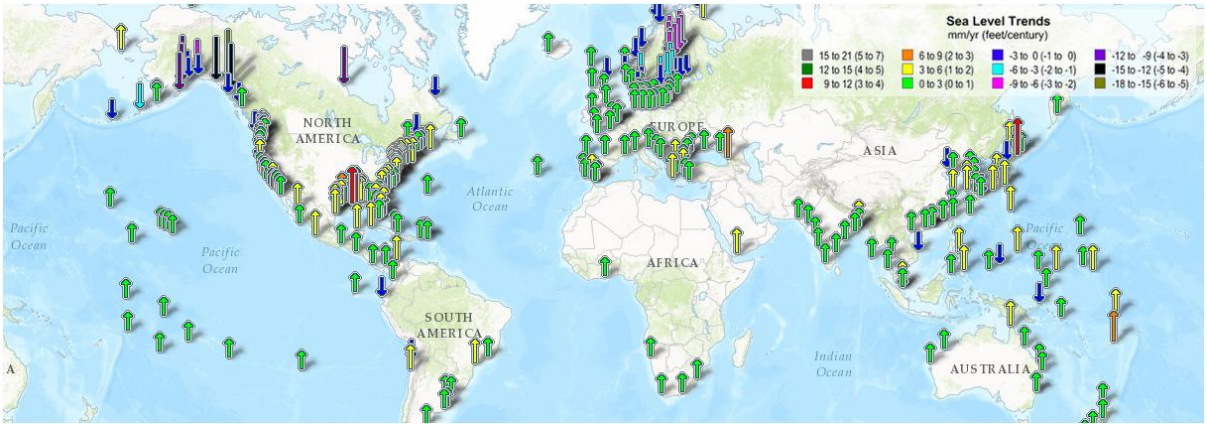

Figure 1.1: Regional trends in sea level change (NOAA 2016)

It is especially sea-level rise that moved SIDS in the centre of global political and media attention as showcases and indicators for ongoing global climate change. However, how are SIDS threatened by rising sea-levels? While there is a high certainty regarding a global trend in sea level rise, regional developments are rather uncertain and uneven. Mostly small islands show a trend of around 0-3mm/year increase in average sea level, though, in some regions the changes can be higher and in some regions lower, or sea levels are even dropping (cf. Figure 1.1). Overall, SIDS are certainly affected by sea-level changes, but place-specific, reliable local data is rare.

To understand local causes and effects of coastal degradation and the potential impacts of climate change, one must consider the interaction between the social and the natural as well as the terrestrial and marine system, which intersect in coastal zones. A perspective of complex social-ecological systems considers marine and terrestrial pressures affecting the natural and social subsystems of coastal and low-lying areas, as well as individual feedbacks (cf. Figure 1.2). This perspective involves analysis of distinct local geomorphological features and local socio-economic conditions and impacts on coastal environments. The concept of resilience addresses both limitations and opportunities regarding small islands adaptability and helps to avoid copying or dictating strategies from continents to islands (cf. Petzold and Ratter 2015).

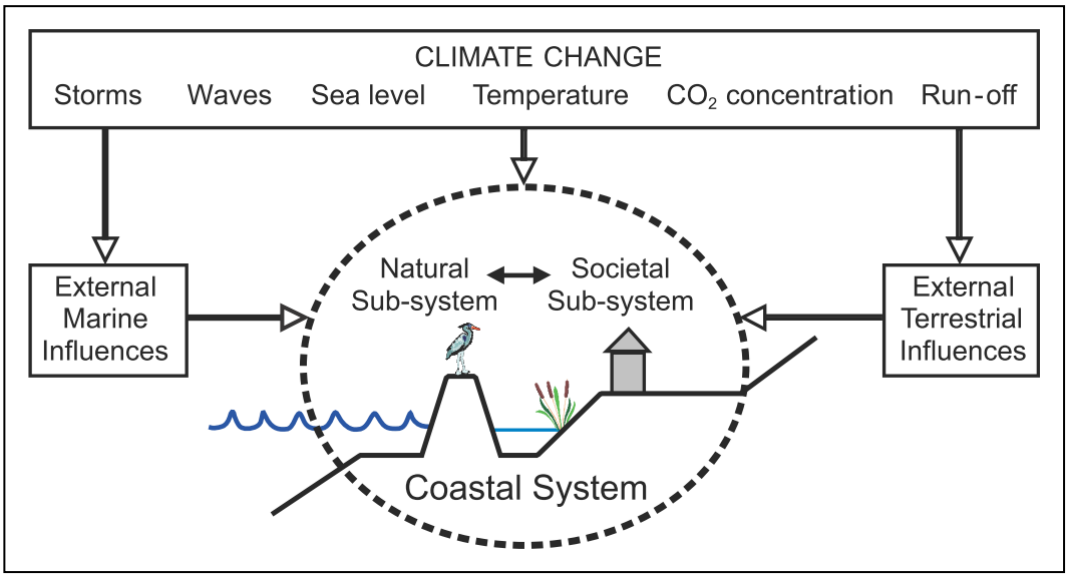

Figure 1.2: Climate change pressures on the coastal social-ecological system (Nicholls et al. 2007: 318)

Meanwhile, global institutions and national governments have integrated adaptation planning and mitigation efforts into their political agendas. Adaptation measures, here, refer to either technological or socio-political measures (Nunn 2009). Technological measures, such as large-scale sea defences, however, are hardly implementable in SIDS, due to limited financial and physical resources. Moreover, such infrastructure can be even unsustainable when large-scale structural sea defences cause further problems (e.g., erosion) (Kundzewicz 2002). Thus, it is a great challenge for island societies and decision-makers to find socially, ecologically and financially sustainable solutions to deal with the impacts of sea-level change. Effective adaptation planning depends on the inclusion of community resources, such as local knowledge and skills, and the integration of collective action for local adaptation, as well as the acceptance and support of communities for decision-making (Mercer et al. 2012; Jones and Clark 2013). Adaptation to climate change is not only a technical and political but also a social challenge.

The Bahamas are a suitable example of flat-lying coral islands which will be particularly threatened by future climate change. Their location in the cyclone track of Caribbean hurricanes, their local geography and past anthropogenic degradations give way to intensive effects of future climate change. In the media, the Bahamas gain especially sad presence when tropical cyclones coat the archipelago on the way northwards to the US coast. Due to their geography, the Bahamas are also considered to be highly vulnerable to sea-level rise. Although there is a lack of reliable data on local sea level trends and future projections, significant coastal erosion appears to be an actual major issue. In the Caribbean in general and the Bahamas in particular, the degradation of natural coastal resources by human intervention is critical. Economic development involving the large-scale construction of coastal infrastructure and the exploitation of marine resources may contradict efforts for long-term adaptation to sea-level rise.

The overarching question we addressed in our study is: What role can social actors play in adapting to sea-level change in a low-lying post-colonial Caribbean island, dominated by tourism?

Methods of fieldwork

With the example of the Bahamas we intended to collect data and analyse factors of local vulnerability, understand how social institutions and people respond to sea-level change and assess the potential to build social resilience for climate change adaptation. For this purpose, we applied a mixed methods approach of qualitative and quantitative research methods and included an empirical data collection phase during the two-week field trip to New Providence, in February 2016.

The preparation for the research study and field trip started with a seminar at the Institute of Geography in October 2015 with the purpose of collecting background information on the Bahamas, gain an extensive and detailed overview of the island state and its population and define research questions and methods.

Four working groups were set up with each a distinct research focus involving different stakeholders that play a role regarding adaptation to climate change on the Bahamas. The four themes we addressed were:

1. Coastal erosion and coastal protection
2. Water resources supply
3. Fishery development
4. Social inequality and societal perception of climate change

The seminar provided the space for the development of different research methods for the empirical field research on New Providence. Each of the groups identified relevant experts and developed semi-structured interview guides. In addition to these expert and stakeholder interviews, all groups collectively developed a population survey "Living on New Providence" including general questions on people's perception of environmental and climate change, as well as more specific questions regarding the different stakeholders of interest.

The following report is structured according to the four working groups' findings with a general overview of the turnout and sample of the population survey preceding.

We sincerely thank the people of New Providence for their support in participating in our survey and for their warm-hearted reception we received during our field work and stay on the island. Our special thanks go to the colleagues from the College of the Bahamas, Jessica Minnis, Margo Blackwell and Dion Hepburn for their introduction to a – for us – foreign society and a colourful new world in the far away Caribbean. You made us feeling at home. Thank you.

Hamburg, 17/6/2016

Beate MW Ratter and Jan Petzold

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2. Overview of the population survey

334 Bahamians living on New Providence were asked 26 questions about their life and their awareness and perception of climate change and sea-level change. Out of logistical reasons, the project focussed on New Providence, which represents the economic and political centre of the Bahamas. Therefore, the result shows only restricted representativeness for the entire Bahamas, since New Providence shows urban structures in contrast to the rural outer islands rather. But how representative was the selected sample of the random street survey for the population on New Providence? The following questions should be answered by looking at the average age and age structure, gender, ethnicity, average income per year, the size of households, migration background, education and other social indicators of the interviewees: Whom did we interview? In how far does the sample give an account of the population of New Providence?

The **average age** of the interviewees is 43 years (cf.), compared to 29 years according to official data (Department of Statistics 2010: p. V). When looking at the age structure of the persons surveyed, a relatively equal distribution within the years of birth can be observed (Table 2.1). The majority of the respondents (64%) was born between '1961-1970', '1971-1980' and '1981-1990' – each case is divided into a frequency of about 21%. 16% of the respondents was 'born after 1990' whereas the remaining 21% were born in the year 1960 and earlier. Almost half of the people who were born in these early years were born within the years '1951-1960' (12%).

Table 2.1: Year of birth

	Minimum	Maximum	Mean	Std. deviation
Year of birth	1930 (= age 86)	(= age 19)	1973 (age 43)	15.2

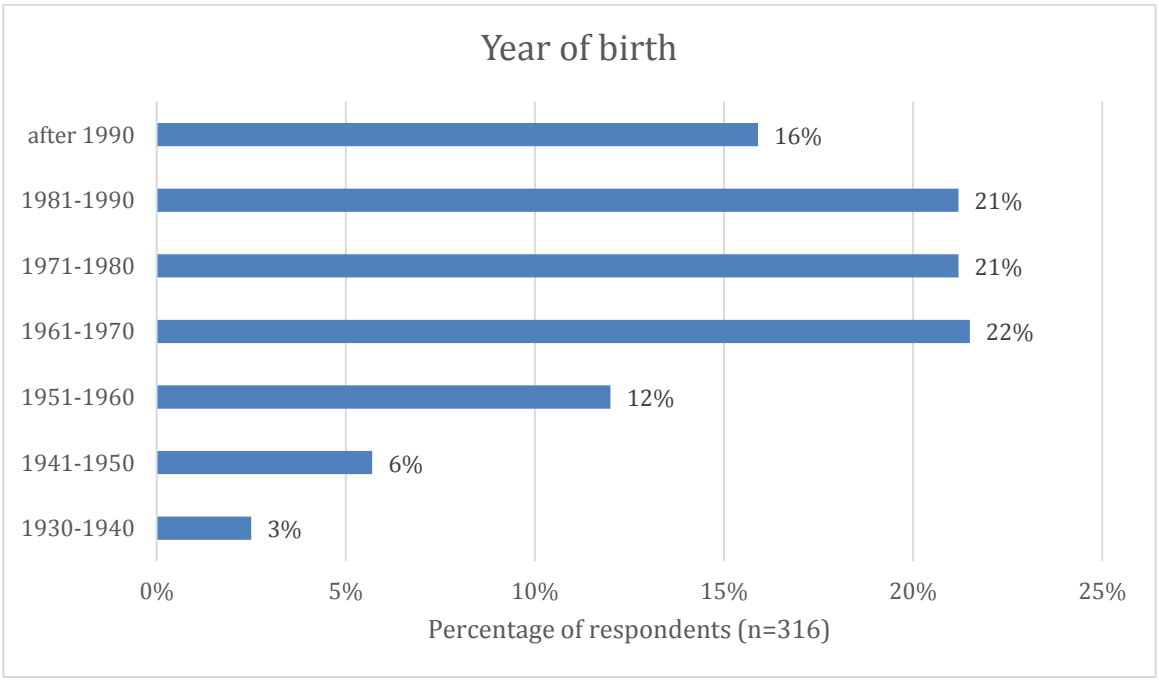

Figure 2.1: Age distribution

More men than women were surveyed (male: 56%, female: 44%) with a **gender ratio** (male/female) of 1.26 compared to 0.92 according to official data (Department of Statistics 2010: p.V). The number of persons identifying themselves as black was higher than that of persons with the self-attribution white or mixed. The **ethnicity** results of the survey are 78% black, 9% white, 7% mixed, and 6% other, compared to 91% black, 5% white, 2% white and 2% other, according to the CIA Factbook (CIA 2016) (cf. Figure 2.2) – however, the latter including all Bahamian islands.

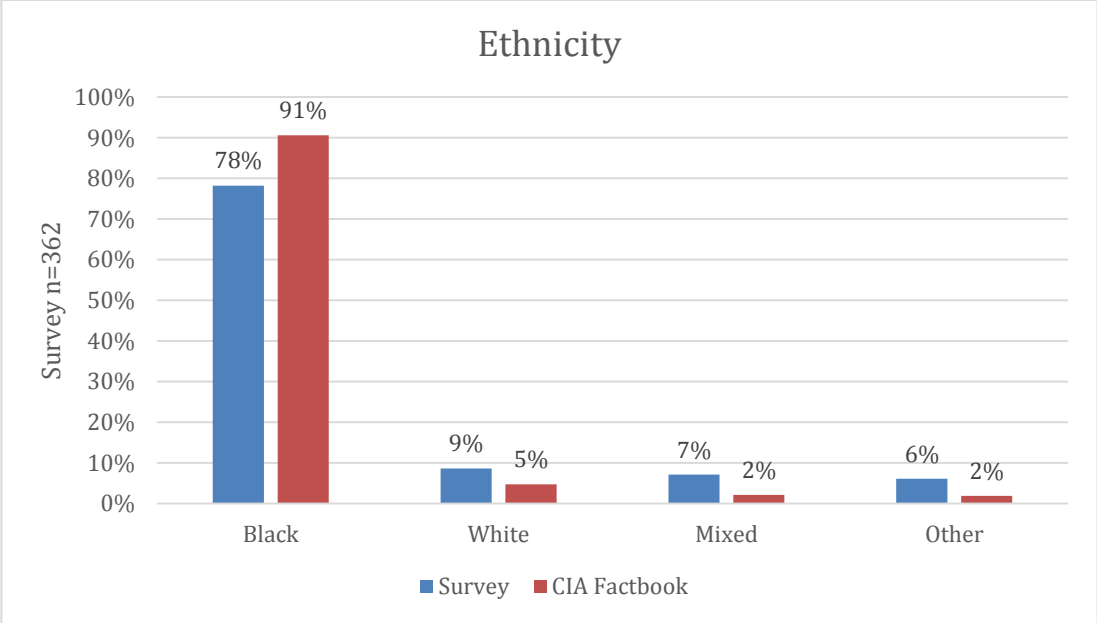

Figure 2.2: Distribution of Ethnicity

The analysis of the **average income** per year is shown in Figure 2.3 below. The majority of respondents (42%) has an average annual income between 10,001 and 50,000 USD. In fact, the average income per year on The Bahamas was 20,980 USD in 2014 (Worldbank 2014). However, while there is a significant group of 38% with rather low income, also the high-income groups with an income of 50,001-100,000 (16%) or higher (5%) are represented in the survey.

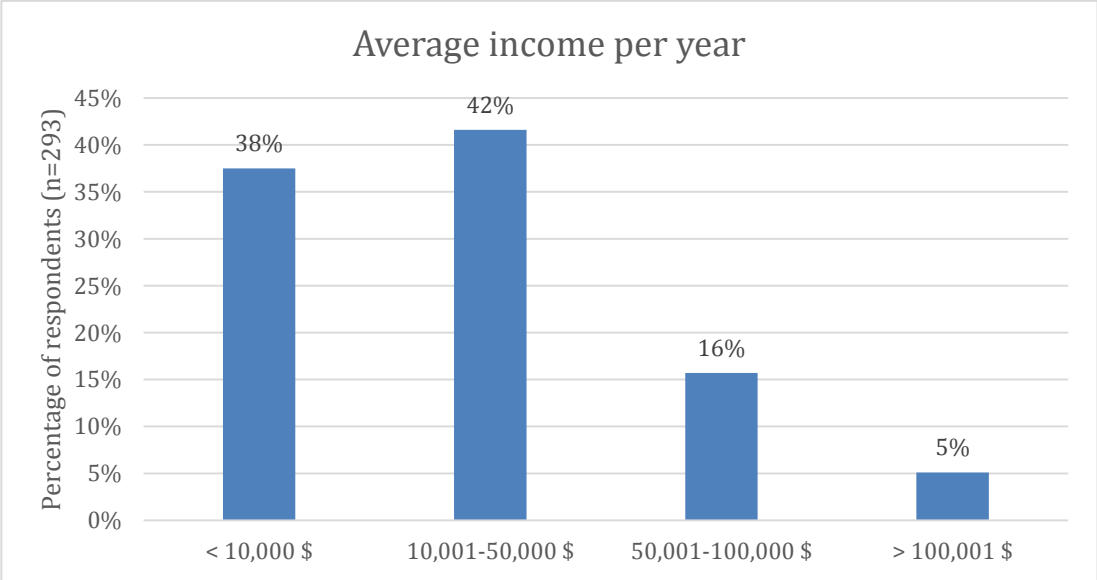

Figure 2.3: Income distribution

Most of the persons surveyed are living in a household with '1-2' (37%) or '3-4' (38%) people. The remaining 26% of the respondents are living together with '5-6' or '7 and more' people, resulting in an average **household size** of 3.5 and is matching with the most recent census data (Department of Statistics 2010: p. V). Moreover, 64% of the respondents are 'homeowners' whereas the rest is living in a 'rented place' (n=320).

76% of the respondents were born on the urbanised islands of 'Nassau/New Providence' and 'Freeport/Grand Bahama' (Figure 2.4) and 14% on the so-called family or out islands. The differentiation between 'urbanised islands' and 'domestic out islands' is based on the assumption in the scientific literature that decisive differences exist between the two most populated islands and the smaller Out Islands. The remaining 10% was born outside the Bahamas and most of them in a so-called 'high-income country', e.g. United States (5.5%).

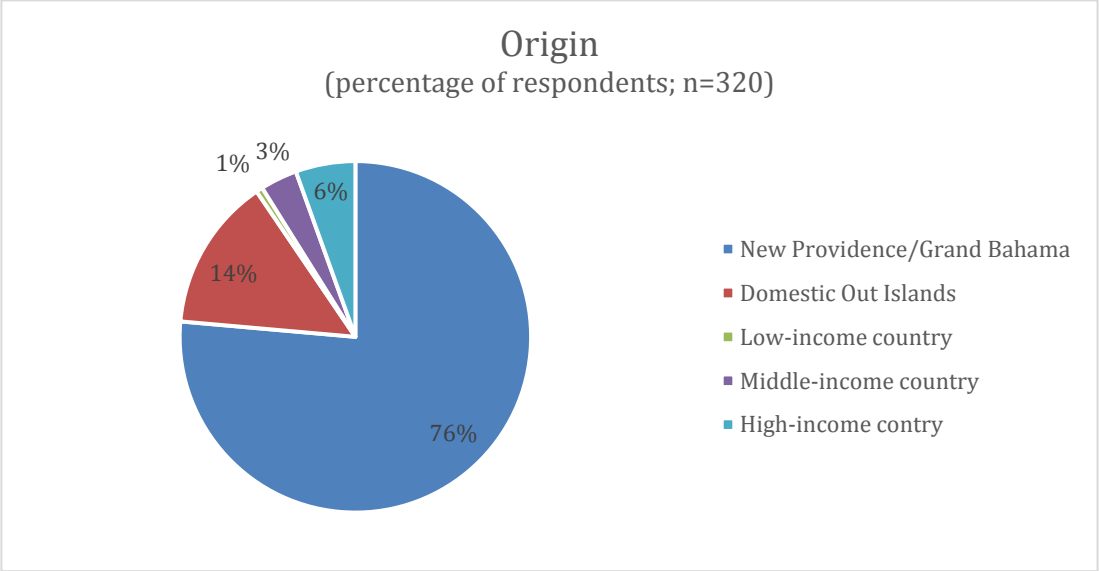

Figure 2.4: Respondents' origin

Migration is a typical feature in the Caribbean and archipelagic states like the Bahamas. The results of the survey analysis show that nearly 40% of the interviewees have – if included domestic migration – a **migration background**. Having in mind that New Providence is the capital of the Bahamas offering most of the employment opportunities, such a high migration ratio can be seen as non-exceptional.

The **educational qualification**, as shown in Figure 2.5, reflects a remarkable high percentage of the respondents graduated from Senior High School (45%), followed by 38% holding a University/College degree and only 3% of the respondents qualified in Primary School.

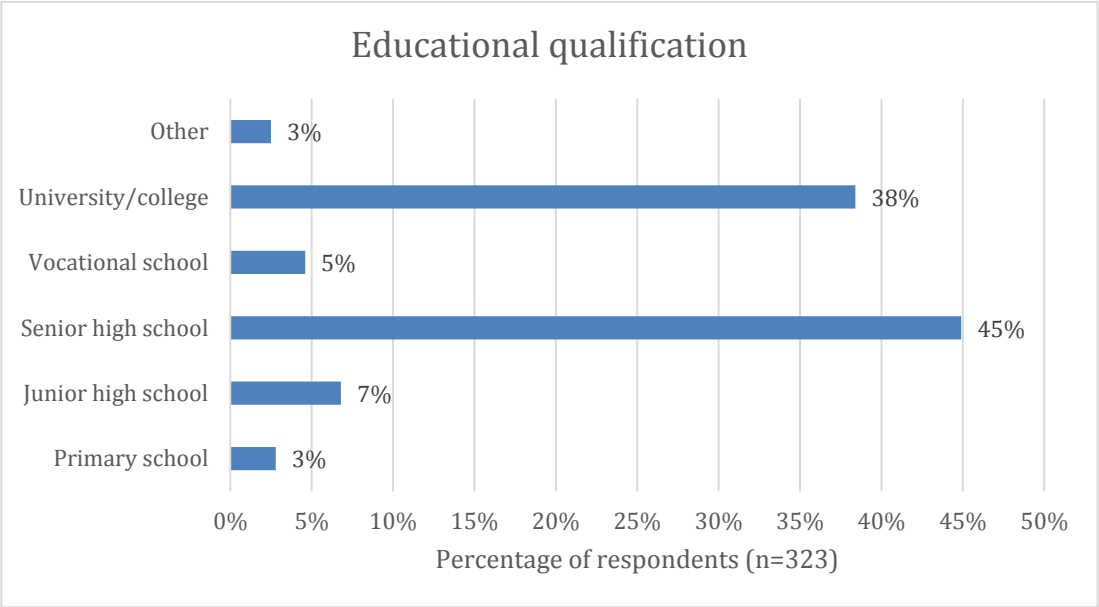

Figure 2.5: Distribution of educational qualification

The respondents' **occupation** diversity varies from 'Construction, transport & logistics' (18.3%), followed by 'Tourism & gastronomy' (17.7%) and 'Management & Administration' as well as 'Retail' (each 14.9%). Among the respondents, only 1.9% indicated to work in the 'Finance sector'.

45% of the respondents are members of a community, club, association or party (n=325) with 'church or a religious community' (37%) as the most important category in societal **membership**. The 'Bahamas National Trust (BNT)' and 'other environmental organisations/groups' (11%), 'Charity Work' (11%) and 'Leisure activity clubs' e.g. sports (10%) represent high ranked responses.

Regarding **religion**, the highest percentage of respondents (28%) claimed to be 'Baptists', followed by 'Further Christian Denominations' (17%). 'Methodists' represented the least frequently given answer (3%).

In conclusion, the drawn sample of the random street survey is not completely statistically representative. However, it widely reflects the population of New Providence and can be considered a valuable and significant sample of the society.

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3. Coastal erosion and coastal protection

Julia Wohlers, Fiona Polzin, Tobias Kleine, Marius Michaelis

3.1. Introduction

An intact coastal ecosystem sustains marine life and flora and provides onshore habitat and nesting areas for many threatened and endemic species (cf. SEALEY et al. 2002: 26). Coastal erosion endangers these species and at the same time human living along the coastline.

Coastal protection of any kind is the single most important measure to maintain a stable coastline. Wind and sea are continuously affecting the coast and may change its shape to some extent. To examine the topic of coastal erosion and protection, this work incorporates precise definitions of related terms, articulation of relevant questions and hypotheses to be discussed. Later on, the chosen approach to obtain knowledge about the local situation on New Providence is explained, and the selected interview partners are briefly introduced. Maps shall give an overview of the current state of coastal protection and erosion. Finally, the results from the interviews and our impressions are presented and followed by a conclusion.

3.2. Definitions

When looking at coastal erosion and coastal protection on New Providence, there is a need for a clear and universally applicable definition of the term coast.

3.2.1. Coast

In most geographical maps of any scale, the coast is usually shown as a single line dividing the sea and the land. Depending on the daytime, current wind and wave conditions this line might not be in the exact same position. A satisfying definition of the term coast, therefore, needs to incorporate the variations of this position of the waterline, considering both changes on short and long timescales (KELLETAT 1999: 84).

Additionally, the coast needs to include the area of effect of seawater spray and the topographic features found along the global waterline. Dunes and changed vegetation, therefore, should also be included in the definition of the coast. This leads to the coast being defined as the area between the highest, furthermost inland and lowest, furthermost seaward domain affected by breakwaters and surf (KELLETAT 1999: 85).

This means that for every part of the coastline, the coast needs to be looked at separately. Our objective is to do a general mapping of the coastline of New Providence and therefore we define the coast as the area between the highest domain affected by breakwaters and the lowest usual.

3.2.2. Coastal morphological processes

The coast is under the persistent influence of breaking waves and the winds and therefore naturally constantly changing in shape. The coast changes on several time scales, ranging from several thousands of years down to instantaneous changes within seconds. Also it is shaped by a variety of

processes. These coastal morphological processes can be subdivided into destructive and constructive processes.

The destructive processes take sediment away from the coast and thereby move it further inland. They can be split up into five types of processes:

1. Loss due to endogenous processes (e.g. rockfall by earthquakes),
2. Loss due to mechanical destruction (wave and ice influence),
3. Loss due to thawing (e.g. calving of glaciers),
4. Loss due to chemical solution (e.g. salt weathering),
5. Loss due to organisms (animals and plants) (KELLETAT 1999: 98).

The destructive mechanical processes incorporate erosion due to swell, storm surges and wind (in the following also called 'erosion caused by geosystem'). The organically destructive processes include the destruction of native vegetation by invasive vegetation (on New Providence this is namely the Australian pine/Casuarina[1]). In some areas of the coast, this might then enable mechanical destruction.

A large portion of the accumulation connected to constructive processes usually comes from the effect of swell which deposits loose (KELLETAT 1999: 102), partially taken from the seafloor and partially taken from other coasts. Also, there are accumulative processes connected to sea ice production (KELLETAT 1999: 102).

These constructive processes may over time form lasting walls of sediment, e.g. dunes, which globally often come along with coasts (KELLETAT 1999: 104). A spatially restricted process is the formation of so-called beach rock, which originates from cemented sand (cf. I1).

3.3. Coastal protective measures

Coastal Protection is the entirety of measures taken in the coastal region to protect the coast of the land and islands from the destructive impact of the sea (DIN 4047-2: 6).

According to this, coastal protection therefore only subsumes manmade structures and efforts to protect the coast.

Considering their shape, coastal protection measures can be divided into area coastal protection, linear coastal protection and punctiform coastal protection (LIEBERMANN, VON SONNENBERG 1999: 68). Each of these kinds of protection features several different elements (Table 3.1).

[1] Casuarinas were planted during the early canonization as wind break and protection against hurricanes. Unfortunately, Casuarinas have a chemical component that kills or harms other (smaller) vegetation around them. In a consequence, they suppress the building of high dunes because these are normally stabilises by small vegetation (cf. NEIL SEALEY, Interview 02).

Table 3.1: Shapes of coastal protection and corresponding elements (ALBERS 2013: 47)

Function	Element
Area coastal protection	Beach nourishment, floodplain, island, dune, tidal flat
Linear coastal protection	Dyke, groin, revetment, dune, reef, breakwater
Punctiform coastal protection	Storm surge barrier, sluice, tidal outlet, coastal pumping station

Considering their purpose coastal protection measures can be subdivided into erosion protection, flood protection, drainage and natural coastal protection elements (see Table 3.2) (LIEBERMANN, VON SONNENBERG 1999: 69). This subdivision differentiates between natural and manmade coastal protection.

Table 3.2: Purpose of coastal protection and corresponding elements (ALBERS 2013: 47)

Function	Element
Elements of erosion protection	Groin, flood plain, beach nourishment, revetment, seawall, breakwater
Elements of flood protection	Dyke, storm surge barrier
Elements of drainage	Sluice gate, tidal outlet, coastal pumping station
Natural coastal protection elements	Island, tidal flat, floodplains

Natural coastal protection also includes mangroves, which act in a decelerating manner towards storm surges.

Coastal protection is a matter that is currently as important as it has ever been and will likely become even more important in future times due to climate change and sea level rise.

Related to the described coastal protection efforts, it is necessary to point out the manmade measurements which are taken on New Providence. The majority of the anthropogenic structures and efforts to protect the coast on New Providence can be categorized to linear or areal coastal protections (see Table 3.1) and are elements of flood or erosion protection (see Table 3.2). They will be described individually in the following part.

3.3.1. Seawalls

Seawalls are the most common coastal defense actions on New Providence. They are a stretched structure of concrete, which is built behind the coastline. Their purpose is the protection of roads, property and other areas from erosion and storm floods. After a couple of years, seawalls usually become unstable through undercutting and the restoration of them is a high expense factor (Dean 2002: 404). On New Providence, one can recognise several types of seawalls (Figure 3.1 and Figure 3.2) which show the former state of knowledge in coastal protection efforts and its development. The newest generation of seawalls does not have a continuous top edge. On the topside, they use gaps to make the seawall less vulnerable. These gaps make sure that the seawall will not be pulled into the ocean when the waves have stepped over the wall because the water has a gap to flow back.

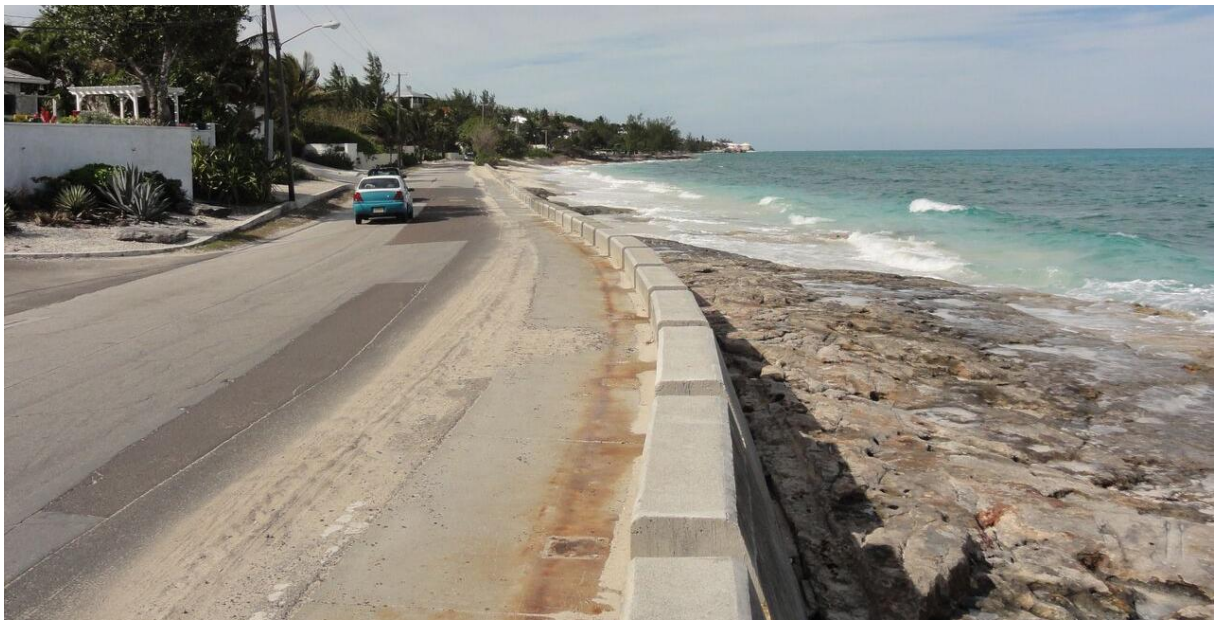


Figure 3.1: Seawall at the corner Bahama West Drive and West Bay Street (Photo POLZIN, February 2016)

Figure 3.2: Another kind of seawall at the Go Slow Bent close to the Bahamar Hotel (Photo MICHAELIS, February 2016)

3.3.2. Tetrapods

Tetrapods are heavy and massive concrete structures which are placed offshore in the ocean. They are placed on the sea ground and atop the other, they are jutting out of the sea. Their tetrahedral or four-legged shaped design is used to reduce the force of incoming waves because they allow the water to flood around and through them (CHARLIER 1998: 219-220). Their main work on New Providence is to protect the harbour and its cruise ship channel from rough sea.

3.3.3. Submerged breakwaters

The submerged breakwaters on New Providence are artificially created from natural lime stone. They are placed under the sea and are normally not jutting out of it. Their main function is to break the water by reducing the force of the waves, similar to the tetrapods, so beaches shall be protected from erosions (DEAN 2002: 398-399). Besides, they also work as an artificial reef to create a new place for sea life. On New Providence, submerged breakwaters can be found in the tourism sector where these reefs are also used as a tourist attraction for snorkelers and divers.

3.3.4. Revetment

A revetment is a combination of a sea wall and a breakwater (see Figure 3.3). Big stones will be placed in front of a seawall to protect the seawall and the area behind. They secure the area by absorbing as much energy as possible by breaking the waves (DEAN 2002: 402-403). On New Providence revetments are the most expensive but also the most effective way to protect the coast (cf. I1). Their dimensions normally do not leave any place for beaches or other natural spaces.

Figure 3.3: Revetment at Rock Point (Photo MICHAELIS, February 2016)

3.3.5. Groin

Groins are right-angled constructions to shore the line. They are built from the coast into the sea and on New Providence the majority consist of big stones (see Figure 3.4). The aim is the interruption of the water flow through a rigid structure, to prevent that sediments are washed away (DEAN 2002: 389-391). On New Providence groins mainly work as protection of selected beaches from erosions.

Figure 3.4: Groins at Saunder's Beach (Photo MICHAELIS, February 2016)

3.3.6. Gabions

A gabion is a metal-filament cage which is filled with stones. They look like prismatic baskets that are stapled and lined up to a wall which should protect infrastructure from the sea. Over the years the metal filaments can become fragile so the stones can fall out and the whole element will lose its structure (CHARLIER 1998: 213-214). On New Providence gabions are not that common. Whenever they are used, they work as a seawall (see Figure 3.5).

Figure 3.5: An intact and a damaged gabion next to the Arawak Cay Bridge (Photo MICHAELIS, February 2016)

3.3.7. Sandbags

Sandbags are normally made of polypropylene or a cotton material which is filled with sand. They are used to protect small parts of areas by breaking the waves and to create dunes. They also help to avoid floods. The long-term impact through sandbags as a coastal protection measure is insufficient because after a month they are rotted away (cf. I1). On New Providence sandbags are used as situational infrastructure protection or as an artificial fundament to create sand dunes.

3.3.8. Beach nourishment

As a response to erosions, beach nourishment can be seen as an adaptation technique to ensure a wider beach as a natural coastal protection. Sand will be brought from another place to create a new beach or to fill up an already eroded beach. The success of beach nourishment is not normally for a long period and after a while, the process has to start again (DEAN 2002: 9-10). On New Providence, beach nourishment is mostly done by private investors from the tourism industry.

3.3.9. Sand fences

A sand fence consists of wood slats, which are connected with a metal filament (see Figure 3.6). It helps to accumulate windblown and drifting sand in the desired place. It also protects areas from sand accumulation (Charlier 1998: 220). Sand fences can be used for the stabilization of sand dunes, to control erosions and to keep sand away from undesirable areas like roads. On New Providence, their main purpose is to keep the sand at the beach and keep it off the roads.

Figure 3.6: Sand fences at Saunder's Beach (Photo MICHAELIS, February 2016)

3.4. Methodology

Regarding coastal erosion and coastal protection on New Providence initially one main research question was formed:

"How is the coast of New Providence affected by erosion, and how can further erosion be prevented?"

To get an answer to our research question it was necessary to develop a methodology. The main method is a mapping of the coastline of New Providence, to get an overview of the coastal environment and the current state of the coast. The aim is to get information about the current state of erosion and accumulation processes, vegetation and development near the coastline. Even so, it will reveal the state of coastal protection. This data also can be used to compare past and future developments. The mapping is done with ArcMap 10.1 which is a Geographic Information System (GIS). ArcMap "is a computer-based tool that analyzes, stores, manipulates and visualizes geographic information on a map" (GISGEOGRAPHY 2016). By using satellite-based pictures from Google Earth 2015 and our on-site mapping, Polzin was able to connect this situational data with long-term knowledge about coastal developments and changes on New Providence.

A population survey is a qualitative research instrument to receive individual information and data for statistical analysis. The following questions 17 and 20 were added in the general survey to receive perceptions, if there is a social response to climate change and coastal protection on New Providence:

> *17. What are the major functions of coral reefs and mangroves?*
> *20. Do you personally participate in local coastal protection efforts (e.g. placing/distributing sand bags, repairing sea-defenses, beach cleaning)?*

The first one is an open question addressing understanding of the need of these natural coastal environments. While the second question can be answered with yes or no, to extract if coastal protection measures are implemented in the society.

Furthermore, for this work the two questions have a subordinate importance for the guideline interviews.

Guideline interviews are a qualitative method and will help to explore the views, experiences, beliefs and motivations of the individual participants. They also help to find out if there is a social response to climate change on New Providence and awareness for coastal issues in the society. The reasons and motivation for protection efforts can only be ascertained by interviewing local participants with expert knowledge. An expert can be defined as a person with special knowledge. This special knowledge has to be obtained from a long-term activity or occupation related to environmental issues like climate change and coastal protection on New Providence (BOGNER 2005: 45).

The experts for the interviews were chosen with the intention to get perspectives from different points of view. It was essential to have official experts from governmental organizations, which are involved in development, tourism and environmental issues (see Table 3.3). The points of view from non-profit organizations and environmental activists are inevitable and. Additionally, a scientific perspective delivers a broad selection of experts for the guideline interviews.

Table 3.3: Overview of the interview partners

Natural and coastal Protection	**Development**	**Tourisms**
Neil E. Sealey (I1)	Physical Planning (I5)	Ministry of Tourism (I6)
BEST Commission (I2)		
Re-Earth (I3)		
Nature Conservancy (I4)		

The BEST Commission (Bahamas Environment, Science & Technology Commission)

The BEST COMMISSION is the official environmental advisory body of the Bahamian government. Since the establishment in 1994, the commission manages the implementation of multilateral environmental agreements (cf. I2). By reviewing environmental impact assessments and environmental management plans, they give advice for development projects in the Bahamas.

Department of Physical Planning

The Department of Physical Planning underlies the Ministry of Works, which is part of the Bahamian government. Their responsibility is the estimation of construction projects and finally, they can give permissions or a cancellation for the projects. Their expert status is a result of the daily governmental business, which includes construction projects near the coastline.

Ministry of Tourism

The Ministry of Tourism is part of Bahamian government. The fact that tourism industry is responsible for many constructions along the coastline on New Providence, the ministry has expertise on environmental conditions and coastal problems. An interview with the Ministry of

Tourism was chosen to deliver information from a governmental point of view of the most important economic sector in the Bahamas.

Nature Conservancy

The NATURE CONSERVANCY was founded in 1951 (THE NATURE CONSERVANCY 2016A) and is the world's leading conservation organisation. It is active in more than 30 countries worldwide, and recently it has established three marine reserves and 15 managed marine areas in the Bahamas, which means an expansion of more than 11 million acres of protected environment. Its main aim is to keep the coastal habitats healthy and robust and at the same time improve the fishery and tourism industry. Because of this and the very close cooperation with the Bahamian government (THE NATURE CONSERVANCY 2016B), it was decided to have an interview with THE NATURE CONSERVANCY to get another perspective from a leading conservation organisation regarding coastal management in a country that lives off of tourism.

Re-Earth

RE-EARTH was founded in 1990 and is a Bahamian Non-Profit-Organization. Their main focus is on animal rights and environmental issues. As a critical opposition group (SAVE THE BAYS n.d.), RE-EARTH is well informed about environmental discussions. Also, they should have background information about ongoing problems and possibly occurring environmental violations on the Bahamian coastline.

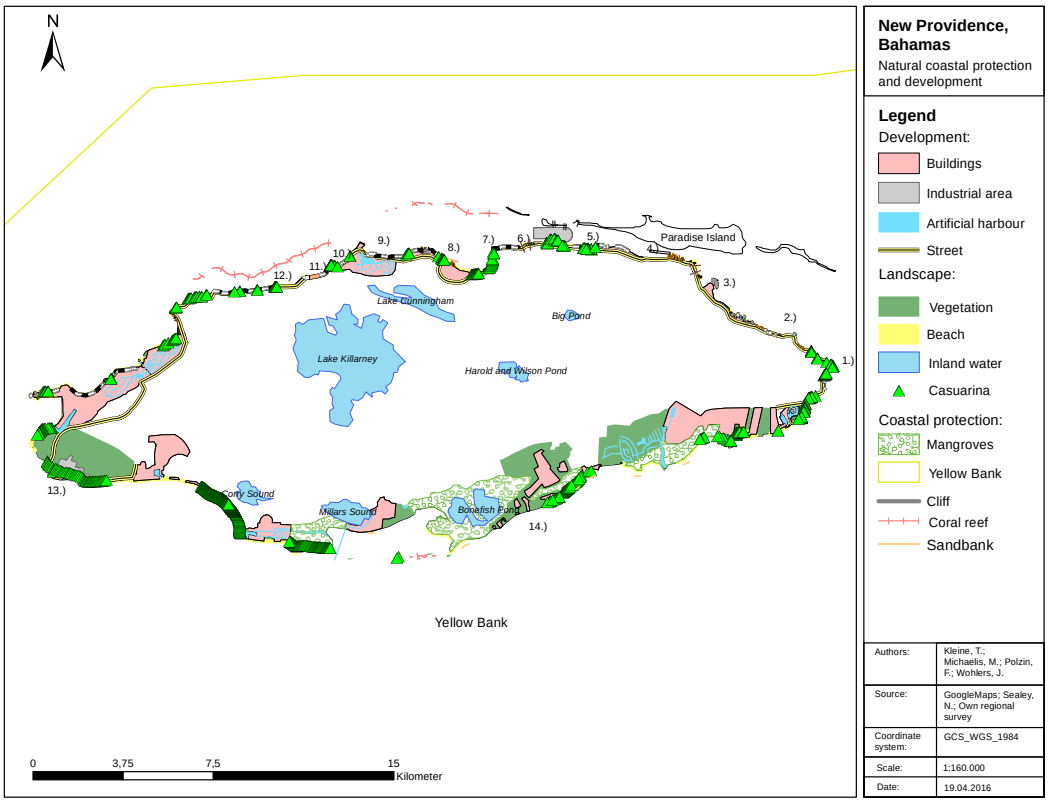
Neil E. Sealey

NEIL E. SEALEY is a widely known Bahamian geomorphologic scientist. His main research fields are geographically related topics on the Bahamas where he has published several books in the *Bahamas today* series. With the publication "*Bahamian Landscape: Introduction to the Geology & Physical Geography of the Bahamas*" and articles about coastal erosions he is an independent scientific expert.

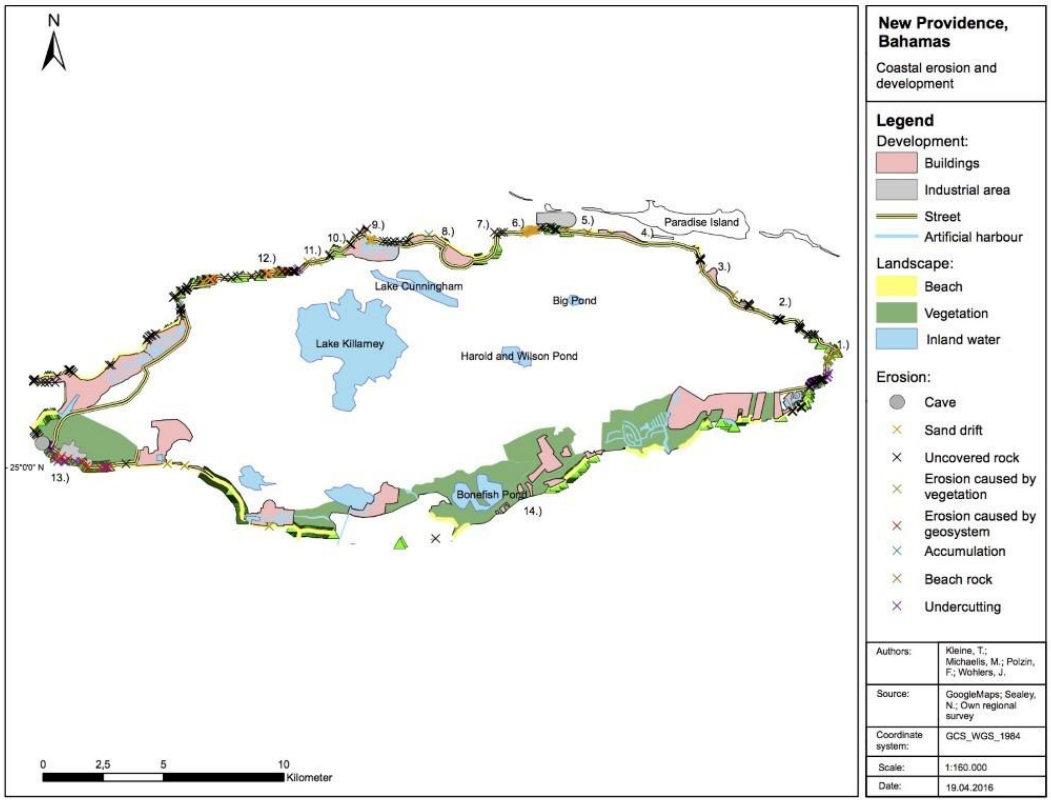
3.5. Mapping of the Coastline

The island of New Providence is situated on a limestone bank that continues south and east towards Exuma, Long Island and Eleuthera. On the northern coast, there is the deep Providence Channel dividing New Providence, Abaco and Grand Bahama. Due to the mean wind conditions related to the trade winds coming from the northeast, the northern coast of New Providence is marked by erosion such as undercutting and sand drift and therefore is ever-changing. The island is sheltered by coral reefs along large strips of its northwestern coast. The reef is around 200 – 500 meters (656 – 1640 ft.) away from the coastline and acts as a natural breakwater (see Map 3.1). Along the northeastern part of the coast, which is naturally be more exposed to the wind and therefore more tempestuous, the conditions are usually quite calm, because of the offshore islands and cays like Paradise Island, Athol Island, Salt Cay and Rose Island. These islands extend out towards the east in the direction of Eleuthera. Eleuthera itself protects New Providence by building a barrier towards the North Atlantic. The southern coast is surrounded by shallow water and sandbanks and is thereby protected.

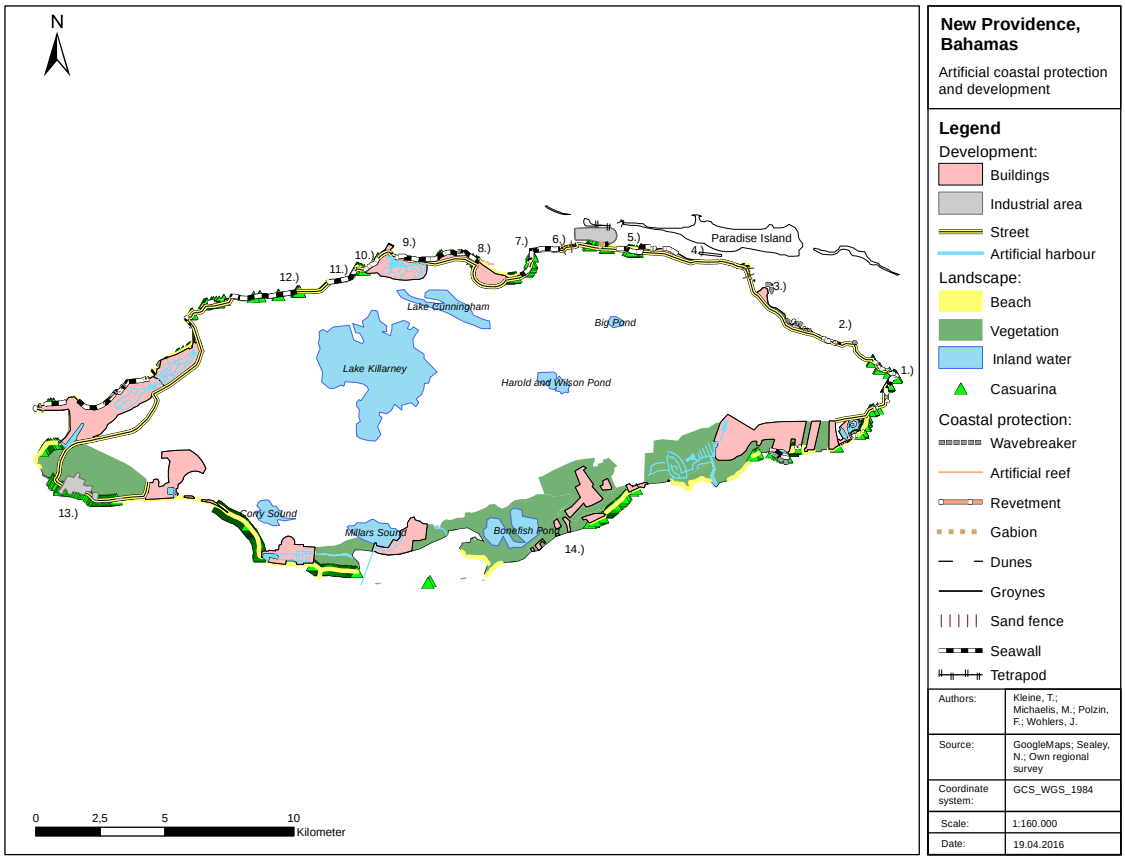
An overview of the coastline of New Providence and New Providence's position within the Bahamas will be shown in the following. Also the state of coastal erosion (see Map 3.2) and coastal protective measures (see Map 3.3) will be shown. Maps shall give further illustration of the different sections.



Map 3.1: Natural coastal protection on New Providence



Map 3.2: Coastal erosion and development on New Providence

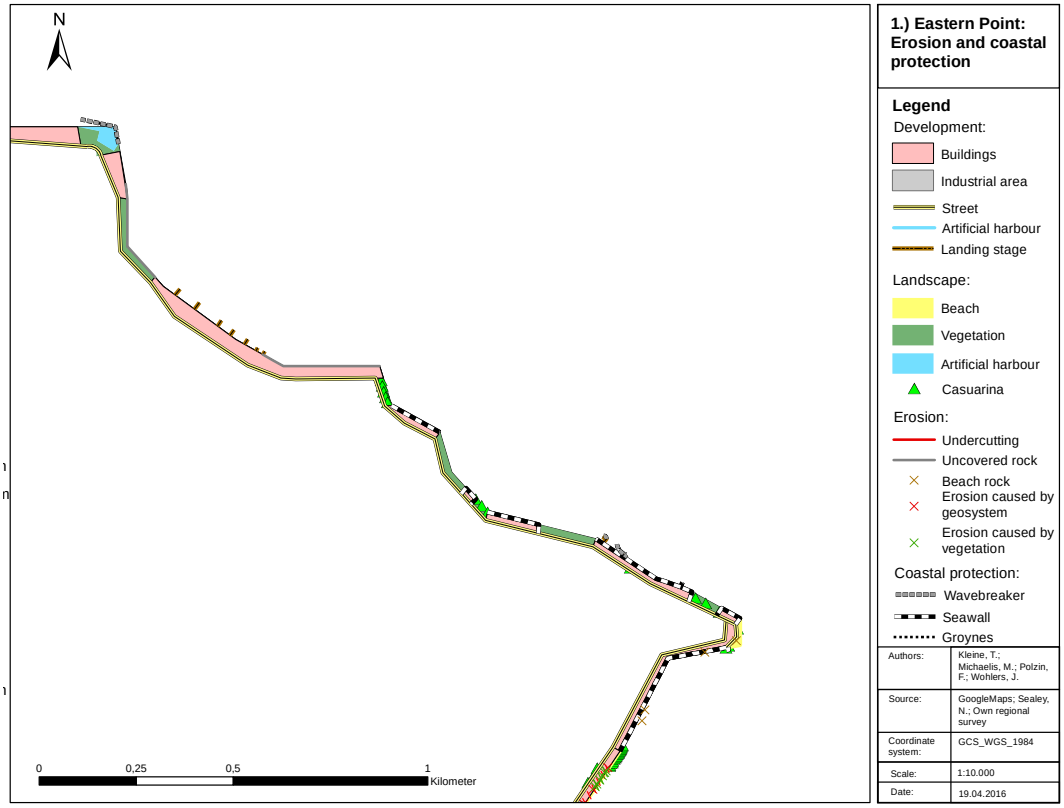


Map 3.3: Artificial coastal protection and development on New Providence

3.5.1. Eastern Point

At Eastern Point, one can predominantly find new seawalls which protect the coast from incoming waves (see Figure 3.7). Nevertheless, some old seawalls still do exist further eastward. The shallow coast consists of rocky beach but does not feature sandy beaches. Even though the presence of beach rock[2] suggests that this part of the coast suffers from erosion, Neil Sealy mentioned that he had never seen a (sandy) beach in this section of the coastline (see Map 3.4).

[2] Beachrock: cemented sand; under the surface of the beach is a wetted area, evaporation leaves calcium carbonate crystals behind which cements the sand. Though, it is quite soft, one can break it with pure hands. As cementation goes on it gets harder. Due to algae it sometimes looks black and is called iron stone. If one side of the beach is exposed, it is a good indicator for erosion (cf. I1).

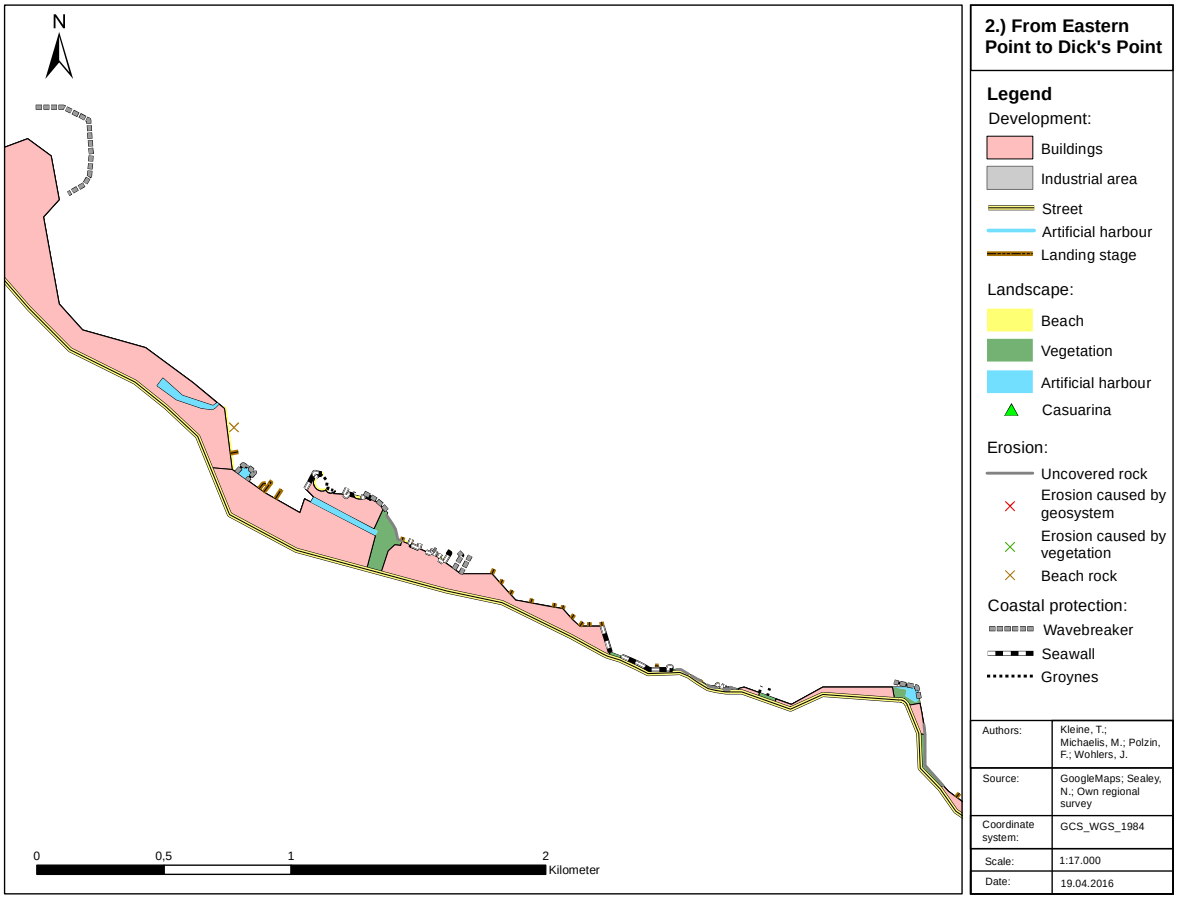


Map 3.4: Coastal erosion and protection on Eastern Point

Figure 3.7: A seawall and stairs with undercutting at Eastern Point (Photo MICHAELIS, 2016)

3.5.2. From Eastern Point to Dick's Point:

The coastline between Eastern Point and Dick's Point is covered by private houses. Often they are built directly at the coastline though there are no beaches in front of the setback. It is rather a rocky shore made up of limestone composite which the locals call "iron bounds". Erosion here takes place quite slowly. Due to private building development, coastal protection is also handled privately (see Map 3.5).



Map 3.5: Coastal erosion and protection from Eastern Point to Dick's Point

3.5.3. Montagu Beach

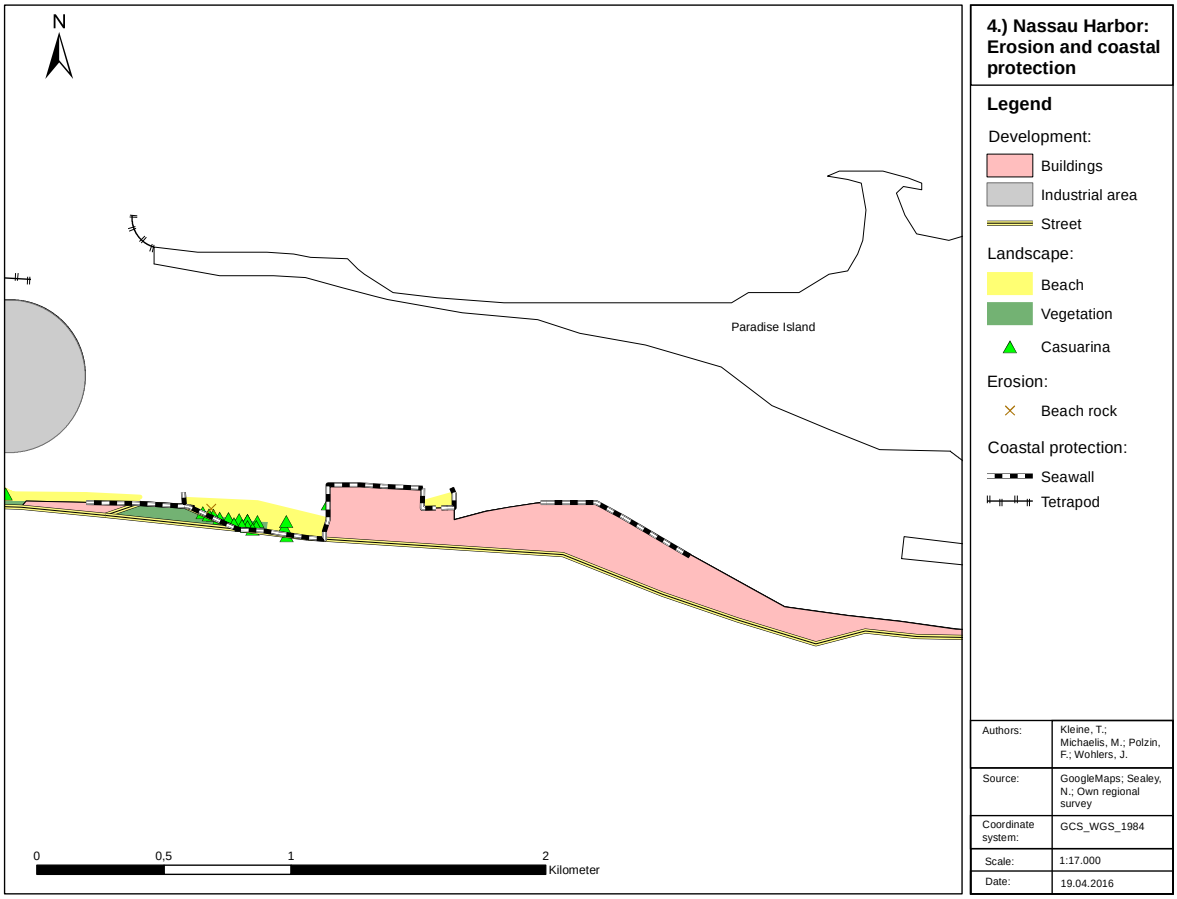
Montagu Beach is a local beach restored by funds provided by the Atlantis Hotel. After replenishing it, the beach is now protected by groins to break the waves from one side and prevented from sand shifting and displacement along the direct coastline. Furthermore, from the other side, sand fences in the hinterland shelter the beach from wind erosion blowing sand inland (see Figure 3.8, Map 3.6). Indicators of a locally used public beach are e.g. toilets, a car park, a playground. All this can be found at Montagu Beach.

Map 3.6: Coastal erosion and protection at Montagu Beach

Figure 3.8: Sand fences and groynes protect Montagu Beach (Photo MICHAELIS, February 2016)

3.5.4. Nassau Harbor

Marinas and private seawalls characterize the area around the Nassau Harbor. The tetrapods, which are built in the North of Arawak Cay, can be seen from Nassau Harbour (see Figure 3.9, Map 3.7).

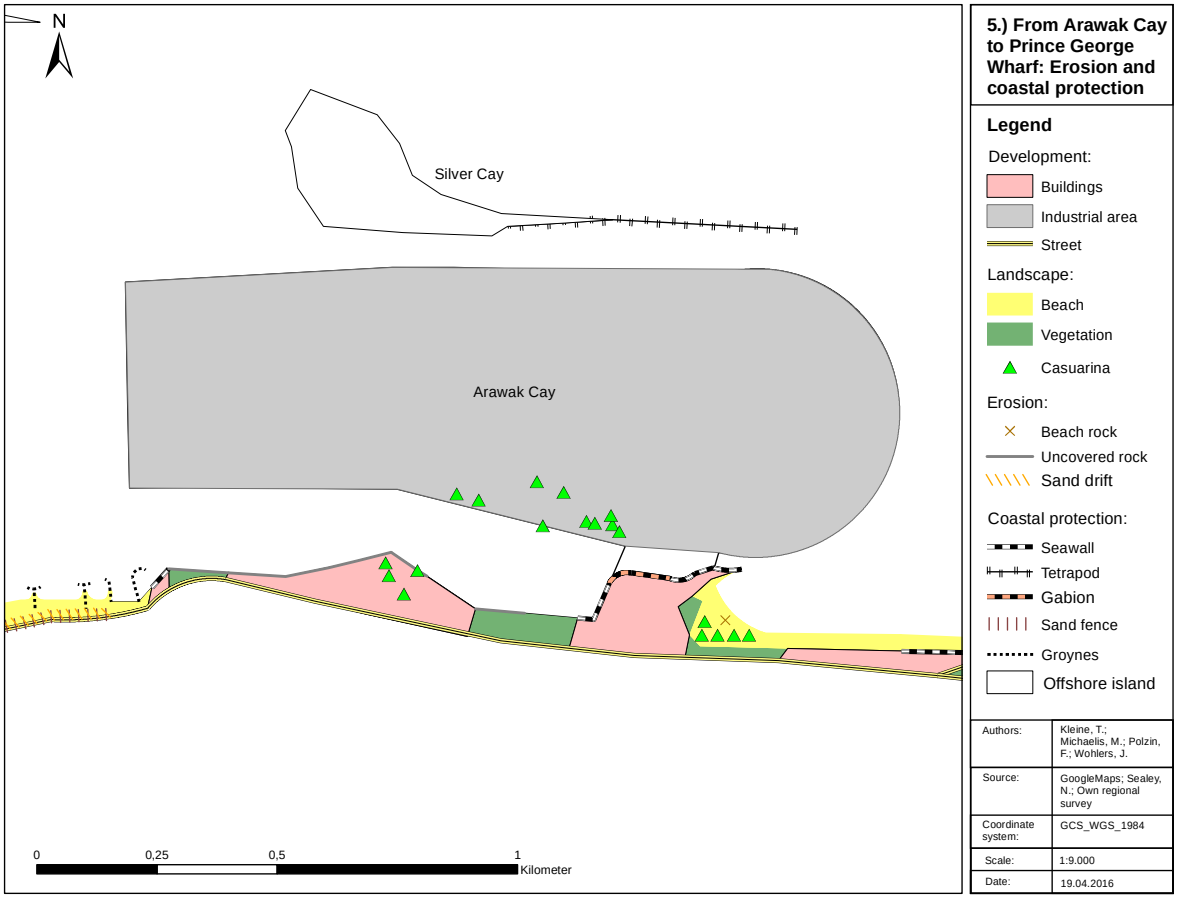


Map 3.7: Coastal erosion and protection at Nassau Harbour

Figure 3.9: Casuarinas on the left and tetrapods on the right in front of Arawak Cay (Photo MICHAELIS, 2016)

3.5.5. From Arawak Cay to Prince George Wharf

Between the Arawak Cay[3] and Prince George Wharf, there is a stable beach with a seawall. It is well protected from bigger waves as there is not only the Arawak Cay but also Paradise Island situated just off the coast. Also, there are also breakwaters located between these two islands. It remains a narrow opening – the port entrance – big enough for the cruise ships to enter. The tetrapods that were installed just at the Western end of Paradise Island are the only single tetrapods along the coastline of New Providence (see Map 3.8). They are very stable and were only shifted once during the devastating storm in 1991 also called 'the perfect storm'.

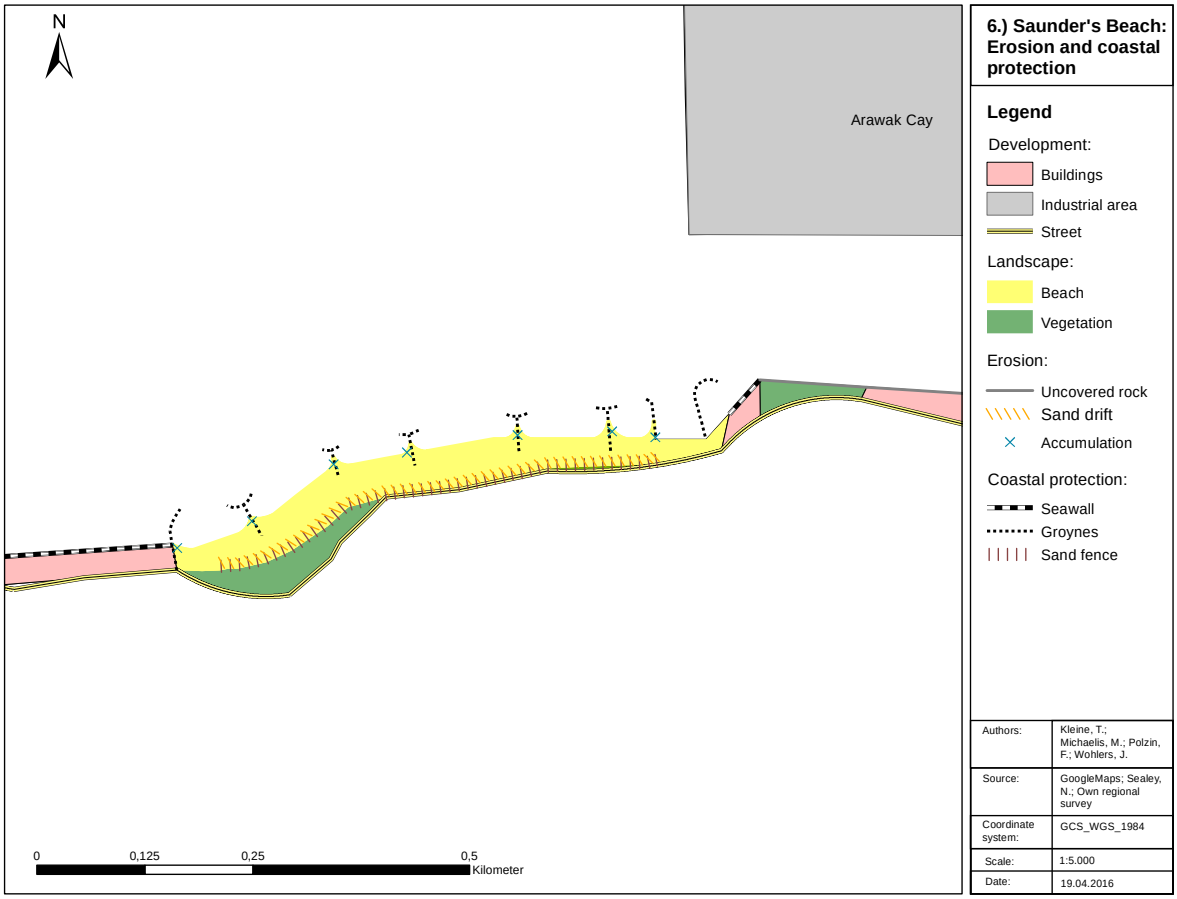


Map 3.8: Coastal erosion and protection from Arawak Cay to Prince George Wharf

3.5.6. Saunder's Beach

Like Montagu Beach, Saunder's Beach is a restored beach, which was totally eroded and watered-down. Similar to Montagu Beach, it is now protected by groins and sand fences (see Figure 3.10, Map 3.9). The biggest problem at Saunder's Beach is the wind blowing from a West-Easterly direction shifting a lot of sand inland.

3 The Arawak Cay is based on a natural but quite small cay. It was artificially enlarged with the fill extracted from the harbor floor (cf. I1).

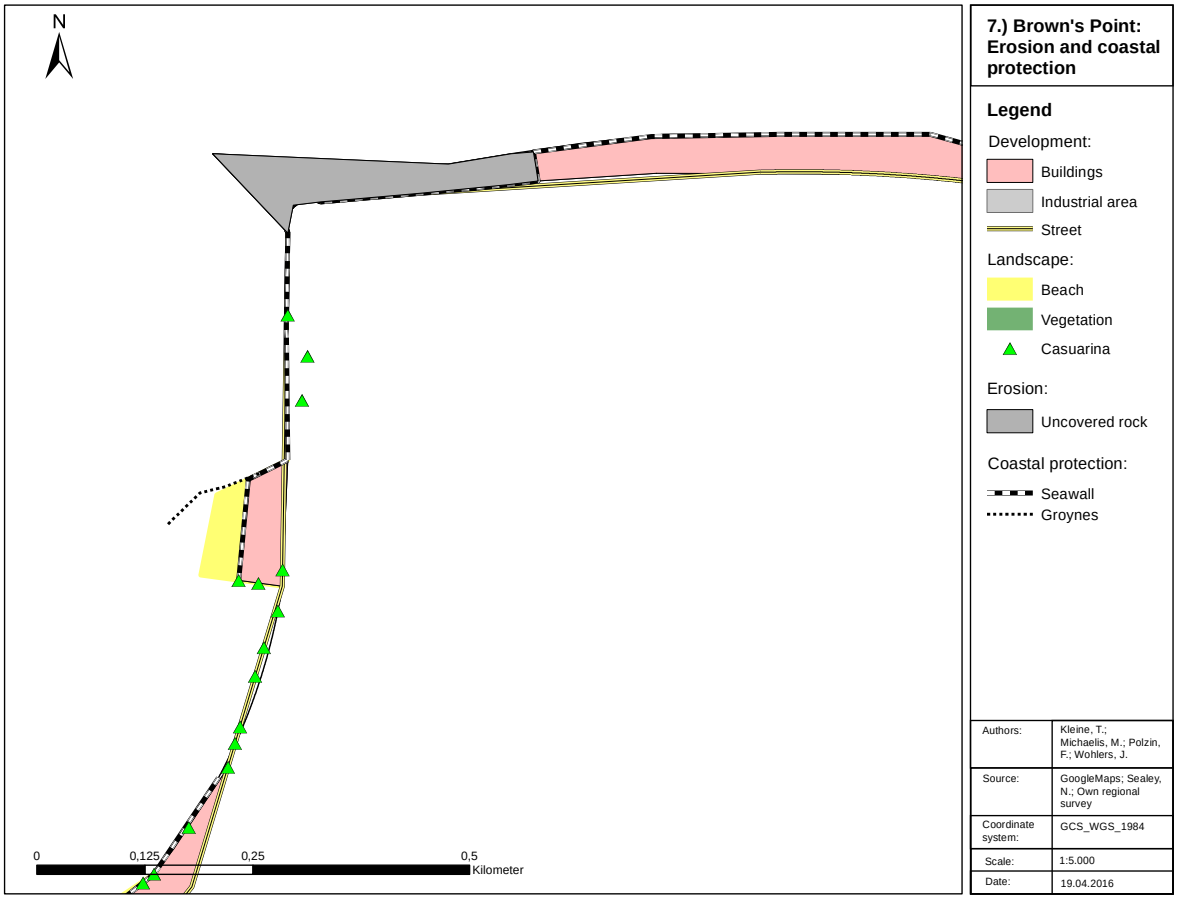


Map 3.9: Coastal erosion and protection at Saunder's Beach

Figure 3.10: Sand fences and groins at Saunder's Beach (Photo MICHAELIS, 2016)

3.5.7. Brown's Point

At Brown's Point [local name: "go slow bends"] private seawalls protect the coast. These private seawalls do not have any interstitials. If the water spills over those seawalls, it pushes them hydrostatically towards the ocean and often breaks them while flowing back (see Figure 3.11). This part of the coastline does not have a beach, except for one little private one (see Map 3.10).

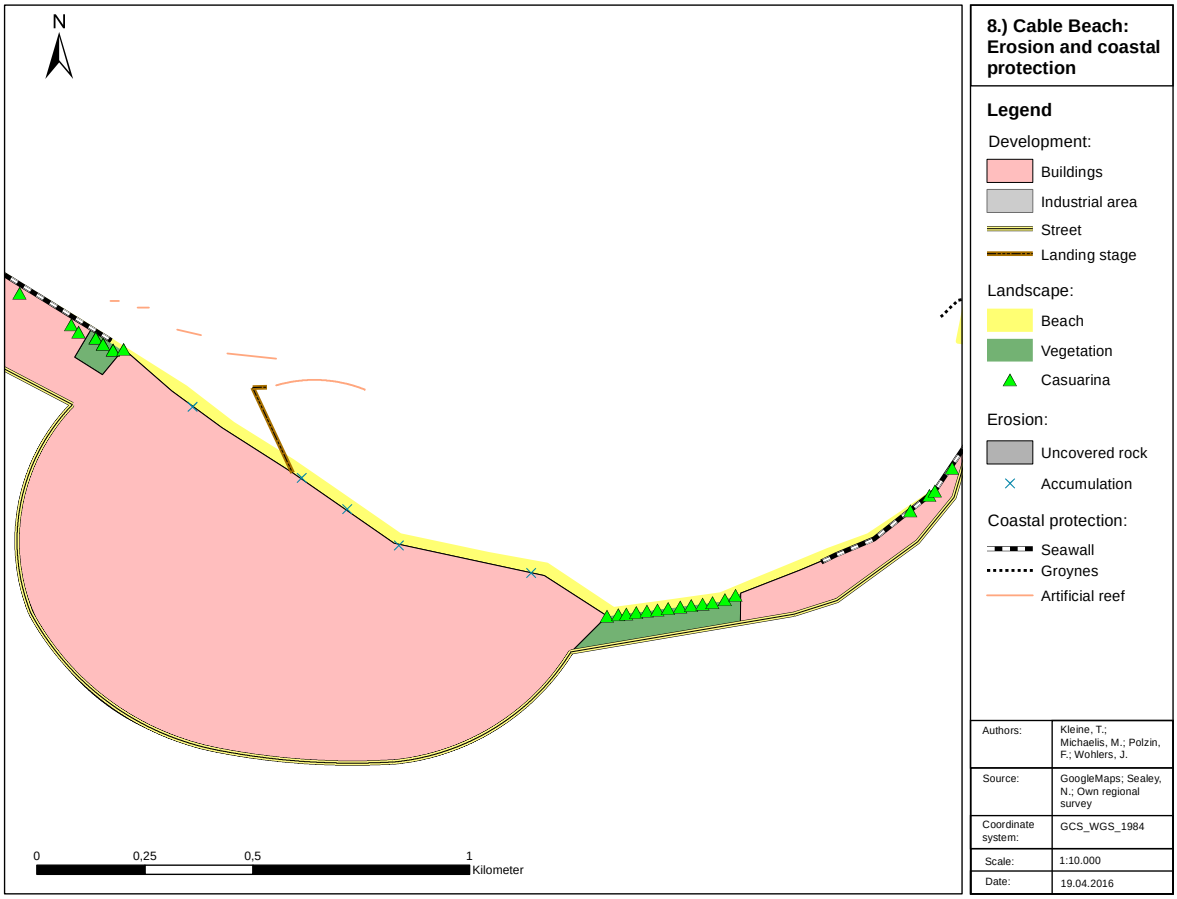


Map 3.10: Coastal erosion and protection at Brown's Point

Figure 3.11: A broken seawall at Brown's Point (Photo MICHAELIS, February 2016)

3.5.8. Cable Beach

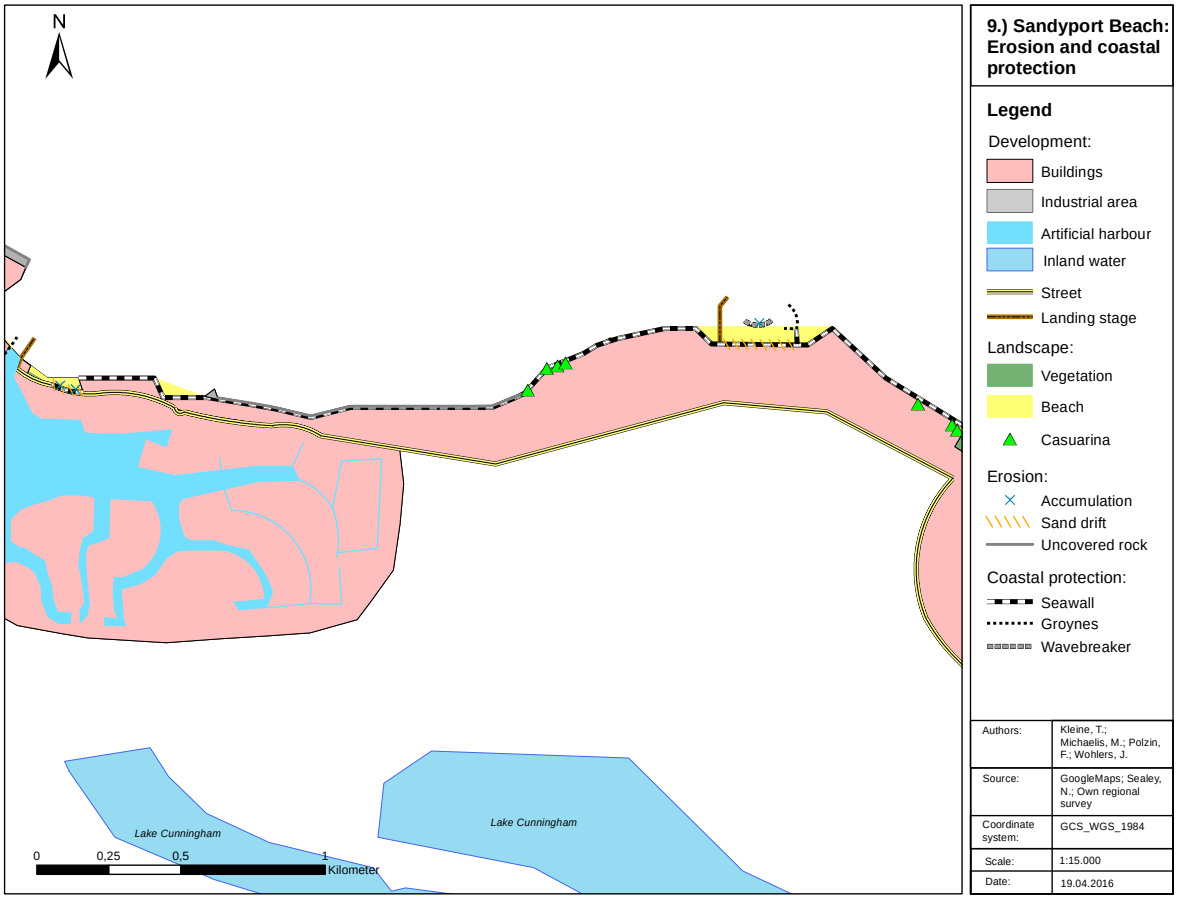
Cable Beach is the main tourist beach of the big hotels on New Providence. It is a nice and sandy beach. The Baha Mar Hotel's new developments include an artificial reef that was installed between the beach and the natural reef to break the waves and protect the beach. Though there are breakwaters in front of the coast, the beach is not protected against wind erosion. Because the setback is not big enough, the natural dune line is shifting further towards the ocean. This leads to aeolian accumulation at the hotel's edge (see Map 3.11).



Map 3.11: Coastal erosion and protection at Cable Beach

3.5.9. Sandyport Beach

The best example of wind erosion and sand accumulation can be seen at Sandyport Beach. At this part of the coastline, a wall was built to protect the street from the inland blowing sand. The sand is stopped by and heaps up along this wall. As a consequence, the discrepancy of the surface height is immense – the beach behind the wall is approximately two meters higher than the street (see Figure 3.12). Along this beach in Westerly direction, a very good example for an intact artificial sand dune can be found that almost works like a natural one. This is the succession of enough space between the ocean and the seawall so a vegetation belt could evolve. Other main aspects about this part of New Providence are seawalls, which line the entire coastline (see Map 3.12).

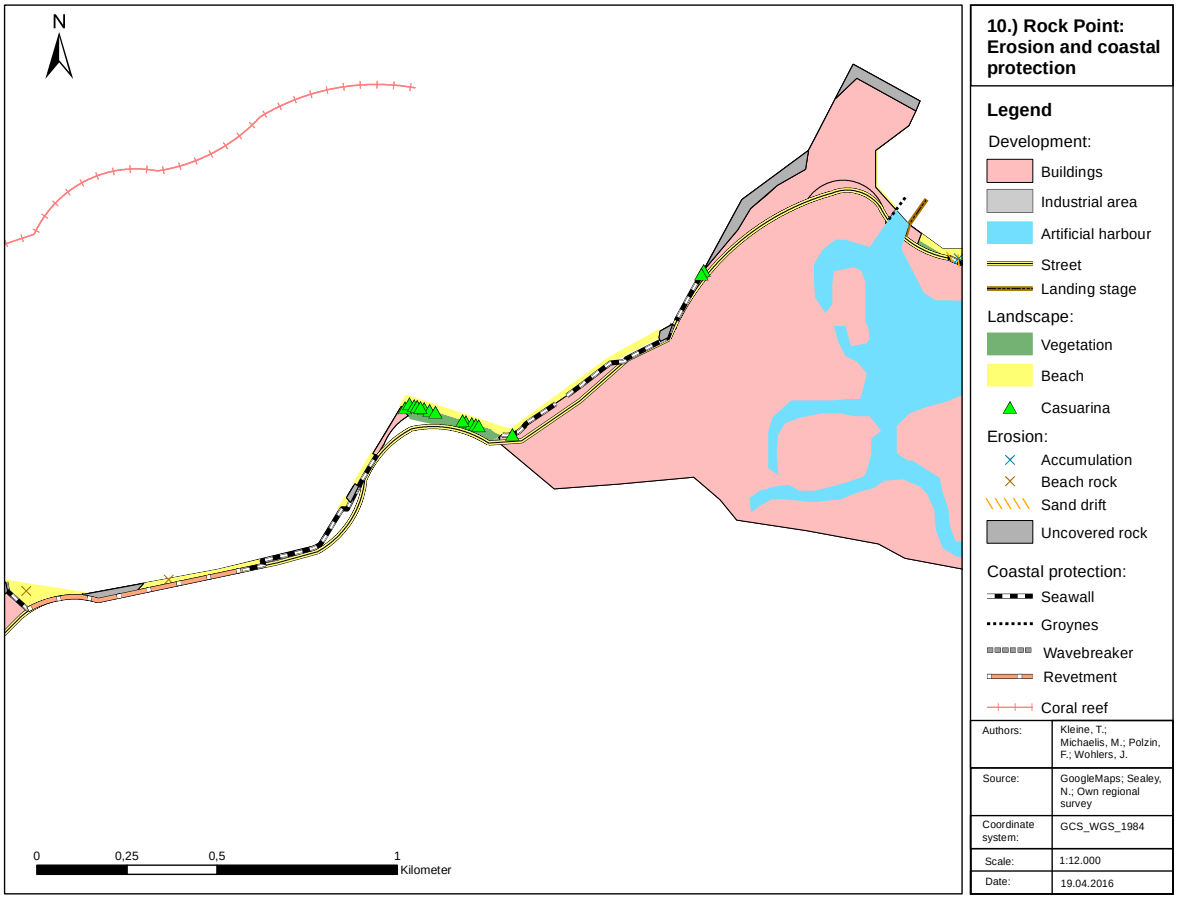


Map 3.12: Coastal erosion and protection at Sandyport Beach

Figure 3.12: Sand stopped by the wall at Sandyport Beach (Photo MICHAELIS, February 2016)

3.5.10. Rock Point

Westwards at Rock Point the erosion was so heavy that there was no other possibility than to build a revetment to protect the street from further erosion and destruction (see Figure 3.13). Furthermore, many Casuarinas can be found at the shore and some beach rock (see Map 3.13).



Map 3.13: Coastal erosion and protection at Rock Point

Figure 3.13: Revetment at Rock Point to protect the street from further destruction and erosion

3.5.11. Cave's Point

New beach rock can be found at Cave's Point. This new beach rock differs from the older one in colour and consistency. New beach rock is lighter and easier to destroy. One can even destroy it by crushing it in one's hand.

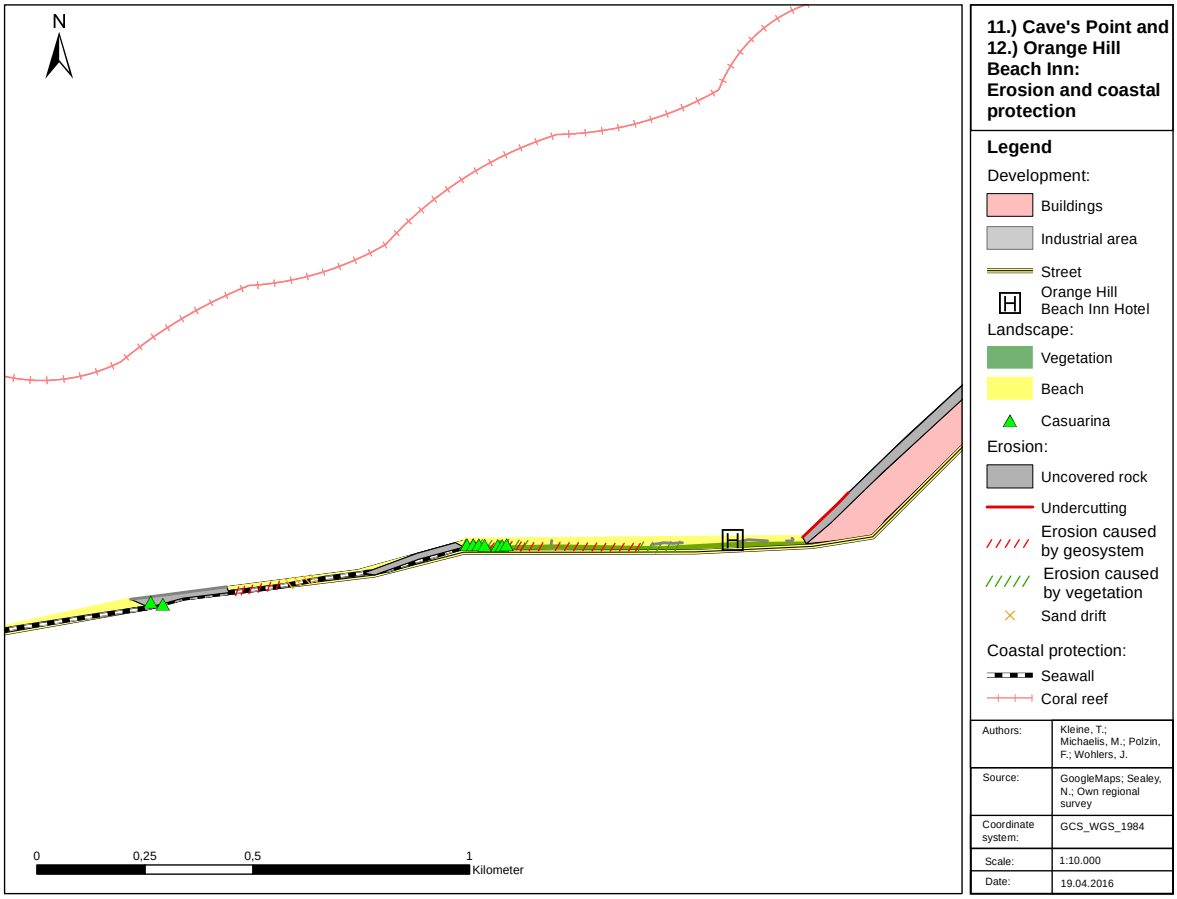
3.5.12. Orange Hill Beach

Orange Hill Beach is currently one of the few remaining sand beaches along the coast of New Providence. Back in 1991, the beach was completely eroded and the water level was right next to the street. Also, the road was flanked by Casuarinas. The residents of Orange Hill Beach decided to clear the remainder of the beach of Casuarinas and tried restoring the beach with an artificial dune made from scrap material, driftwood along with cement. This was supposed to catch sand and in the long haul provide space for vegetation to grow.

The effort proved to be successful (see Figure 3.13) and Orange Hill Beach is currently free of Casuarina population and the newly built-up dune is stable and boasts a large population of Seagrape and Scaevola. At the very eastern end, there is a bit erosion caused by roots and the waves (see Figure 3.14) and on a couple of metres, the makeshift artificial dune can still be seen. The beach itself is several meters wide and features sedimentary rock poking through the sand (see Map 3.14).

Figure 3.14: Photographs of Orange Hill Beach (eastern end) in 1991 (top) (Photo SEALEY, 2013)

Figure 3.15: Photographs of Orange Hill Beach (eastern end) in 2009 (bottom) (Photo SEALEY, 2013)

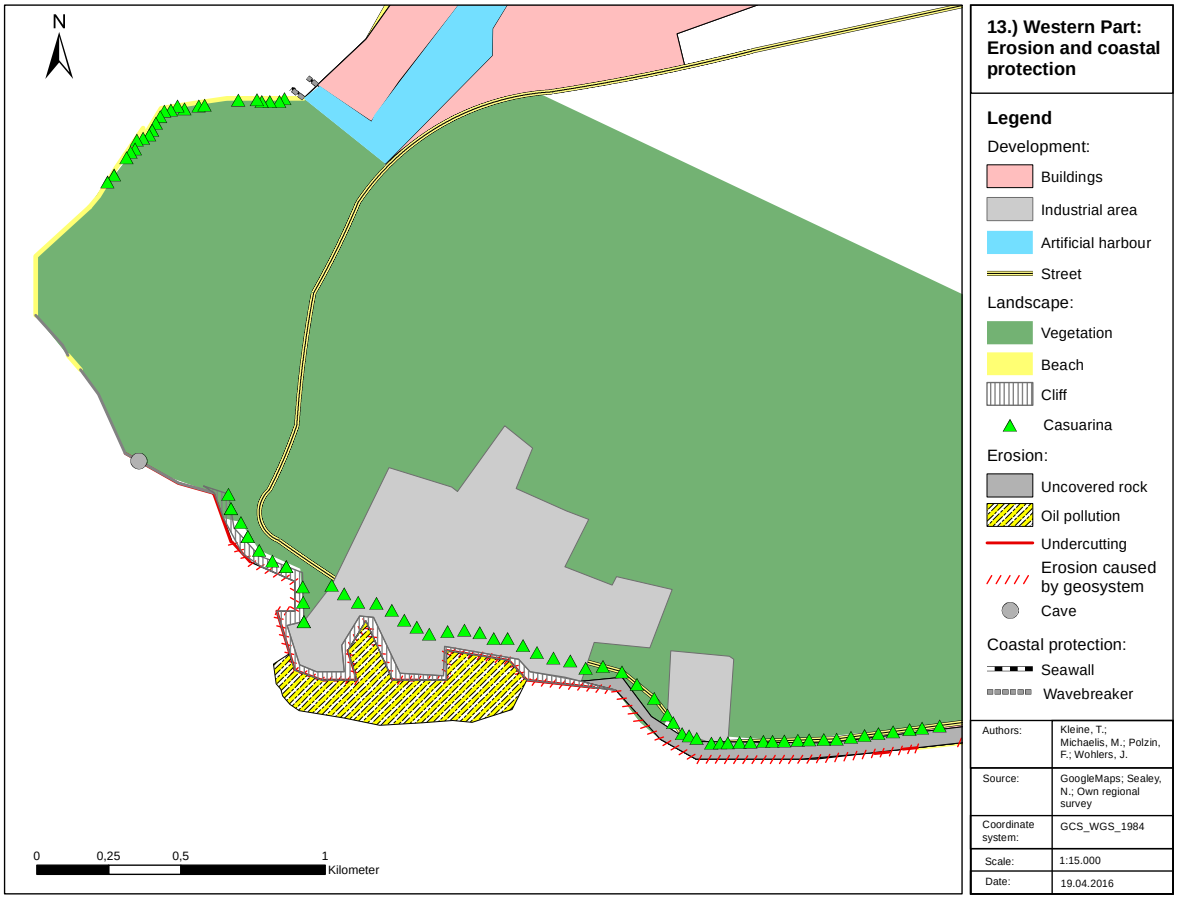


Map 3.14: Coastal erosion and protection at Cave's Point and Orange Hill Beach

Figure 3.16: Erosion caused by roots and waves at the very Eastern end of Orange Hill Beach (Photo POLZIN, February 2016)

3.5.13. Western Part

This part of New Providence has the only steep coast of the island. Besides the Clifton Pier diesel power station and the Commonwealth Brewery, this area is marked by coastal erosion such as undercutting and a cave, but also there is a lot of oil spill due to the diesel power station (see Figure 3.16). Another conspicuous factor is a lot of casuarinas, which line the coast of the western part and increase the coastal erosion (see Map 3.15).



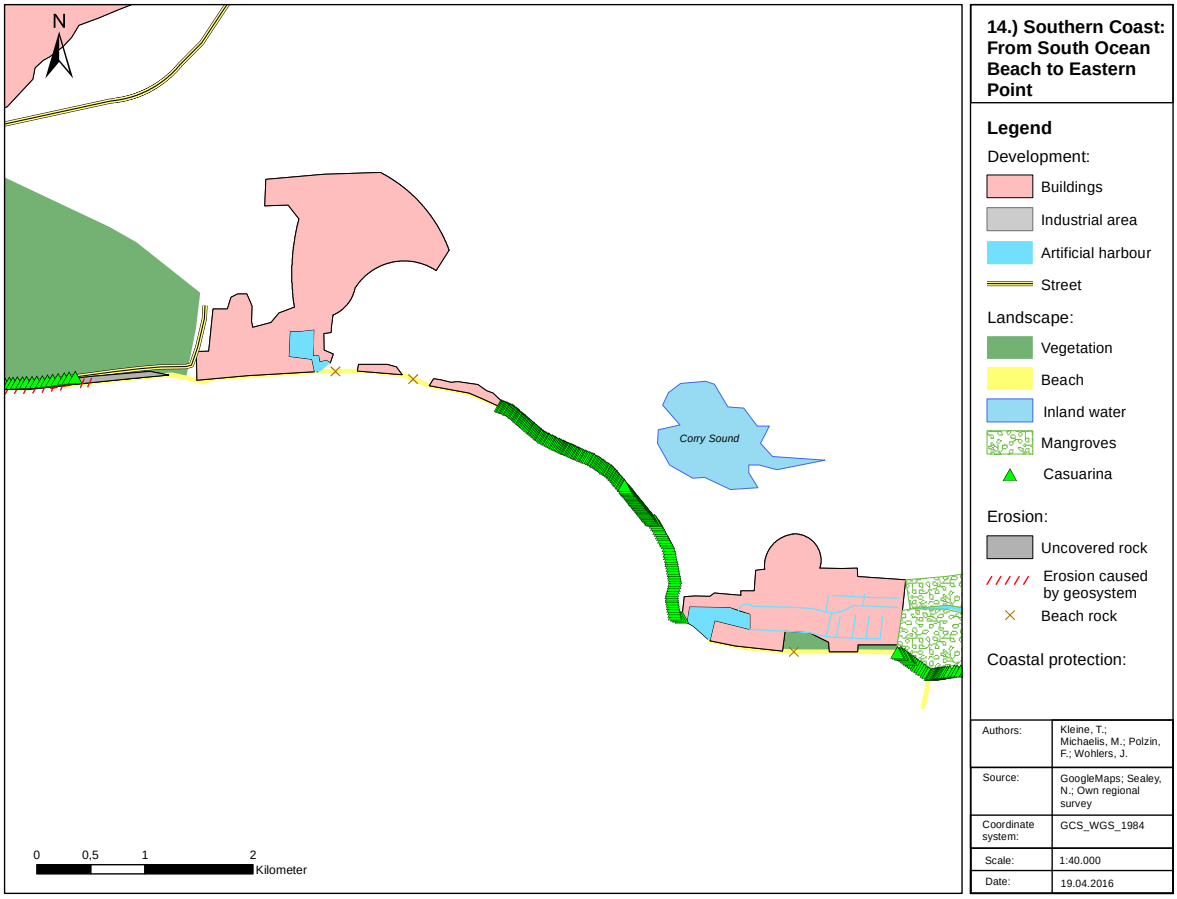
Map 3.15: Coastal erosion and protection at the Western Part

Figure 3.17: Erosion at the only cliff of New Providence oil spill and undercutting (Photo POLZIN, February 2016)

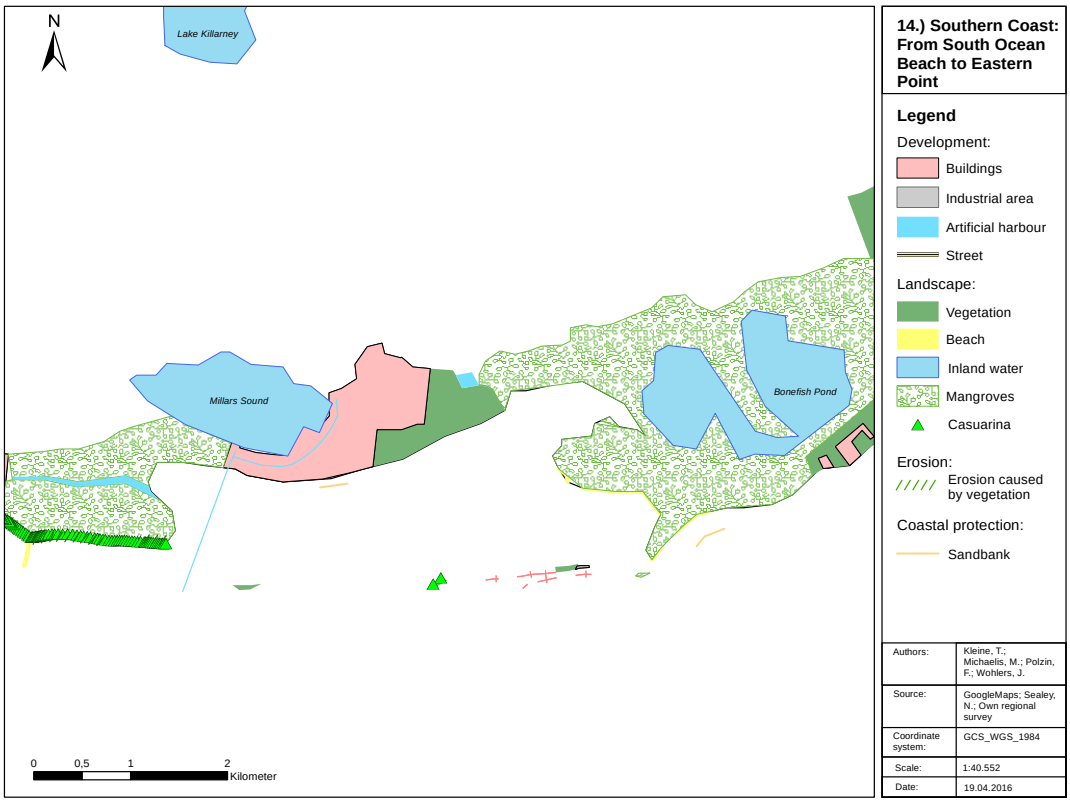
3.5.14. Southern Coast: From South Ocean Beach to Eastern Point

This part of the island is not very diverse and is less settled than the rest of the island. The western part of this section is alternated between beaches and rocky sections (see Figure 3.17). Most of the beaches contain beach rock and the rocky parts are marked by undercutting. Casuarinas are found everywhere along the southern coast, except for bonefish pond, where mangroves grow and a

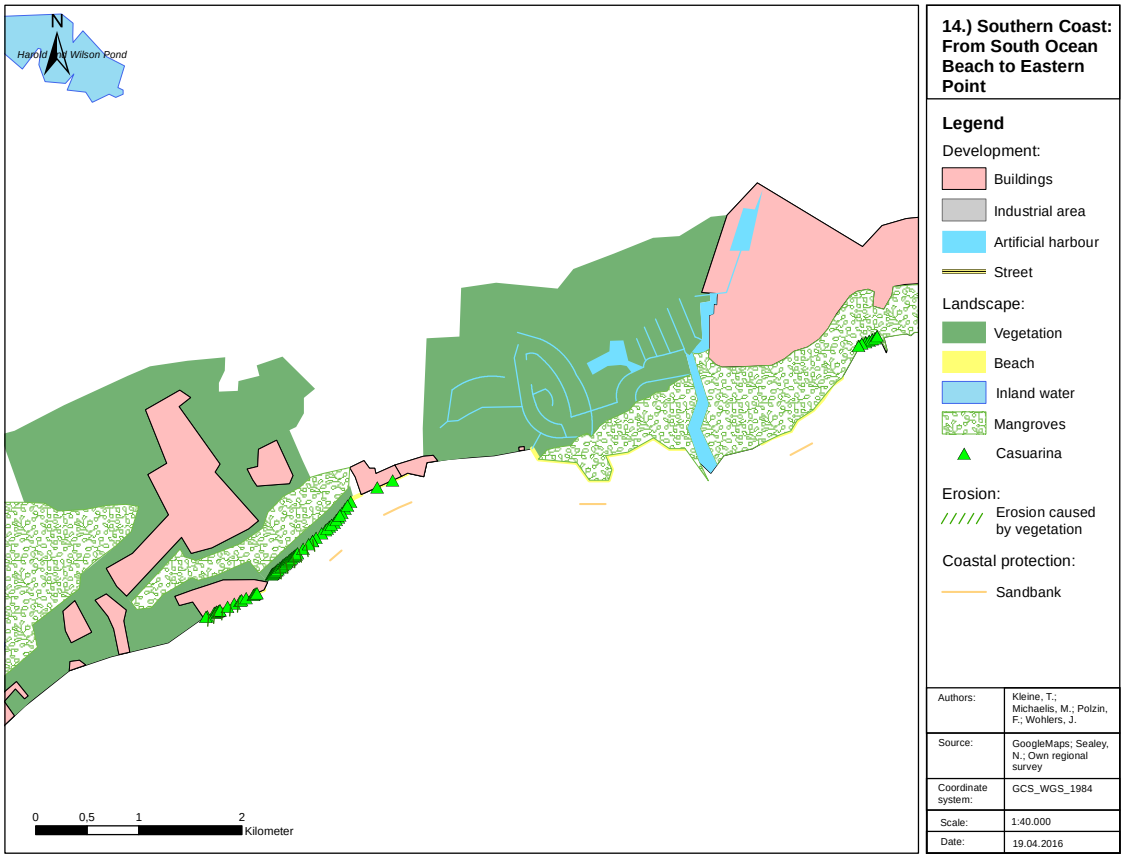
lagoon protects the coastline. The few settlements and villages such as Adelaide Village do not have much coastal protection such as sea walls or dunes. By satellite images, we were able to find out, that the gated community Albany probably protects itself with seawalls. It is conspicuous that the Southern coast has very shallow sea, which extends itself for approximately 200 meters and is protected by many sandbanks. Coming closer to the South-Eastern part of the island, the BNT planted mangroves, which are still very small but are supposed to protect the coastline from erosion in the future (see Figure 3.18, see Map 3.16, Map 3.17, Map 3.18 and Map 3.19). All in all, this part of the island is very difficult to access, due to much vegetation and less infrastructure.



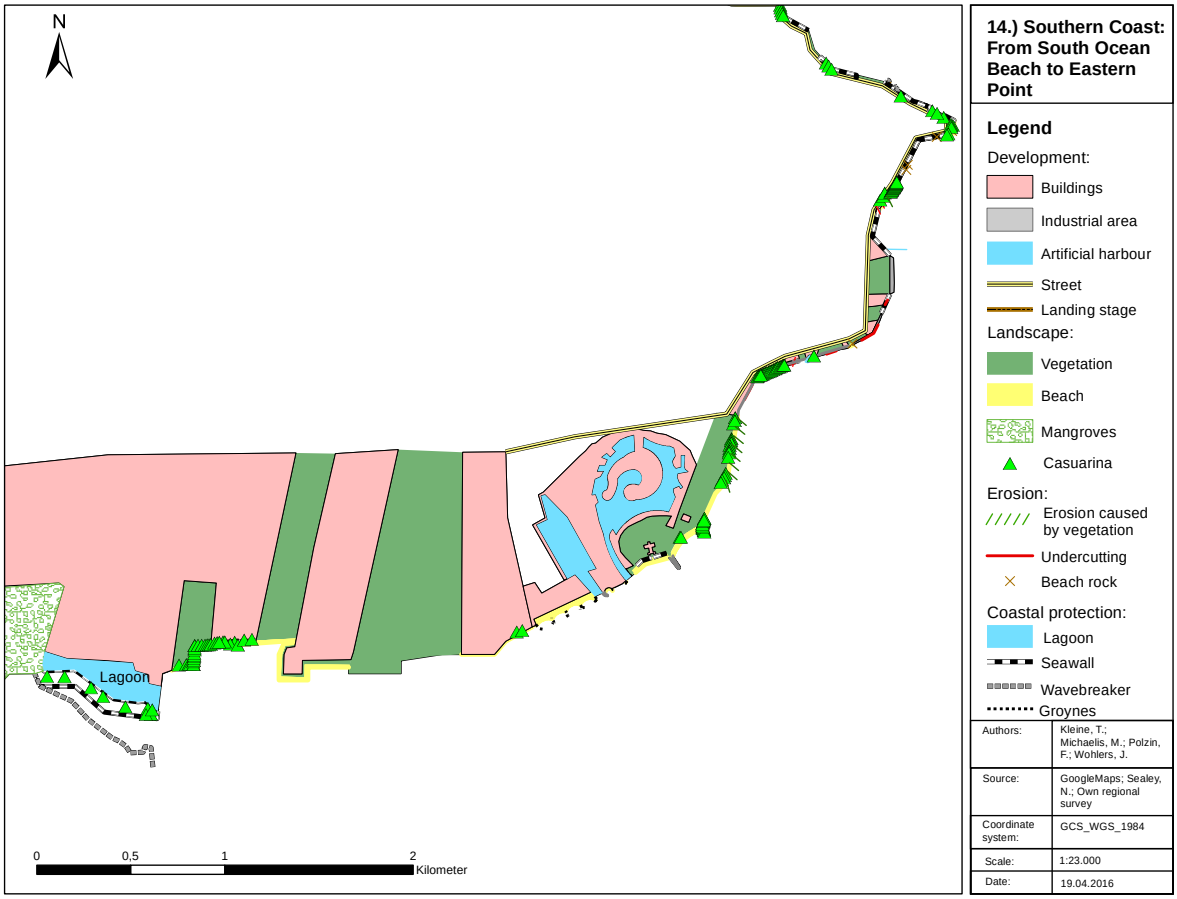
Map 3.16: Coastal erosion and protection at the Southern Coast. Part 1



Map 3.17: Coastal erosion and protection at the Southern Coast. Part 2



Map 3.18: Coastal erosion and protection at the Southern Coast. Part 3



Map 3.19: Coastal erosion and protection at the Southern Coast. Part 4

Figure 3.18: A rocky section with Casuarinas at the western part of the Southern coast (Photo POLZIN, February 2016)

Figure 3.19: Mangroves planted by the BNT at the Southern coast (Photo POLZIN, February 2016)

Summary

When assessing the effect of erosion on the coast of New Providence one can see that it is essential to distinguish between the northern coast and the southern coast.

The northern coast is characterized by a protectively acting coral reef sheltering the coast from the worst wave impact and also retaining the dispersed sand. Additionally, there is a lot of manmade coastal protection of varying efficiency and a strong influence of the wind.

The southern coast is mostly sheltered from strong wave impact by the presence of a huge shallow shelf area. Also, the coast is lined with mangroves and only in few places manmade infrastructure interferes with nature.

3.6. Results

Having given the necessary definitions and having introduced the methods and participating experts the following chapter mainly deals with the results of the interviews with these experts.

3.6.1. Hypotheses

Initially not only a research question was formed but also five hypotheses were made and several guided expert interviews were planned to gain the relevant information concerning these question and hypotheses. In the following, the outcomes of these interviews shall be used to prove or disprove the initial hypotheses and answer the research question.

Thesis 1: „One consequence of the sea level rise is an increased coastal erosion on New Providence“

All interview partners mentioned that coastal erosion is an existing problem for the coastline of New Providence. Also, during the stay on the island, several signs for coastal erosion such as undercutting, exposed beach and exposed Casuarina roots were observed. Since it was a very short period, everything that was witnessed is just a snapshot, which makes it impossible to assess the change of the coastline in the long term or to notice increased erosion. Moreover, as coastal erosion is a natural process, it happens at every coastline in the world at any moment. Where there is a coast, there will always be erosion. Even though some erosive activity was recognized, expert knowledge and long-time monitoring over many years are needed to be able to identify the reason for erosion and to see the impact of an increasing sea level.

Thesis 2: “Infrastructure built at the coast enhances erosion”

Erosion and accumulation are constant companions when walking along any coast. “The coast has changed, is changing and will always change” (cf. I2). So coastal erosion is a natural process, but it might be strengthened by infrastructure built along the coast. The current road system along the north coast of New Providence (West Bay Street, Bay Street and East Bay Street) originates from paths within the dunes that, back in the day, were used for transportation, because further inland there are impassable swamps and wetlands studded with mangrove forests. So these paths were the fastest way to go along the coast. Naturally, with industrial development, the paths were not suitable anymore and got replaced by roads. With sometimes less than five metres distance to the water, these roads are built too close to the coast (cf. I1). With progressing development, the coast got more and more covered with infrastructure. Naturally, this infrastructure changes the dynamics of the coastal system. Changed topography due to infrastructure changes wind conditions and creates the opportunity for the wind to erode existing dunes. As soon as dunes have vanished, the infrastructure behind them gets exposed to a level of stress that was not anticipated during construction (see Figure 3.20).

Figure 3.20: Destructive impact of erosion at Caves Point West Bay Street, New Providence (Photo: Neil Sealey, 2013)

With the majority of the current building projects being ad-hoc developments (cf. I1, I5) a lot of the environmental impact and the naturally following impact on the development itself, are not

thoroughly considered. Though environmental impact assessments (EIA) have become a requirement for building projects in recent past (cf. I1) it seems as if still too many building projects are hurried. Additionally, building licenses will not be obeyed, even though the license was given before. As a result, coastal infrastructure which is built too close to the coastline and which is not properly (according to building codes and requirements) constructed, has potential to strengthen coastal erosion.

The fact that there is potential for strengthening of erosion due to infrastructure is omnipresent along the New Providence northern coastline. West Bay Street is one of the most striking illustrations for the hypothesis. For the entirety of its length, it closely follows the coast. Along it, there are several places where erosion severely affected manmade infrastructure in return for it being built too closely to the coast (cf. I1) (see Figure 3.18). Relocating the infrastructure, in particular roads, is more costly than building protection (Interview: Physical Planning) though by now it is possible to build roads through wetlands in the hinterland of the coast of New Providence (cf. I1). This becomes problematic when the road encourages erosion of the dunes acting as a natural protection for the roads. By now, as observed during our stay on New Providence, there are close to no dunes guarding the roads from the offshore wind and waves along the northern shore.

Overall it can be seen as proven, that the initial hypothesis that anthropogenic infrastructure increases is at least partly correct. Properly carried out building projects may not have an immediate impact on erosion but still, the manmade infrastructure should always have a setback from the coast (cf. I1).

Thesis 3: "Natural protection measures for coastal protection are not considered to the extent they ought to, the Bahamas rather rely on artificial protection measures"

According to the NATURE CONSERVANCY New Providence is a flat island that "relies heavily on natural protection". Natural protection measures on the island include coral reefs, mangroves, dunes and sandbanks. Similar to sand banks, coral reefs "slow down the wave action". Currently, the reefs are in a bad shape but even "the structure of dead corals still buffers" (cf. I4). Also, mangroves work as a buffer and absorb wave energy. The condition of the red mangroves – a species living closest to the shore and therefore being the most interesting one when dealing with coastal protection – are healthy in the areas they exist in. However, in many areas they were removed in the past to allow for building development. Though mangroves are protected by the Forestry Act 2010, which was enacted in 2010 to protect, develop and manage the forest resources of the Bahamas (FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS 2010), nowadays they are still being removed. This is very destructive because mangroves protect areas from flooding. To get the permission to remove mangroves, the BEST COMMISSION and BNT have to be asked and then they consult the government. On the one hand, Mangroves have been given a value by the Forestry Act 2010 and are now therefore protected, on the other hand, the right for direct access to water is also granted by law (cf. I2)**.** These facts lead to a conflict. Aggravating the BEST COMMISSION is only an advisory body for the government and can consequently only give advice. The BEST COMMISSION has to balance economic and ecological interests in politics**.** The Bahamian government, which makes the final decisions, however, is dependent on the population that elects them. Political parties have few ecological topics on their agenda. The economy comes first, it creates jobs and jobs secures voters. Also, this leads to another problem: There is a lack of knowledge about the means of natural protection measures in the population (cf. I4). This can also be seen in the results of our street survey we did on

New Providence. Most parts of the population only believe that mangroves and coral reefs are solely habitats for fish. Only few knew the important role they play in the context of coastal protection. During the interview, RE-EARTH they said: *"*The Bahamian society is far behind on being aware of coastal protection or climate change*"*. There might be less interest in the preservation of mangroves and other natural coastal protection because interest in the creation of jobs remains in the foreground of political activity (SURVEY). Regarding coral reefs, there are no regulations for the protection of these yet, but the responsible parties are working on the Coral Reef Protection Act (Interview: NATURE CONSERVANCY). Keeping these facts in mind, it might be still questionable why the government does not protect mangroves and coral reefs appropriately if the existence of the Bahamas relies heavily on natural protection measures. A Forestry Act 2010 has been written, a Coral Reef Act is in process, the "National Policy for the Adaption to Climate Change 2005*"* addresses the protection of the coast and especially the importance of mangroves and sand dunes, but still there are no strict laws and registrations. One answer might be that changes in politics always implicate a change in priorities. It depends on what it is on the priority list. New politicians may not know about the policies brought in during the last legislative period. Nevertheless, the government puts future development of coastal protection according to climate change on their radar and agenda. The BEST COMMISSION and the BAHAMAS NATIONAL TRUST know that the Bahamas need to look at natural and anthropogenic protection since a combination of both is important. In the long run, sea walls cannot protect New Providence properly and something longer-lasting is needed. However, "once natural protection is there, it is there". Although human-made protection is still needed at the moment, because rebuilding, replanting and regrowing of coral reefs and mangroves takes time (cf. I4).

In the past, there was a large coastal mismanagement due to lack of knowledge. Today, there is more knowledge about it, but the mismanagement still continues (Interview: RE-EARTH). This could have several reasons:

While the BEST COMMISSION actually cares about the environment, economic development always has to proceed (cf. I2). Even if there are restrictions that are followed, these limitations are enforced stricter near Nassau than further away. There is not enough human capacity to keep an eye on every project in the Bahamas because the BEST COMMISSION only employs about five to six people. There are not enough people to govern an area of the size of Jamaica (cf. I1).

Last but not least, it seems as if the Bahamas only rely on ad hoc-planning (cf. I5). Remembering that regrowth of mangroves and corals takes time, the consequence is self-explanatory. Only a few farms are planted on New Providence in contrast to the necessity of long-term planning.

As a conclusion, it can be said that the government of the Bahamas knows about the importance of natural protection measures, but the importance of economic interests does not make it possible to fully respect this knowledge and give it proportional attention.

Thesis 3: "Coastal protection measures are predominantly a reaction to a situational threat on infrastructure"

The fourth thesis expresses the assumption that the taken measures in the coastal protection are predominantly a reaction to situational erosional threats on infrastructure. According to the two interviews with NEIL E. SEALEY, many problems caused by erosion will not be solved in advance and the constructions of seawalls or revetments are a last minute reaction before losing infrastructure.

Most of the roads and developments are built too close to the coastline, which can be seen in chapter number five "Maps and description of the coastline", too. As a result, it seems that spontaneous actions dominate the coastal protection efforts to protect the damaged area. According to the DEPARTMENT OF PHYSICAL PLANNING, the taken measures are ad hoc developments, which mean that they are inadequately proven. It is not taken into account that the taken measures could shift the problem to another place. If a homeowner creates a seawall to protect his property, it is commented that he has no agreements or arrangements with the neighbouring properties (cf. I5). Their properties will normally become more affected because erosion problems are only shifted from one property to the neighbouring property. These problems are related to the already mentioned point of mismanagement (cf. I3) and fundamental communication problems which were mentioned from the NGO, scientist and the governmental interview partners. The problems in communication between involved actors and ambiguous scope of responsibilities (cf. I5) create an atmosphere of ad hoc developments with no sense of responsibility for negative long-term developments (cf. I1). These problems are enforced through compulsory bureaucratic processes (cf. I2) and it seems that upcoming duties should be solved conveniently before running the risk of creating an intricate procedure. By consideration of these added facts, the hypothesis can be accepted and it can be said that coastal protection efforts are predominantly a reaction to a situational threat on infrastructure.

Thesis 4: "Private economic interests are placed over climate and coastal protection"

Tourism and the related businesses are an essential part of the Bahamian economy and constantly in competition with the Caribbean island states (cf. I6). Tourists obviously want a beach right in front of their accommodations, so the tourism sector is building closer to the coast (cf. I6). This might violate the restrictions of the project initially set by the BEST COMMISSION, but the further away from Nassau, the less control there is concerning building codes. These restrictions are often enforced until a real estate broker comes into play, buys the ground and sells it to customers while making promises, which the building code actually cannot accommodate (cf. I1). This crux of planned development is then often resolved by special permissions that, according to RE-EARTH, are bought by the developer and might in some cases resemble corruption. Usually, when a development has chances of creating secondary employment (e.g. housekeeping, service, day-tour-staff), the chances are that it will get permission to be built easier than without that (cf. I1). This essentially means that every single large development on the coast of New Providence linked to tourism is waved through with the excuse of the creation of jobs. This is closely linked to the corresponding current government, where priorities of the corresponding previous party in power get thrown over board and the "friends" of the party in power figuratively "get their backs scratched" (cf. I3). The 45-100 ft. setback of infrastructure from the coast pleaded for by the PHYSICAL PLANNING Committee (cf. I5) might get ignored in this case (cf. I3).

The BEST COMMISSION is one of the leading agencies concerning coastal protection and conservation and means to get many things done. Though they are often choked off by their small budget and their lack of authority (cf. I1). And even though there is legislation covering development and coastal protection (cf. PLANNING AND SUBDIVISION ACT 2010) there are not any fines or even enforcement of this legislation (cf. I2).

There is hope for sustainable development since in recent years natural coastal protection, such as mangroves, has become an issue and accordingly is now partly protected by law (cf. FORESTRY ACT

2010). Also mitigation for large development projects needs to be provided, usually with about twice the size or value of the area used for the development (cf. I2) and climate change and sea-level rise, in general, are getting more attention (cf. I1). However, ultimately, climate and coastal protection are currently being neglected under private economic interests.

3.6.2. Summary

The interviews with the experts explain why we could only witness a few and no standard coastal protection measures around the island. Coastal protection is not a centrally organized effort to maintain the coastline but rather a vast amount of small and smallest efforts organised by individual committees and or actual individuals taking care of small areas. This means that not the entire coast is protected but rather just small patches. This patchy coastal protection can actual damage or destroy coastal area around it due to changed currents and winds. Also, there are no binding building codes, no matter if it comes to streets or houses, that are based on central legislation but rather common practice.

The coast of New Providence is strongly affected by erosion, which might in some places get enhanced by uncoordinated coastal protection. This problem might be solved by constituting a central agency that coordinates an integrated approach to coastal protection, communicates this, provides legislation governing coastal protective measures and enforces said legislation. There is also a lack of central legislation governing the way building projects are realised. As mentioned earlier, building projects are mostly ad hoc and also do not necessarily follow the imposed building codes or the common practice as given by the BEST COMMISSION.

The general conclusion from the hypotheses shown above is that all coastal erosion, flooding and any other kind of negative impact of the ecosystem on human infrastructure can be traced back to either manmade structures or their vicinity to the coast. This visualizes that many erosion-related problems that the Bahamas are currently dealing with are homegrown and can be solved by actively controlling where which infrastructure is built and by whom with which intention.

3.7. Conclusion

The coastline is the connection between the ocean and the mainland. It is formed and shaped by the movement of the ocean's waves. Due to climate change and sea-level rise flooding in coastal regions heap up. For this reason, coastal protection as a social adaption to climate change is irremissible.

During our stay on the Bahamas, we were able to determine that coastal protection is also a topic of politics of the archipelagic state. In most of the cases, it is ad hoc development that serves as defense for the endangered infrastructure. A huge problem for coastal protection on New Providence is the lack of responsibility. There is no officially responsible agency. The responsibility depends on which type of infrastructure is affected. As a consequence, it is organized by the Ministry of Works, the Ministry of Environment, the Ministry of Health as well as the BEST COMMISSION or private investors. In the end, no one is responsible for the coastal management and protection.

Besides, climate change is recognised as an issue, more value is attached to economic topics like the development of the tourism sector or creation of new jobs. Economic development on New Providence has to proceed. That is why environmental issues are always left behind. For example, for newly built hotels or houses, there are hardly any restrictions or laws to comply with when it

comes to minimum setbacks or the sustainment of mangroves. Indeed, there are official regulations, but they only count in the beginning, because the real estate agents try to sell their property by making promises that are not according to the regulations. As soon as the property is sold, the regulations are basically not in place anymore. Moreover, gated communities can hardly be controlled concerning regulations. The DEPARTMENT OF PHYSICAL PLANNING mentioned in the interview that "often Bahamians do not see a need for something if the problem is not directly occurring". This is one of the reasons; climate change is not too urgent in everyday politics.

Another problem is that the Bahamas are competing with other Caribbean tourism destinations. Especially Cuba is going to become a great competitor in the next few years, being a new tourist destination for US Americans. Though the Bahamians are aware that it is not practical to build at the coastline, tourist's expectations have to be met and tourists want to spend their vacations in a hotel directly at the beach or coast. Also elaborations like the "Policy for Adaptation to Climate Change" are written to meet international expectations.

About the future expectations on New Providence according to coastal protection as an adaption measure to climate change, one can say that the awareness has increased. The climate change issue and sea-level rise particularly are getting more attention. NGOs and activists are getting more involved. Vulnerability is always present, and the future challenge is to improve coordination of the communication between the involved committees, ministries and agencies. The problems of coastal erosion and sea-level rise can be dealt with by a concentrated, joint effort to preserve the marvellous landscape of the Bahamas and especially New Providence.

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4. The impacts of climate change on water resources

Lukas Sorgalla, Kim Stolle, Karina Wiening

4.1. Introduction

Without water, life on planet earth would not be possible. This makes it one of the most important and most valuable resources in the world. The Bahamas, as most of the Small Island Development States (SIDS), have to deal with the problem of freshwater provision already and thus are particularly vulnerable to increased stress on their water resources (cf. GLOBAL WATER PARTNERSHIP 2014: 10). As of today, natural freshwater availability is so low that it is considered 'scarce', according to United Nations criteria (cf. US ARMY CORPS OF ENGINEERS 2004: i). Regarding the general topic of the study project 'Social response to climate change – sea-level rise in the Bahamas', this fact makes the topic manageable for us and gives us a base for our research besides the main topic.

Rainfall is the only natural freshwater source for the Bahamas. 'The rainfall forms freshwater lenses in the ground as well as wetlands, small pools at the surface, and seasonal ponds.' (ibid.: 15). Most of the freshwater reserves are found in freshwater lenses (see Figure 4.1) of various sizes and quality. Due to their geography, the different islands of the Bahamas receive different amounts of freshwater which differ by about 40%. That means less rainfall in the southeastern islands compared to the northern islands and leads to issues of freshwater distribution among the islands (ibid.: 15).

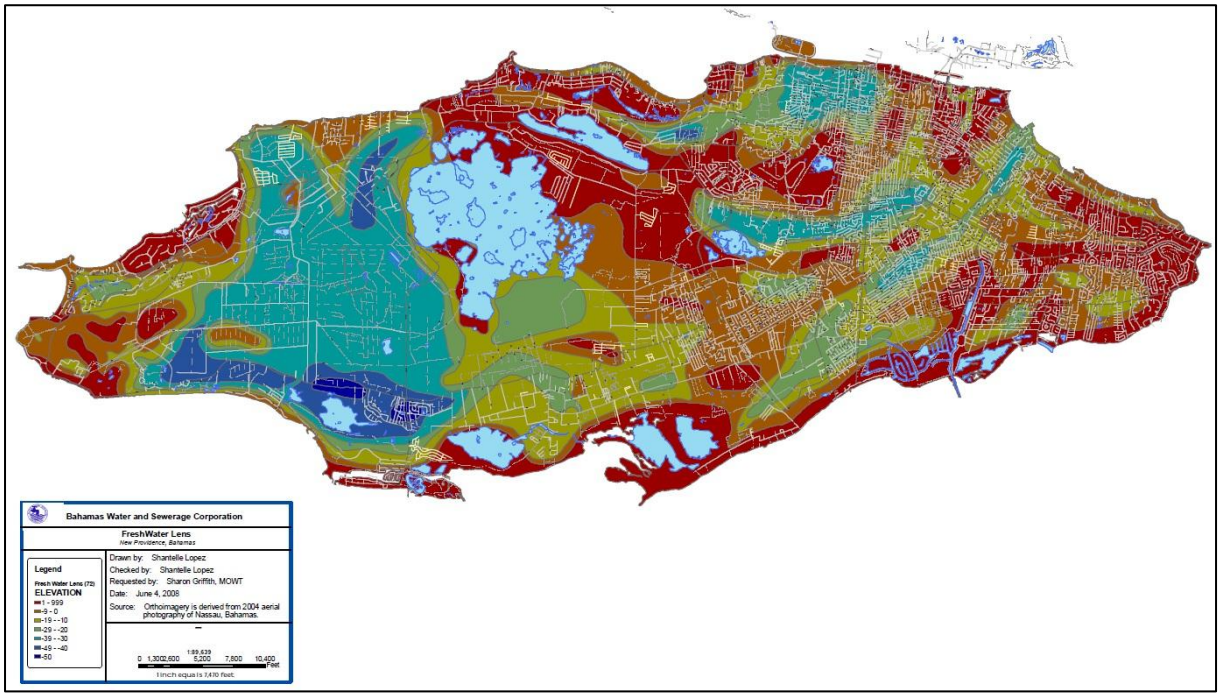

Figure 4.1: Distribution and thickness (in feet) of the freshwater lenses on New Providence (Water and Sewerage Corporation 2008)

Until about six years ago, the Water and Sewerage Corporation (WSC), which is the governmental water distribution agency, used to ship about half of the freshwater demand of from the

neighbouring island Andros. This changed when the decision was made to switch the water provision to reverse osmosis (RO) desalination (cf. I1). Due to rising demand, desalination is becoming more important as a source of freshwater (cf. US ARMY CORPS OF ENGINEERS 2004: 16).

The relevance of our topic arises from the question which impact Climate Change will have on the water resources and if they will be stressed further by these implications. It seems that experts have not agreed on these impacts yet as we found opposing statements during our literature review. Some sources have already noted decreases in total annual rainfalls over the past century (cf. US ARMY CORPS OF ENGINEERS 2004: 28). Others predict a general increase in rainfall for this area (cf. GLOBAL WATER PARTNERSHIP 2014: 25). Both scenarios would have an impact on freshwater resources in the Bahamas, which makes investigations in this field interesting in any way. In this context, we would like to receive insight on water management strategies in the Bahamas and possibilities for a sustainable and efficient use of the water resources in the future.

Following the system theory, which states that different aspects or subsystems of society are all interlinked and form one overall system, we want to collect data on different aspects of society. This will help us to summarise important facts out of a great amount of widely spread information, as we will look at the subsystems first and then draw a conclusion for the main system (ROPOHL 2012: 19).

It should be noted that the data we based our research on is just for New Providence. There are possible discrepancies to other islands of the Bahamas which are not considered in our research.

4.1.1. Development of central question and sub-questions

These considerations lead to the development of our central question: What are the impacts of climate change on water resources (occurrence, supply, sustainable use) on New Providence, the Bahamas?

Based on the central question, we developed a number of sub-questions which specify our research interests according to our system theory approach. As water and water resources are important for all parts of society, we have chosen the following five topics for further investigations.

1. *Which impact does Climate Change have on natural water resources?*
2. *Which impact does Climate Change have on anthropogenic water resources?*
3. *Which impact does Climate Change have on personal water resources?*
4. *Which impact does Climate Change have on political water management?*
5. *Which impact does Climate Change have on economic water management (focus on tourism)?*

Our five subsystems are thus the natural and anthropogenic water resources, the personal water use and the political and economic water management.

To each - the central question and the sub-questions - we phrased hypotheses and performed an operationalisation to develop research variables, which will be discussed in chapter 3. The verification or falsification of the individual hypotheses shall lead to the answering of the sub-questions, which will then be used to answer the central question at the end of our research process.

4.1.2. Clarification of terms

However, before the start of the field research, a clarification of some terms was necessary. One of our main issues was the term 'freshwater'. In Germany, freshwater is a synonym for drinking water. The definition of drinking water includes the human consumption and the use for e.g. cooking purposes (cf. WWW.DUDEN.DE). In the Bahamas, it is the case that the term 'drinking water' is not the same as 'freshwater' or 'tap water'. As the tap water often does not meet drinking water quality standards, a large 'bottled water' industry has developed in the Bahamas. On New Providence, about 85% of the population buys bottled water for drinking and cooking (cf. US ARMY CORPS OF ENGINEERS 2004: 15). For our research, it will be important to know, that sometimes we need to distinguish between drinking water and freshwater while trying to consider both in our assessment of water sources.

The second term that needed clarification is the term of extreme weather events. According to the IPCC, an extreme weather event is '*the occurrence of a value of a weather or climate variable which is as rare as, or rarer than the 10th or 90th percentile of the observed values of the variable. Characteristics of these events may vary*' (cf. IPCC 2012: 557). This definition tells us that we are looking for statistically rare events, which are characteristic for the Bahamas.

4.2. Research methods

After the phrasing of our research questions and hypotheses, we decided on a mix of quantitative and qualitative research methods. On the qualitative side, we planned to undertake a number of semi-structured expert interviews to receive information that goes beyond the literature. Also, a visit of one of the desalination plants on New Providence was important for our second sub-question.

Our quantitative methods included the evaluation of weather and climate data which we wanted to obtain from internet research and the Bahamas Department of Meteorology in Nassau. Furthermore, we draw on the results of the population survey (n=334, see cf. chapter 2) and we evaluated literature, statistics, websites, newspaper articles, press releases and governmental reports that could help us answer our research questions.

4.2.1. Selection of experts for semi-structured interviews

To obtain answers to all our sub-questions, we selected various institutions and organizations which we wanted to interview and which represent all of our five sub-topics.

I1: Water and Sewerage Corporation (WSC)

I2: Consolidated Water Ltd. (CW)

I3: Ministry of Tourism (group meeting)

I4: Bahamas National Trust (BNT)

I5: The Bahamas Department of Meteorology

I6: ReEarth (group meeting)

As we cooperated with other research teams in our group, we led four of these interviews; the other two were held during meetings with several groups.

As already mentioned before, the WSC is the governmental water association and responsible for the supply and distribution of water and was one of our main sources for answering the sub-questions. Our interview partner was a hydrologist who works for the WSC and provided background information on the natural water resources, as well as on the future water management by the WSC. Consolidated Water Ltd. is the company that operates the two desalination plants on New Providence in cooperation with the Water and Sewerage Corporation. We expected them to give us information on the functionality and issues of the plants, additionally showing us through one of their plants. The Ministry of Tourism was interviewed to gain insight on water use in the tourism industry, to answer question five. The Bahamas National Trust is a non-governmental organization which runs campaigns for a sustainable water use and is concerned about the natural water resources. In this interview, we hoped to gain an independent view on the Bahamian water management. The Department of Meteorology was selected for the provision of weather and climate data, and to give insight on the impacts of Climate Change on the Bahamas and especially on the water resources. At the end of the field trip, we also had the opportunity to get an interview with an activist from ReEarth, another non-governmental organization, which helped us to obtain another independent point of view regarding sustainable water use.

All in all, we got plenty of material to answer our sub-questions besides the information we got through the random street survey. The answers will be provided in chapter 4.3.

4.2.2. Questions for the population questionnaire

To answer our third research question, we developed the following questions for the population survey:

1. *Where does your daily needed water come from? [no bottled drinking water]*
2. *How do you assess your water supply security?*
3. *How do you assess your water quality?*
4. *How much money do you spend monthly on fresh water?*
5. *Do you apply any water-saving means at home?*

With the help of these questions, we wanted to receive information on the personal water sources and the people's evaluation of their water service. In question four, we asked about the personal water costs (in this case tap and bottled drinking water). The last question aimed to learn if the (non) governmental campaigns reach the population and if they are applied.

4.3. Results

In this chapter, our field results will be analyzed to first assess the individual hypotheses, to answer the sub-questions. In the second part, these answers will be summarized to evaluate the central question.

4.3.1. Sub-questions

4.3.1.1. Which impact does Climate Change have on natural water resources?

Thesis 1.1: If climate change causes a decrease in precipitation, this will also cause a decrease of freshwater resources.

As it is stated in our introduction, the only freshwater source of the Bahamas is rainfall. “On New Providence, we have a deficit in terms of freshwater from those [natural] reservoirs” (cf. I5). Hence, there already is a limited amount of water available, speaking of natural ground water resources on New Providence.

The Bahamas Department of Meteorology has to deal with uncertainties regarding predicting the rainfall patterns in the future: “Rainfall patterns can change, but the question is: how will they change? Will there be an increase or will there be a decrease?” (ibid.). Even when looking at large scale events, like El Niño and La Niña, it is not easy to connect these phenomena to the shift of rainfall patterns in the Bahamas. There are peaks in precipitation which can be related to those events, but some peaks are cyclic in nature, they do not line up with El Niño and La Niña years (ibid.). It is difficult to compare large-scale events or predictions and weather models with a small scale precipitation pattern like New Providence.

Figure 4.2 shows the annual mean precipitation recorded at Nassau International Airport. The pattern varies very strongly, but each section of less rainfall is followed by a period of heavier precipitation. This cyclic nature is remarkable, but in our analysis, we found no trend indicating an increase or decrease. Nevertheless, it is important to keep in mind that the shift of rainfall patterns is nothing to happen in years, it is something that happens over decades. Climate is defined by the World Meteorological Organization (WMO) as the average weather over a period of 30 years (cf. www.ipcc.ch). What is depicted in Figure 4.2 is thus roughly two climate periods.

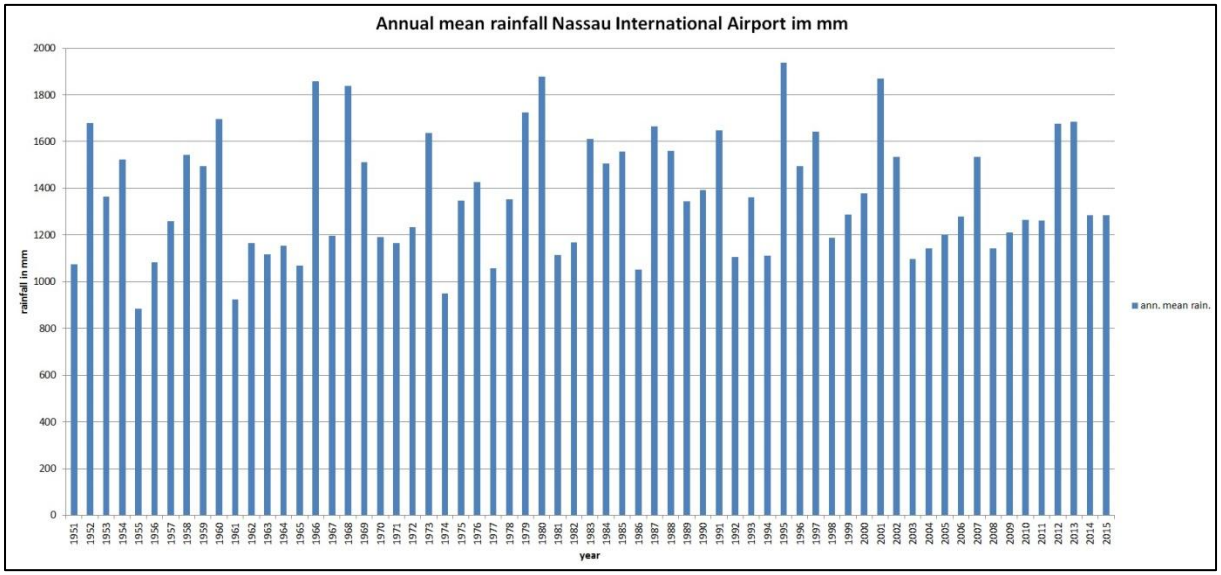

Figure 4.2: Annual mean rainfall on New Providence during two climatic periods (own figure)

Additionally, looking at one data set is not sufficient; “complete analysis would have to be done” (I5), but if there was a decrease in rainfall, it would affect the Bahamian freshwater resources, according to the Bahamas Department of Meteorology (ibid.).

For the first hypothesis, there is no clear validation. There is variability in rainfall which is natural to a certain degree, and the considered precipitation data does not answer the question if there is less rainfall.

However, if there was less rainfall, it would affect the natural fresh water resources on New Providence. Additionally, not only can the change in precipitation patterns affect the water resources, but there are also processes which are more short-term based which need to be considered.

Thesis 1.2: If the occurrence of extreme weather events (storms, hurricanes) increases, the ground water resources will be under increased stress.

Storms, hurricanes and storm surges are events which could affect the water lenses on New Providence in a more direct way. Thus, it becomes necessary to reconsider the definition of an extreme weather event. As stated in the introduction, the definition of the IPCC is partly vague. The definition we got from the Department of Meteorology of the Bahamas is not more precise than the one given by the IPCC: "[Extreme weather events are] for example excessive rainfall, which is not really frequent in the Bahamas" (I5). Regarding the definitions we received it becomes clear that we did not get an exact definition of the term as we had expected.

According to the IPCC Fifth Assesment report, it is quite certain that the strongest tropical cyclones already have increased in frequency and intensity in the North Atlantic basin (cf. HARTMANN et al. 2013: 217). With this in mind, we analysed the data we received from the Bahamas Department of Meteorology.

Table 4.2 (see annex) shows the hurricanes and the impacted islands of the Bahamas from 1960 to 2012. In the time between 1965 and 1992 (27 years), New Providence was involved in three events which had a mean intensity of around three on the Fujita-Scale. In the next period, from 2001 and 2012 (11 years), there were four hurricanes with a mean intensity of two on the Fujita-Scale. Thus, it is not possible to draw a conclusion from this little amount of data for New Providence.

Table 4.1 shows the "tropical storms and hurricanes which were centered within 100 miles of the area enveloping all Bahamian Islands" (THE BAHAMAS DEPARTMENT OF METEOROLOGY 2012: 1), grouped together under the term "extreme weather events", which shows no consistent data either. The largest occurrence of events can be found in the period between 1933 and 1963. However, some events might have been considered "extreme weather events" in the past but would not be considered the same today.

Table 4.1: Number of extreme weather events between 1871 and 2012 (The Bahamas Department of Meteorology)

Climatic time period (30 years)	**Extreme weather event** (hurricanes and tropical storms)
1871 - 1901	54
1902 - 1932	44
1933 - 1963	66
1964 - 1994	18
1994 – 2012	26

Even though we did not find any evidence for an increased hurricane intensity or an increased occurrence of hurricanes for New Providence caused by an increased sea-surface temperature, there is still a need to consider the possible influences of such events on the natural water resources.

Storm surges and floods can pollute the ground water, for example through salt water intrusion. Storm surges bring salt water inland and it is drawn to the ground where it contaminates the fresh water lenses (cf. I1). It takes a long time "for the lenses to clear up again" (ibid.). Many well fields of the Water and Sewerage Corporation are already inundated by salt water. To clear the lenses, the water has to be pumped off and the system needs to be shut down for some time until there is recharge during the raining season (ibid.). This can have severe impacts on the freshwater availability as it was the case in 2004 on Andros after Hurricane Frances caused a storm surge in the WSC well fields (cf. HOLDINGS; ALLEN 2015). This heavily affected New Providence as well because the water that was shipped from Andros originated from those well fields. Problems also arise if storms do not act as predicted in the models, such as Hurricane Joaquin in 2015 (cf. I5).

To summarise, the fresh water lenses on New Providence, which were already stressed by former overuse (ibid.), are likely to be stressed further in the future through sea-level rise as well as flooding and storm surges.

This means that the second hypothesis is also complicated to verify. Through our interviews, we learned how the natural freshwater resources of New Providence could be affected by extreme weather events, but we did not find any data evidence for stronger events or an increased occurrence of these. This would have to be examined further – in more detail and a more long-term research.

Thesis 1.3: If the sea level rises, there will be saltwater intrusions into groundwater lenses.

As already stated, ground water in the Bahamas is stored in fresh water lenses which are floating on top of the sea water because of the higher density of the fresh water (cf. I1). Through the rise of the sea-level, those fresh water lenses would "be pushed above ground and [become] exposed to evapotranspiration […], [so the] only open waters you [would] come across are brackish waters." (I1). This, of course, would be the case after very long-term processes.

It tells us that climate change and sea-level rise could heavily affect the natural ground water resources of New Providence; but is there already sea-level rise noticeable? This question accompanied the whole study project. Our interview partner at the Water and Sewerage Corporation indicated that some "areas have changed [their] levels drastically, but it is also seasonal,

so you can never know for sure." (I1). The interview partner from The BNT had heard about a sea-level rise of about one foot in 50 years but also stated that the Bahamas might be sinking (cf. I4), so again there is no data on that.

In conclusion, we can confirm our hypothesis because we found out about the possible impacts of sea-level rise in the freshwater lenses. However, whether there is a sea-level rise and to what extent, we do not know at this point.

The answer to our first sub-questions 'Which impact does climate change have on natural water resources?' can be summarised as follows: the natural water resources will be impacted by storms, floods and sea-level rise but we cannot be sure to what extent. One of our interview partners made a statement which might explain the lack of data: "People usually don't do studies on anything unless there is a funding behind it" (I4). Thus, we can conclude that further studies on these topics, especially with a focus on the Bahamas, are needed in the future.

4.3.1.2. Which impact does climate change have on anthropogenic water resources?

Thesis 2.1: If there is a population increase and thus an over-use of groundwater resources, desalination will be the most important freshwater source in the future.

Already today, desalination is the most important fresh water source for New Providence. According to Consolidated Water limited "currently about 90% of the supply of water" (I2) to WSC is from RO desalination. The ground water lenses were overused in the past but since the change to RO desalination, they are not used as much as before. There are still many private wells, but there is no actual data on the status of the lenses, as WSC does not monitor them (cf. I1). Nevertheless, there are heavy pollution concerns due to a lack of sanitation (cf. I4).

To date, only 30% of the population of New Providence is supplied with water by WSC. So, before looking at an overall population increase, the increase of WSC customers is to be considered. Consolidated Water and WSC would be able to supply the whole population with water quite easily (cf. I1 and I2), because the expansion of the RO plants could be done without great efforts. Thus, an increase of the total population of New Providence (see Figure 4.3) would not pose a big problem regarding water supply. Additionally, WSC is currently working on a strategy to reduce the non-revenue water (NRW: water that is lost unused due to leaks and bad pipes), so the water demand is even decreasing at the moment, easing the current situation (cf. I1 and I2).

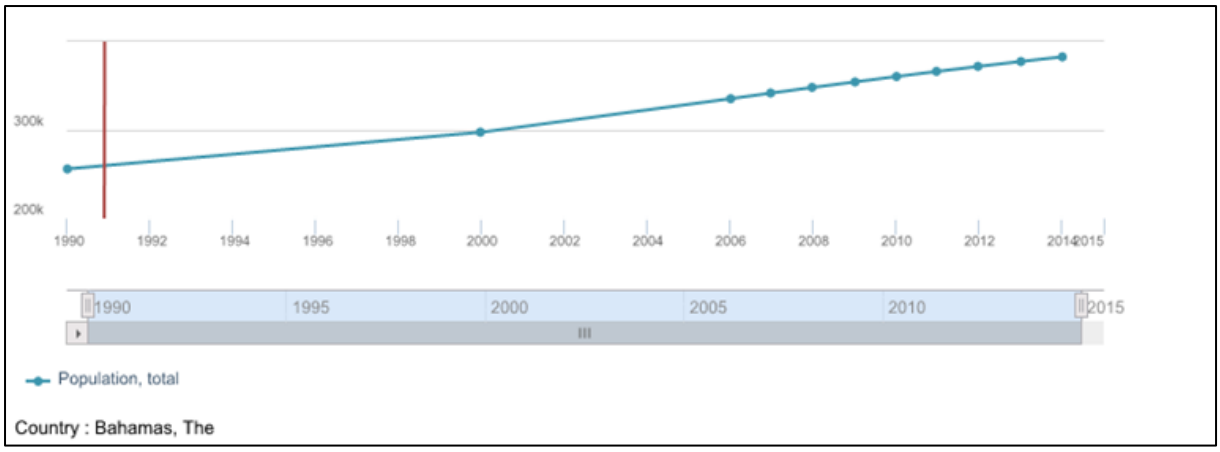

Figure 4.3: Development of population in the Bahamas from 1990 to 2014 (World Development Indicators 2016)

The current supply capacities of the Windsor Field plant on New Providence is two million gallons per day blended with one million gallons per day from the WSC well field, the plant at Blue Hills has a daily capacity of six million gallons and the expansion of four million gallons (www.cwco.com). This means in total about 13 million gallons of fresh water could be provided on New Providence every day. A few years ago the plants were at their production maximum, but due to the already mentioned reduction of NRW, this is not the case anymore (cf. I2).

In conclusion, this hypothesis can be validated, as RO is the most important fresh water source and can also cope with an increasing water demand. However, as long as WSC keeps the well field at Windsor Field, it will not be the only fresh water source for New Providence (cf. I2).

Thesis 2.2: With the increased importance of desalination, problems concerning the treatment of waste products and the long-term safeguarding of power supply of the RO plants will arise.

For analysing this hypothesis correctly, it is necessary to understand the process of RO desalination (e.g. the Blue Hills plant, which we visited during our interview with Consolidated Water Ltd.): The water is piped into the plants from extraction wells that reach into the sea-water level under the island (60-90m deep) (see Figure 4.4). It is then pumped through filters for a pre-processing. After this step, high-pressure pumps, driven by diesel engines, push the water through the actual filtering membranes. Here, two streams derive: the filtered fresh water and highly concentrated salt water, called brine. The brine contains a lot of pressure energy and is thus reused to drive the pumps, which makes the whole plant more energy efficient. The filtered water is then pumped into the post-treatment system, where chlorine, caustic, carbon dioxide and calcite are added before it is stored in huge reservoirs. The re-used brine stream is discharged back into the sea through deep wells, horizontally and vertically separated from the extraction wells.

The power demand for the plants is very high, even though energy efficient technologies are used (cf. I2). The prices for the RO process are dependent on the diesel and energy prices which will pose a long-term problem to the Bahamas. At the moment, no alternative energy sources are used for RO plants on New Providence as this would not be cost-effective, but it will be considered in the long-term (ibid.).

Figure 4.4: Extraction well Blue Hills (Photo Stolle, February 2016)

The only real waste product of RO desalination is the highly concentrated brine (salt water) which is disposed of in the deep discharge wells into the limestone horizons of the island. The environmental impacts of this are unclear. Consolidated Water Ltd. does not see any environmental concerns (cf. I2). Activists, e.g. from ReEarth, are more critical on this issue, as they see that chemicals added to the water for the preprocessing might affect the ecosystems when the water is injected back into the sea (STRACHAN 2010: 5). However, after having reviewed some environmental impacts assessments from other parts of the world, the deep well injection seems to be the best way to treat the brine water (cf. DAWOUD; AL MULLA 2012).

In summary, the second hypothesis can be partly validated. The high energy demand will pose a problem in the future. Currently, customers do not even pay the real price for the water as the government is subsidizing the water prices (cf. I1). Once the real price for water is charged, water prices on New Providence would strongly increase. The issue of environmental concerns of RO desalination has not been sufficiently researched yet. Thus, no statements can be made on this topic. Further studies should be undertaken on this subject.

After having evaluated the importance of RO desalination for the island of New Providence and the problems that might arise due to the dependency on this form of water supply, also the impacts of climate change on the process shall be examined. Consolidated Water's RO plants are hurricane proof and there is a hurricane preparation plan which includes, among other, the filling of the water and diesel reservoirs (see Figure 4.5) before a storm. The facilities are only shut down in the case of very severe weather conditions. Temperature increase and sea-level rise would not affect the RO process either (cf. I2).

However, climate change could make RO the only fresh water source for New Providence eventually. If the WSC well fields or the aquifers still used by the population become unusable due to storm surges or sea-level rise, the current RO plants will have to be expanded to supply the whole population. The critical point is mainly the diesel supply respectively the future energy supply in general.

Figure 4.5: Diesel reservoir Blue Hills (Photo Stolle, February 2016).

4.3.1.3. Which impact does climate change have on personal water resources?

Thesis 3.1: There is awareness of the limited water resources in the population.

The data to evaluate this hypothesis derived from the population questionnaire and the expert interviews. The analysis of the population questionnaire was done using the statistics software SPSS.

Very importantly, we asked the people if they applied any water saving means at home to get an idea about their awareness of the limited water resources on New Providence. 333 people answered this question and 56% said they would not apply any water saving means at home, while 44% said they would. This reveals that the majority of the interviewed people is unaware of the limited water resources or does not care about a sustainable water use.

However, in the following, we want to look deeper into the 44% who said they would be applying water-saving means. As the specification was an open question, we categorized the answers into the following seven categories:

1= avoiding leaks 2= turning tap off 3= collecting rainwater

4= recycling water 5= using less water 6= education 7= other

The total number of data sets we looked at in this case was 145. Category seven contains all answers that do not include water saving means in our opinion, like “buying water bottles prior to a hurricane”. Figure 4.6 shows the percentages of the seven categories. The most common water saving means that are applied by the Bahamians we asked, seem to be “turning tap off” and less water use in general (like taking shorter showers, etc.). Rainwater catchment and water recycling, which are quite effective means, are not that common, but still applied by some people. Category six, ‘education’, only contains one data set ‘teaching children how to save water’ which we thought was still worth mentioning, because education is a crucial aspect of awareness.

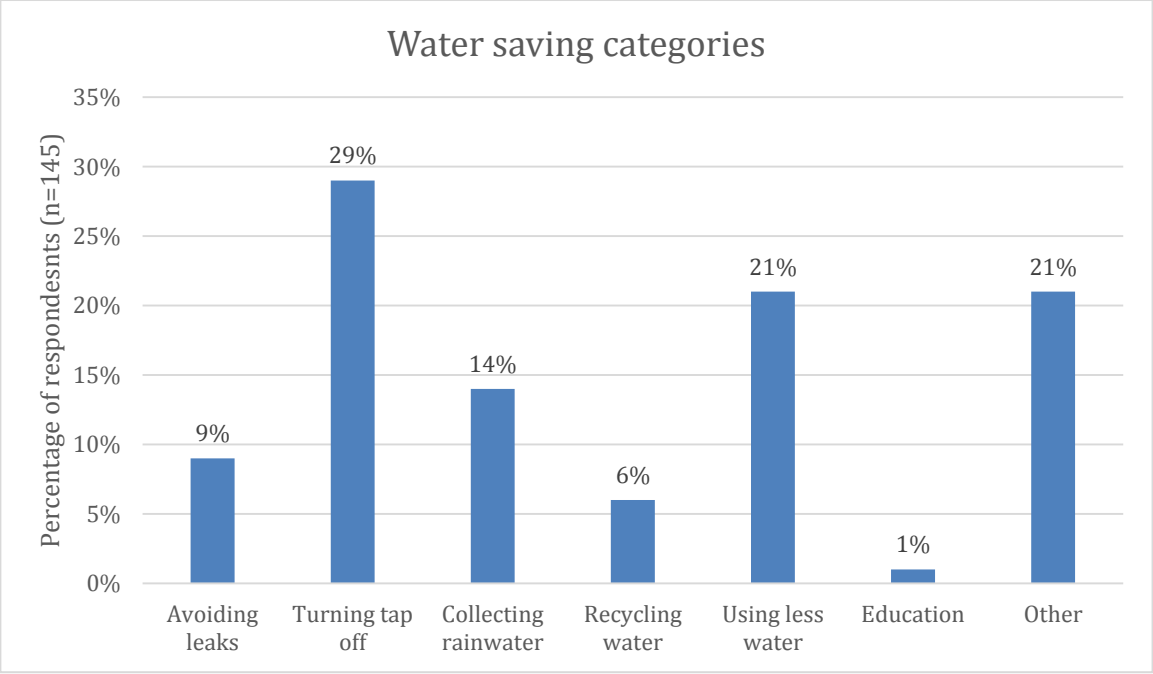

Figure 4.6: Categories of water saving in the Bahamian population

Another aspect we examined was the source of the daily needed water (except the bottled drinking water). As WSC told us, only 30% of the population of New Providence is connected to the water distribution system and the majority still uses private wells. Those are however polluted, due to a lack of sanitation; and the aquifers might be affected by climate change and sea-level rise. That is why we asked for the people's water source. There were three answer categories available: water pipe (e.g. WSC), private well and other (cf. Figure 4.7).

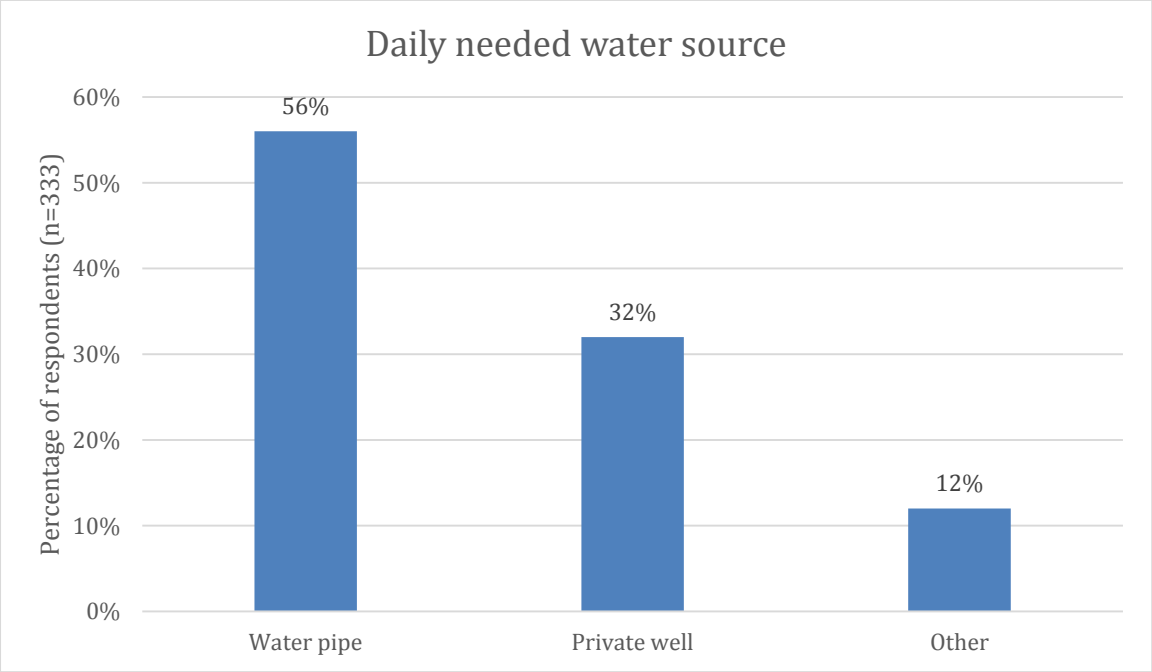

Figure 4.7: Distribution of water sources for the residentially needed water

In contrast to the information we got from WSC, the majority (56%) of the people we asked are connected to the governmental water system. This discrepancy might result from our extremely small number of data sets. Only one third uses private wells. Of the 12% that was categorised as 'other', half use both a private well and the pipe system. We again sub-categorized the answers into five categories:

1= both

2= government well

3=desalination

4= rainwater

5= other

The total number of data sets, in this case, was 40. Figure 4.8 shows the percentage distribution of the five categories.

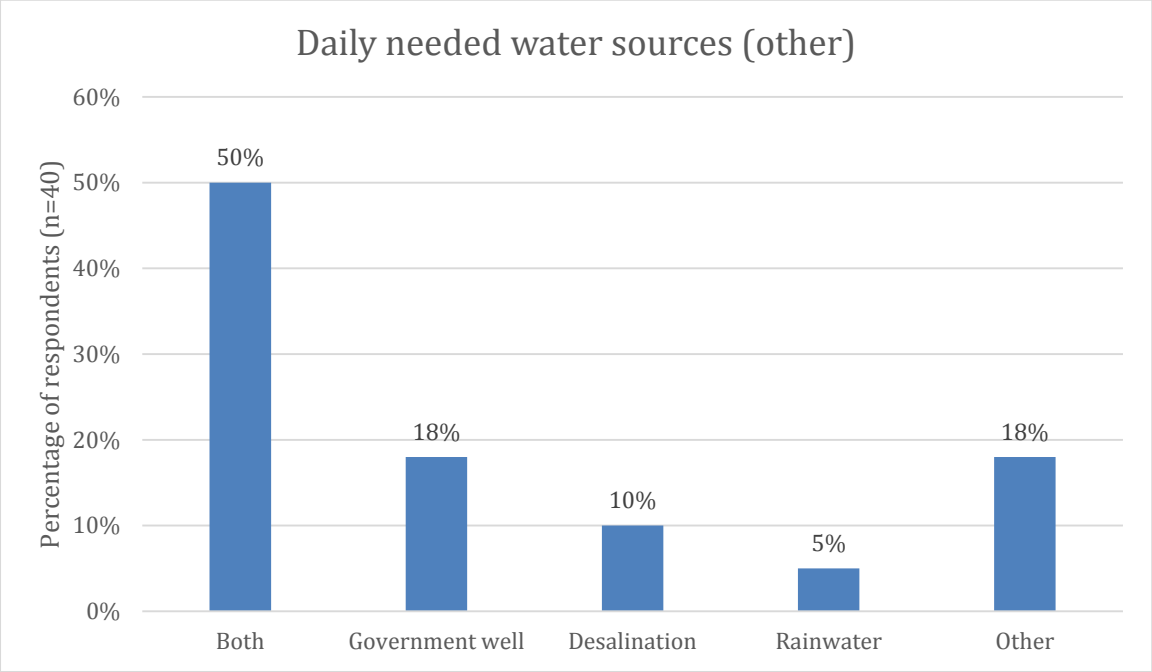

Figure 4.8: Percentage distribution of different water system set ups

As already mentioned, a majority of the people that answered 'other', uses both pipe and well. 17.5% out of this category mentioned a well provided for the community by the government, as this is the case in the poorer and less developed part of Nassau. A few others mentioned rainwater catchment, as it is very common on the family islands, and own RO systems. Category five includes all answers that were unclear, like 'tank'. Taking this into account, we can conclude that about two-thirds of the interviewed people are connected to the governmental water system and thus are securely supplied with good water.

This also corresponds to the question on the water supply security, where the interviewed persons were asked to rank their water supply security on a scale from 1 (not satisfied) to 5 (very satisfied). Figure 4.9 shows the results of the 333 data sets evaluated. It is obvious, that half of the people are completely satisfied with their water supply security and 20% more are almost completely satisfied. This makes about 70% of the people we asked, who are definitively satisfied which is a significant value. It shows, that the service by the government has improved compared to the past and that the people have learned to trust the government again regarding their water supply.

To conclude and to evaluate the first part of the hypothesis, it can be summarised that the people we asked are not very aware of their limited natural water resources. Only few effective water saving means are being applied. However, as most of them are connected to the public water system, which is based on RO, they are not dependent on the polluted and limited groundwater resources. Problems in this field could arise if there was a problem with the RO plants or if the government stopped subsidizing the RO water prices.

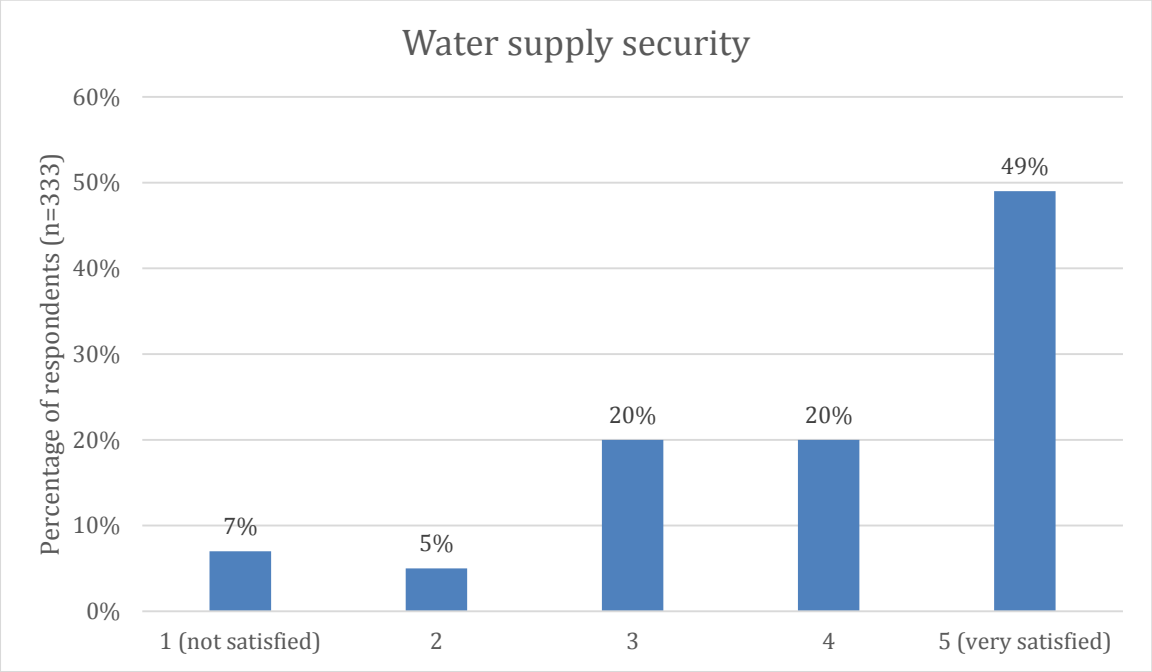

Figure 4.9: Satisfaction of water supply in the population

Thesis 3.2: The population will have to expect rising water prices.

Originally, we planned to compare our findings from the population questionnaire to the data from 2011, to see if the water prices had risen. That is why we included a question on this. However, as we learned during our field trip, the water prices in the Bahamas have not risen since 1999 - except for the VAT introduction in 2015 - because the prices are subsidized by the government (cf. I1). The prices will rise only if the subsidizing decreases because, for example, more people connected to WSC or the energy prices increased drastically.

To sum up, this hypothesis cannot be validated for the short-term; long-term statements cannot be made either as we do not have any data on this.

4.3.1.4. Which impact does climate change have on political water management?

Thesis 4.1: Political campaigns influence the consumption behaviour of water in the population.

Political campaigns are an important matter for a state in general, not only are they necessary to change consumption patterns in this case, but to draw attention to a topic of increasing importance. In the Bahamas, many campaigns concerning water resources have taken place already if one looks at the switch from water shipping to RO as a political campaign (US ARMY CORPS OF ENGINEERS 2004). However, for now, concerning the consumption behaviour of the Bahamian population, there are few different types of awareness campaigns about water consumption.

The WSC, which is, in fact, a governmental organization, makes efforts to win old customers back and to add new ones by advertising improved piping systems and introducing new sewerage treatment facilities. Thus, getting the population to use the unpolluted RO water, rather than accessing private wells for fresh water, which the majority of the population is doing right now because WSC only serves about 30% of it. The individual consumption behaviour is indirectly changed by this campaign because WSC customers would not overuse the natural water resources on New Providence anymore (cf. I1). However, this cannot take credits for an individual change of

consumption patterns, because the customers still could and would overuse water at home, taking into account the figures that more than half of the population neither applies any water saving means at home (see chapter 4.3.1.3), nor pays the real price for water because it is subsidised by the government (cf. I1 and I4).

A different approach comes from the Bahamas National Trust. They want to lower the overall use of water in the Bahamas which "is generally kind of high in the Bahamas because we never had a reason to not use it" (cf. I4). The BNT considers water to be the "most limiting resource" (I4) of the Bahamas and tries to raise awareness with several campaigns to educate people regarding water usage, prices and pollution.

Both, WSC and BNT participated in the "national water week" on New Providence, in order to raise awareness about water scarcity and impacts of climate change on the water resources (NASSAU GUARDIAN 2015). The BNT additionally organized an exhibition about water leakage and average water usage per household in the Bahamas (cf. I4). They "did what [they] could with this little money" (I4) to raise awareness and change consumer behaviour in favour of protecting the natural resources. Their political campaigns continue constantly on smaller scales, rather focusing on protecting existing natural water resources in national parks (cf. I4).

A different type of political campaign comes from the non-governmental organization ReEarth. The organization tries to focus on getting media attention for environmental problems on New Providence, also concerning water resources. By doing so, they try to raise public awareness to cherish their environment and their health. ReEarth favours a more or less bottom-up approach when it comes to changing consumer behaviour, by getting the population directly involved with the existing problems, protesting against the governmental actions, and thus trying to change minds (cf. I7).

To sum up for the first part of the hypothesis, effort is made by various parties to influence the consumer behaviour and raise awareness regarding water. It is postulated in the NATIONAL CLIMATE CHANGE POLICY from 2005. However, the campaigns have little success because there are more major problems the government, as well as NGOs, focus on since the water supply is secured through RO desalination (I1). Concluding, political campaigns which should draw attention to water concerns in the Bahamas regarding climate change mitigation were not successful yet.

Thesis 4.2: If supply shortages should occur, the government undertakes measures to sufficiently supply the population with water.

The temperature already slightly heightened in the Bahamas and it is still not clear in how far the rainfall patterns will change over time, so the Small Island Developing State has got to prepare for the possibilities of water shortages. Before dealing with the potential avoidance of future water shortages, the population's current freshwater accessibility needs to be prioritized.

In 2004, the last general Water Resource Assessment took place in the Bahamas through the US Army Corps of Engineers. They recommended regulating "the resource through integrated groundwater management" and that the "ground water should be treated as a strategic national resource" (US ARMY CORPS OF ENGINEERS 2004: ii).

Not only in general but especially as an adaptation measure to climate change and the higher probability and possible higher intensity of storms and storm surges, more RO plants were planned

in 2004, (including more and safer storage capacities) to secure the water supply. Further regulation and legislation were additional recommendations, as well as water conservation guidelines and penalties, public education campaigns (as mentioned in hypothesis 4.1) recycling programs, and strengthening the education of the population. The responsibility of implementing the plans was, among others, in hands of the WSC and BEST-Commission (ibid: 61). In 2005, the government provided the population with the "National Policy for the Adaptation to Climate Change", planning to reinforce building codes and to push a public education and outreach strategy, to inform about national adaptation plans (NCCC; BEST 2005: 28-30).

In 2015, through an "Intended nationally determined contribution under the United Nations Framework Convention on Climate Change (UNFCCC)", the government reported on political campaigns and management plans to adapt to climate change influences on water, naming RO plants, which ensure the future water supply for the whole Bahamas. They also claim that mitigation will not protect the Bahamas completely, which implies that water saving is not necessarily needed (cf. UNFCCC 2015: 3).

As of today, the government took action and realized most of the recommendations from 2004. The majority of the water supply today is done by Consolidated Water Ltd. desalinating saltwater and selling it to WSC, which distributes it over the island (cf. I1; I2). Also, there are storage tanks providing about a week of regular water supply on New Providence at this point of time (cf. I2). However, there is no regulation that reinforces the Bahamian population to use the RO water instead of using free ground water. Additionally, there is the problem of a foreign entity (CW) to provide over 90% of the water. Furthermore, RO plants still depend on fossil fuels (cf. I1), hence, regarding the Bahamian water supply, a slight level of insecurity remains.

In general, the government could supply the population with sufficient water if it were the case to experience sudden water shortages in the future. Consolidated Water Ltd. can expand their RO plants with little effort and time (I2) and WSC can provide more percent of the population with water because the system is already set up (I1). However, there is room for further improvement, regulating water access more sufficiently and educating people about saving water.

4.3.1.5. Which impact does climate change have on economic water management (focus on tourism sector)?

Thesis 5.1: If a further shortage of water resources should occur due to climate change, the tourism sector does not react to this.

Tourism is the biggest industry in the Bahamas and most of the population depends on this sector as the main economic activity directly and indirectly. The tourism sector requires a high level of water supply, taking into account watering of plants and golf courses of the hotel properties, changing towels every single day and cleaning pools. Tourists use about two to four times more water per day than the Bahamian population (STRACHAN 2010: 5). "We should encourage every hotel to let their guests save water. It's not a resource that we should be wasting" claimed a ReEarth activist (I7). Some hotels (for example the Atlantis on Paradise Island) have their own desalination plants to be independent of the WSC water supply, but this is rather unusual (cf. I3). To date, the tourism sector pushes the excessive use of water in the Bahamas, even though there is natural water scarcity on the islands already (cf. I7). The Ministry of Tourism claims WSC to be responsible for coping with any

possible water shortages in the future, even though the sector is dependent on water prices to maximise their profits (cf. I3).

Since there are only few regulation measures from the government to restrict the tourism industry, the sector is not rushing towards more sustainability. Even though it becomes more common to use water saving facilities, “consumer habits are hard to break” (ibid.), and long-term climate change impacts are given low priority. The tourism sector adapts more than it tries to mitigate (ibid.).

To validate our hypothesis, the economic water management in the Bahamas is not seen to be changed crucially through climate change yet, taking measures from the hotel industry as an indicator.

Thesis 5.2: If the water prices rise, the tourism sector will sustain a profit loss.

The prices for water have been stable since 1999 in the Bahamas. As WSC told us, the water prices are fixed in a contract with CW and cannot rise because of water shortages. The only possible change in water prices could happen if the government was not able to subsidise the water for the residents further (cf. I1), which now is not in sight. Thereby it is not possible to figure out if the tourism sector will sustain a profit loss if water prices rise.

In general, the tourism sector is always dependent on water prices and those prices are what “investors always want to keep at a minimum” (I3).

4.3.2. Answering and discussion of central questions

After having evaluated all of the subsystems, they shall now be concluded to answer the central question which stated as follows: What are the impacts of climate change on the water resources on New Providence?

Aiming to answer this question, we developed a hypothesis: There is water scarcity on New Providence in general which will increase through climate change.

This hypothesis can be confirmed regarding the natural water resources as, historically, water imports were necessary to supply the population of New Providence with water and thus the natural resources of the island were not sufficient. Hence, the natural resources can be considered as scarce. Climate change could have an impact, especially on these resources through sea-level rise, storm surges and salt water intrusion.

Despite the current water situation, there is no water scarcity on the island. Through RO desalination, the government can provide enough water for the population and through the subsidies, the water is also affordable for all groups of society. That is one reason why the population does not feel the need to save water and would not consider water a scarce resource.

When looking at the political campaigns that deal with water, there are campaigns that people should “ditch the well” (WSC ADVERTISEMENT 2016) and switch to the public system and thus to RO water. However, there is no focus e.g. on the importance of ground water for wetlands (cf. I4) as economic interests seem to be more in the focus of the Bahamian government than environmental ones.

One of the biggest water consumers on the island is the tourism sector. There are no legislations concerning sustainable water management but rather a self-regulation system which is not working very well. The awareness for sustainable water use should be raised in this sector.

To summarise, regarding natural water sources one can speak of scarcity on New Providence, but there are other sources of fresh water which sufficiently provide the population with water.

To answer the central research question, we can state that an artificialising of the water resources has taken place on New Providence. This could be a mitigation measure against climate change to some extent, but the switch to RO also lead to an increased supply security of the water supply and also an increase of the water quality.

Even though the natural water resources are very likely to be affected by climate change, they cannot be regarded as a resource anymore for our research, as they have already lost most of their importance for the fresh water supply for the population and this trend is predicted to continue. Quite likely, climate change could lead to a complete reliance on RO desalination. Hereby, the long-term problems will be the power supply and the questions if the expensive technology can stay affordable for all groups of society. Renewable energies are already used on some of the family islands (THE NASSAU GUARDIAN 2015) but on New Providence they can only be a long-term solution.

4.4. Conclusion

As stated in the introduction, there would be no life without water. We live in a country where the tap water is drinkable and one does not have to worry about water shortages. On New Providence, the water issue is much more crucial since the natural water resources will be influenced by climate change and sea-level rise, even if our current data is not coherent and thus does not tell us to what extent and in which time frame. The switch to reverse osmosis for water supply is the only social response to climate change and sea-level rise; however, so far only 30% of the population are supplied with RO water.

Talking to citizens on the streets revealed low awareness regarding those topics. Political campaigns have not been able to change the consumer behaviour yet. There are attempts to secure water resources by switching the water supply to reverse osmosis and increase the national awareness for example through national adaptation plans.

During the research, it occurred to us that sustainability is not a priority for the Bahamian economy in general. The tourism sector solely applies a self-regulation system regarding water usage which did not appear very liable to us.

Compared to other SIDS in the Caribbean region there is no real fresh water issue on the Bahamas as desalination replaces the natural water resources. This enhances the dependency on fossil fuels and the foreign entity which operates the desalination plants. Despite the high costs of RO desalination, the Bahamian government can subsidise the water prices due to the high earnings from the tourism industry. As long as the cooperation between the WSC and Consolidated Water Ltd. is unimpaired, the water supply for the inhabitants of New Providence is secured. Other SIDS, which cannot rely on a strong tourism sector, might be struggling with the costs of this technology or might not have the infrastructural preconditions to build and operate an RO plant.

Using a mix of quantitative and qualitative methods made it possible for us to acquire profound information. The population surveys and climate data, in combination with our expert interviews, allowed us to adjust our questions for the experts during the research progress. We also got information from other groups while working on their topics, which lead to other interesting side aspects of the water topic.

Concluding, there are many socially related problems on New Providence, which are more important than climate change and sea-level rise matters, partly originating from the dependency on mass tourism. That is also the reason why mitigation is not happening yet. The question is if this behaviour will change once there are clear signs of climate change. This would have to be evaluated in further studies.

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4.5. Annex Chapter 4.

Table 4.2: Hurricanes in the Bahamas from 1960 to 2012 (The Bahamas Department of Meteorology)

Table indicating islands impacted by hurricanes

Hurricanes	Month - Year	Days	Category	Abaco	Acklins	Andros	Berry Is.	Bimini	Cat Is.	Crooked Is.	Eleuthera	Exuma	Grand Bahama	Inagua	Long Island	Mayaguana	New Providence	Ragged Island	Rum Cay	San Salvador	Total
Donna	Sept. - 1960	7,8,9	4		*	*				*						*		*			5
Flora	Oct. - 1963	8,9	1		*					*				*		*		*			5
Cleo	Aug. - 1964	26,27	2			*		*					*								3
Isbell	Oct. - 1964	14	3										*								1
Betsy	Sept. - 1965	6,7,8	3 - 4	*													*				2
Inez	Oct. - 1966	2,3,4	2	*																	1
David	Aug. / Sept. - 1979	31,1,2,3	2			*	*	*									*				4
Kate	Nov. - 1985	17,18,19	2		*					*				*	*	*		*			6
Emily	Sept. - 1987	22,23,24	2											*		*					2
Floyd	Oct. - 1987	12,13	1	*			*	*					*								3
Andrew	Aug. - 1992	23,24	4			*	*	*			*						*				5
Erin	Jul. / Aug. - 1995	31 / 1	1 - 2	*					*		*		*							*	5
Bertha	Jul. - 1996	9,10	2	*					*		*					*				*	5
Lili	Oct. - 1996	18,19	1 - 2			*			*			*			*					*	5
Georges	Sept. - 1998	23,24,25	1 - 2			*								*				*			3
Dennis	Aug. - 1999	24,25,26,27,28	1	*																	1
Floyd	Sept. - 1999	13,14,15	2	*					*		*		*							*	5
Michelle	Nov. - 2001	4,6	1			*					*						*				3
Frances	Sept. - 2004	1,2,3	1 - 3	*					*		*		*							*	6
Jeanne	Sept. - 2004	17,18,25	2	*									*								2
Katrina	Aug. - 2005	26	1				*	*													2
Wilma	Oct. - 2005	24	3	*		*	*	*					*				*				6
Hanna	Sept. - 2008	1	1											*							2
Ike	Sept. - 2008	6	4		*				*	*		*			*	*			*	*	1
Tomas	Nov - 2010	4,5,6	1		*					*					*	*			*	*	7
Irene	Aug. - 2011	23,24,25,26	2 -	*	*	*	*		*	*	*	*	*	*	*	*	*		*	*	15
Sandy	Aug - 2012	25,26,27	1 - 2	*		*	*		*		*	*	*		*	*	*	*	*	*	12
Total				12	6	10	7	6	8	6	8	4	10	8	6	9	7	6	5	7	

5. Influences and impacts of climate change on fish stock and fishery industry

Freya Rixen-Cunow, Felix Pfeiffer, Lisa Ettlich, Tilmann Gahrau

5.1. Introduction

"The threats of climate change to human society and natural ecosystems have been elevated to a top priority since the release of the fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 2007. While the importance of fisheries and aquaculture is often understated, the implications of climate change for these sectors and for coastal and riparian communities in general are difficult to ignore." (COCHRANE et al. 2009: 1)

As this excerpt highlights, climate change and its impacts on societies as well as on the worldwide food system is an increasingly discussed issue in science and media. Specifically, the connection between climate change and changes in marine ecosystems is increasingly being covered by diverse publications (e.g. "Climate Change: Implications for Fisheries & Aquaculture" from HOLMYARD 2014 or "Vulnerability of national economies to the climate change on fisheries" from ALLISON et al. 2009). Many scientists agree that changes in the oceans influence the marine species and, hence, impact the fishery industry and all livings connected to it (cf. HOLMYARD 2014: 4 ff.; ALLISON et al. 2009: 4). On a global scale, the fishery sector provides food and work for millions of people, and its importance increases with a growing population. The scale of the fishery sector in the Bahamas is economically relatively small in comparison with other sectors and contributes together with agriculture only five percent of the national GDP (cf. SMITH & ZELLER 2013 according to ANON 2002 & SACKS 2006). According to the „National Fishery Sector Overview" from 2009, it represents just two percent of GDP (numbers from the Department of Statistics, 2005, provisional) (cf. FOOD AND AQUACULTURE ORGANIZATION OF THE UNITED NATIONS 2009: 1). Twenty years ago it was estimated through census data that approx. 9300 full-time fishermen work in the Bahamas, which was approximately three percent of the population.

The most important targets of fishermen were and still are the spiny lobster, Nassau grouper and conch, which they catch in the large and productive shallow waters of the western Atlantic that belong to the Bahamas (cf. ibid.; BUCHAN 2000: 94; BEST 2002: 6). However, despite those numbers, the fishery sector still plays a big role in this island state, as part of Bahamian cultural and traditional heritage; for example, the flyer "Conchservation. Acting today to ensure CONCH for tomorrow" from the BNT highlights the cultural and economic importance of the conch that "is an important part of Bahamian culture. Whether a main ingredient in savoury dishes or as a curio like shell jewellery, the humble conch generates millions of dollars for local economies. It is plain to see that there is a special relationship between the people of the Bahamas and this treasured marine mollusc." Also, the tourism sector benefits from an intact marine life as many tourists come to the Bahamas for diving, snorkelling and especially fishing. If the fishery and tourism sectors are regarded together, "the Bahama Islands are dependent on their seas to maintain a GDP of US$ 2.7 billion through tourism and harvest of marine resources. To date, the fishing industry has benefited from the

relatively high ecological productivity of the shallow banks and their related habitats" (BUCHAN 2000: 94). The fishery sector connects thereby not only ecological and economical, but also cultural aspects. This is why our research group developed the idea that there must be a clear connection between the ocean, the fishery sector and the Bahamian society. We expected a high awareness for changes due to climate change amongst actors of the fishery industry as it depends on the ocean and its condition. We, therefore, wanted to find out how vulnerable the Bahamian fishery sector is to such changes. As outlined before, it is scientifically proven that changes in this sector take place worldwide. Now the question was how strong the impacts of climate change influence especially the Bahamian fishery. The consideration of physical processes and circumstances connected to climate change is a big part of the research process. However, also social and economic dynamics of the fishing community must be taken into account to understand the impacts on the people (cf. ALLISON et al. 2009: 2). How is awareness and the subsequent willingness to act reflected amongst the Bahamian society? ALLISON et al. (2009: 3) called this idea "physics-to-fish-to-fishers" which summarizes the central research interest in a short term. As mentioned before, the fishery sector on the Bahamas is rather small, which implies a manageable number of actors in our research field.

The study project called "Social response to climate change – sea-level rise on the Bahamas" took place from February 07 until February 21, 2016. Embedded in this context and the components mentioned earlier, this paper is now focusing on the following central research question:

How do the consequences of climate change influence fish stocks and hence the fishery sector on the Bahamas, and how do involved players perceive these changes?

From the central question and with the information predominantly from the texts "Climate Change implications for fishery and aquaculture" (COCHRANE et al. 2009) and "Climate Change: Implications for Fisheries & Aquaculture" (HOLMYARD 2014) as model, a hypothesis has been formulated which will be the basis of the discussion in this paper:

Changing physical, chemical and biological conditions of the ocean due to climate change influence the stock of marine species and hence impact the Bahamian fishery sector negatively.

To validate the hypothesis, different sub-questions have been developed which have also been used in the interviews as guidelines.

1. *Are economic or political actions taken in the context of a changing fishery sector?*
2. *Which climatic changes seem to have the biggest impacts on the fishery sector?*
3. *What roles do other (anthropogenic) influences like invasive species, overfishing or pollution play in this context?*
4. *Do the different players related to the fisheries sector perceive changes and if so, which ones and how?*

It is not our intention and beyond the scope of the project, to provide a scientifically proven statement about the impact of climate change on the fishery sector in the Bahamas. The purpose of this project is first to analyze the perception and information of different players connected to the topic and to draw conclusions from this information. The research methodology which was used to find answers to the questions presented above will be outlined in chapter 5.2. The findings and results will be highlighted in chapter 5.3. The focus will hereby be split on the main fields of interest from our central research question: the fishery sector on the Bahamas, the influences through

climate change and other challenges and the awareness of the different players. After a critical reflection, chapter 5.4 gives a conclusion and short discussion about the vulnerability of the Bahamian fishery sector.

5.2. Methods and research program

This section describes the methods we applied within our research project. The research was performed in three phases; 1) the preparatory work, 2) the main survey conducted during the field trip on New Providence and 3) the evaluation of the results and the entire project by answering the central question and confirming or rejecting the hypothesis that was suggested at the beginning. The preparatory work was predominantly quantitative and consisted of literature search and the collection of existing data and information on the research project's topic. Its purpose was to take stock and gain a basic knowledge of the current and past conditions of the Bahamian fishing industry as well as the marine environment on which the fisheries rely. We were then able to use the current state of research as a basis for the expert interviews we conducted during our field trip to the Bahamas. Another target was to fill gaps in the current state of research by questions addressed to the experts. In addition to the expert interviews, questions related to our research topic were developed for the population survey on "Living on New Providence". Observations during our field trip eventually enabled to gain a clearer understanding of the current situation of the marine environment and the Bahamian fisheries sector, the behaviour of the involved players as well as their relationships amongst themselves and with the environment.

5.2.1. Expert Interviews

The conducted expert interviews were of particular importance because they served as primary means to receive as much information as possible about the Bahamian fishery sector and the impact of anthropogenic climate change on it. For this purpose, we used partially standardized questions. In this way, we aimed to conduct an empirical survey on the missing data about the impacts of climate change and other threats to the marine environment, the fish stock and the fishery sector. Furthermore, we intended to receive qualitative answers through open or partially open questions which enable to draw conclusions about the awareness of the individual players. Even though the experts belong to different fields, they are all related to the marine resources and marine ecosystems of the Bahamas which in turn are linked to the Bahamian fisheries sector.

Table 5.1: List of interviewees sorted by field, institution/ players and position

Field	Institution/Players	Position
Politics	Ministry of Agriculture, Marine Resources and Local Government (Department of Marine Resources)	Interviewee 1 *Officer*
	Bahamas Environment Science and Technology Commission (BEST)	Interviewee 4 *Director*
Academia	College of the Bahamas (Climate Change Initiative)	Interviewee 3 *Assistant Professor*
	The Bahamas Meteorology Department	Interviewee 5 *Deputy Director*
Environmental Protection	The Nature Conservancy	Interviewee 7 *Conservation Specialist*
	Bahamas National Trust (BNT)	Interviewee 2 *Officer*
	Bahamas Reef Environment Educational Foundation (BREEF)	Interviewee 6 *Manager*

With the aim to cover all important fields that are linked to the Bahamian fisheries representatives of politics, industry, academia and environmental protection were contacted for a requested interview (cf. Table 5.1).

Except the representatives of the fishing industry due to no response, inaccessibility or cancellations, interviews with all other contacted persons took place, resulting in seven expert interviews in total. After cancelling the interview appointment Andoni Lisgaris from the sports fishery 'Reel Dreams Charters' offered to answer our questions via email. However, until now we have not received a reply.

The interviews with the research-related players were conducted in their institutions, whereby the number of interviewers of our research group varied. In the interview with representatives of the BEST Commission, however, all students of the study project concerning the Bahamas participated. Except this particular interview, all interviews were recorded and ranged from 20 minutes to about one hour. The questions asked were similar for each interviewee and covered three main sections; industry, marine environment and climate change. According to the interviewee's field of expertise, the questions were adjusted or even changed if new knowledge had already been gained during the conducted interview or through previous interviews.

In the third phase of our research program, after the field trip, the recorded interviews were manually transcribed as regards content (cf. referred interviews). In this form, the interviews have been used for the content analysis and eventually the evaluation of the sub-questions and the central question (cf. chapter 5.3).

5.2.2. Population survey

Particular questions of the population survey on "Living on New Providence" were developed to receive answers about the consumer behaviour of the inhabitants of the Bahamas. For this purpose, closed questions were used. Moreover, we aimed that the answers of the respondents might help to draw conclusions about the importance of local fish and seafood within the population and its culture.
Following questions were asked to receive information about the consumption of fish and seafood:

Question 9: How often do you eat seafood and fish per week?

1.) Not at all 2.) Once or twice a week 3.) More than twice a week

Question 10: Is the seafood and fish you consume predominantly of local or international origin?

1.) Local 2.) International 3.) I don't know

Furthermore, questions about the environment and marine ecosystems were used for our research. By these means, we targeted at answers providing insight into the population's awareness regarding nature, marine resources and ecosystems as well as environmental and climatic changes. Since some questions of the survey were open questions, we aimed to use them if answers concerning the marine environment, the fishery sector and fish stocks were given. In this way, the answers of the respondents might give information on the research-related sub-questions, such as "Which role play other (anthropogenic) influences in the Bahamian fishery sector, as for instance invasive species, overfishing or pollution?" or "Do the different actors perceive changes?".

Following questions were chosen to receive potential answers about the meaning of marine resources and ecosystems as well as environmental and climatic changes perceived within the population:

Question 11: What is nature for you?

Question 12: Which environmental changes have you observed in recent years?

Question 13: What do you think are the main impacts of climate change on the Bahamas?

Question 14: What comes to your mind when you think about the lionfish?

Question 16: What are the major functions of coral reefs and mangroves?

The empirically collected data of suitable open questions, such as question 11 (What is nature for you?) and 12 (Which environmental changes have you observed in recent years?), were classified into categories. If a person gave multiple answers but they implied the same issue, for instance, climate matters ("higher temperatures" and "shifting seasons"), they were summarized as one category; in this case 'Changes concerning *Climate & Weather*'. However, if a person mentioned two different topics, for instance, "higher temperatures" and "more oil spills", the answers were counted as separate categories, '*Climate & Weather*' and '*Pollution*'.

Figure 5.1: The implementation of the population survey on New Providence (1) (Photo Rixen-Cunow, February 2016)

Figure 5.2: The implementation of the population survey on New Providence (2) (Photo Rixen-Cunow, February 2016)

5.2.3. Observations

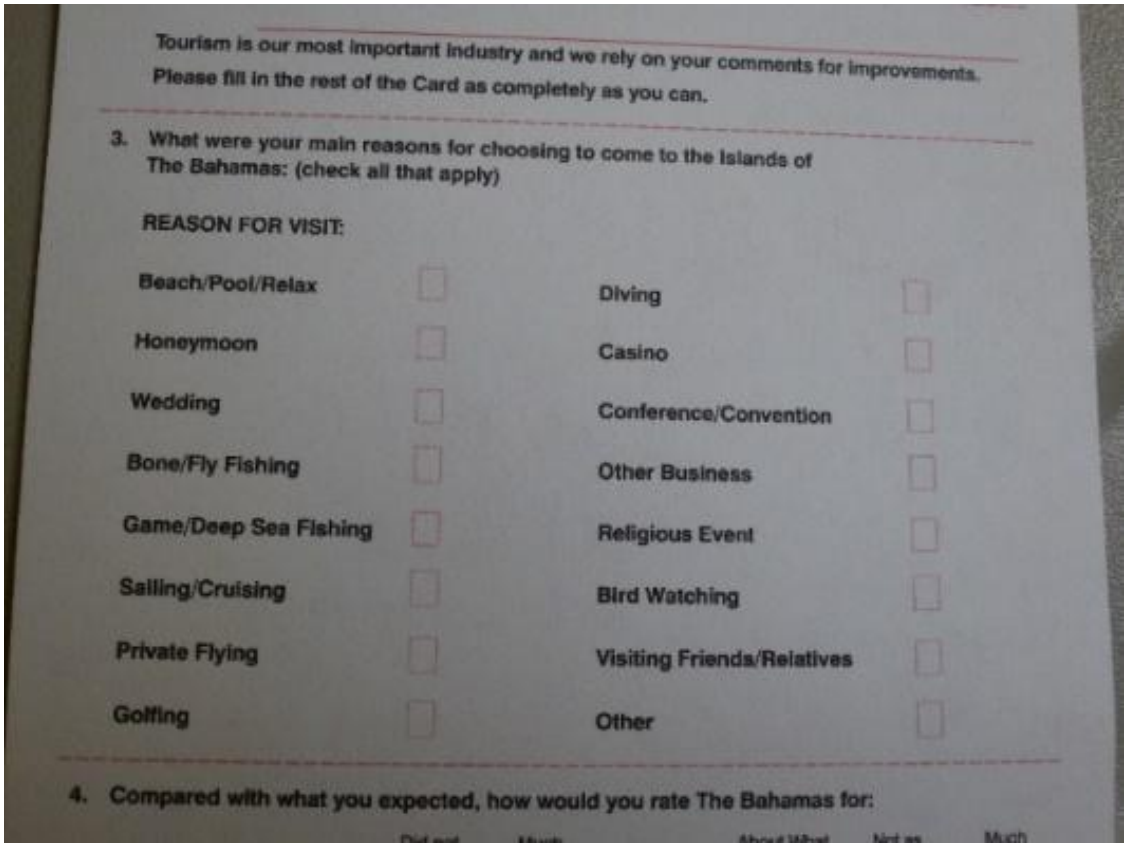
This subsection includes all participating observations made during our field trip to the Bahamas. They happened spontaneously or intended and can be used to support or disprove the information and results received in the research program. Since observations took place nearly the entire time of the conducted research, a wide range of situations and objects have been observed and noted. They include, among other things, the behaviour of fishermen (cf. Figure 5.4) and other players, events like the sale of fish and seafood at the local fish market (cf. Figure 5.5), documents like the evaluation survey on tourism in the Bahamas (cf. Figure 5.6), conversations as well as interviews with involved players and even the observations of natural phenomena like changes in ocean conditions caused by oil spills.

Especially observations at the local fish market as well as conversations with fishermen were helpful to gain an insight into the consumption behaviour of the inhabitants and the daily routine of fishermen. Furthermore, it enabled to investigate the amount and type of fish and seafood being sold on the local market.

Figure 5.3: Empty conch shells along the fishing harbour (Photo ETTLICH, February 2016)

Figure 5.4: Fisherman selling conchs to local and foreign customers (Photo ETTLICH, February 2016)

Figure 5.5: Potter's Cay fish and seafood market on New Providence (Photo RIXEN-CUNOW, February 2016)



Tourism is our most important industry and we rely on your comments for improvements.
Please fill in the rest of the Card as completely as you can.

3. What were your main reasons for choosing to come to the Islands of The Bahamas: (check all that apply)

REASON FOR VISIT:

Beach/Pool/Relax	☐	Diving	☐
Honeymoon	☐	Casino	☐
Wedding	☐	Conference/Convention	☐
Bone/Fly Fishing	☐	Other Business	☐
Game/Deep Sea Fishing	☐	Religious Event	☐
Sailing/Cruising	☐	Bird Watching	☐
Private Flying	☐	Visiting Friends/Relatives	☐
Golfing	☐	Other	☐

4. Compared with what you expected, how would you rate The Bahamas for:

Figure 5.6: Evaluation survey on tourism (Photo RIXEN-CUNOW, February 2016).

5.3. Results

5.3.1. The Bahamian fishery sector

The fishing sector is, as much as the sea itself, a profound part of the Bahamian lifestyle and tradition. Looking back at the first settlers on the archipelago, evidence of early fishing methods is found giving an impression of a close relationship that, after decades, still lives on in people's daily routine. Fishery is an important contributor to the economy as it generates jobs, raises food security and furthermore enhances tourism, attracting sports fishermen and visitors from around the world (cf. Interview 1). As mentioned before, the GDP's most stimulating factor is tourism, the fishing sector accounts for only 1.6 percent, with total landings in 2014 gaining 70 million USD, the true value of the fisheries and its resources is found in the Bahamian culture (BROWN 2014: 3).

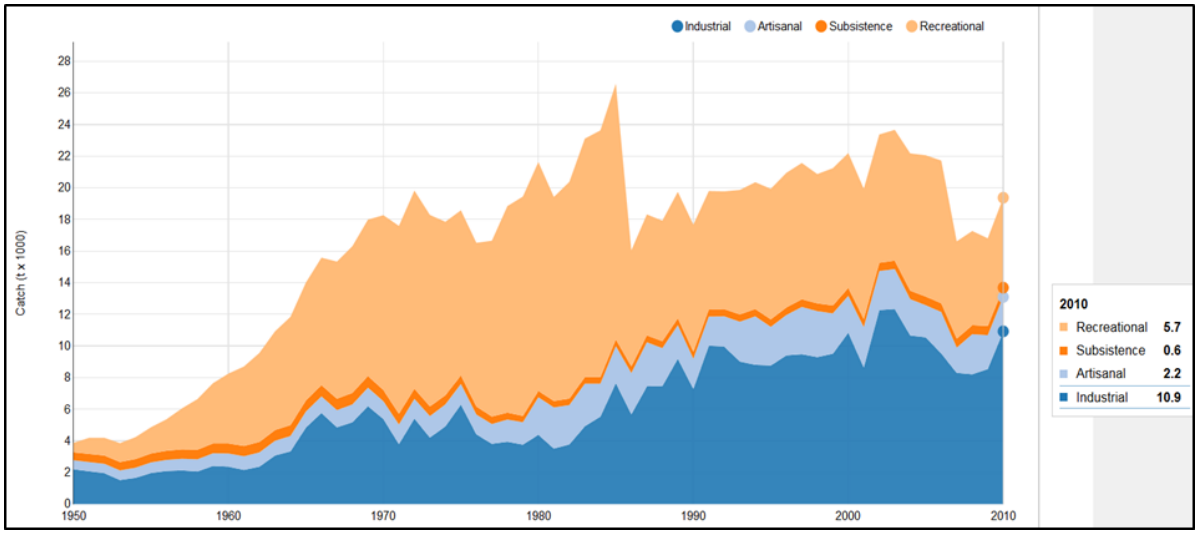


Figure 5.7: Catches by fishing sector in the waters of the Bahamas (SEAAROUNDUS.ORG 2010)

The Bahamian fishing economy is dominated by its industrial sector, as seen in Figure 5.7, indicated by Catch in Tons x1000. The catch is predominantly sold in regional markets in the Caribbean or being exported. Destinations are e.g. the close US, although lately exports to Asia, e.g. Singapore, have taken over as new customers with an insatiable appetite (THE WORLD FACT BOOK 2014). Recreational fishing is closely related to tourism and sports fishing making up for the second-largest group by catch. Also triggered by tourism is the artisanal industry that provides art or accessories made from marine products. The smallest group represents subsistence fishing, which is mainly located on the small Family Islands, and will, therefore, be excluded from this study focusing on New Providence. Catches are not continuously monitored or regulated on site, the Bahamian Government administrates an open fishery, where most of the data on the amount of catch are figured up by reports delivered by the fisherman to the DMR (cf. Interview 1).

The main resource for the Bahamian fisheries is the Caribbean spiny lobster, commonly referred to as 'crawfish' in Bahamian terminology. Its abundance and high price in local sale and exports to overseas markets build the foundation of the fishing industry. With a 70 million USD share, it made up for almost 90 percent of the value of landings in 2007. The queen conch is second in terms of value and third in terms of weight (cf. Table 5.2). They are particularly integrated into the island culture, used in various forms as food and as a cure-all. Spiny lobster and conch fishers use small vessels, ranging from three to seven meters that do not need special fishing equipment and thereby

allow an easy entrance into the market, totalling in a fleet of approximately 4000 vessels (cf. THE MINISTRY OF AGRICULTURE 2010: 15; Interview 1). The Nassau Grouper is a local species of the Common Grouper, highly-valued for its taste, as much as the snapper, together they make up for the largest groups in both live weight and value.

Table 5.2: Recorded landings of commercially exploited species 2007 (NATIONAL FISHERY SECTOR OVERVIEW)

Resources	Live weight (tonnes)	Value (USD)
spiny lobster	6 976.74	70 366 282
snappers	568.56	2 848 370
conch	378.98	3 051 282
nassau grouper (Epinephelus striatus)	157.44	1 592 827
jacks	83.50	619 452
other grouper	59.01	401 214
grunts	39.25	102 967
stone crabs	30.97	582 527
other	28.62	114 235
grouper fillet	6.67	64 374
turtle (loghd)	1.07	3 880
TOTAL	8 330.81	79 747 410

Locations and Sites

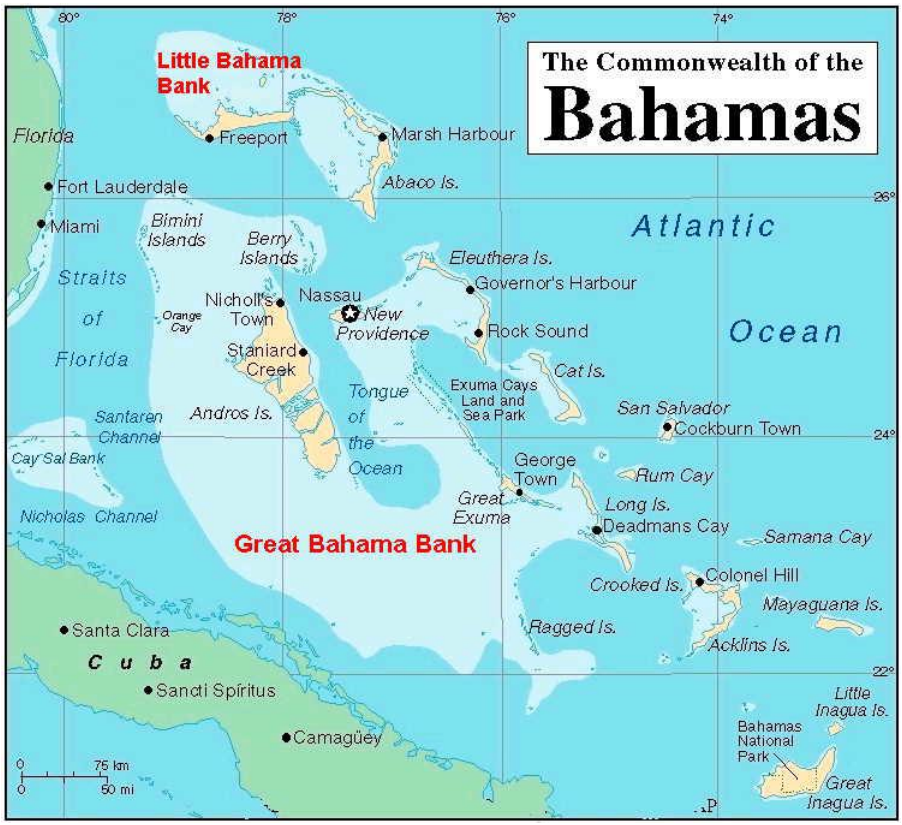


Figure 5.8: Fishing Grounds (NATIONAL FISHERY SECTOR OVERVIEW)

Fishing grounds are spread around the Great Bahama Bank south of Andros and Little Bahama Bank north of Grand Bahamas. They are typically marked by shallow waters, framed by vulnerable reef ecosystems towards the open sea and mangroves along the coast. When asked, Fishermen in Nassau/ New Providence added that within the Bank they regularly change fishing grounds for queen conches due to seasonal changes, however, did not mention any governmental regulations. The main ports for vessels are located on New Providence, Grand Bahama, Abaco, Eleuthera and Long Island (DMR 2009: 12).

Economic and political changes for a sustainable fishery sector

What economic or political measures are taken concerning a sustainable fishery sector?

The governmental regulations for all commercial fishery resources as well as species-specific regulations are in place under the Fisheries Resources (Jurisdiction & Conservation) Regulations dating back to 1986. Up to today, only limited changes and few adaptations have been issued. The fisheries regulations also concern the use of fishing gear. An excerpt of notable laws and regulations is shown in the National Fishery Sector Overview submitted to the Food and Agriculture Organization of the United Nations:

Fishing methods and materials:

- SCUBA diving for any fisheries resource is prohibited.
- Compressors can be used for commercial fishing only when the lobster season is open and only if the user is in possession of a permit.

- Use of spears is prohibited within 1 mile of the southern coastline of New Providence and Grand Bahama as well as within 200 yards of other islands.
- Noxious chemicals cannot be used for fishing and permission is needed to have them aboard a vessel for cleaning purposes.
- There are limits on the types of nets, traps and mesh sizes that can be used.
- Possession of lobster tails that have had the swimmerets removed is prohibited.
- Traps utilized in the lobster fishery must be made of wooden lathes and the dimensions must be 91.4 cm x 61 cm x 61 cm with slats no less than 2.54 cm apart unless there is authorization to do otherwise.

Closed seasons, definitions in size or prohibitions:

- Conch must have a well-formed flaring lip to be harvested.
- There is a lobster closed season of April 1st through July 31st. Restaurants must also declare all quantities that are in storage at the onset of the closed season.
- Harvesting and possession of egg-bearing lobsters are prohibited.
- The minimum harvestable size for spiny lobsters is 31/4 in (82.6 mm) carapace length and 51/2 in (139.7 mm) tail length. The regulation regarding tail length is only enforced when the carapace is absent.
- There are closed seasons for turtle and stoned crab.
- There are size limits for various species of sponges.
- There is a minimum size limit of 3 lbs (1.36 kg) for all groupers. Closed seasons for the Nassau grouper fishery have been declared in most years since the late 1990s and have had varying durations up to a maximum of 3 months during the December- February spawning season.
- The limits of sports-fishing bags have been modified during 2006 and 2007.
- An export quota for queen conch is set annually.

General Regulations:

- The Minister responsible is empowered to declare closed areas.
- Aquaculture operations require a license.
- It is illegal to sell bonefish (Albulidae sp.).
- In 2009 three new marine protected areas were declared.

In comparison to international standards, this excerpt may look like a small list to consider, but regarding an archipelago just on the verge of developing its own sustainable fishing concepts, it remains ahead of many of its surrounding Caribbean states legislatures, a report of the Tenth Annual CRFM Scientific Meeting in Belize shows (CRFM 2009: 98).

Main Factors impacting adequate Laws and Regulations:

“Although in the past there have been various genuine efforts to manage the environment and to police natural resources, there have been slippages which, if go unchecked, could have resulted in serious damage.” Governor-General Sir Orville Turnquest (Bahamas Environmental Handbook 2001: III). Governor-General Turnquest’s quote represents a common impression given by many involved players in this sector: Even though the government is forced to act by international pressure and

does so, its decrees either end up derailing as tinder for political campaigns, as observed in the running election of 2016, or fail due to the overwhelming task of efficient monitoring and subsequent control. When asked during the group surveys concerning whether they were aware of any laws and/or government regulations many fishermen boasted of being able to slip through enforcement or ignoring it, the group found. In the following a list of the main factors impacting adequate laws and regulations evaluated by the group after the interview with information from the DMR:

a) Lack of adequate enforcement.

Lack of enforcement is negatively impacting the spiny lobster, grouper, snapper, and conch fisheries. Illegal unreported and unregulated fishing by foreign commercial vessels (e.g., Dominican Republic), foreign recreational vessels (e.g., U.S.), and Bahamian vessels/fishermen is a growing problem to the fisheries. Without the much-needed equipment, no police, customs, or defense force officers, who are appointed fisheries inspectors by law and are routinely engaged in training in recognising infractions by the DMR, can enforce government laws and regulations.

The DMR itself announced in its 5-Years Plan 2010: “The Department of Marine Resources currently lacks adequate resources to meet existing much less the increasing demands (e.g., data collection, certification of wild fisheries, international agreements, research for major fisheries, establishment of marine reserves, and stock assessments.” (THE DEPARTMENT OF MARINE RESOURCES 2010: 5). As stated by the DMR on their homepage six vessels are available full-time to assist the department in its data gathering and enforcement duties:

- The Guanahani, a 65-foot research trawler, is currently seconded to the Royal Bahamas Defense Force to assist with patrols in the southeastern Bahamas, but can be made available to the department when necessary.
- A 26-foot Paramount patrol vessel equipped with twin, 250 horsepower (hp) engines, is stationed in Treasure Cay, Abaco.
- Three, 21-foot Sea Chasers equipped with single, 200 hp engines are stationed in New Providence, Grand Bahama, and Marsh Harbor, Abaco.
- A 17 foot Boston Whaler runabout, equipped with a 90 hp engine, is stationed in New Providence.

The Bahamas Reef Environment Educational Foundation (BREEF), stated that most of the fleet is being maintained at the moment, implementing this as a reoccurring state and would not guarantee enough capacity to address all foreign poachers alone if fully operative.

The missing enforcement leads to an irresponsible use of marine resources and creates a phenomenon called “Nature deficit disorder”. Jobs and income and therefore a massive development are prioritised. This development destroys the environment, especially the coastal zones and the benefits they provide (cf. Interview 2).

b) Illegal unreported and unregulated fishing

As confirmed by Interviewee 6, unreported fishing is a big issue for both marine resources and local fishermen. Illegal poachers come from Haiti and the Dominican Republic to fish in Royal Bahamian Waters without permission given by the Ministry of Agriculture and threaten local fishermen to fish elsewhere (cf. Interviews 1, 6).

c) Lack of adequate regulations

Although there has been progress in sustainable fisheries, there are varied upcoming topics to address. One of which is the much-needed protection of spawning aggregations. BREEF started information campaigns concerning spawning aggregations of the Nassau Grouper that led to the closed season, but other groupers and snappers need their adequate closed areas as part of marine reserves in combination with closed seasons, too (cf. Interview 6). The queen conch also needs areas in which it can reach a sufficiently high-density level necessary for successful reproduction so that the population can recover from the ongoing harvest. Furthermore, the BNT in cooperation with other different partners set their sights on enforcing a change in legislation regarding the harvest of queen conch with the help of the 'Conchservation campaign'. Their goal is that future juveniles will be protected in a way that only conches having at least a 15 mm lip thickness are allowed to be harvested (cf. Interview 2).

d) Lack of environmental, economic, and social data

All agencies interviewed by the group described the lack of biological long-term monitoring data that could derive any future impacts. A lot of the data is collected by international research teams during their field trips and later shared on a scientific level. Also economic data must be up-to-date to guarantee a safe adaptation and realistic impact studies on fisheries (cf. Interview 6).

e) Public education, consultation, and outreach

To prepare a quick adaptation to upcoming changes, the public needs to be consulted and educated in an early stage. Now the involved people still follow their economic well-being without realising the need to act as a group and which action to take. A perfect example is BREEF itself, channelling the call for more education for teachers spreading a sustainable idea, into a reliable source of expertise. Many campaigns today are done as Joint Ventures between different organizations, like the 'Conchservation Campaign'. Its goal is to "bring together researchers, government agencies, non-governmental agencies, concerned, private entities and most importantly, the Bahamian public to share information, and to both give and receive feedback on what might be the best practices to ensure that The Bahamas, and our guests, continue to enjoy conch dishes and curius, and the income they generate." (THE BAHAMAS NATIONAL TRUST 2016).

This involvement of multiple perspectives to a project might cause a long-term discussion between stakeholders, but the cumulated effect might also create a more genuine public reaction and adaption to its concept.

f) Marine Reserve Network/National Marine Protected Areas (MPA's)

The existing National Marine Parks are managed by the BNT and should be extended to allow natural spawning aggregations and retreat areas for marine life. As for the Nassau grouper, some fish have so-called resident aggregations, formed by fish that only travel short distances to the aggregation sites, and assemble there on a regular basis, sometimes almost daily and for extended periods. For fishermen, this is a predictable way to fish. In 2002, the North & South Marine Parks with the size of 5000 acres were established as Andros has the third longest barrier reef in the world. These two parks were established to help preserve significant parts of this valuable reef ecosystem (cf. Interview 2). The Department of Marine Resources announces in its 5-Year-Plan that: "[They] continue its work to establish a Network of Marine Reserves throughout The Bahamas. Efforts related to the implementation of management plans in the first 5 of the Reserves and the establishment of their respective boundaries will be made."

The dire need for a basic sustainable fishery sector is evident to any close observer. All laws and regulations issued by the government need a proven scientific perspective, next to an economic approach that, if targeted alone, is as worthless as the many crawfish-shells along the coast. Without it, the work of all of those pointing in the right direction, NGOs and Government, aims into another sinkhole that cannot adapt to such a major threat as climate change depicts. Once properly enforced, improvement might be measurable and thus representable to all of society to further stress the importance of a sustainable outcome for both sides – sea and man. A closer look at any measurements taken towards climate change shows no results, most actions taken appear either long overdue or as an impulsive reaction to a visible problem. However, as Interviewee 6 stated: "Another thing is the hurricane belt in which the Bahamas are situated. The appearance of hurricanes is related to climate change in both intensity and frequency. 2015 hurricanes showed a shift in usual patterns. Hurricanes of category 5 started a discussion of opening the scale, to measure upcoming events. The time hurricanes stay above and around the island is also increasing." This might further increase the necessity and prompt the economy to united action.

5.3.2. Threats to the fishery sector and recent challenges

As already mentioned in the beginning, the collected scientific findings, reports and prospects of the IPPC´s fifth progress report, have significantly contributed to the formation of this hypothesis. To find an answer to these two following questions which have derived from the hypothesis, - (1) Which climatic changes seem to be the biggest threats to the fishery sector? and (2) What role do other (anthropogenic) influences like invasive species, overfishing or pollution play in this context? - these findings, reports and prospects shall be presented in short and afterwards, with the help of the expert interviews, be verified concerning their validity on the Bahamas and New Providence.

According to computer models referred to by the IPCC, climate change will continue over the 21st century. "If emissions continue to rise at the current rate, impacts by the end of this century are projected to include a global average temperature 2.6 - 4.8 degrees Celsius (°C) higher than present, and sea levels 0.45 - 0.82 meters higher than present." (HOLMYARD 2014: 2). Climate change can be expected to impact fisheries through a diverse range of pathways and drivers. As illustrated in Figure 5.9, this range consists of potential indirect ecological, direct and indirect socio-economic impacts on fisheries (cf. COCHRANE et al. 2009: 111). Although socio-economic effects always have to be considered, this research and accordingly this paper focuses on the direct and ecological effects of climate change on fishery.

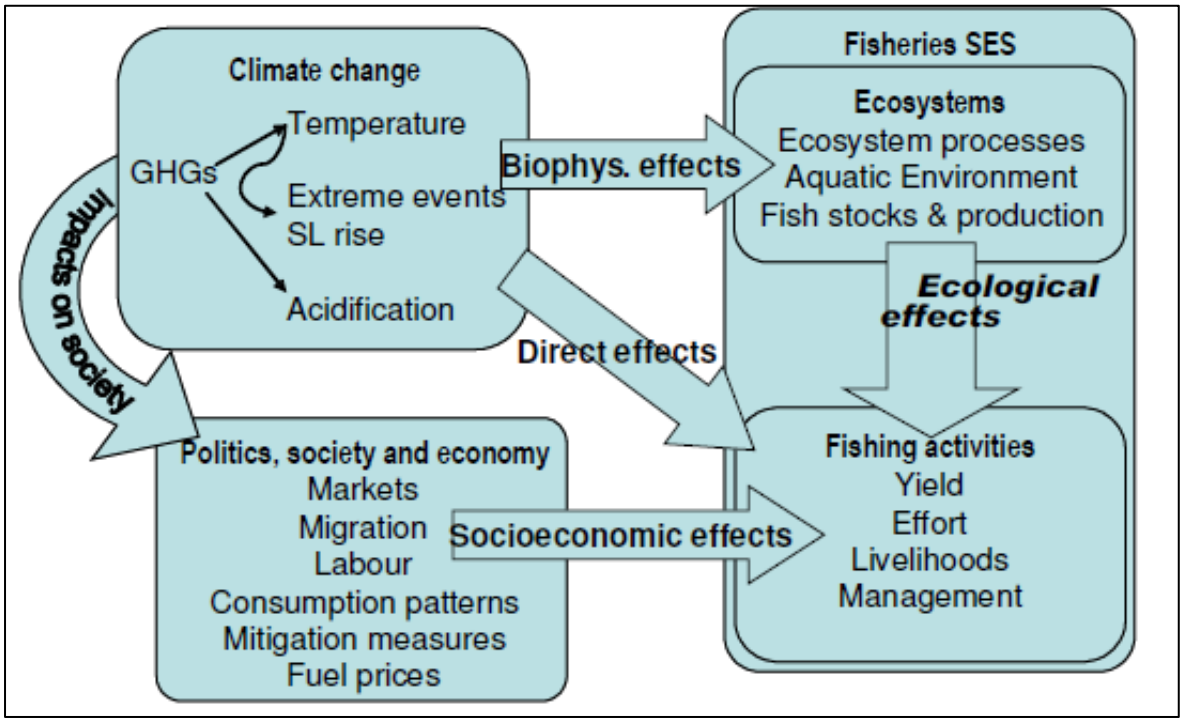


Figure 5.9: Ecological, direct and socio-economic impacts of climate change on fisheries (COCHRANE et al. 2009: 111)

Oceans are vital for the production of food from fisheries, but their ability to provide this service is sensitive to climate change and ocean acidification. Climate change affects the physical and chemical properties of the oceans and these drivers, in turn, affect the biological properties of marine organisms. Rising levels of atmospheric CO_2 result in more CO_2 being taken up by the oceans which causes a lower pH value of the water and intensified ocean acidification. Since the beginning of the industrialization, the mean pH value of the oceans has already dropped by 0.1 which means that since then, marine waters were getting 30 percent more acid. Until the end of the century, a continuous drop of about 0.3 to 0.4 is expected. These processes put calciferous animals, e.g. molluscs, crustaceans, corals, echinoderms and some phytoplankton which form shells by using calcium carbonate, at risk. It can cause plankton and other marine species moving to different (higher) latitudes, changing the zooplankton composition and be the reason for the loss of coastal fish breeding and nursery habitats, e.g. mangroves and coral reefs. Also ocean acidification may have direct effects on the behaviour of fishes, physiology and, as already mentioned, the distribution of fish populations. Consequently, potential impacts on fisheries are potentially reduced production for calciferous marine resources and ecologically related species and declines in yields (cf. COCHRANE et al. 2009: 112; HOLMYARD 2014: 5 f.).

Another point is the warming of the upper layers of the oceans. As just mentioned above, higher water temperatures can cause high-latitude invasions of species as well as high local extinction rates in the tropics and semi-enclosed seas, too. Warm-water species replace cold-water species which again leads to the changing of species' compositions. Rising temperatures reduce the oxygen-carrying capacity of the oceans. This limits the maximum body size large fish can achieve which results in the fact that more catches of smaller fish are predicted for the future as well as it leads to an increasing number of so-called 'dead zones' (zones in the oceans depleted in oxygen) which are affecting coastal ecosystems (e.g. coral bleaching events) and fisheries by inhibiting growth. A further growth of such Oxygen Minimum Zones (OMZ) is projected. In combination with changes in

ocean currents, higher water temperatures also can cause an increase in harmful algal blooms, invasive species and diseases as well as a change in sex ratios and altered time of spawning which all results in reduced productivity of fisheries (cf. COCHRANE et al. 2009: 112; HOLMYARD 2014: 4 and 7; UNFCCC 2001: 47).

Not least because of the certainty that the low elevation with more than 80 percent of the landmass of the Bahamas within 1.5 meters of mean sea level, sea-level rise constitutes a serious problem for the archipelago. An increase in sea level would result in beach and coastal (shoreline) erosion which could be disastrous not least for the biggest economic driver tourism. Coral reefs and mangroves provide effective barriers and coastal protection to low-lying areas on most of the islands, exposed to storm surge and ocean waves. The problem is that sea-level rise effects bigger waves which can harm the reefs and the mangroves and thus destroy the function as a natural barrier (cf. UNFCCC 2001: 46; Interview 6; UNEP 2005: 36).

The Bahamas are located in the Atlantic hurricane belt and fisheries have always been affected by variable climate, including rare extreme events such as hurricanes and flooding. Climate change is likely to be experienced as an increased frequency of extreme events. Damages of hurricanes include those to physical or capital stocks (e.g. buildings, piers, roads, that also affect the fisheries) as well as environmental goods and services such as aquifers, reefs and seagrass beds. Storm surges as a result of tropical storms and hurricanes are the principal causes of flooding in the low-lying islands of the Bahamas which leads to damage to property and infrastructure, contamination of wells and aquifers and directly impacting freshwater supplies which all affects the Bahamian fishery sector (cf. UNFCCC 2001: 46; COCHRANE et al. 2009: 105; UNEP 2005: 34 and 36).

All aspects mentioned above are major threats to the diverse ecosystems, nursery grounds and natural habitats like coral reefs, mangroves and seagrass beds including all the plants and animal communities and species living in those ecosystems. These impacts of climate change are generally exacerbated by other (anthropogenic caused) factors such as overfishing and pollution which should be elucidated shortly below (c.f. HOLMYARD 2014: 4). “Following rapid increases in production since the 1950s, the yield of global fish has stagnated and may be declining. Many stocks have been, or are at risk of being, overexploited […]. Statistics from the United Nations Food and Agriculture Organization (FAO) support this view, reporting that marine fisheries production peaked in the 1980s and that over recent years, approximately half of fisheries have been exploited to their maximum capacity, one quarter overexploited, collapsed or in decline and only one quarter have had potential for increased production […]. […] In addition to stock collapses, overfishing, in general, has reduced revenues and economic efficiency, increased variability and reduced the resilience of stocks and catches […].” (COCHRANE et al. 2009: 100 f.).

Threats to the environment and the fisheries by anthropogenic pollution include sedimentation (caused by activities that increase turbidity), surface run-off carrying excessive amounts of nutrients from fertilizers, raw sewage disposal throughout the Family Islands, accidental or incidental grounding of marine vessels, inappropriate use of fishing gear (such as dragnets), coastal development (such as construction of docks, piers, hotel facilities, etc.) and insufficient ultimate disposal of the generated waste. Most of the waste generated in the Bahamas has been disposed of in dumps with little protection from scavengers, vermin or cover material. Indiscriminate dumping along roadsides and on abandoned land is not uncommon, even in the islands with sanitary landfills. This situation is largely due to the dispersed nature of the population of the Bahamas on various

islands, the volume of waste generated and the number of facilities available to adequately handle its accumulation (c.f. UNEP 2005: 23 and 28).

Situation on the Bahamas

All significant causes concerning climate change and anthropogenic impacts that are threats to the fishery are mentioned above. Below, all these facts and predictions shall be verified concerning their validity with relation to the Bahamas:

The 2001 released report from the UNFCCC 'First National Communication on Climate Change' provides results of observed national changes in temperatures, sea level and occurrence of extreme events. Accordingly, the Bahamian weather data over the last 100 years (state of the year 2000) indicates an increasing mean daily maximum temperature for July at a rate of 2.0 °C. Due to the fact that there does not exist any analysis of the Bahamian sea level changes an examination was made of the rise in sea level, recorded at long-term sea level sites in neighbouring countries. The results indicate that the sea level in Bahamian waters is rising approximately 1.52 mm/year to 2.54 mm/year. Usually, the archipelago is affected by a very active hurricane season averaging three passing within 160 kilometres of the country. Besides, the fact that there seems to have been a slight increase in the number of hurricanes during the past decade there also seemed to have been an increase concerning the intensity of storms and hurricanes. Relating to an analysis of Bahamian hydro-meteorological data over the last 100 years, an increase in the number of North Atlantic Basin tropical storms per year from seven to about ten is detectable since the year 1905. In the end, it has to be said that overall wind speeds are decreasing and since 1945 spring and fall months have been getting sunnier (cf. UNFCCC 2001: 45).

Experts (cf. Interview 1, 2, 3 and 6) agree on the fact that the Bahamian marine ecosystems are very vulnerable and in general that the Bahamas is one of the ten most vulnerable countries concerning climate change. The problem of ocean acidification is not only well known in the context of the calcium carbonate composition (limestone) of the Bahamas from these experts, too. Interviewee 6 explains that marine animals are also influenced since their shells thin down (e.g. queen conch) and Interviewee 2 points on coral reefs which will suffer from a changing PH of the oceans. However, the problem is that data is "only from a global perspective, not really specialized on the archipelago" (Interviewee 6). Changes in the fish stock have not been noticed from the DMR so far, the fish stock "is still stable". However, there could be an indirect link between climate change and an impact on fish stocks which is the so-called algae 'Sargassum'. The DMR does not know for sure what caused these harmful algal blooms, but they suspect that it is some aspect of climate change which might have a negative impact on the fish stock. For this reason, scientists are currently doing research concerning this problem. Referring to Interviewee 1 right now the biggest influence on marine ecosystems and fisheries arises from sea level rise. Supporting this statement, Interviewee 2 says that "sea level-rise is one of the biggest threats" and Interviewee 6 notices that "sea-level rise is a big concern". Also, she explained that data about sea-level rise is collected since 1970 by the BEST Commission, which is still unpublished yet. She reminds that sea-level rise causes bigger waves which cause more damage to the island. This is because the reefs are located on the windward side of the Bahamas protecting the island, getting harmed by the bigger waves and thus destroy the function as a natural barrier. Interviewee 3 criticizes the fact that the Bahamian "get rid of the mangroves which are of course very important to the marine ecosystem and very important as an adaption measure to climate change". Interviewee 7 also knows about the importance of intact coral

reefs and mangroves for coastal protection issues and rates the current state of mangroves and coral reefs in New Providence as diverse, “some healthier, some less”. In addition, Interviewee 7 appoints this depredation of the coral reefs and mangrove systems as a result of climate change and reminds that those ecosystems function as a breeding area which means that all marine species will be affected by this kind of changes.

As mentioned above, the Bahamas are situated in the Atlantic hurricane belt and “hurricanes impact the fisheries” (Interviewee 1). Interviewee 6 and Interviewee 1 explain that the impact of climate change consists of more frequent storms or rather the intensity and frequency of the appearance of hurricanes which is related to climate change. Every time storms and hurricanes happen they destroy vessels and fishing gear and disrupt the fishing industry of the Bahamas. Although, hurricane impacts are temporary, the fishermen are forced to deal with it more often, and the government has to find a way to address that financially. Another point is that saltwater contamination rises and private wells will be negatively affected if bigger waves are flooding more land which both causes negative socioeconomic effects on fishing activities.

According to the statements of the DMR the stocks for all major species are stable, except localised overfishing for conch. In contrast to this opinion, Interviewee 2 asserts that “there is definitely overfishing”. A scientist who goes out every spawning season observed that in terms of the Nassau grouper the numbers decrease. Another indicator of overfishing across the food web is introducing parrotfish on the market. In other Caribbean countries, it turned out that when people started selling the parrotfish they fished out everything else. Recently, this fact started to show up as a fatal development concerning Bahamian markets as the parrotfish is essential to the coral reef ecosystems. They control the growth of algae which otherwise could overgrow and kill the reefs. Just as Interviewee 2, Interviewee 6 confirms: “Yes, there is overfishing”. She explains that poaching is a significant problem. Interviewee 2 and Interviewee 1 as well recognize that poaching is a big problem. Most of the poachers are from the Dominican Republic, which means they are not allowed to fish in the Bahamian waters. Despite this, the problem is their fishing methods. They have large trawlers and they “just dig up the whole seabed and whatever comes with it, they take that” (Interviewee 2). The Royal Bahamian Defense Forces (RBDF) does not have enough equipment (functioning vessels) to focus on the ecological protection issue while having the task to prevent further illegal immigration from Haiti. “The problem of human trafficking and migration weighs harder than fish.” (Interviewee 6).

“The lion fish invaded the waters of the Bahamas and the rest of the Caribbean, so that is something we are trying to mitigate.” (Interviewee 1). There is not seen any interruption concerning the major species like lobster and conch. But nevertheless it is for sure that there is an ecological impact and that is going to cause a disruption. There have been attempts to encourage fishermen and the public to go after it for domestic consumption. Interviewee 6 shares a similar opinion about the lion fish: “The invasion is so severe, that the only thing they can is live with it and adapt it (by eating). Adaptation through awareness is the best method here, so at least there is a use for it. Raising awareness brings rising demand and thereby an economic interest can be created.”

Interviewee 1, Interviewee 2 and Interviewee 6 state that the majority of Bahamian towns are constructed basically along the beaches and jobs and income and therefore a massive development is prioritized. This development destroys the environment, especially the coastal zones and the benefits they provide. Although it is not supposed to be allowed, but because of poor management

in many areas, there is also a lot of sand dredging for constructional use and that has bad impacts on the beach structure and species using sand (e.g. conch, sting rays or bone fish).

In general, coastal construction (e.g. harbours, docks, dredging for canals, buildings) always influences the marine ecosystem in various ways, because during the construction the coastal shape is heavily influenced. One example is that pesticides used on a new golf course next to the ocean are lastly influencing the marine ecosystem because they reach groundwater and then spread in the coastal areas. Another example is that sea-grass is often mistaken for not being the important nursing and transition areas they are for example for the queen conch. Also building processes around the coast can damage reefs.

Referring to Interviewee 2 there are also some oil spills on New Providence that are affecting the ecosystems. Interviewee 6 occupied this statement and explains that oil spillage is not really widespread, although there are specific places, as at the oil landing site (cf. Figure 5.10, Figure 5.11). On this specific place, the oil spill tank was overflown and has not yet been repaired. Also spills happen during the oil landing itself. Another aspect of the pollution is mentioned by Interviewee 1 and again Interviewee 6. Sometimes vessels strand on the reefs and there is a lot of garbage floating in the waters. Thus, marine debris and plastics find its way into the food chain. On many islands, especially on the Family Islands, there is no such thing as a waste water system. It is set in tanks in a whole in the ground and it is leaching from those into the marine environment.

Figure 5.10: Oil spills off the coast of the oil landing site of New Providence (1) (Photo ETTLICH, February 2016)

Figure 5.11: Oil spills off the coast of the oil landing site of New Providence (2) (Photo PFEIFFER, February 2016)

Interviewee 1 summarises that "in general our ecosystems are quite intact. It is nothing to worry about right now." "As a dynamic system, the oceans will continue to respond to past and current changes in global climate. Ocean-wide changes in ecosystems are already occurring and are projected to accelerate from 2050 onwards. Such changes have implications for fisheries management, sustainability, food security, and income generation, particularly in low-latitude and small island nations. These changes to ocean systems will continue for centuries." (HOLMYARD 2014: 5). As shown in the results above, the Bahamian fishery sector and the marine ecosystems are slightly affected by climate change issues and (anthropogenic) influences such as pollution, overfishing and invasive species. The problem with the summary of Interviewee 1 above is, as Interviewee 3 and also nearly all of the other experts recognise, that there is a significant lack of academically based research knowledge which could help screening those impacts. The Bahamas is one of the most vulnerable places and there "is very little research and very little awareness" (Interviewee 3). The general problem of the Bahamas is that there is no (governmental) funding for scientific research and it is not a priority of the government to educate people about climate change. Therefore "we need political support and funding" (Interviewee 3) to avoid changes with negative implications for fisheries management, sustainability, food security and income generation.

5.3.3. Awareness of the different players

This chapter will focus especially on the last part of the central research question: the awareness of the players. Awareness is understood as "knowledge or perception of a situation or fact" (OXFORD DICTIONARIES 2016) which is also reflected in the related sub-question: *Do the different actors realize changes and if so, which and how?* The previous chapters already gave an overview of the scientific position from which a worldwide high awareness predominantly about climate change issues but

also its impacts on small island states as well as on marine ecosystems and the fishery sector can be assumed. As already mentioned in chapter 5.2.1 and illustrated in Figure 5.9, “climate change can be expected to impact fisheries through a diverse range of pathways and drivers.” (ADGER et al. 2008: 17). Or, more specifically: “Climate change affects the physical and chemical properties of the ocean, and these drivers, in turn, affect the biological properties of marine organisms“ (HOLMYARD 2014: 5). The last IPCC report (2013) is mentioning the fishery sector, for example in the context of ocean acidification (ibid. 295), carbon dioxide fluxes and changing marine ecosystems (cf. 499) or the ENSO-phenomenon (cf. 1469). It was recognizable in the conducted expert interviews that science provides the knowledge and information which is the basis for the awareness about climate change and its impacts. All of the ministries and NGOs have access to scientific material which is then used as working base. This can be material from international researchers and foreign teams as well as own collected data. As the BNT explained, it is difficult to observe changes in just a few years of observation but scientists who have been working on the Bahamas for 20 to 40 years reported remarkable changes in the ocean. The BNT itself does not have own vessels to collect data but if they want to conduct their studies (e.g. dives), some vessels get hired. The DMR also benefits from this collected data, as all NGO communities provide their research to them. Apart from that, interviews and questionings of fishermen are methods of the Department to collect data. In Interview 2 it was mentioned, that this can also be a problem as the fishermen are afraid of regulations, so they do not necessarily divulge full and true information. This assessment was also confirmed through own observation and talks with fishermen. The fear of new restricting laws is far higher than of any climate changes. Still, this does not imply the absence of an awareness for ecological or climate changes. In fact, the results of the street survey demonstrate the high awareness for changes in the climate in recent years. As seen in Figure 5.12, 32 percent allotted to matters concerning climate or weather. Mostly, the answers applied to colder or warmer temperatures, storms and shifting seasons.

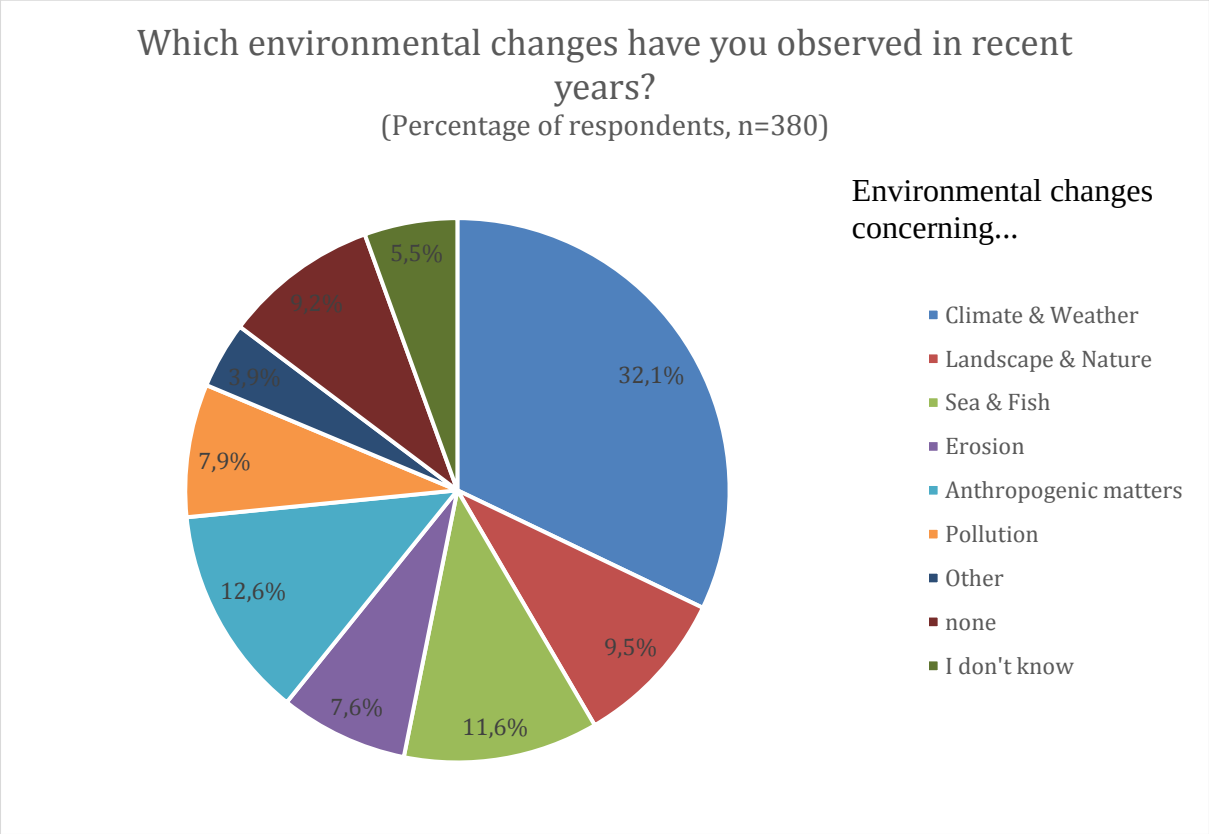


Figure 5.12: Environmental changes in recent years

The 'anthropogenic matters' also contributes with almost 13 percent a big part of the votes. It includes for example building activities, waste treatment, political actions or tourism. Tertiary follows with 11.6 percent the observed changes concerning sea and fish, which in our context are of especial interest. The interviewed persons named various components, such as 'flooding', 'mangrove decline', 'coral bleaching' or 'sea-level rise', but also more specifically in relation to our topic 'more sharks', 'more seaweed', 'lion fish', 'dead fish' and 'less fish', 'fishing seasons shifted' or 'overfishing'. A number of surveys took place on and around fish markets (for example at Potters Cay fish market, Montague Beach fish market or the fish fry of Arawak Cay) which results in a relatively high percentage of fishermen been interviewed. Out of 334 people stated 7.5 percent (25 people) directly an occupation related to the fishery sector (e.g. fisherman or sports fishery). It therefore is possible to assume, that many of these answers presented, but not exclusively, are from fishermen or people who are somehow related to the fishery industry. Even though many of them said in the first place that nothing besides the laws changed, the answers to the questionnaire draw a different picture. When reconsidering some topics, many showed a detailed awareness for their environment. This comes not necessarily with the knowledge *why* things are changing but often just *how* things are changing. An example here is the awareness about stronger storms, shifting fishing seasons and grounds or composition of the catch. All of the interviewed experts (from the Departments of Marine Resources and Meteorology, BEST Commission, CCI, BNT, BREEF and Nature Conservancy) bring those components (at least partly) in connection with climate change.

To find out about the connection of the Bahamian society to seafood in general and their awareness about the origin of it, two questions were asked in the survey concerning this matter. To the question “How often do you eat seafood per week?” out of 334 people almost 50 percent stated a consumption of sea food ‘more than twice a week’. 42 percent eat seafood at least ‘once or twice a week’, whereas 9 percent eat ‘not at all’ seafood (cf. Figure 5.13). Seafood can thereby be evaluated as an important part of the Bahamians nutrition. Also, most of the people still buy their fish and seafood on local markets as the answers to the question “Is the seafood you consume predominant of local or international origin?” show (cf. Figure 5.14). Only 7 percent prefer seafood with international origin, such as salmon. There is also a high percentage of ‘no indication’ at this question which can be related with a non-understanding of the question or not knowing where the seafood comes from.

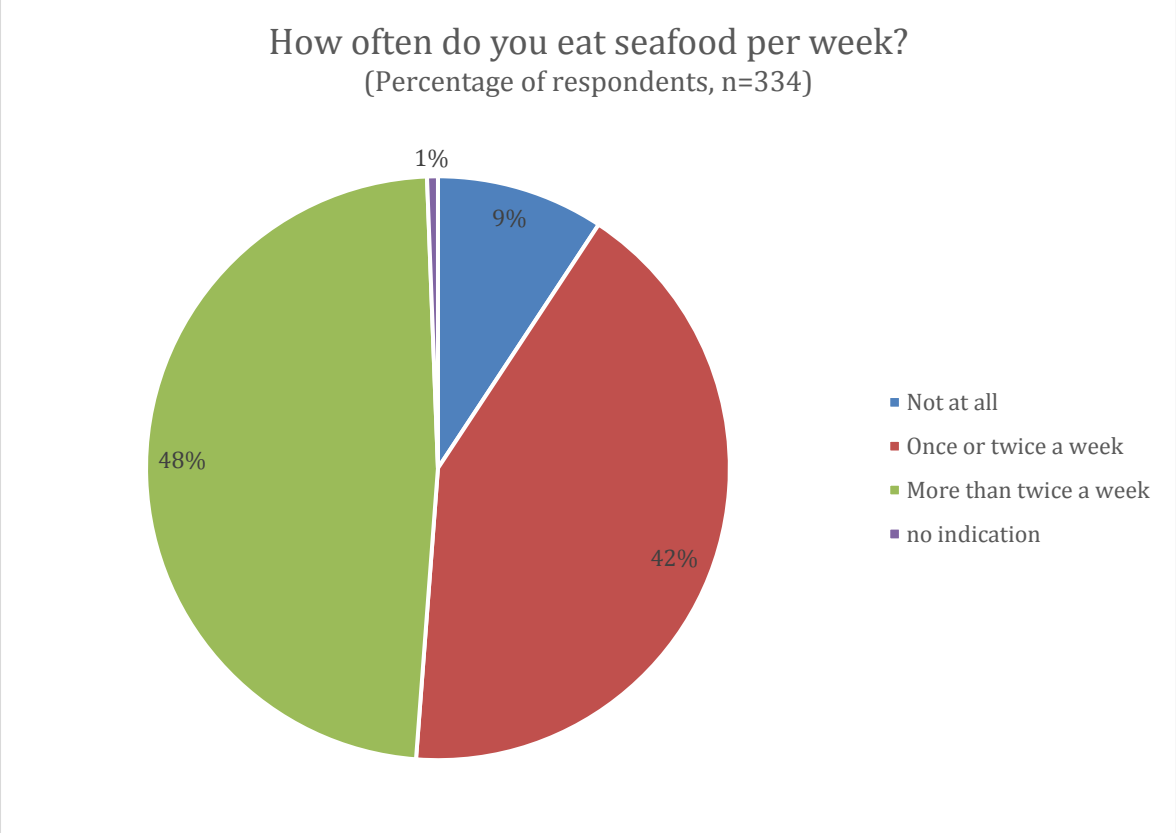


Figure 5.13: Consumption of seafood

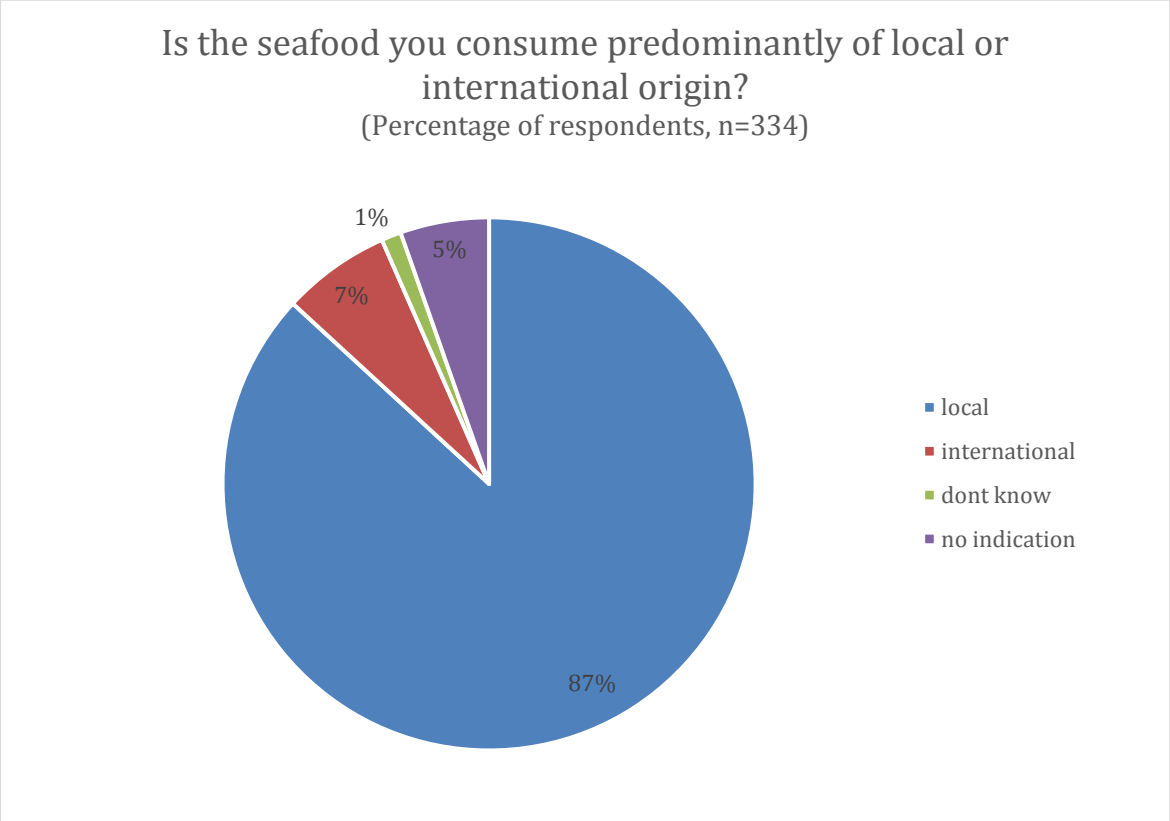


Figure 5.14: Origin of seafood

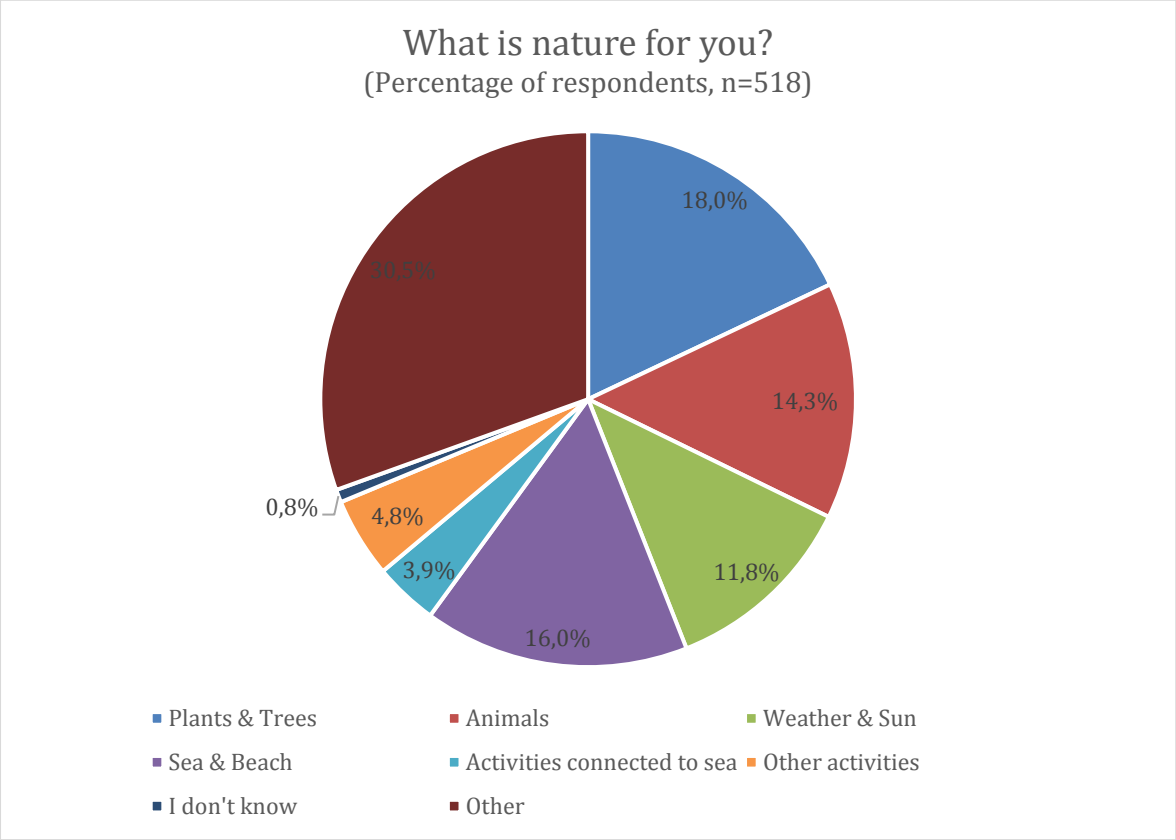


Figure 5.15: Meaning of nature

The general connection of Bahamians to the sea can be read out of figure 15 which illustrates what nature means to Bahamian people. The highest amount of votes falls with 30.5 percent on the category 'Other' which includes terms like 'everything', 'outside', 'beautiful', 'unique', 'love', 'god', 'peaceful', 'food', 'freedom', etc. Almost everybody mentioned such a general term or feeling next to another, "material" term. The most mentioned terms hereby are within the category of 'Plants and trees' (18%). But also animals (ca. 14%) and weather connected matters like 'sun', 'wind' and 'sky' (ca. 12%) play an important role. Very important in matters of "nature" are also the sea and the beaches. 16 percent of the votes refer to an ocean-related topic. Activities connected to the sea are excluded and constitute approx. 4 percent. From this it follows that approx. 20 percent of the here represented sample connects "nature" with a term which is connected to the sea. This supports the general opinion about the connection between Bahamians and the sea, even though the percentage was lower than expected as the Bahamas are an island state with an important history connected to the waters surrounding them.

As already said in chapter 3.1.5, Interviewee 2 mentioned in this context that "about 70 percent of the Bahamian population is living on New Providence and they are completely out of touch with the environment and what is happening". This opinion shall not be further discussed at this point as it would go beyond the scope of our research topic. Still, if true or not, the fishery as part of the culture is 'deep-seated' in the Bahamian society. The DMR appoints what the people think: "Even when tourism is bad, you can go fishing. Resources are sustainable". This is also reflected in the answers of figures 13 and 14 which lead to the assumption that seafood as a resource is in the focus of the people's awareness. It is 'just' a part of every-day-life and as nutrition. Interviewee 7 stated: The Public mainly does not think about fish in connection with climate change, they just think about temperatures. And as the DMR pointed out that seafood is seen as a 'never-ending resource' which was and always will be available. People are not keeping themselves busy with thinking about possible threats to this 'unlimited' resource.

But as mentioned in the very beginning, science and knowledge are the keys to awareness. Once awareness is achieved, it can also function as a key to adaptation and mitigation to the impacts due to the climate change. The BEST Commission, called this effect line "saving the house of cards before collapsing" and BREEF agrees on "adaptation through awareness is the best method […]. Raising awareness brings rising demand and thereby an economic interest can be created." So, to raise awareness within the population several projects have been implemented, mainly through educational NGOs like the BNT, BREEF or 'Friends of the Environment' in Abaco and other. One big project is, for instance, the national project "Conchservation" for the protection of the Queen Conch which has already been mentioned several times within this paper. Also the booklet "Who tief muh conch?" (cf. *Figure* 5.16) from the BEST Commission provides various information about the possible effects of climate change in the Bahamas. The central story of the booklet is the change of the ocean due to climate and its impacts on the people. One of the main characters is thereby a fisherman who cannot sell seafood because of the consequences of climate change.

Figure 5.16: Information booklet and flyer

Another project is the fight against the invasive lion fish. As Interviewee 6 states, the only way to live and adapt to the lion fish is by eating it. Many people are afraid of eating it as they think wrongly the fish's meat is poisonous. To stimulate the awareness of the people for this topic, several posters and flyers have been developed in collaboration between different players such as the Department of Marine Resources, BEST Commission, Bahamas National Trust, Nature Conservancy, BREEF and even with international support from UNEP and others.

So, on the whole, there is a high awareness about physical changes due to climate change amongst the official stakeholders connected to the fishery sector. However, at the same time, several voices also outlined that the Bahamas are not causing climate change: "We are not the one responsible for climate change. The major countries like US, China, India and so, they are the ones responsible for it. Not us. But we are being forced to adjust with it and plan for it. A particular unique situation for the Bahamas is that it is difficult for us to access funding to mitigate these impacts. That is because we are categorised as one of the more developed of all of the developing countries" (Interviewee 1).

There seems to be a high awareness amongst Bahamians for the "role allocation" within the topic of climate change. Interviewee 2 is also worried: "We don't know how to tackle or address it [climate change], because, on a large scale, I think it is too big of a problem". Even though awareness is achieved, it can fail with the implementation, too. Interviewee 2 mentioned for instance that for fishermen the economic reasons so far still weigh heavier than ecological ones. Also Interviewee 5 holds the view that the Bahamians should be aware of the problems through printed and electronic media- but how much of this information has been received is another question. Much more could be done in his opinion. Interviewee 7 describes the awareness amongst the different players as well as very various. People who work in this sector are more aware than others and a lot of research and awareness projects need to be done in her opinion. "In the end, we will conserve only what we love,

we will love only what we understand and we will understand only what we are taught" (Baba DIOUM, quoted in Interview 6).

5.3.4. Critical Reflection - Research problems and limitations

One major problem that is commonly mentioned in this paper is the lack of adequate or new scientific data on climate change impacts on the Bahamas as well as data on Bahamian fish stocks and fisheries. This was also noted by several experts. Accordingly, statements of experts must be regarded as critical because it is not always clear which evidence they are based on, for instance statements like "[…] Concerning the overall fishery we believe the stocks for all major species are stable" (Interviewee 1), especially if one considers that monitoring of species is insufficient. Limited data impeded the research on physical, chemical and biological processes in the Bahamian sea, too, which was of particular significance since it was seen as a basis for our study, as demonstrated in its hypothesis. The research that is taking place in the Bahamas is mostly conducted by international scientists. The Bahamas themselves have only very few scientists that are engaged in local research. Another aspect is the limited equipment available for conducting research in marine environments; the BNT, for instance, does not have vessels that are essential for the research on climate change impacts on marine resources and ecosystems (cf. Interview 2).

Moreover, contradictions in the statements of individual experts resulted in the reception of unreliable information. During the interview 1 for instance, the interview partner initially said that ecosystems are intact, however, as the interview continuous he states that climate change will be of major concern in the future and coral reefs have already started to change. Partially it seemed like the experts endeavoured to only provide information that does not burden other players or lacks meaningful content to either cover up their ignorance.

Another aspect considered critical is the interaction of the players within different sectors. The responsibility of certain tasks was not always clear and when asked for further information, for instance, data on changes in ocean conditions, the research group was often referred to other experts; in this case, Interviewees 1 and 2 referred to experts of BREEF, who in turn stated that most of the research is collected from foreign teams. Many of the players act independently but their hands and feet are tied when it comes to enforcing changes in legislations, for instance, a change in policy to harvesting conch with an at least 15 mm lip thickness (cf. Interview 2). Besides, a close collaboration between individual sectors was not clearly noticeable. The impression was gained that some sectors were valued higher than others. For example, tourism and the related construction of facilities in the coastal region, which has an impact on the marine environment, seem to receive more attention, due to potential economic benefits, than coastal protection efforts. Interviewee 4 mentioned that the Bahamas themselves could be considered a real estate project. In this case, economic benefits outweigh environmental protection receiving financial and political support.

From a political point of view, this imbalance of interests influences the decision-making during e.g. an investment from abroad, as some actions taken only mean to silence any renitence against it. Other factors leading to 'greenwashing' might be caused by international pressure applied through the introduction of new standards regulations worldwide.

Limitations were also experienced by the size of the Bahamian economy. To truly investigate a matter, all players must be taken into account, all perspectives seen. During our research we talked to both people directly involved in the sector, e.g. fishermen, people indirectly involved in it, NGO's,

or governmental institutions regulating it. While the government and NGO's had representatives that contributed an official representative of fisheries, either industrial or recreational, did not answer any attempts by the group to add their very opinion on the matter.

5.4. Conclusion

The target of this study was to define impacts of anthropogenic climate change on fish stocks and fisheries in the Bahamas. Additionally, it was aimed to find out the perception of all players related to Bahamian fisheries in terms of consequent changes within the sector and the marine environment on which it relies.

For this purpose, general impacts of climate change on oceans and the marine environment were initially analysed through research of existing literature and the collection of data. In a second step relations between changes in the oceans and the fish stocks had to be figured out coming to a conclusion that in tropical waters a wide range of marine fish species is particularly dependent on marine ecosystems being present in shallow waters, such as coral reefs and mangroves. Subsequently, it was necessary to find out the vulnerability of those ecosystems, especially to the consequences of climate change. In a next step, the acquired knowledge was transferred to the case of the Bahamas. The inadequate information concerning the relations in the Bahamas that our research group received from literature research was aimed to be increased by expert interviews during the field trip. Another goal of this process was to identify the connections between changes in fish stocks and the impact on local fisheries as well as to draw conclusions about the perceptions of the players involved in this study. In this respect, it was essential to find out the importance of fish and fisheries for the Bahamian community which was done by a population survey and observations. Having the reason to believe that a high importance, either economic or cultural, results in a high awareness, the aim was to confirm or reject this assumption.

The research process as mentioned above induces that several partial results were necessary to come to a main conclusion. To receive them, four sub-questions were developed at the beginning of the project. The results the research group received from this study and that have been discussed will be summarised to answer the sub-questions in the following.

With the assumption that climate change is taking place and is leading to impacts on the Bahamas, the research group wanted to find out if political or economic regulations exist or are being planned towards a sustainable fishery and to mitigate or adapt changes.

"Are economic or political actions taken in the context of a changing fisheries sector?"

A requirement to answer this question is the fact whether changes are even observed. Due to inadequate data and monitoring concerning fish stocks and changes within the marine environment of the Bahamas, it is difficult to verify changes. From a political point of view only few actions are taken by the DMR regarding regulations for fishing methods and materials, closed seasons (e.g. for lobsters), definitions in size or prohibitions (e.g. conch can be harvested with a well formed flaring lip) and a few general regulations. Since the Bahamian fishery is an open fishery without fishing quotas, the existing regulations consequently do not ensure sustainable fish stocks. The measures taken are also just preventions of potential overfishing of certain species or actions against current or visible issues. This also includes the existence and the establishment of Marine Protected Areas, which is a measure to protect the spawning of commercial fish and the ecosystems functioning as

nurseries. However, particular actions regarding the impact of climate change are not clearly defined or ignored after introduction. The DMR attempts to receive adequate reports of fishermen in the future which may lead to the development of necessary measures. Though they only fulfil their potential benefit if enforced properly which is currently and without doubt not the case in the Bahamas according to experts from environmental fields.

From the educational point of view, it seems like more actions are taken, particularly to raise the awareness of the Bahamian community regarding climate change and its impacts on marine resources and ecosystems. The focus is especially on the outreach of the population through educational programs and information brochures, for instance, the “Conchservation Campaign”. The awareness-raising might lead to further actions taken regarding mitigation and adaptation measures against climate change impacts on the marine environment and consequently on fisheries.

One necessary basis for this research was to find out in which way climate change impacts the fish stocks and the Bahamian fishery sector. Accordingly, one sub-question is:

“Which climatic changes seem to have the biggest impacts on the fishery sector?”

Since climate change impacts on the marine environment are often associated with ocean temperature rise and acidification through increased dissolution of $CO_{2,}$ the research group assumed that Bahamian fisheries will mainly be impacted by according changes of the marine ecosystems (e.g. through the affected calcium carbonate composition of several marine animals). However, these impacts seem to be secondary and more direct consequences associated with climate changes, such as the increase of frequent storms and hurricanes as well as the increase in their intensity, influence the Bahamian fishery sector primarily. The fisheries are affected, in so far as fishermen are not able to go fishing and fishing gear and vessels have been destroyed more frequently leading to higher economic costs. The financial resources of the government, however, are limited. Also sea-level rise has a significant influence on fisheries in a way that storm waves become bigger from time to time and access to fishery-related locations like harbours and fish markets gets cut off more frequently due to flooding.

The research group assumed that it is difficult to distinguish the causes of changes in fish stock and fisheries. Eventually, the marine environment is impacted by further influences than climate change. The aim was to figure out all impacts and their significance by following sub-question proposed at the beginning of this research:

“What roles do other (anthropogenic) influences like invasive species, overfishing or pollution play in this context?”

After analysing the impacts of the individual influences, even though not all of them can be clearly defined due to inadequate scientific data (e.g. overfishing), it can be noted that they influence marine resources and ecosystems at least as much as climate change. In most cases, it is even difficult to tell them apart. Often the impacts of one influence are intensified by another. For example, changed conditions of the ocean induced by climate change benefit invasive species, such as the plant ‘Malaleuca’ having an impact on wetland ecosystems (cf. Interview 2). The threats are very well connected according to Musgrove. Another example is that habitat destruction, for instance, the destruction of mangroves to build facilities for tourism, is often connected with pollution, in this case originating from coastal construction work. The overall changes in the ocean and marine environment cannot be traced back precisely to their causes which is why direct

anthropogenic influences always have to be considered, too, when talking about changes in fish stocks and fisheries.

The last sub-question that needs to be answered is related to the second part of the research topic and particularly highlights the social context of this study.

"Do the different players related to the fisheries sector perceive changes and if so, which ones and how?"

To receive information about the awareness of the population in which different players related to the research topic are included (e.g. fishermen, consumer) this research primarily relies on the results of the population survey. They reveal that the population is highly aware of environmental changes that can be linked to climate change, such as increasing temperatures, storms or shifting seasons, as well as the marine environment, such as destruction of mangroves, coral bleaching, sea-level rise, more seaweed, shifted fishing seasons or overfishing. The experts particularly perceived stronger and more frequent storms, shifting fishing seasons, changes in the composition of catch and occurrences of algal blooms as a result of nutrient enrichment (cf. Interviews 1, 2, 6). In numerous cases, however, it is not clear that many changes can be linked to climate change that has future impacts, too, but is rather seen as a current and visible state that is being tackled as an adaptation measure with no intention of a sustainable development (e.g. beach cleaning). Politically important players such as the DMR even state that fish stocks are stable and no visible changes have been observed. This statement indicates that potential changes due to climate change are not always taken seriously, and current benefits from fisheries seem to be more important than the necessity that fisheries also provide benefits, particularly food security, in the future. Reasons for this might be the allocation of tasks among the fishery-related players and the lack of adequate scientific data resulting in no need for immediate actions of various players. To adapt to climate change it would be necessary to draw the Bahamian populations attention to the fact that the perceived environmental changes can be linked to anthropogenic climate change and might pose a threat to them and the Bahamian economy in the future if being ignored.

The results and conclusions of all sub-questions are now used to answer the central question of this study:

"How do the consequences of the climate change influence fish stocks and hence the fishery sector on the Bahamas, and how do involved players perceive these changes?"

Our assumption regarding this two-part question before conducting the study is reflected in the following hypothesis:

"Changing physical, chemical and biological conditions of the ocean due to the climate change influence the stock of marine species and hence impact the Bahamian fishery sector negatively."

Specifically concerning the Bahamas, the hypothesis can neither be confirmed nor entirely rejected. Necessary scientific data that indicate the connections between physical, chemical and biological processes in the Bahamian waters used for fishing and fish stocks as well as local fisheries is either incomplete or inadequate. The results of this study through interviews with experts revealed that most of them have heard of some changes, for instance shifting species compositions, but cannot give scientific proof. When asked for data concerning research-related issues like changes in fish

stock most experts referred to international researchers. The lack of reliable data impedes to rebut our presumption.

However, the hypothesis includes a provisional assessment that the changes mentioned above influence marine species and the Bahamian fishery sector in a negative way. According to the expert interviews, observations and the population survey no relevant negative impacts on the fishery sector have been observed yet. Only individual events like strong storms or hurricanes have negative impacts on the fisheries in a way that their income is affected since vessel cannot depart or fishing gear is destroyed. Direct impacts of changes in fish stock on fisheries are assumed to be observed by players with a closer connection to the sea such as fishermen. Due to insufficient monitoring that is implemented by reports of fishermen no relevant data on potential impacts exist (cf. Interview 1). However, the reports are not necessarily reliable because fishermen might be afraid of potential measures or regulations by the government (cf. Interview 2). Unreported changes lead to inadequate awareness of other players involved in the fishery sector which in turn may result in major consequences for it in the future, thus, when no necessary actions have been taken to mitigate or adapt to them.

This eventually leads to the answer of the central question. The consequences of climate change will be of major concern in the future. All experts agreed on this statement. Even though many of the impacts of climate change are not visible yet it is commonly approved that climate change is happening. This fundamental position is based on the knowledge of impacts of climate change to oceans in general. Another consensus is the assumption that its consequences for the marine environment and all economic sectors that are linked to it will be very difficult to adjust to. “Climate change is a big whopper. We don’t know how to tackle or address it just because on a large scale, I think it is too big of a problem” (Interviewee 2). In this respect impacts of climate change are reflected that most players involved in the fishery sector are aware of it and its future consequences, though they do not necessarily feel responsible for taking actions against it because it is intangible at the moment. Another reason is the blaming of big industrial countries, such as China or the U.S., for the causes of climate change. This and the aspiration for the economic development of the country leads to the fact that climate change and its potential future impacts on fisheries does not seem to be valued as important as for instance the insurance of present economic benefits from fisheries.

In conclusion, the perceived irresponsibility does not apply to all of the players. Particularly environmental agencies are willing to adjust to the impacts of climate change visible in many projects concerning the raise of awareness. A very important point is the essential cooperation among the players, particularly regarding raising awareness and mitigation and adaptation measures. Through observations during the study, the research group ascertained that this cooperation is yet not fully developed. Fundamentals are in place, the task now is to outreach the Bahamian population in a way that need for action is required and legislations are enforced more strongly. It is especially necessary to draw attention to the aspect that a sustainable use of marine resources, also in consideration of developing mitigation and adaptation measures regarding impacts of climate change, will ensure their existence in the future and consequently ensure the livelihood of future generations.

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6. The impact of social inequality on climate change perception

Freya Brunswig, Katharina Meyer, Simon Strobelt, Ronja Winkhardt-Enz

6.1. Introduction

Despite its comparably small size[4] New Providence (NP) is the most populated and urbanised island of the Bahamas. It is home to almost 73% of the total population, houses the national capital city of Nassau and is therefore undoubtedly the political and economic centre of the Small Island Development State (SIDS) (DEPARTMENT OF STATISTICS 2014: 10). Reasons for this historical development are, among others, the island's large body of freshwater as well as its natural protection against adverse impacts of hurricanes and storm surges due to its relatively sheltered geographical location in the centre of the archipelago (CRATON & SAUNDERS 1999: 391f). Nevertheless, like all of the 30 inhabited islands of the Bahamas, NP is a low-lying coral island with a high proportion of coastal population. It is therefore highly vulnerable to projected sea-level rise (SLR), an increase of extreme weather events and other potential effects of a changing climate (CCCCC 2014: 2; KELMAN & WEST 2009: 3; SMITH 2012)[5]. Although some research suggests that there are currently probably more acute reasons for ongoing coastal erosion on NP (SEALY 2006; ibid. 2001: 15ff), there is no doubt that the Bahamian society is facing an urgent need to set up suitable adaptation measures to SLR and the multifarious effects of climate change (CC) to reduce its vulnerability and to enhance resilience (MERCER et al. 2012: 1908f; RATTER 2015).

Any form of adaptive behaviour, however, requires awareness about a problem, which can vary enormously within a society. While CC and SLR have been relevant issues on an institutional level for several years (BAHAMAS NATIONAL TRUST 2013: 37; THE GOVERNMENT OF THE BAHAMAS 2015: 1f; NCCC & BEST COMMISSION 2005: 1ff), it still remains unclear if there is also a certain amount of awareness about these processes among the wider Bahamian population. In 2012, NEELY conducted a study about CC perception among the Bahamians, using a limited sample drawn from a small and specific segment of the Bahamian population (NEELY 2012: 35ff). Further empirical studies about CC perception are unknown but essential to creating a baseline understanding of public CC awareness on NP and to develop suitable adaptation measures for the future.

Existing data indicates that the population of NP is highly heterogeneous and characterized by significant social, economic and cultural inequalities. Obvious differences can be identified, for instance, regarding the distribution of economic wealth, access to education and knowledge as well as participation opportunities in different fields of public life (BROWN 2012; LOWE 2012; WHO 2013). While in 2013 the Bahamas had a Human Development Index (HDI) of 0.789, only slightly below the highest segment of human development defined by the United Nations Development Program (UNDP), the country had a Gini index of 57.5 in the same year. This value illustrates a very high grade

[4] Total land area: New Providence 80 mi² (207 km²); Andros 2,300 mi² (5,957 km²) ; Abaco 649 mi² (1,681 km²); Inagua 596 mi² (1,544 km²); Grand Bahama: 530 mi² (1,373 km²) (DEPARTMENT OF STATISTICS 2012: 5)

[5] The vulnerability of the island is additionally exacerbated by the high grade of dependence on imports, the fragility of its main economic sectors tourism and banking, and several other factors (PETZOLD & RATTER 2015: 37; IPCC 2014: 636)

of unequal distribution of income in international as well as regional comparison[6] (CARIBBEAN DEVELOPMENT BANK 2013: 1; UNDP 2013: 140ff; WORLD BANK 2016). According to the latest Household Expenditure Survey of 2013, around 43,000 Bahamian citizens (12.2%) were living below the national poverty line of 4,247$[7] per year (11.64$ a day) while the average income in the same year was 20,690$ (DEPARTMENT OF STATISTICS 2014: 26ff). Moreover, Nassau is characterized by a pronounced socio-spatial urban segregation as well as high levels of crime (KARAGIANNIS 2009: 75f; OSAC 2015).

Besides the significant economic and social heterogeneity of NP, a considerable, mostly historically based ethnocultural diversity can be identified. This diversity includes a variety of identity shaping and delimitation factors such as skin colour, ethnic origin, religious denomination, language, legal status (BETHEL 2002: 245f). In this context it must be highlighted that in 2010 around 91% of the Bahamian population identified themselves as being black and 5% as white while the remaining 2% described themselves as mixed (DEPARTMENT OF STATISTICS 2012: 10). The Bahamas are as well a country of recent immigration. According to UNICEF around 40,000 Haitians (75.6% of all migrants) and around 5,800 Jamaicans were living in the Bahamas in 2013, the overwhelming share of them on NP (UNICEF 2014). Besides the socio-economic position (class) and the ethnocultural background of the individual (ethnicity), a further substantial structural feature of the Bahamian population is gender, which is partly reflected in considerable differences between men and women in the public sphere as well as in the private sphere and in some cases even in the legal sphere (BETHEL 2014; SMITH 2014). In comparison with its south-western Caribbean neighbours, the Bahamas have performed an outstandingly positive economic, political and social development (GEWECKE 2007: 82). However, some investigations about the Bahamian population structure assume potential correlations between class, ethnicity, gender and social inequalities (DEPARTMENT OF STATISTICS 2014: 27ff).

In order to develop a baseline understanding of CC awareness on NP and to approach the question who exactly has to adapt to CC and SLR, an empirical study about CC perception on NP appears to be necessary that takes into account the social backgrounds of its inhabitants or, more specifically, the relevance of the three major drivers of social inequality class, ethnicity and gender (SWINN 2008: 21; MCCALL 2001: 3ff). Therefore, this study is trying to approach the following key question:

What is the impact of social inequality on climate change perception on New Providence?

To make it more feasible to address this overall research question, it was divided into the following set of sub-questions which will be addressed consecutively:

What is the impact of ethnicity and gender on the socio-economic position according to the 'meritocratic triad'?

What is the impact of class, ethnicity and gender on climate change perception?

What is the impact of a person's place of residence on climate change perception?

Following this introductory, we address the theoretical framework of the research topic, briefly outlining SWINN's concept of multidimensional inequality analysis as well as an overview of theoretical approaches to perception studies. The next chapter will explain and critically reflect the used methods in detail, including a chronological outline of the research process. Subsequently, the

[6] Global average 36.4; Germany 28.3; USA 40.8; Jamaica 45.5; Dom. Republic 47.2; Haiti 59.2

[7] The Bahamian dollar is pegged to the U.S. dollar on a one-to-one basis

results of the empirical study are analyzed systematically, starting with a descriptive presentation of the survey results and continuing with an in-depth analysis and interpretation by using qualitative data which was also collected during the field work in February 2016 to gradually approach the above set of sub-questions. Finally, the results of the data analysis will be summarized and linked to address the superordinate key question *"What is the impact of social inequalities on Climate Change perception on New Providence?"* and to discuss the empirical findings in a broader perspective and its relevance for a necessary climate change adaptation strategy.

6.2. Theoretical framework

This study is based on a constructivist perspective that regards alleged realities and social phenomena such as class, ethnic, and gender differences as socially constructed, respectively subjective and man-made (BERGER & LUCKMANN 1967: 147ff). Against this background and to give this study a deeper analytical framework, further theoretical embedding of the research questions is needed that covers the two main research subjects social inequality and perception.

6.2.1. Social inequality

The article 'On the Analysis of multidimensional Relations of Inequality' [translated] by T. SWINN (2008) provides a suitable and useful theoretical framework for a systematic analysis of multivariate social inequalities. SWINN identifies class, ethnicity and gender as the three major drivers of an uneven distribution of socioeconomic success among the members of a modern meritocratic society (SWINN 2008: 20ff).

Unlike in the European medieval estate-based absolutism or as in race-based apartheid systems, in a meritocracy (merit, from Latin mereō "I earn" and -cracy, from Ancient Greek kratos "strength, power") the socio-economic position of a person is based on his personal success in the fields of education, occupation and income, known as the meritocratic triad (see *Figure 6.1*). Therefore, a modern state based on meritocratic principles is theoretically purely performance-oriented, strives to overcome a legally determined social stratification and attempts to guarantee equal opportunities for every member of the society regardless of his or her class origin, ethnic background or sex/gender (SWINN 2008: 22).

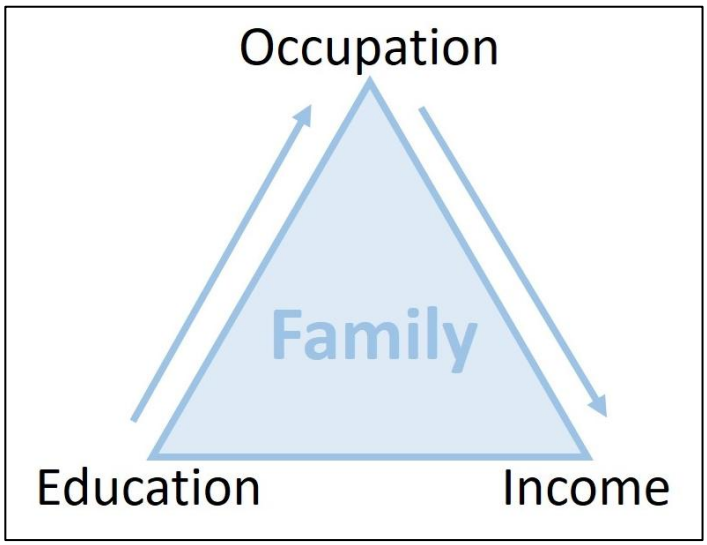


Figure 6.1: Meritocratic triad (Own illustration)

Nevertheless, the questions remain why and how social inequalities – especially regarding class, ethnic and gender differences – are also (re)produced in meritocratic systems? For SWINN, the core of the present "landscape of inequalities" can be found in the interconnection of the institutional fields of the meritocratic triad of education, occupation and income which are family, educational system and job market (SWINN 2008: 27). For the effective enforcement of equal opportunities and thereby for the avoidance of discrimination of specific groups, a high degree of institutional formality is required. While the educational system and job market are highly formalized institutions, the family is mainly informally organized (ibid.). Due to this lack of formal organization, the family provides a large potential for the production and reproduction of inequalities in terms of class, ethnicity and gender and consequently influences the personal development and the changes of success of its members in the meritocratic triad: The family background of a person facilitates or complicates the access to a higher level of education, which is in turn decisive for the achievement of a respected occupation and an appropriate income. Conversely, education, occupation and income of a person influence the choice of a partner and family founding and therefore generates specific "start conditions" for the next generation. Besides the production and reproduction of class differences by family origin, the ethnic background of a person is likewise predefined by family origin and also gender differences and role models are particularly produced and reproduced in the family (SWINN 2008: 28).

Because social inequalities, however, are inseparably connected to the distribution of power within a society, the political dimension cannot be ignored in the analysis. The disadvantaged groups in terms of the three major drivers of social inequality (class, ethnicity, gender) which are lower classes, ethnic minorities and women, wield a deficit of power due to a lack of sufficient conflict ability which is required for the enforcement of interests (SWINN 2008: 29). According to SWINN, the lack of conflict ability of lower classes is mainly based on their dwindling market power and representation of interests in policy and labour unions. The lack of conflict ability of women is based on the dominance of the economic production sphere over the familial reproduction sphere and the uneven distribution of men and women in these two spheres. Ethnic minorities often have the lowest conflict ability due to their weak representation of interests in the wider society (ibid.).

In summary, due to the different starting conditions of every person as well as the deficit of political power of some specific groups, equal opportunities are very unlikely to exist in a performance-oriented or meritocratic society. Chances of success and life opportunities are dependent on the three major drivers of social inequality class, ethnicity and gender – a fact that should be considered in an empirical study of the social system and its nexus with CC perception on The Bahamas.

6.2.2. Perception

According to SCHACTER et al. (2012) perception is defined as "[...] the organization, identification and interpretation of a sensation in order to form a mental representation" (SCHACTER et al. 2012: 123). A myriad of external impulses are absorbed by the human senses and subsequently processed and combined with the consciousness to form an internal reconstruction of the external world (ibid.).

The individual perception of the external world and its many different spheres and aspects differ from person to person. This individual perception is understood by a person as true and real, generally shapes the personal awareness about specific circumstances and can be regarded as the basis of the personal reality. Therefore, a variety of different 'realities' does exist side by side. A

pluralism of realities, however, is impossible from an ontic epistemological perspective (HACKING 1999: 16ff). Consequently, the human perception is regarded as an individual (re)construction of the outer world based on diverse variations of absorbed impulses, different processing chains and interpretation patterns. Latter are influenced, among other things, by personal experiences and collected knowledge (SCHACTER et al. 2012: 124f).

However, the individual perception of specific circumstances is not invariable but can be changed due to the influence of additional impulses by newly gained experiences or information. Thus, additional information can cause a change of perception which generates a change of awareness of a specific problem and, respectively, a changed personal reality. In an ideal scenario, such change of awareness leads to the willingness of adaptation to the new 'reality' (BYG & SALICK 2009: 156f).

This chain of individualistic 'realisation' (*perception → awareness → adaptation*) is an essential theoretical basis of this study (see 6.1). It can be assumed that the three major drivers of social inequality (*class, ethnicity, gender*) as well as additional social variables such as age and place of residence structurally influence the individual perception of CC due to possible similarities of impulse patterns, processing chains and interpretation patterns among the members of each specific social group. Consequently, the social variables also influence individual awareness of CC and SLR and hence the willingness for adaptation. Therefore, an empirical study of the relations of social inequalities and CC perception on NP is crucial for further scientific investigations dealing with the social response to CC and SLR.

6.3. Methodology and reflection

The applied methods comprised a random population street survey, expert interviews and participatory observation. An interview guideline for the expert interviews was being developed, which were to enrich the statistical outcome. Both the questionnaire for the street survey and the guideline for the expert interviews were corrected and improved through several test runs; the interview guideline was further adjusted with the assistance of our interviewee I who was interviewed in Germany before the field trip to NP. The interview with him, who lived and worked in academic environments in both countries for a long time, enabled us to ask specific questions on the implementation and concept of the project, and in that way adjust it to his suggestions.

Potential experts on our research topic, who had been identified and contacted before our arrival on NP, were being interviewed, following the developed structured interview guideline. The selection of so-called “experts” was based on the identification of relevant social and political institutions and their representatives, of whom we expected to gain a profound picture on social inequalities due to their local residence and contact to different segments of the population and society (see 0).

During our empirical research, we were able to visit a range of different regions in NP, e.g. Bain Town, Downtown Nassau or a Haitian squatter community, where we as a research team were able to gain further impressions on the island and the Bahamian population in general. After completion of the field trip on NP, the questionnaire used for the street survey was analyzed according to our research questions. Relevant questions were distinguished into two categories, 'direct information' to be used for further correlations and 'indirect information' to be used for supportive interpretations. For the open questions of the questionnaire, the answers had to be categorised for statistical analysis. Origin and migratory background of the interviewees were categorised according to the UN classification ‘Economies by per capita GNI in 2012’ (UNITED NATIONS 2014: 148).

For the analysis of the nexus social attributes and climate perception, we developed a special scoring system which was to make visible the perception of CC (see 6.4.2). The expert interviews were transcribed and coded and the information gathered was used as a base for interpretation of the statistical data. The places of residence identified by persons surveyed were integrated into the analysis and converted into several maps, on which the distribution of the different social attributes is visualized (see 0).

Our research encountered a range of difficulties and problems which, partially due to the empirical research situation and partially due to lack of experience**.** Every research is of subjective nature and highly influenced by the opinions, backgrounds, approaches and actions of its researchers. The entire analysis and interpretation, therefore, cannot be understood as factual and objective knowledge, but rather as a subjective social research in a specific scope. Although many of our questions were tested in advance with the help of Bahamian colleagues, within the group we could not entirely predict, which questions would be appropriate and understandable and which questions would exceed the local level of knowledge and education or readiness to answer. A certain degree of Eurocentrism is unavoidable and this in practice became especially visible as some questions delivered either highly divergent results or no outcomes at all, which is partially due to the assumed existence of similar worldviews and popular opinions. Further, it should be acknowledged that the random selection of survey participants most likely lead to an underrepresentation or failure of consideration of certain social groups since they were either not present at a given time or in the given street/area of the survey or generally avoiding the public. Though it was our intention to survey the whole range of population with various backgrounds, a detailed overview of the population cannot be provided due to the time restriction of the field research, which didn't allow for an in-depth exploration of all areas on NP, and the limited access to certain population or ethnic groups. While many participants reacted positively and were willing to contribute, some persons either rejected the survey (due to lack of trust or enthusiasm) or agreed, only to sell something to the interviewer or ask for money in return. Documented options and answers cannot be examined to the extent where the interviewer finds out about whether the answers given are (1) accurate or corresponding to the opinion of the speaker, (2) rather given to satisfy the interviewer or (3) not given for different reasons.

The classification and division into categories as well as the score system were done at our discretion and inevitably resulted in the partial inclusion and exclusion of selected data. Decisions on assignment, emphasis and relevance or irrelevance were made based on our team's construction, which makes the entire research our interpretation of prevailing phenomena and realities.

6.4. Analysis and results

At the beginning of the data analysis, we provide the pure calculated frequencies for a selected set of survey questions, considered as relevant for our study (see 6.4.1). Subsequently, a detailed explanation of the Climate Change Perception Score (CCPS) is given – describing the grade of one's personal CC perception derived from the given answers (see 6.4.2). The following chapters (see 6.4.3) are chronologically addressing one of the three formulated sub-questions of this study (see 6.1).

6.4.1. Perception of nature, environment, climate change and social inequalities

In this section, we provide the results of 12 selected survey questions which are relevant for our research interest. The set of questions comprises subjects concerning the people's perception of the environment, climate change, general threats, their societal participation and perceived social inequalities within the Bahamian society. All of the proportionate data is displayed in percentage. In some cases, categorizations compress many given answers within one category, especially regarding open questions on the personal opinion concerning 'nature' or 'recent changes', as well as the 'occupational status' of a person. This approach is indispensable regarding statistical results – nevertheless, a further analysis of the categorizations might be of interest. However, due to the amount of data, a full exploration of such was impossible.

a. How would you describe New Providence to a foreigner?

The majority of persons responded consistently positive as can be seen by the amount of given answers within the categories 'positive perception of island features' (34.5%) or 'positive feelings/vibes/atmosphere/ spirit' (16.5%). In contrast, given answers related to a negative category constantly score below 5.0%, e.g. 'negative perception of island features' with a value of 4.1% (see Figure 6.2).

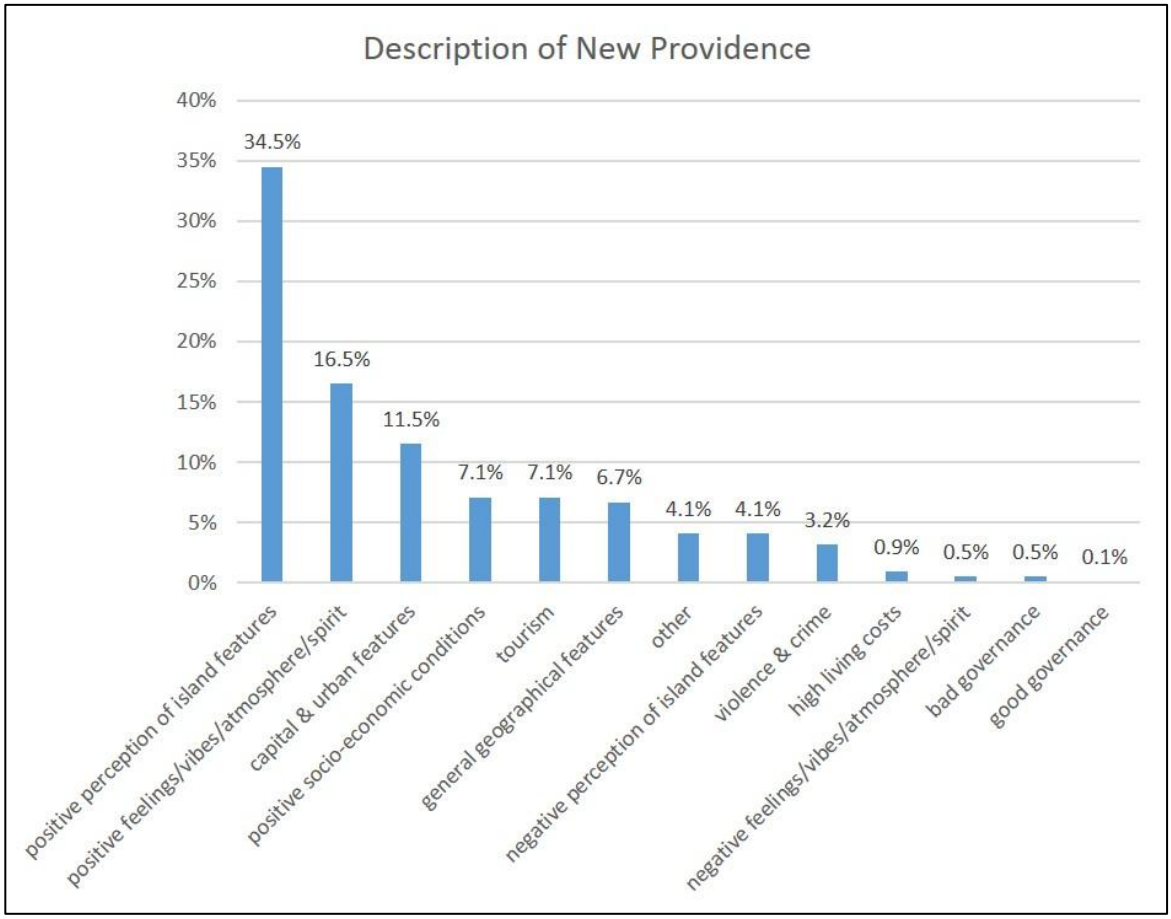


Figure 6.2: Description of New Providence [n=886]

b. What are the most important recent changes on New Providence that you have experienced?

The majority of the given answers concerning the most important recent changes is mainly negatively afflicted: 'Increase of living costs' (15.0%), 'Negative socio-economic development' (14.7%) and 'Increase of violence & crime' (10.4%). Besides these answers, there are also positive related responses as can be seen by looking at the fourth frequent given answer: 'Positive development of island & tourism infrastructure' (9.7%). Talking about infrastructure and development, the 'Baha Mar' was mentioned several times directly. This explains why it exists as an individual category (5.8%). However, 3.2% of the persons surveyed still do not perceive any changes at all (see Figure 6.3).

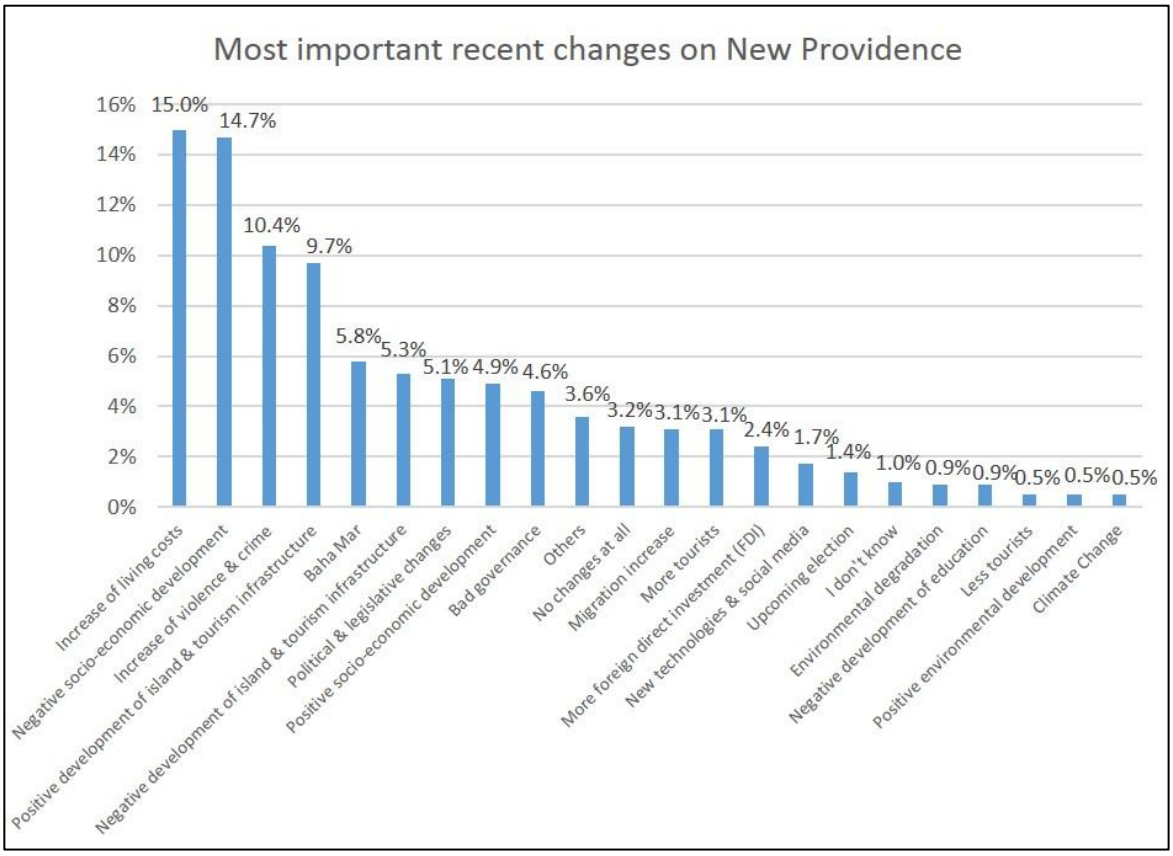


Figure 6.3: Most important recent changes on New Providence [n=587]

c. What are the major dangers or threats you are afraid of?

When asking about the major dangers or threats, the respondent is afraid of, by far the most given answers fit the category 'crime, drugs & violence' (54.3%). With a value of 8.6%, the answer 'nothing' is ranked the second frequent answer. 'National socio-economic insecurity' ranges below the latter category (7.6%). All other answers again remain under a 5.0% frequency (see Figure 6.4).

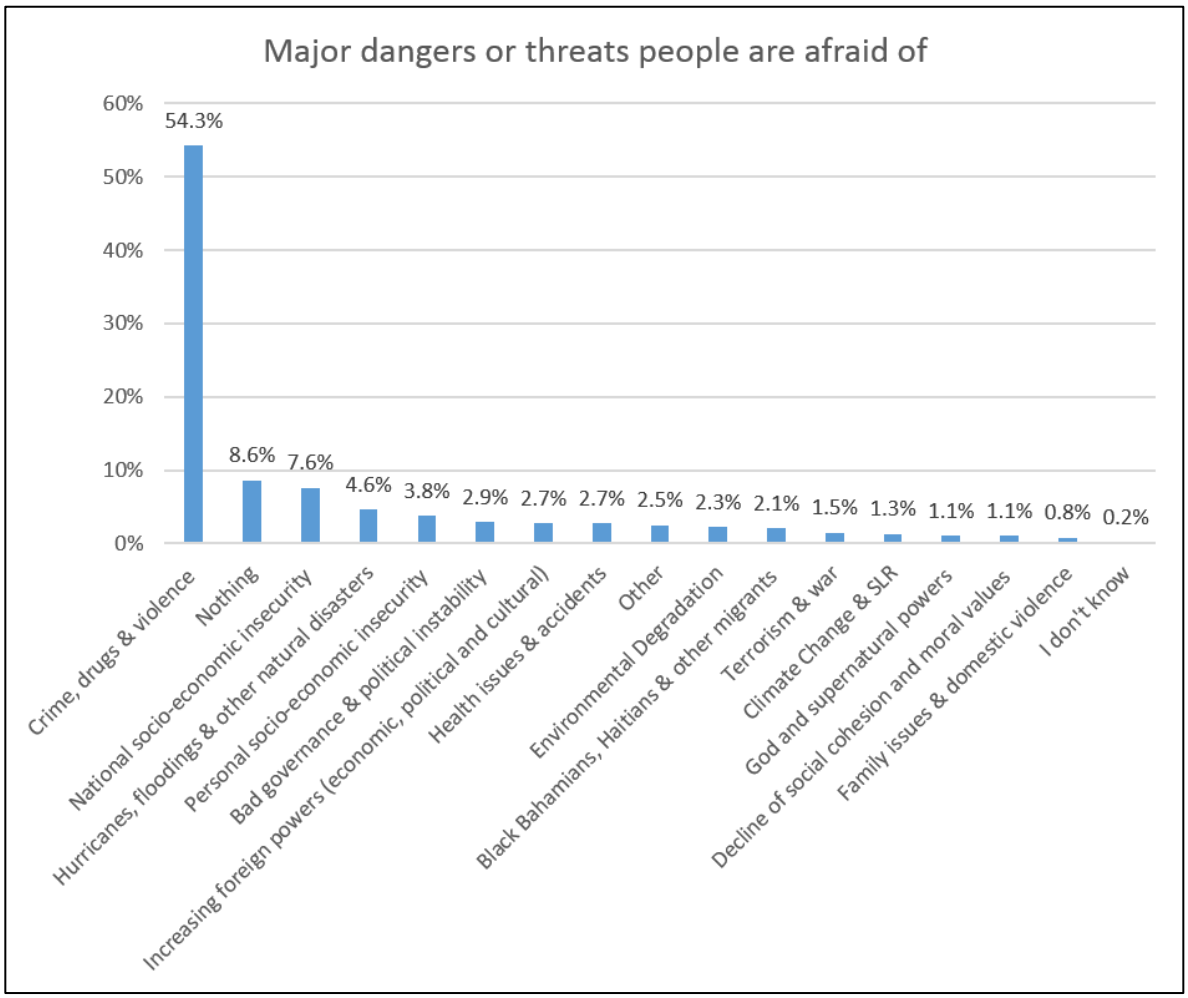


Figure 6.4: Major dangers or threats people are afraid of [n=525]

d. What is nature for you?

'Flora/fauna/physical feature' represents the category with the highest frequency (60.7%) regarding the question "What is nature for you?". Besides that, people also mentioned 'outdoor activities & leisure time' (14.5%) as well as 'positive feelings/ references' (13.5%) (see Figure 6.5).

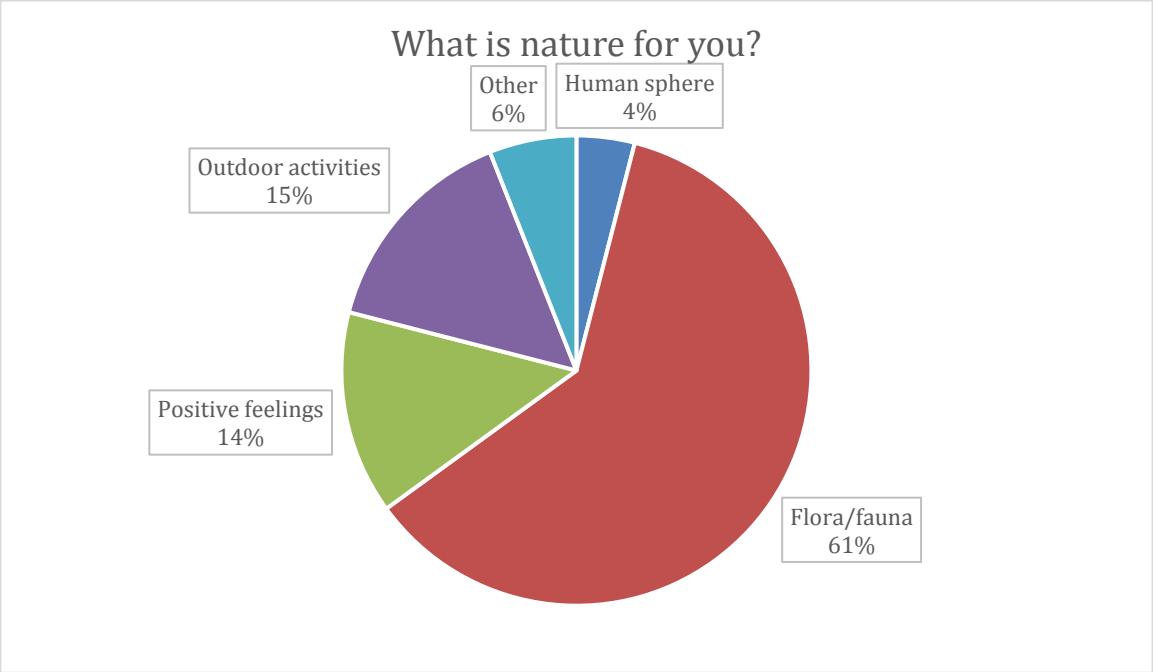


Figure 6.5: What is nature for you? [n=732]

e. Which environmental changes have you observed in recent years?

'Man-made land changes' was the most frequent answer (14.8%) regarding the "observation of environmental changes in recent years", followed by answers within the topic 'Environmental Degradation' (12.0%). 'Climate Change' was mentioned as the third frequent (10.6%) environmental change in recent years. Only a minority of 2.8% of the respondents referred to the issue of 'Sea-level rise' (see Figure 6.6).

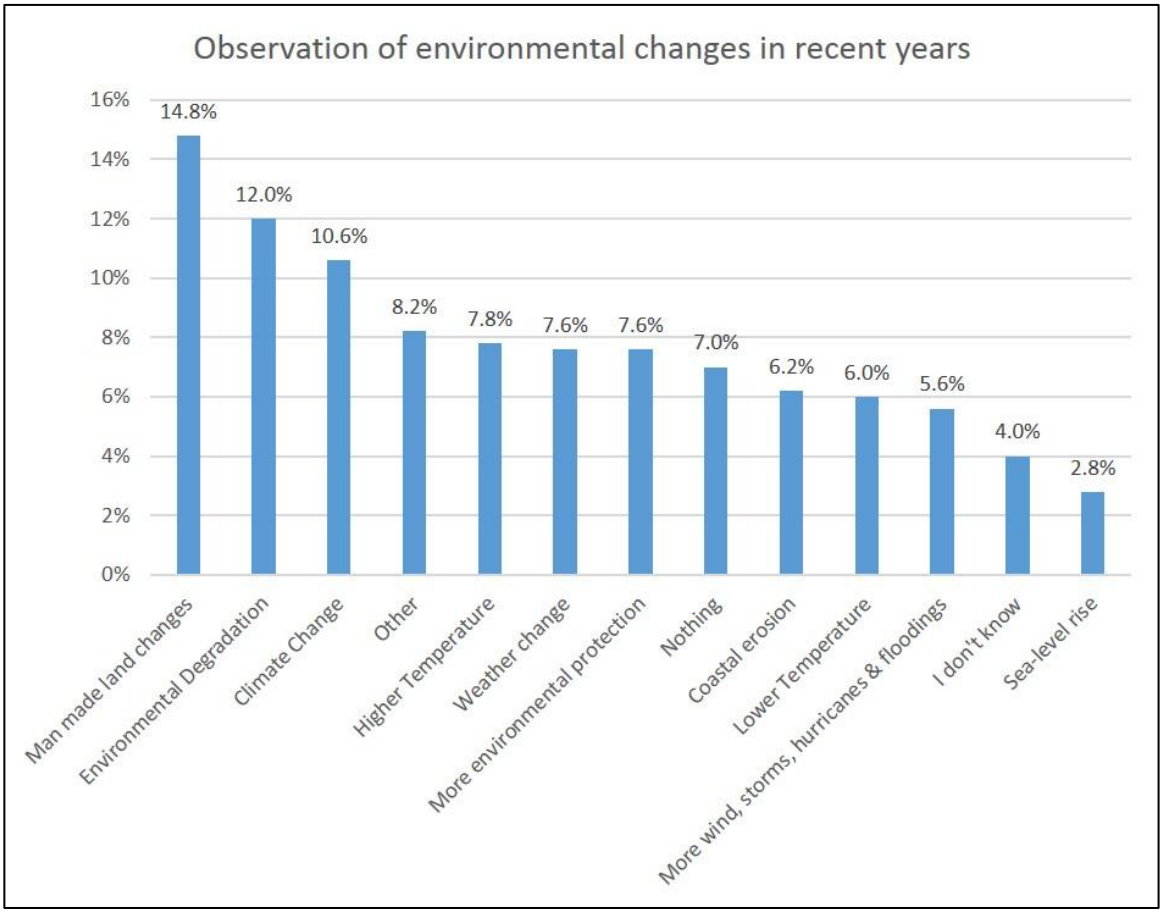


Figure 6.6: Observation of environmental changes in recent years [n=501]

f. What do you think are the main impacts of climate change on the Bahamas?

In comparison to that, the most frequent answer to the question about the main impacts of CC on the Bahamas is 'Sea-level rise' (13.0%). Besides that 'Environmental Degradation', 'Higher Temperature' and 'Weather change' were given answers with a frequency of more than 10.0%. 9.8% of the respondents rejected, in contrast, the idea of an impact of CC on the Bahamas (see Figure 6.7).

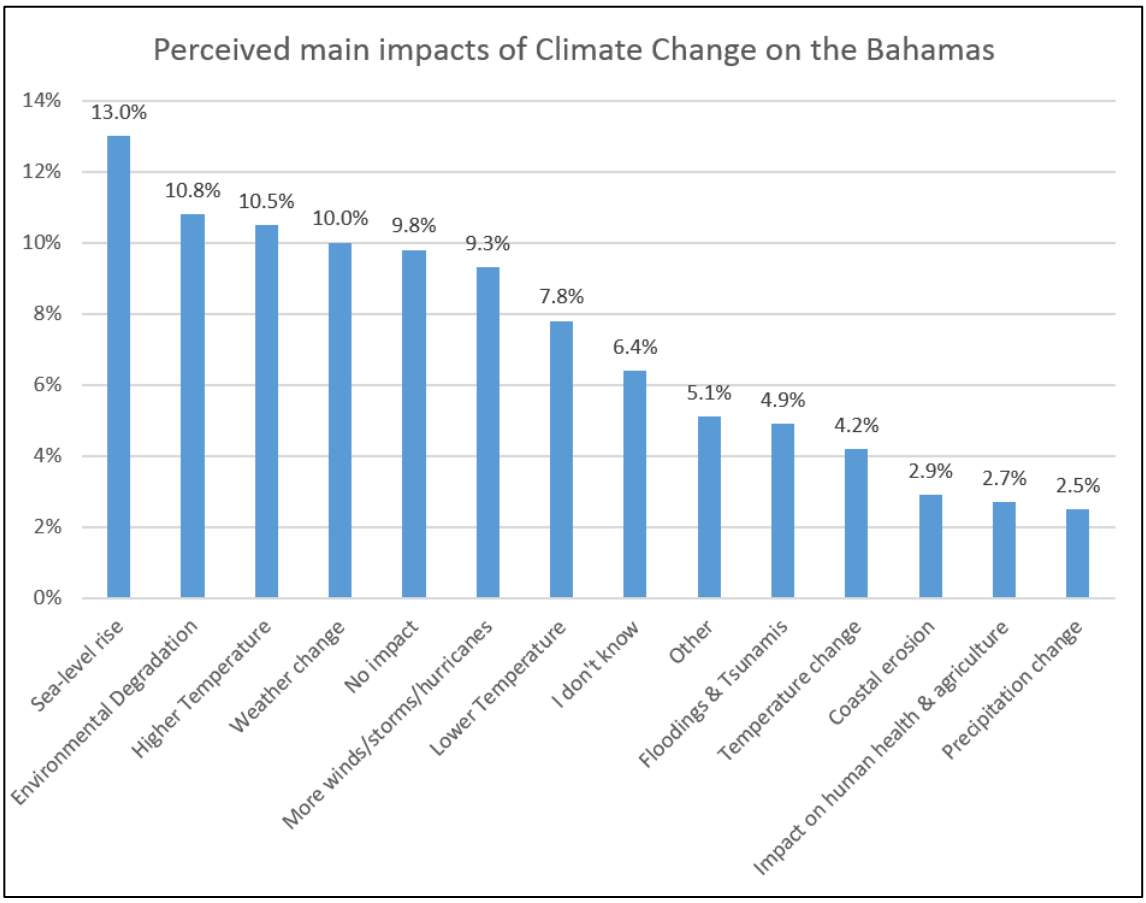


Figure 6.7: Perceived main impacts of climate change on the Bahamas [n=408]

g. What are the major functions of coral reefs and mangroves?

By far the most given answer to the question about the major functions of coral reefs and mangroves are located within the subject category of 'Protection of marine & coastal ecosystems' (42.9%), followed by the function of 'Natural coast protection' e.g. wave breakers (13.8%). 'Breeding area for sea life & birds' was also mentioned by 12.3%". 'Oxygen production & Carbon dioxide storage' was mentioned only five times in total (1.0%) (see Figure 6.8).

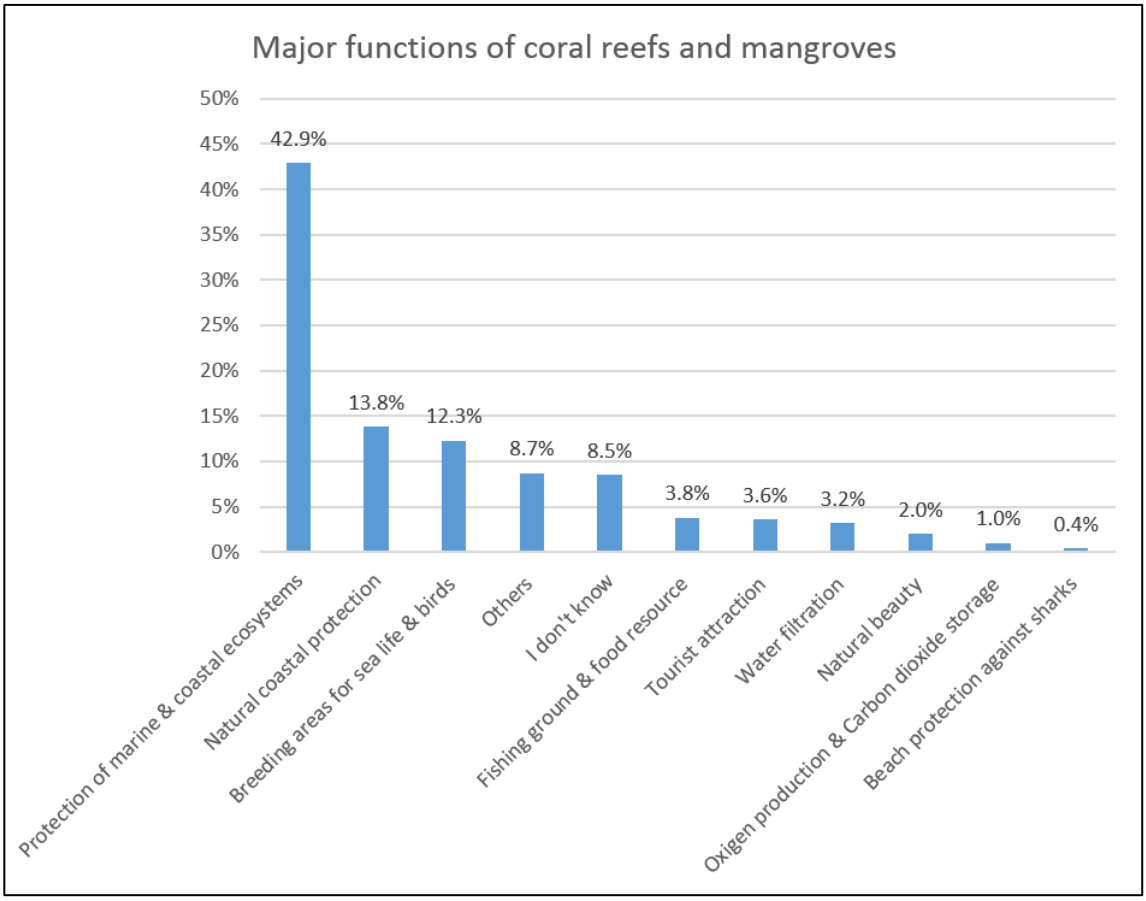


Figure 6.8: Major functions of coral reefs and mangroves [n=506]

h. Do you feel yourself affected/threatened by sea level rise?

65.0 % of the respondents believe that the Bahamas are threatened by SLR (n=323). 42.3% of the respondents also feel personally affected/threatened by SLR (n=326). The most frequent given explanation within this context was 'yes, because of the island geography' (26.3%), followed by 'yes, because of occurrence of natural disasters' (17.0%). Regarding the explanation of why persons did in fact not feel affected, the most frequent statement was 'no, because it's not an urgent problem' (8.8%) (see Figure 6.9).

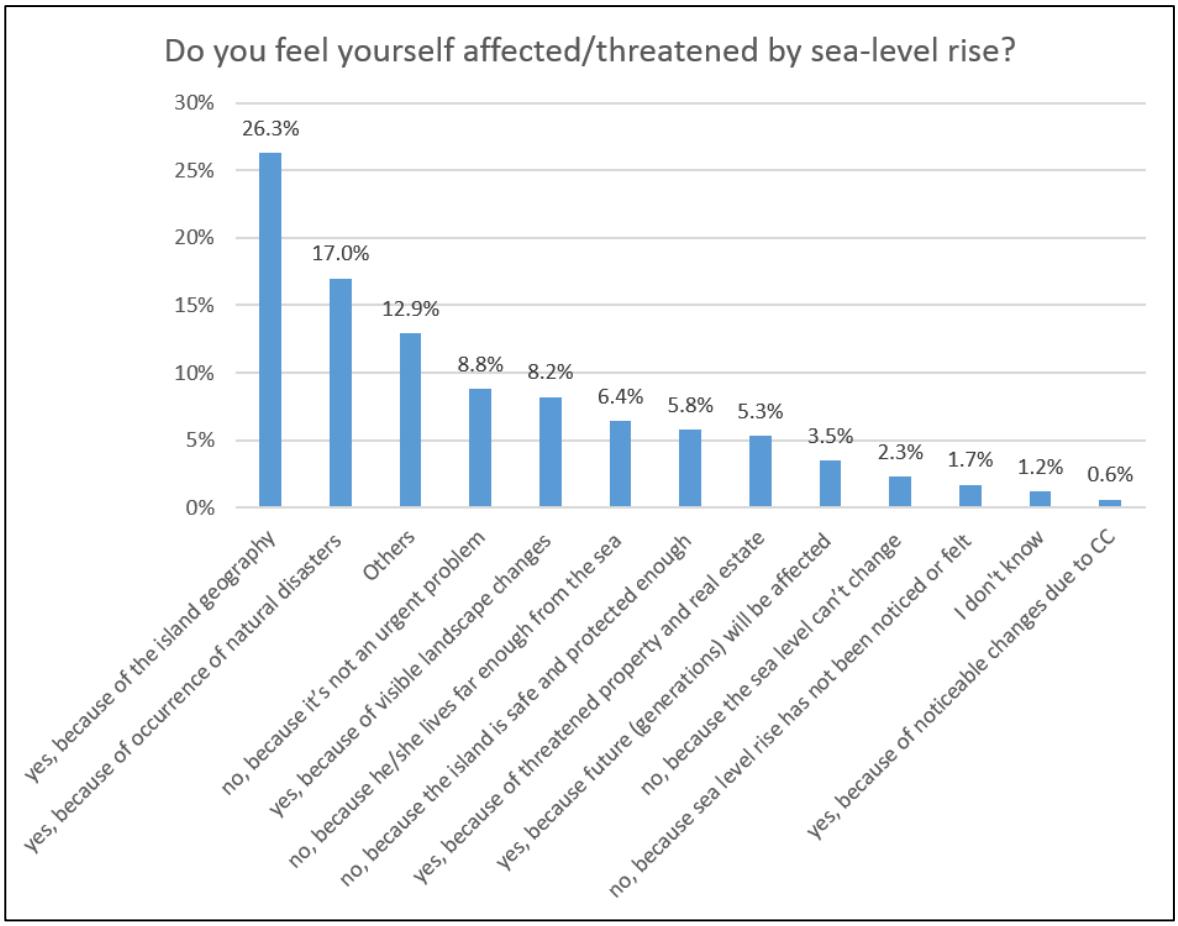


Figure 6.9: Do you feel yourself affected/threatened by sea-level rise? [n=171]

i. Do you personally participate in local coastal protection efforts?

38.7% of the respondents participate in local coastal protection efforts (n=328). By enumerating this result in detail, the frequent explanation of efforts made was 'Beach or sea cleaning' (59.6%), followed by 'Organization, Management and Research' (14.2%) (see Figure 6.10).

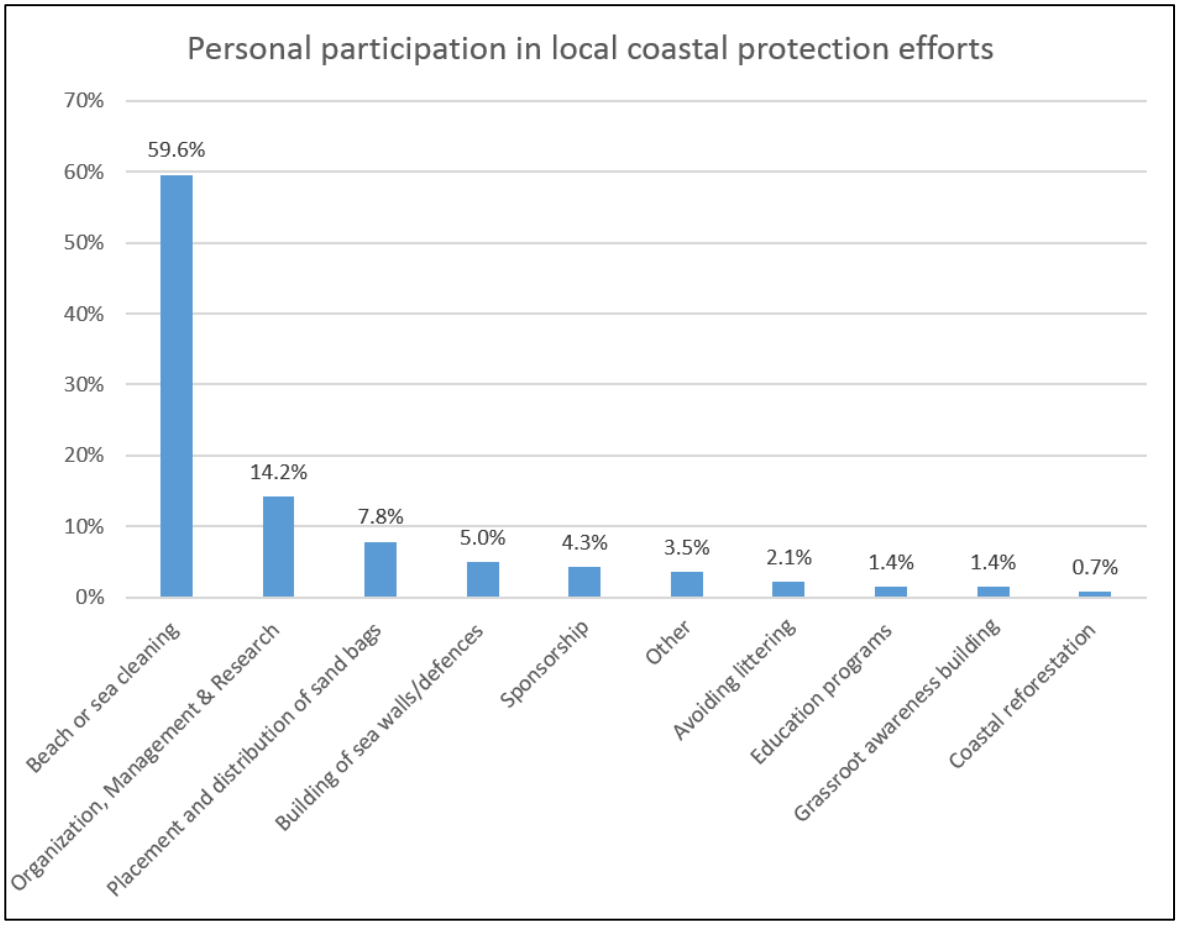


Figure 6.10: Personal participation in local coastal protection efforts [n=141]

j. Where do you get information about climate change from?

45.1% of the respondents feel sufficiently informed concerning CC and/or SLR (n=326). Most of these persons get their information from 'TV & news' (36.6%), followed by the 'Internet' (19.6%). Remarkably, 7.7% of the respondents take part in 'own self-education & research' by reading scientific papers or books about these processes (see Figure 6.11).

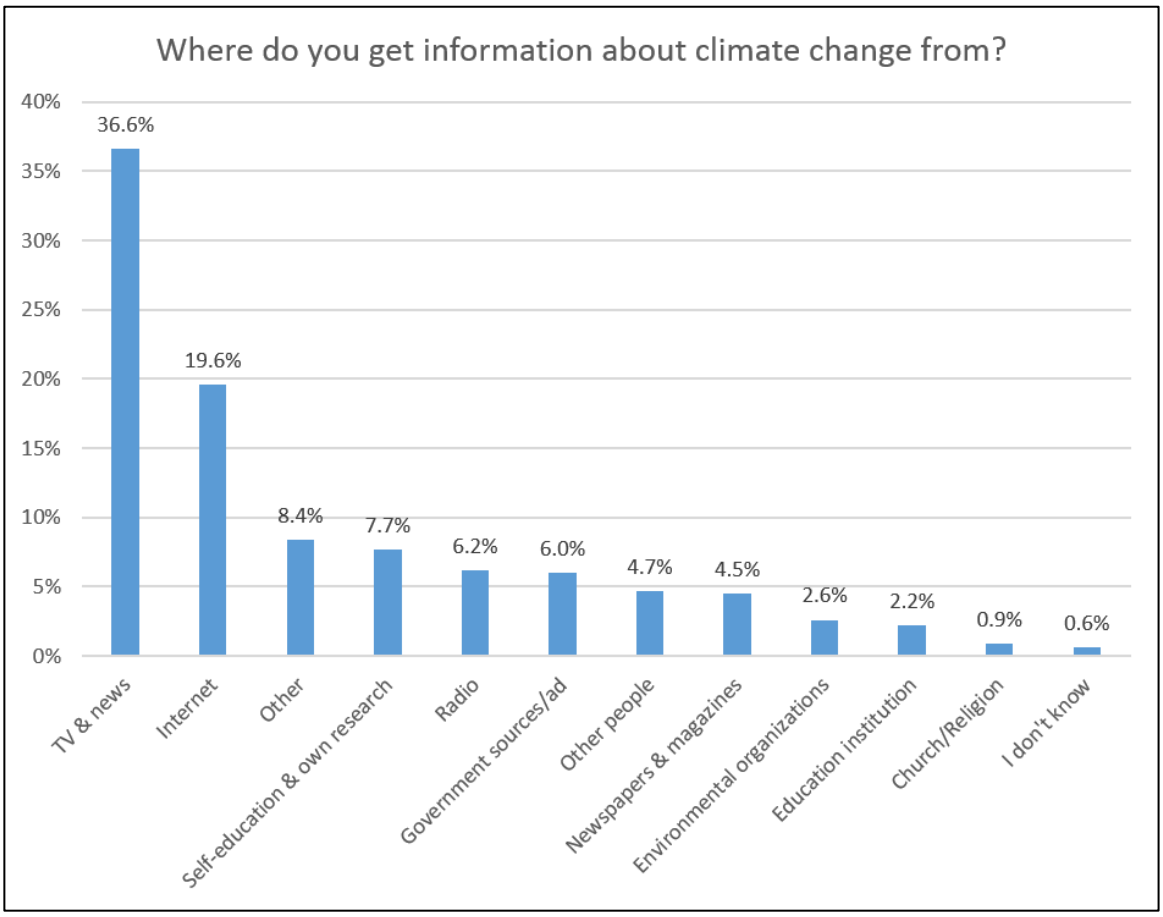


Figure 6.11: Where do you get information about climate change from? [n=465]

k. On which means of support can you generally rely in case of a personal emergency?

For most of the people interviewed, 'Family' (34.5%) was the most important answer to this question. Second came answers of the category 'Government facilities and services' in which we summarized e.g. hospitals, police or ambulance (30.7%) (see Figure 6.12).

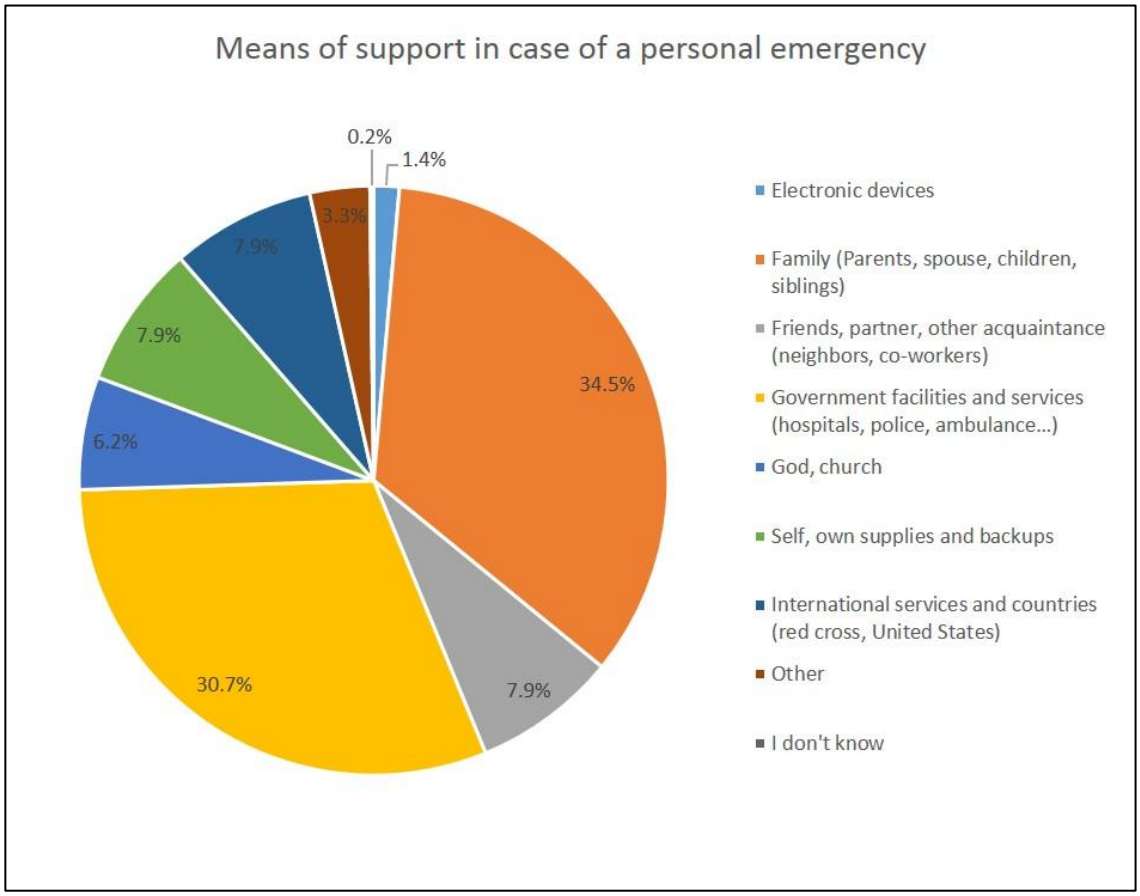


Figure 6.12: Means of support in case of a personal emergency [n=420]

l. Do you perceive inequalities within the Bahamian society?

67.9% of the respondents perceive inequalities within the Bahamian society (n=318). A frequently given explanation to this answer was related to 'Socio-economic inequalities' (36.6%). %). 'Racism & Xenophobia' (21.7%) was explicitly mentioned by some of the respondents. The third most frequent answer fits the category 'Political inequalities' (15.7%), followed by 'Gender & sexual orientation' (12.3%) (see Figure 6.13).

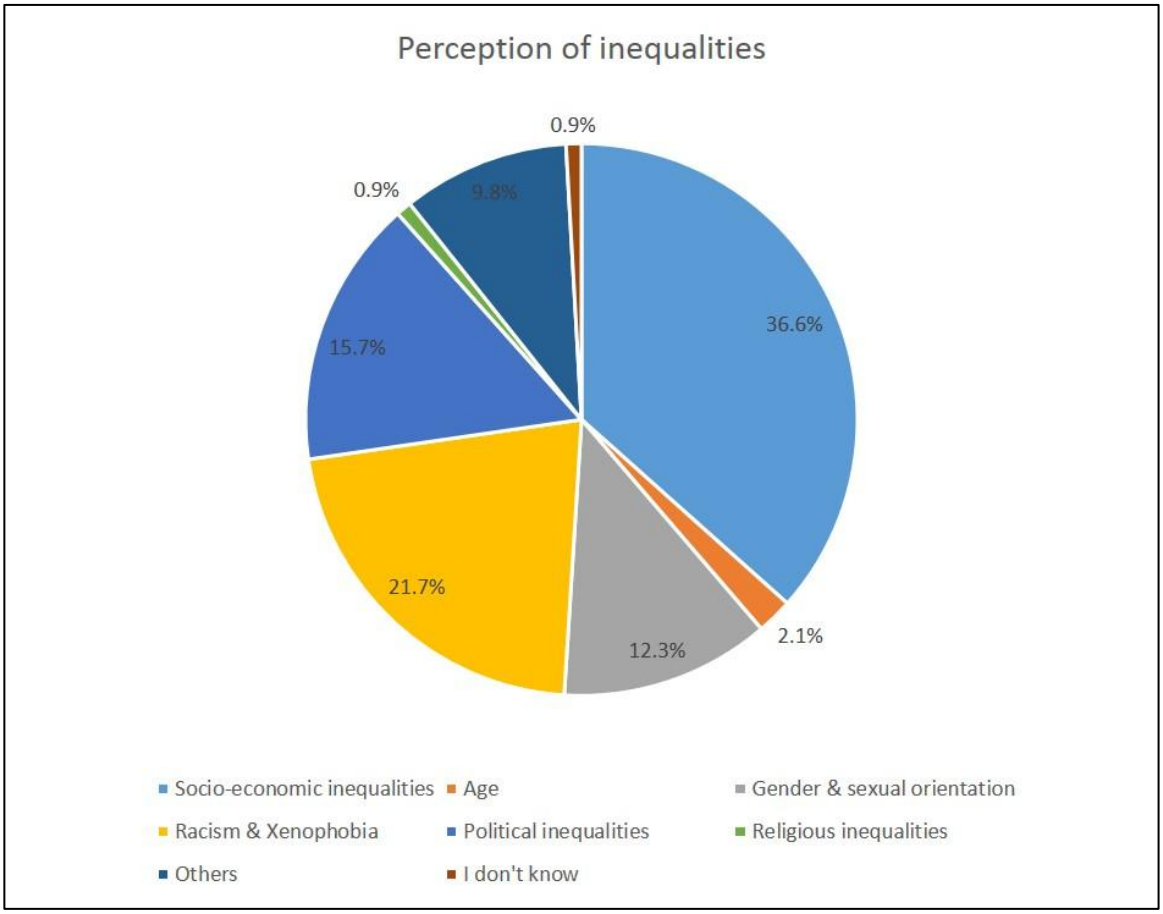


Figure 6.13: Perception of inequalities [n=235]

6.4.2. The Climate Change Perception Score (CCPS)

A special CC Perception Score (CCPS) was developed based on selected answers of the population survey. For the questions 2, 3, 12, 13, 17, 18, each mentioned keyword equalled one score point, adding up to an individual CCPS per interviewee (min. 0, max. 10, Ø 3.089).

Figure 6.14 is illustrating the result of the CCPS distribution among the participants of the survey. The majority's CCPS is not that pronounced. Most of the respondents reflect a perception of '3' (18.6%), followed by '1' (16.8%) and '4' (14.4%). Only in each case, one respondent possesses a perception of '9' and '10' (each 0.3%).

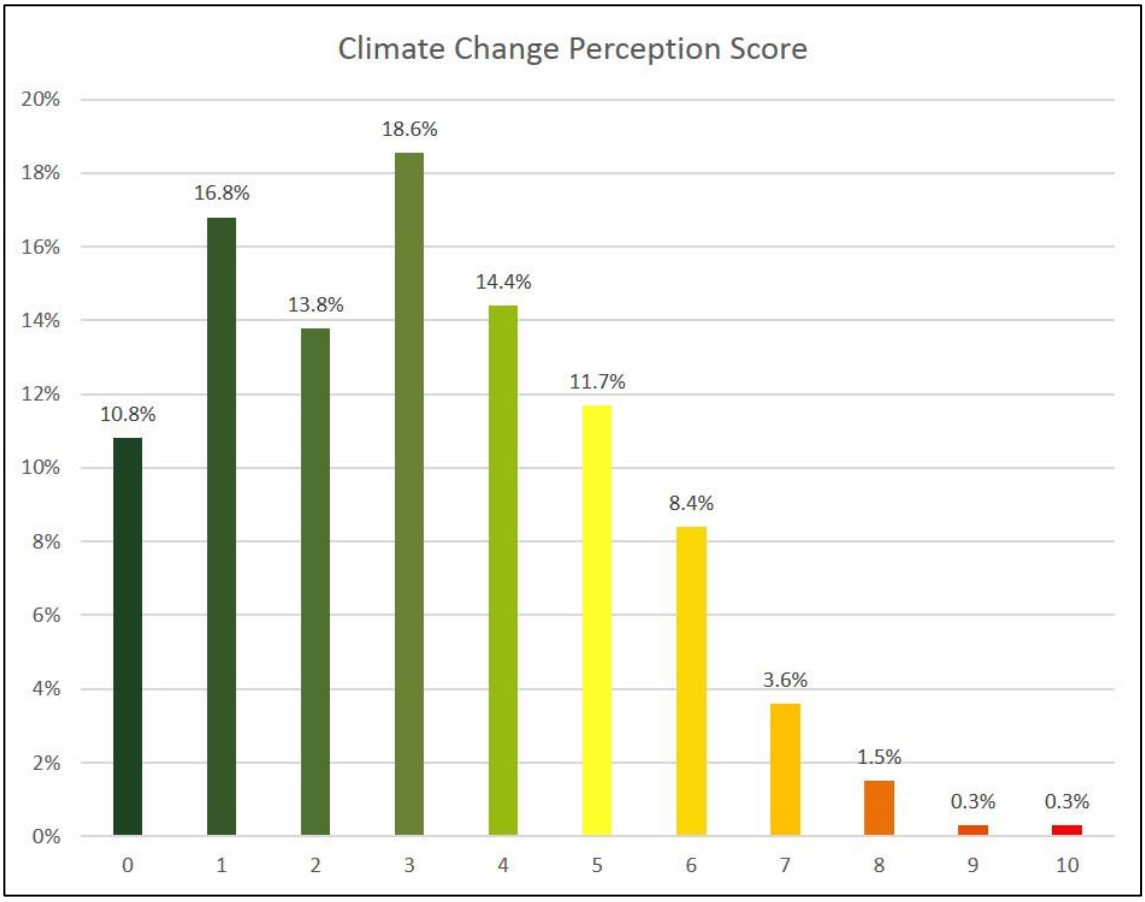


Figure 6.14: Climate Change Perception Score, distribution in % [n=334]

6.4.3. The impact of ethnicity and gender on the socio-economic position

To break down and analyze our primary research question, *What is the impact of class, ethnicity and gender on climate change perception on New Providence?,* we formulated three sub-questions. The following analysis explores the influences and interplays of ethnicity, gender and class as defined by the meritocratic triad. Since all three terms are multidimensional and consisting of numerous aspects, an operational definition is necessary before looking at the ways that ethnicity, gender and class intersect.

For this research project, the socio-economic position or class of an individual is defined by education, occupation and income. The term ethnicity subsumes the aspects of skin colour, origin, migration background and religion. Gender describes the physical and social condition of being male or female. Not directly included in any of the three is the factor age, which nevertheless will appear

as part of this analysis as it appears to be of relevance in the context of social inequalities on NP. Questions about education, income, gender, skin colour, origin, migration, religion and age were included in the street survey and therefore statistically evaluated and interpreted. The question of migration refers to the migrant background of the participant's parents, while this in the guided expert interviews mainly refers to both immediate and generational migration. Although included in the survey, occupation was not statistically analyzed from the questionnaire as we found the results of rather low informative value regarding our research questions. Information regarding this matter, therefore, stems from the statements made by our interviewees. In the following paragraph, the interplay of the aspects class, ethnicity and gender will be explained and interpreted based on our surveyed statistical data and the outcomes from the expert interviews before drawing a conclusion regarding the first of our sub-questions.

Access to education influenced by income

The influence of income on the access to education is not possible to answer since our statistical information concerning income in our survey refers to the informant's income only. However, education, in the most cases, is not primarily dependent on own income but on the resources of an older generation (parents, grandparents). Interviewees stated that the availability of financial resources does affect the access to education in the Bahamas. Education institutions of higher standard, e.g. private schools or international universities, demand tuition fees that are significantly higher than those of public schools. Therefore, new generations of students depend on the parent's income resulting and confirming the emergence of a class system (Interview I, IV & XIV).

Income influenced by education

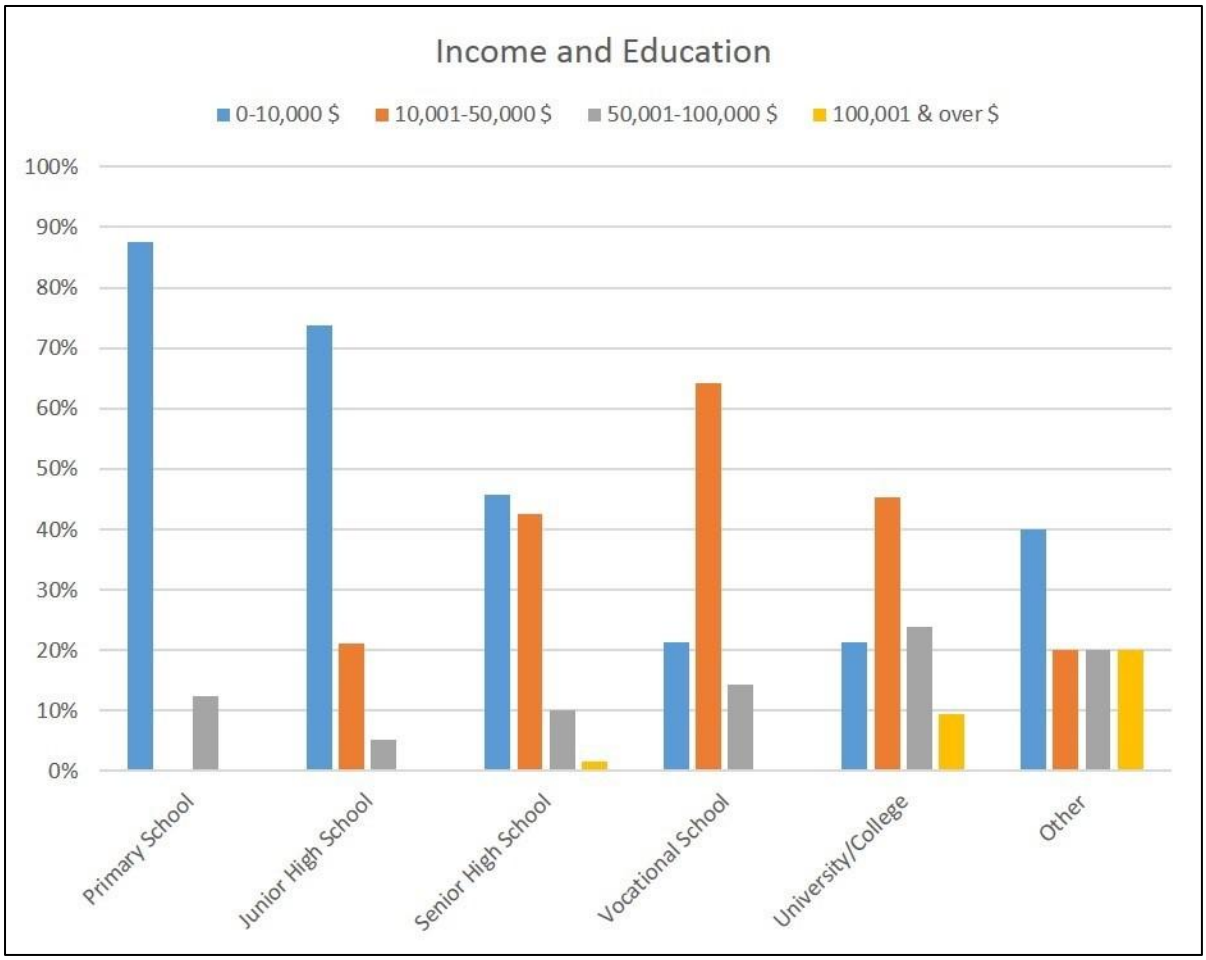


Figure 6.15: Impact of education on income [n=292]

Figure 6.15 displays that income is indeed influenced by education qualifications. Yet the figure suggests that a College or University degree does not guarantee placement in the higher income categories. The majority of graduates from Colleges or Universities (45.3%) has an average annual income of 10,001-50,000$.

Access to education influenced by skin colour

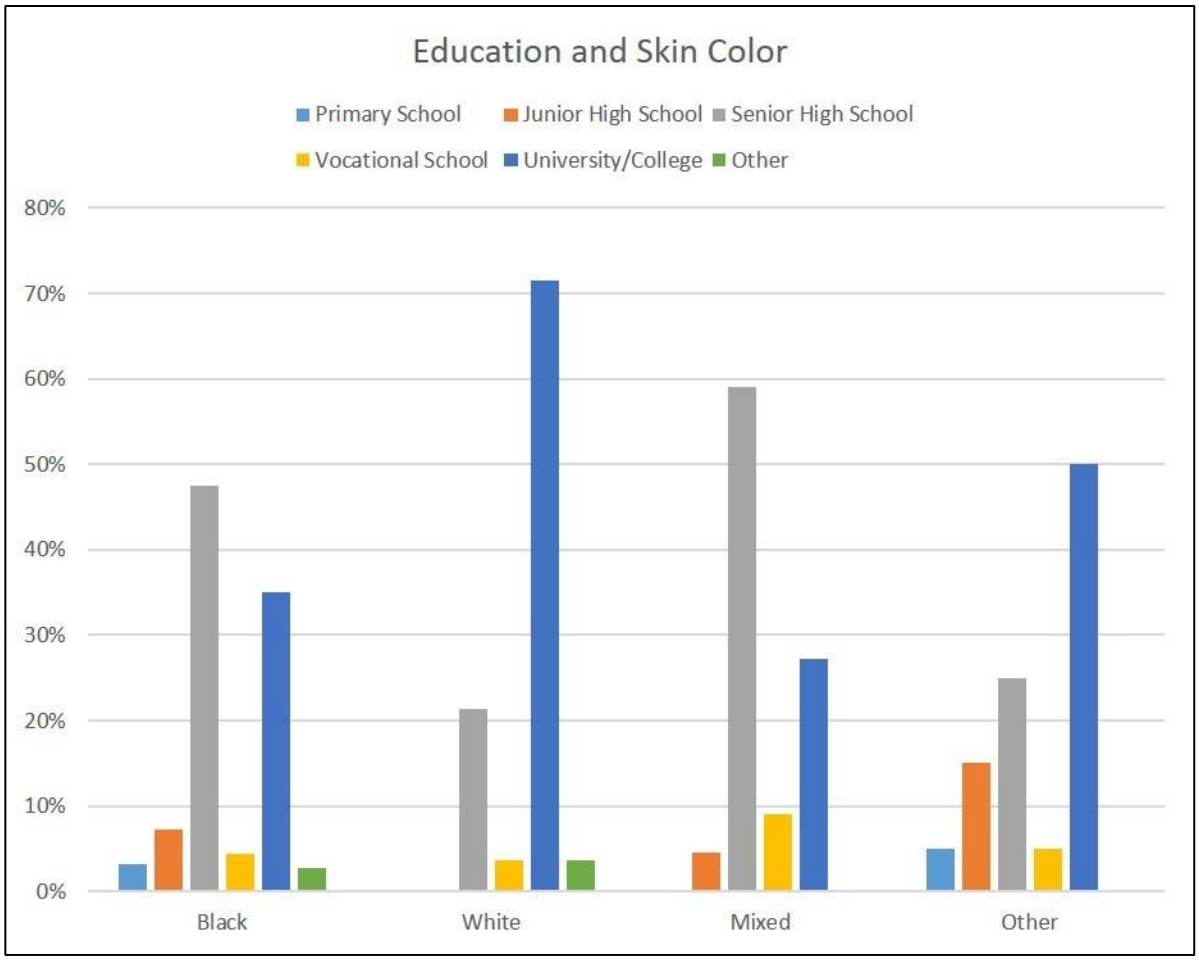


Figure 6.16: Impact of skin colour on education [n=321]

Our statistical information suggests (see Figure 6.16) a relation between the access to education and skin colour. Interview material on this issue was rather implicit. While many interviewees did not perceive skin colour discrimination a relevant topic in the Bahamas, it was mentioned that rather an intersection of background, income and skin colour plays a role regarding social inequalities (Interview XIV).

Access to education influenced by origin

Figure 6.17 demonstrates, there is a possible relation between access to education and origin or background. In this particular case, the category 'low-income country' only provides two surveyed persons, which makes the figures not comparable with the rest of the data.

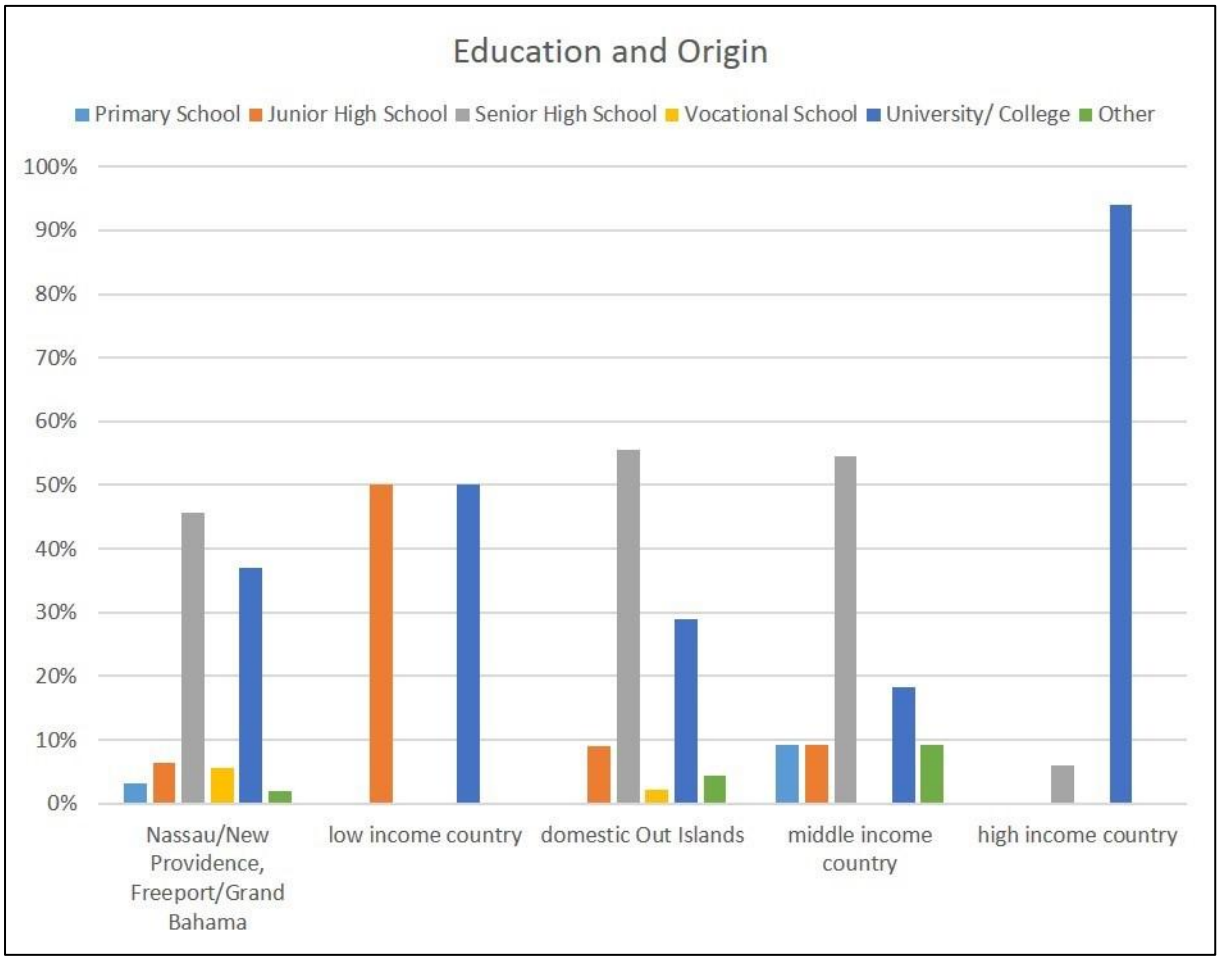


Figure 6.17: Impact of origin on education [n=323]

According to the interview information, especially young person's originating from low-income countries like Haiti and Jamaica gain access to education only with great difficulty. Factors such as names (which can indicate the person's origin) are used as pretexts and reasons to discriminate against persons coming from these countries (Interview V & XIV).

Access to education influenced by migration

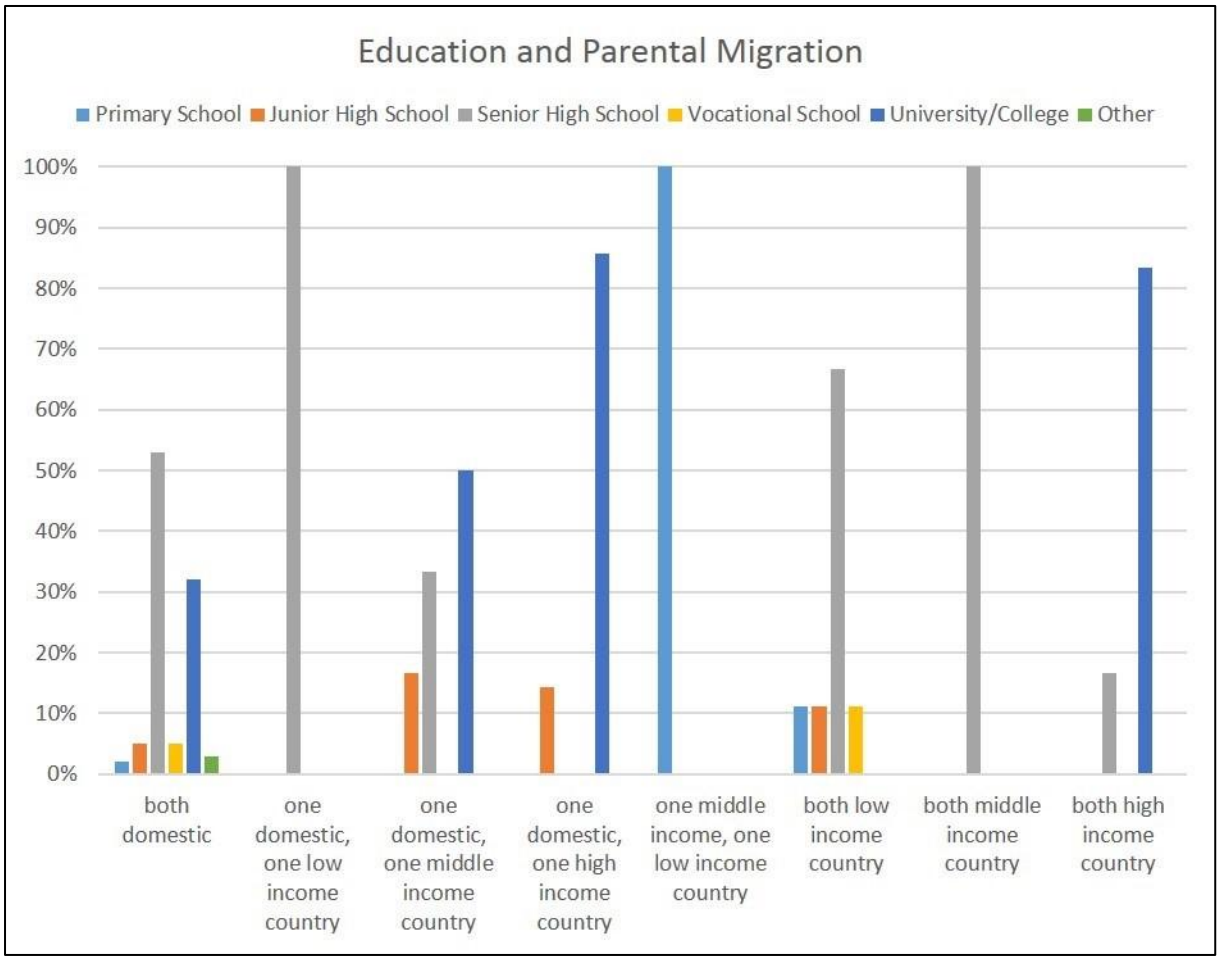


Figure 6.18: Impact of parental migration on education [n=131]

Figure 6.18 suggests, migration has the potential to negatively impact the access to education. This finding was overall supported by the outcome of our interviews. Wealth is unequally distributed over the country and the family islands are generally 'poorer' than NP, so when migrating from these islands to NP the living costs and expenditures increase (Interview I). Especially illegal immigration from countries like Haiti and Jamaica have a huge influence on the access to education, since the acquirement of official documents and the recognition of status from the Bahamian government becomes harder if not impossible; as long as a person (and his/her children) holds an illegal status access to education cannot be ensured (Interview XIV).

Occupation influenced by skin colour

Although there is no clear discrimination against any specific skin colour, people generally perceive lighter skin with more opportunities on the labour market, better treatment and increased acceptance (Interview VIII & XIII). Among the interview partners, we found different perceptions on whether an applicant with darker skin colour, holding the same qualification as an applicant with lighter skin, would have a disadvantage regarding receiving an offer. While some interviewees did not think skin colour would play a leading role due to a mainly black population on the Bahamas (Interview I & XIII), others stated that it would be more likely for a person with lighter skin to receive the job (or generally a higher position than someone with darker skin) due to the perception of

superiority of white skin colour (a remnant from colonialism and slavery) (Interview IV & XI).

Occupation influenced by origin and migration

Persons, especially from impoverished areas, find themselves trapped in a vicious cycle of lack of monetary resources, missing formal education and as a result lack of competitiveness on the job market. The occupation sector is influenced by origin in a way that low-paid jobs and illicit work (e.g. gardening, looking after children) are often performed by persons having migrated illegally and who are willing to fulfil these tasks for a much cheaper wage than Bahamians (Interview VII). Immigrants without official documents or legal status in the Bahamas face the struggle of having to take these low-paid, illegal jobs; their status neither allows for them to negotiate over working conditions or wage nor does it leave them much choice as they have to fear to be deported back to their home country at any time (Interview IV & V). At the same time persons with foreign background (and lighter skin colour), coming from high-income countries, may experience some level of admiration and appreciation regarding placements in the job market (Interview IV).

Occupation influenced by religion

The Bahamas are considered a Christian nation in which religion plays a role in many aspects of social life. Religion influences occupation to the extent that some jobs (especially anything related to politics) require the job holder to express a certain degree of religiousness (Interview XIII & XIV). Some of the interview partners mentioned that certain Christian denominations, in this case, Anglican and Catholic, have a higher tendency to place their community members in more favourable jobs. Reasons for that are the pronounced relations of power within these churches, therefore allowing their members to become part of wider social networks (Interview IX).

Income influenced by skin colour

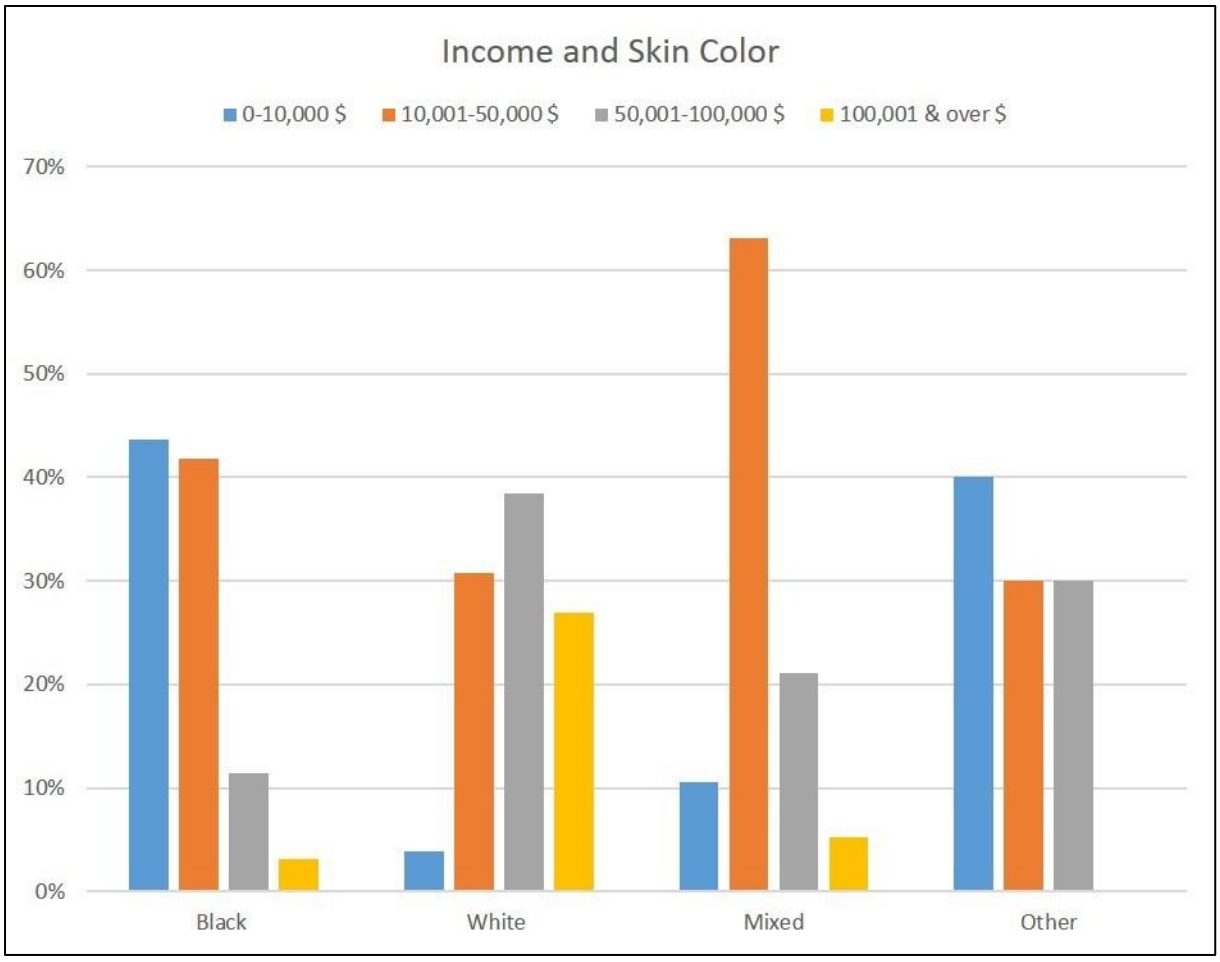


Figure 6.19: Impact of skin colour on income [n=292]

The statistics, visualized in the graph above, reveal a possible connection between income and skin colour (see Figure 6.19). As stated in some of our expert interviews, wealth and income are unequally distributed, and many white Bahamians find themselves in more favourable positions as they can trace wealth back from before the majority rule or from times in which racial segregation played an even more important role as today (Interview IV). Resources and power are passed on through lineages within families who remain in control for a long time (Interview 4). These families are not merely of the same ethnic or racial background, nevertheless, they appear to be generally of lighter skin colours (Interview XIII). According to one of our interview partners, there remains a white minority on the Bahamas that holds an oligopoly on the wholesale trade of the islands (Interview I).

Income influenced by origin

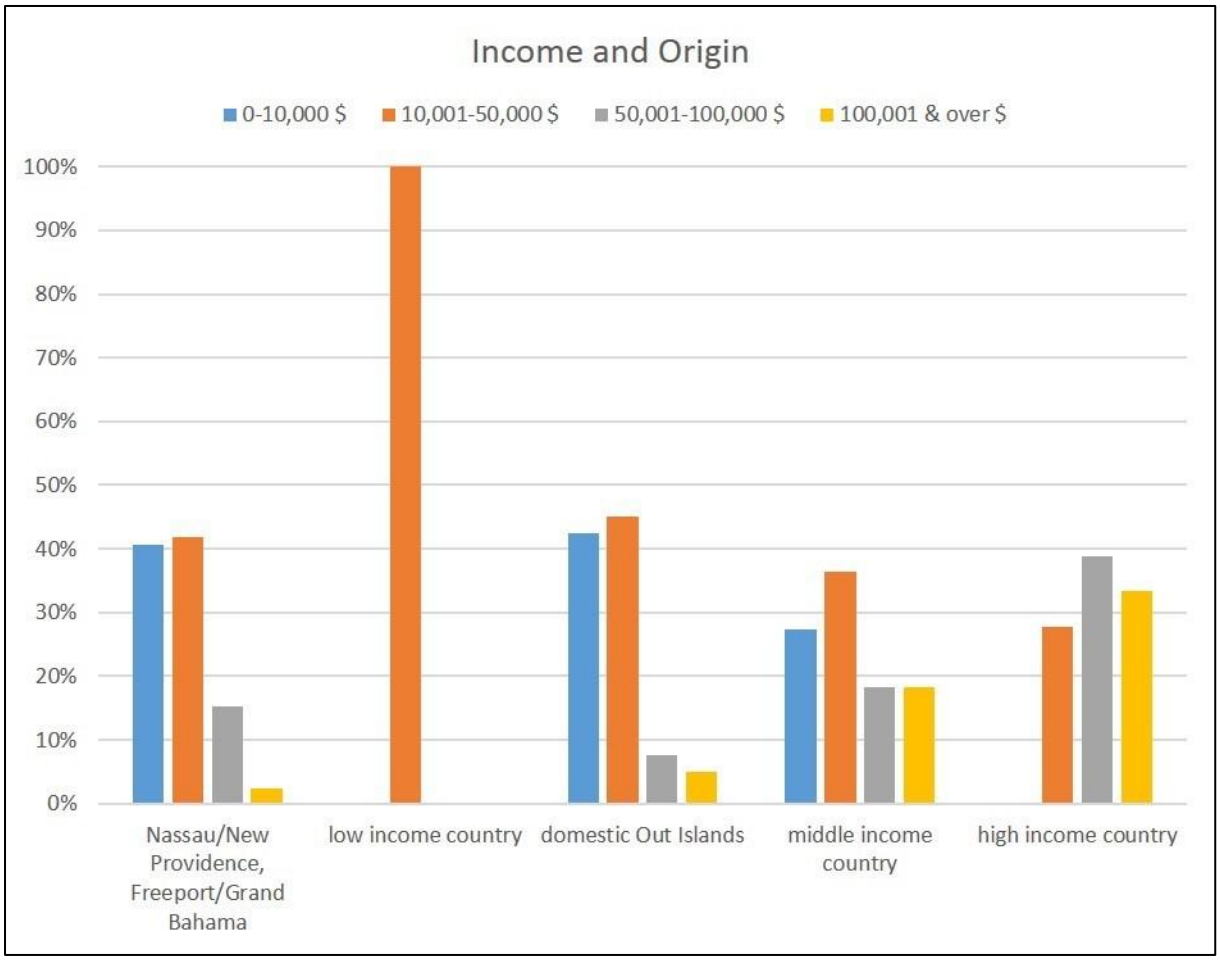


Figure 6.20: Impact of origin on income [n=293]

Individuals originating from places other than Nassau or Freeport are generally more strongly represented in the higher income categories. Persons with origin from both Nassau/Freeport and the outer domestic islands hold significantly lower incomes than persons originating from middle or high-income countries (see Figure 6.20). (Since income is directly linked to occupation, conclusions can be linked to the output of question g. (the influence of origin and migration on occupation). As foreigners from middle or high-income countries are perceived to be more easily accepted and valued than local persons or persons originating from low-income countries, they may hold more favourable positions in terms of placement in the labour market and negotiating over levels of income. When looking at domestic migration one factor that contributes to higher representation of persons from the outer islands in lower income categories is the high living costs prevailing in NP (Interview I).

Income and occupation influenced by age

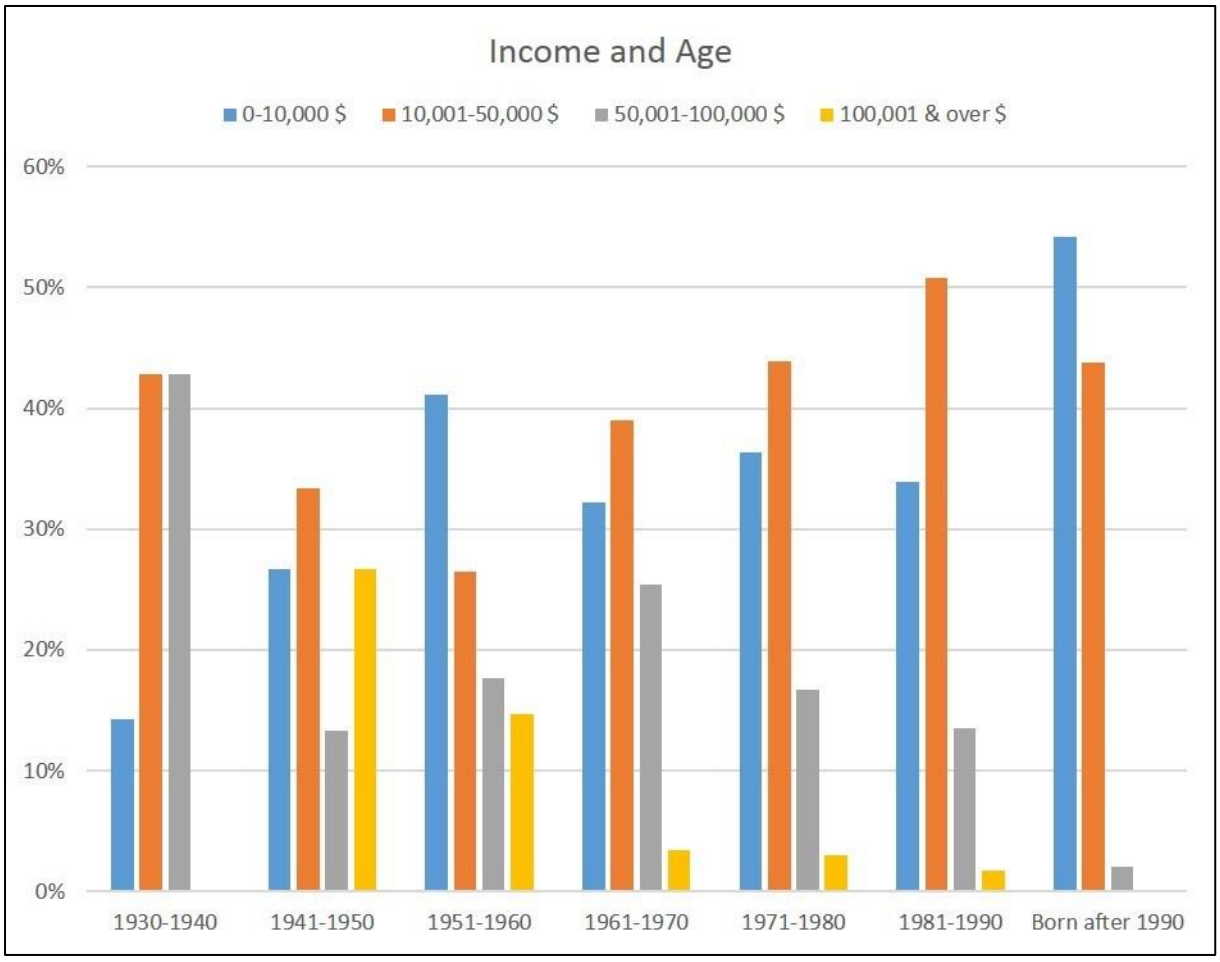


Figure 6.21: Impact of age on income [n=288]

Age plays a role regarding income (see Figure 6.21). This is, by all means, logical, since persons develop working experience over time and accumulate knowledge, skills and as a result, income and wealth, over the years. Many young people find themselves unemployed not merely because of lack of education and therefore incapacity of competition on the labour market (Interview VIII), but also because there is a tendency of preferring to employ older persons who are likely to be more experienced and "reasonable" (Interview XIII). Besides bearing the danger of sliding directly into a state of poverty, the unemployment and lack of perspective specifically at a young age creates helplessness and frustration and is partially responsible for the high crime rate in and around Nassau (Interview II, III, IX, XIII & XIV).

Access to education influenced by gender

The statistics displayed in Figure 6.22 show that the majority of females surveyed who held an education qualification had a college or university degree (48.3%). Compared to that, only 30.6% of males surveyed held the same qualification, the majority (51.1%) completed senior high school only.

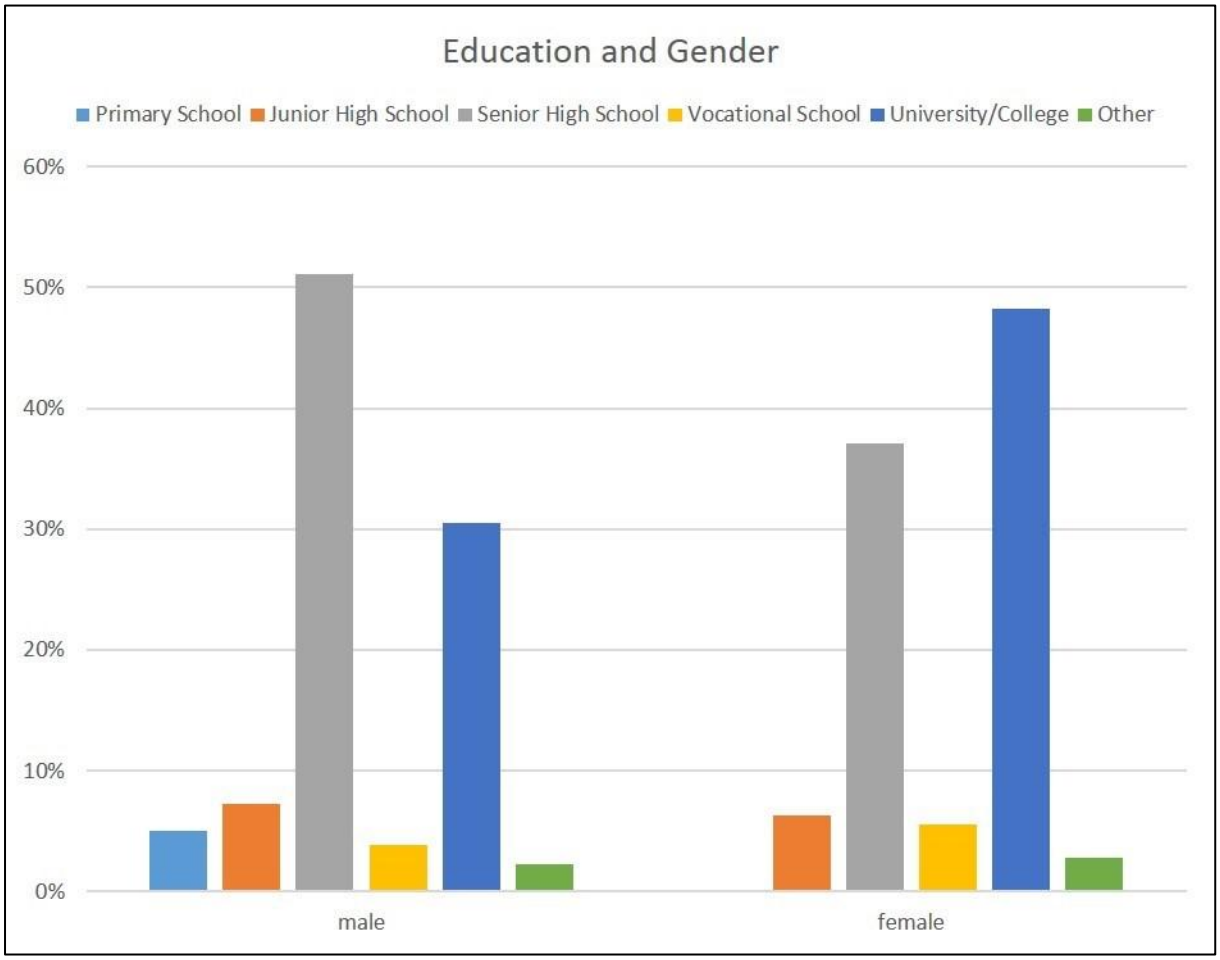


Figure 6.22: Impact of gender on education [n=323]

Income influenced by gender

As Figure 6.23 depicts, a greater percentage of females than of males is represented in the lowest income group (44.5% females and 32.1% males). As for the highest income group males surveyed exceeded females by 2.1%.

Interesting about this is the percentage of females surveyed who held a college or university degree, which was 17.7 percentage points higher than males holding the same qualification. This underlines the statement by some of the interviewees that higher education qualifications are no guarantor of finding or working a well-paid job.

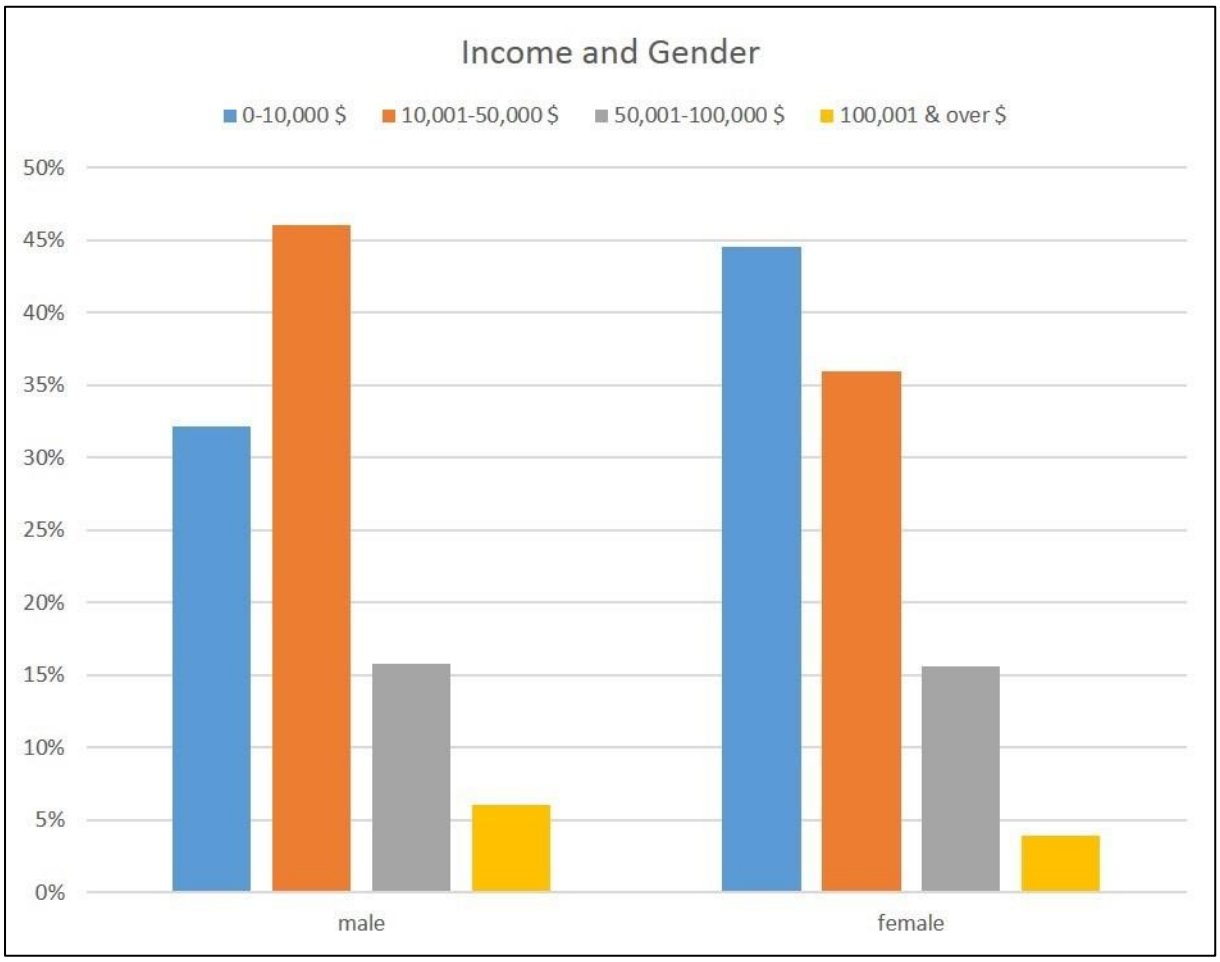


Figure 6.23: Impact of gender and income [n=293]

Results: impact of ethnicity and gender on the socio-economic position

The analysis of relations between the different aspects of class, ethnicity and gender shows that education, occupation and income are dependent on skin colour, origin, migration background, religious affiliation and sex or gender to greater and lesser extents. Whereas gender differences and inequalities regarding income and education qualifications are visible in the statistics, interviewees held different opinions and perceptions on this topic and its significance for the Bahamas. The same applies to the question of the importance of skin colour. Opinions among the persons interviewed on the prevalence of racial discrimination were divided, whereas certain tendencies towards the unequal distribution of skin colours in income categories and awarded education qualification could be identified.

Due to little religious diversity, we found that discrimination or inequalities based on religious affiliation do not play a leading role on the Bahamas at present. The only difference seen in the statistics and mentioned by the interview experts was the establishment and use of social and political networks among the different denominations, which may have an influence in terms of job opportunities and higher income for their community members.

The main factor contributing to the development of social segregation and evolvement of class hierarchies is origin and migration. Especially illegal migration has recently gained enormous importance and poses one of the biggest challenges for the Bahamas these days. Its effects on the

access to education, occupation and income not only restricts the mobility of persons directly affected but causes tensions within the majority local society and encourages the emergence of stereotypes and prejudices at a larger scale.

Unemployment, poverty and crime – by many of the interviewees and persons surveyed viewed as one of the major threats and challenges at present - can be evaluated as the outcome and expression of social inequalities existing within the population of NP and therefore only be resolved when looking at the interplay of all aspects that class, ethnicity and gender consist of.

6.4.4. The impact of class, ethnicity and gender on CC perception

This chapter links the interpretation of the first subquestions outcome with the information surveyed on CC as well as the CC Perception-Score generated. The following analysis will focus on the notions of class, ethnicity and gender and their impact on CC perception.

How is climate change perception influenced by class?

As class is defined by education, occupation and income, the table shows that of these three social categories education has the main impact on the perception on CC. The chart below visualizes that persons holding a primary school degree reached scores between 0 and 3. Senior high school graduates achieved similar results to university graduates. This illustrates that the higher the individual level of education is, the higher is the awareness of climate change. Interestingly enough, the respondent with the highest score of CC perception holds a Junior High School degree (see Figure 6.24). Interviewee XII states: “Education does make a difference, but there is just not enough of it. “

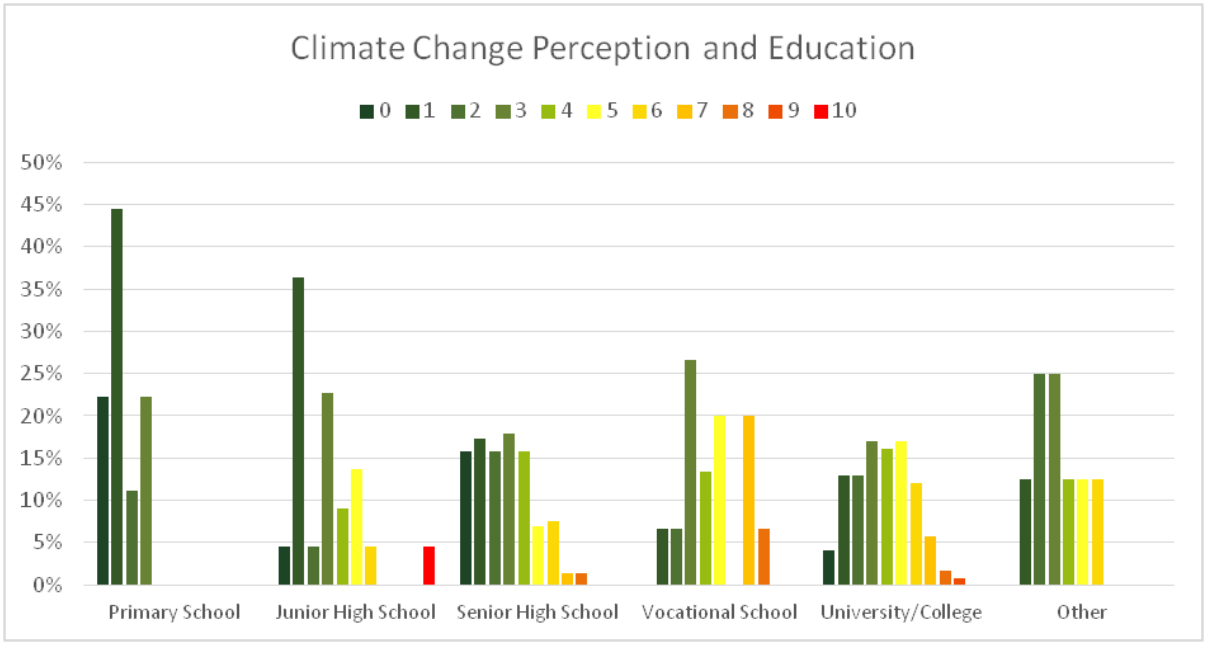


Figure 6.24: Impact of Education on CC perception [n= 323]

Besides education, income has a high influence on CC perception on the Bahamas. The following figure illustrates the outcome of the cross-classified table between the score system and the income. The majority of the Bahamian population without awareness of CC has an average income of up to 10,000$ per year. In the three other income categories, the percentage of people without CC

perceptions stays equal. Focusing the higher scores the statistic shows the tendency that the income groups of 50,001-100,000$ and 100,001$ & over have the highest CC perceptions (see Figure 6.25). Interviewee I affirms this by saying that being aware what CC means for oneself or the country is reserved for the country's elite (ibid.).

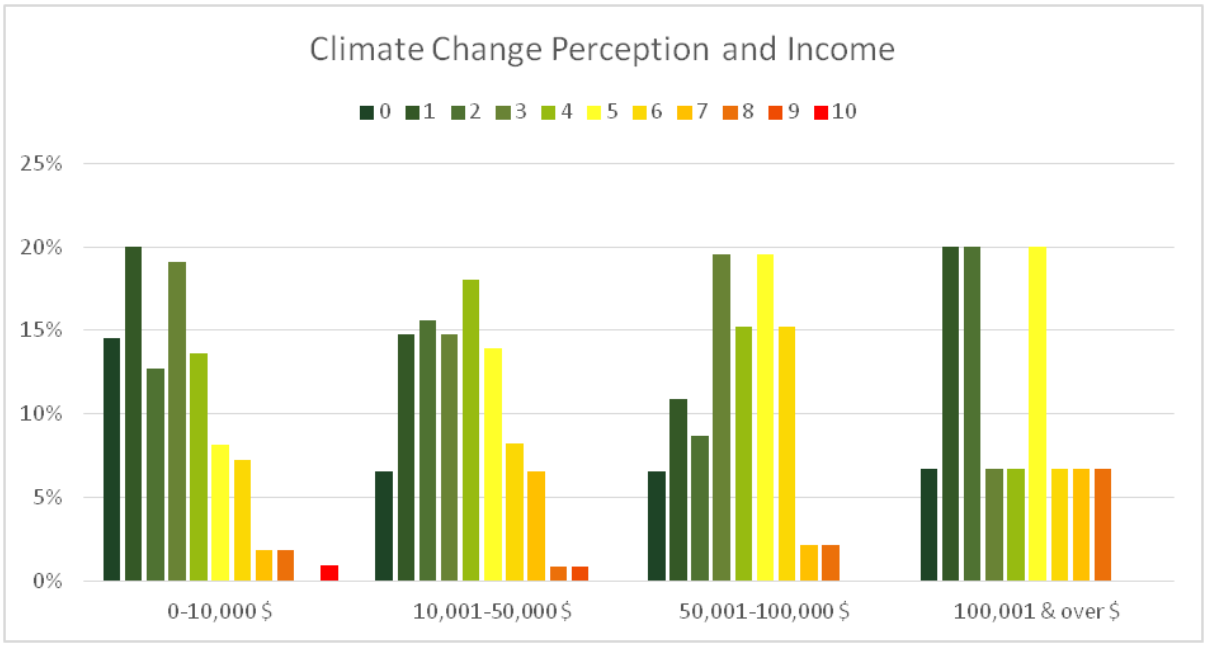


Figure 6.25: Impact of income on CC perception [n=293]

Income plays a major role at present and even more in the future in terms of adaptation to CC and SLR. Persons without financial security are unable to insure their homes, and since they invested all of their life savings in *"one house, they don't have options to move in case of SLR"* (Interview XII). Whereas people in some of these bigger homes they can hire an engineer and see what should be done. Alternatively, they just sell their houses (Interview XII).

How is climate change perception influenced by ethnicity?

Ethnicity contains the aspects of skin colour, origin, migration background and religion. Looking on how CC perception depends on skin colour, Figure 6.26 shows that black is the only skin colour with a full range of scores. It is remarkable nevertheless that the groups of other skin colours have a higher percentage (30%) of over average score. On the question if there is any relation between skin colour and the perception of CC our interviewee's answers were generally similar to that of Interview XII: "*I think it's more about social class than about skin colour"* (ibid.).

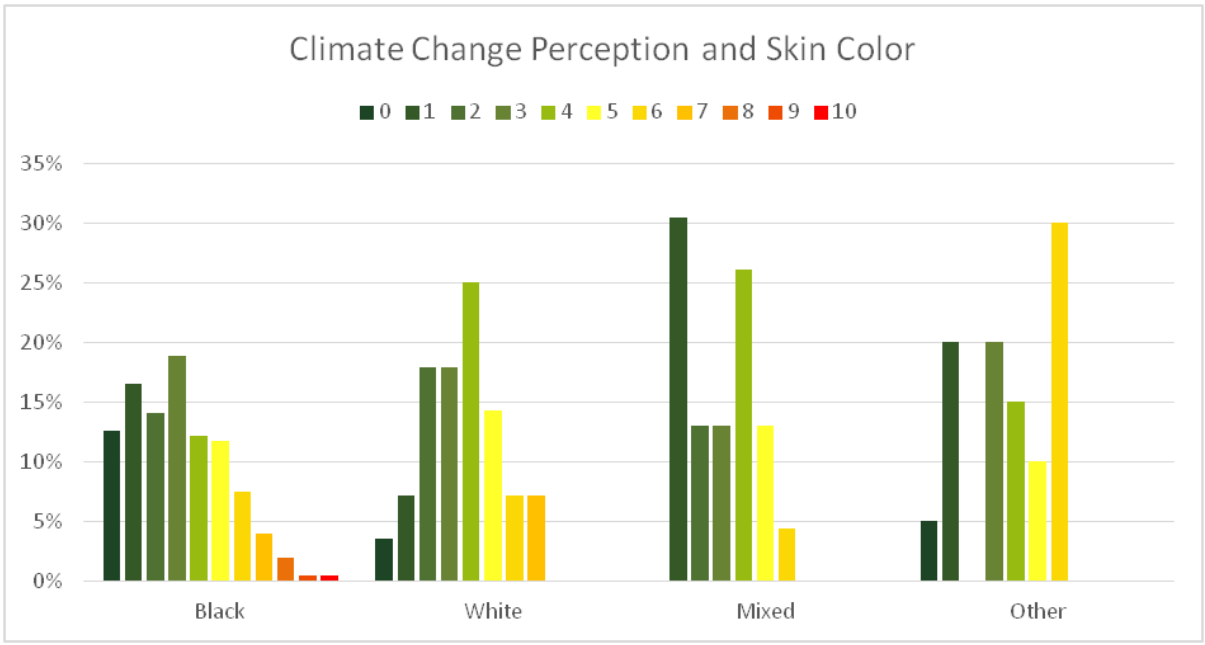


Figure 6.26: Impact of skin colour on CC perception [n=326]

As mentioned in chapter 6.4.3 there seems to be a connection between origin and migration. Outstanding in the statistics on low-income countries, which is because only two informants, namely those of Haitian origin, fit into this group (see Figure 6.27). Generally spoken, due to missing access to information, the Haitian community in NP is not aware of CC issues (Interview V).

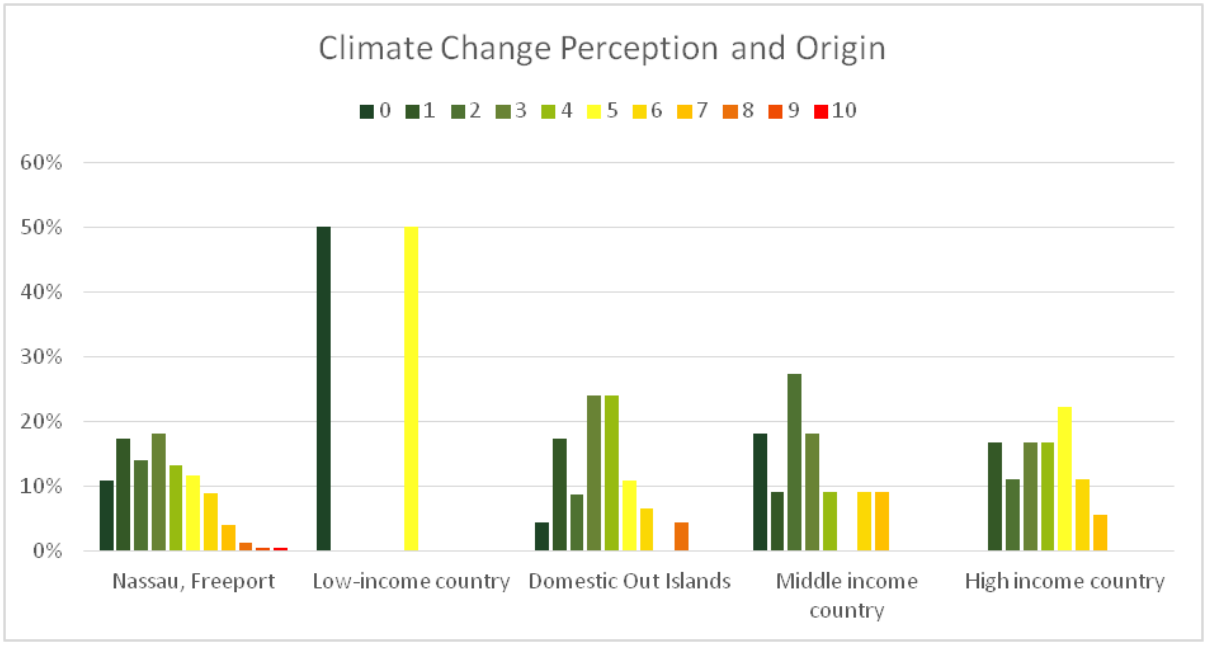


Figure 6.27: Impact of origin on CC perception [n=326]

Over 10% of persons surveyed originating from NP and Grand Bahama have not achieved any CCPS based on their answers given, however, at the same time the three highest scores were achieved by persons originating from the two islands. Looking on persons from NP/Grand Bahama, the percentage of low scores is overtopping. Persons originating from high- income countries hold a minimum score of 1 and over 5% scored between 6 and 7 points.

Comparing this statistic to the one on parental migration and its influence on CC perception shows that persons with at least one parent from a low- income country never reached a score above 5. However, the majority of respondents were not affected by parental migration. Looking at both origin and migration, there is a tendency that persons with a background of a high-income country have higher levels of awareness than persons with backgrounds from other areas.

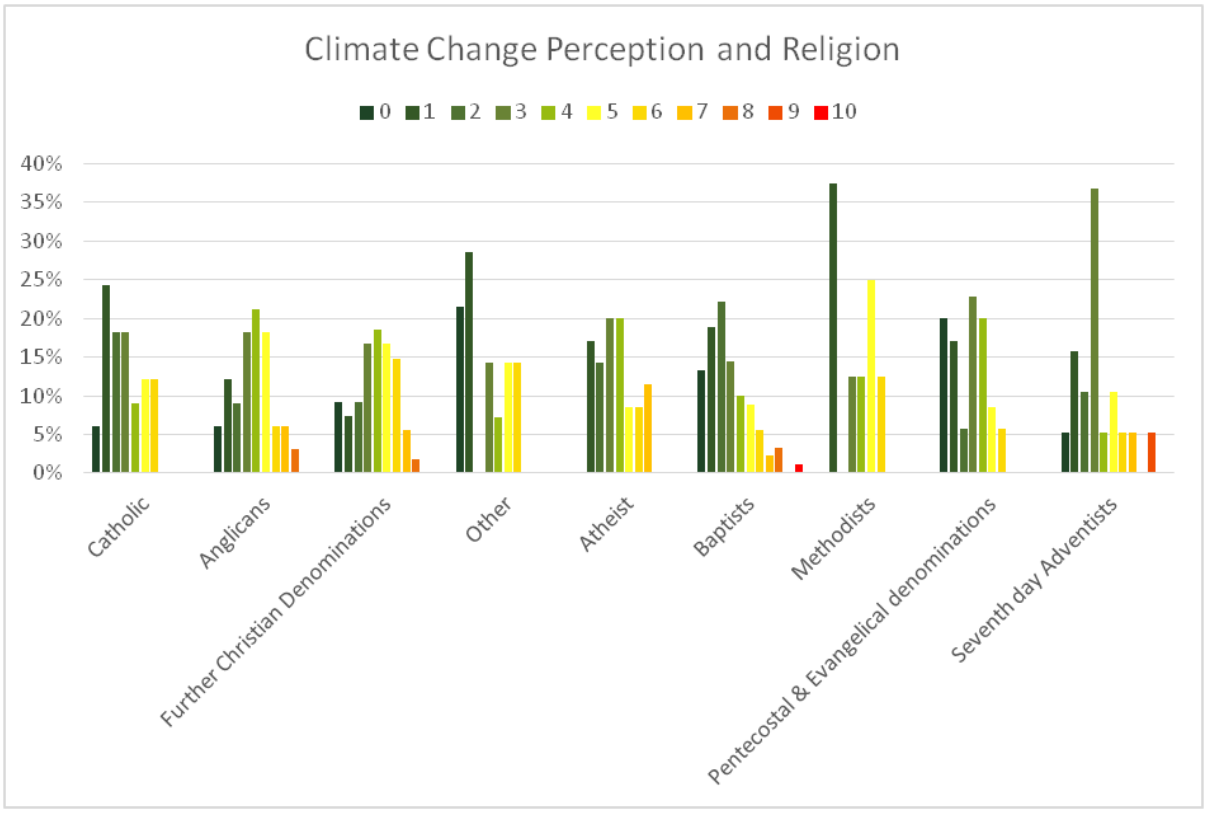


Figure 6.28: Impact of religion on CC perception [n=321]

Looking at Figure 6.28 it is evident that the CC perception among different religions/denominations is very similar. That is also because the Bahamas are a Christian nation, though they have a segregated Sunday (Interview VI & IX). The other reason is commented by Interviewee VIII: *"It's not something for the church, in my opinion."* (ibid.) Interview VI states: *"I do not talk about CC issues because there is no reference quotation in the Bible."* (ibid.) Both Interviewees indicate that there is almost no CC perception within the Bahamian society.

How is climate change perception influenced by gender?

The CC perception between male (3,084 Ø) and female (3,093 Ø) is very much equalized. The two persons with scores of 9 and 10 are male, though more females hold a score of 8. Regarding the analysed gender inequalities in chapter 4.2, it is surprising that this statistic is seemingly well balanced. Thus while gender is an important issue regarding social inequality, it has no impact on CC perception (Figure 6.29).

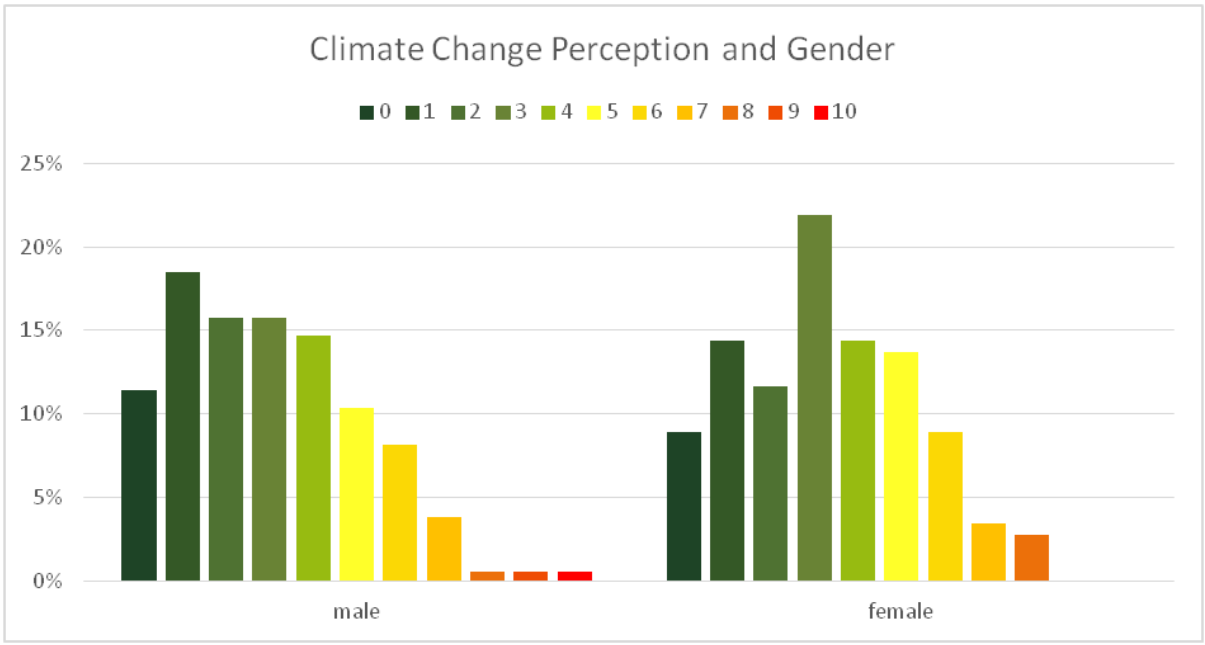


Figure 6.29: Impact of gender on CC perception [n=330]

How is climate change perception influenced by age?

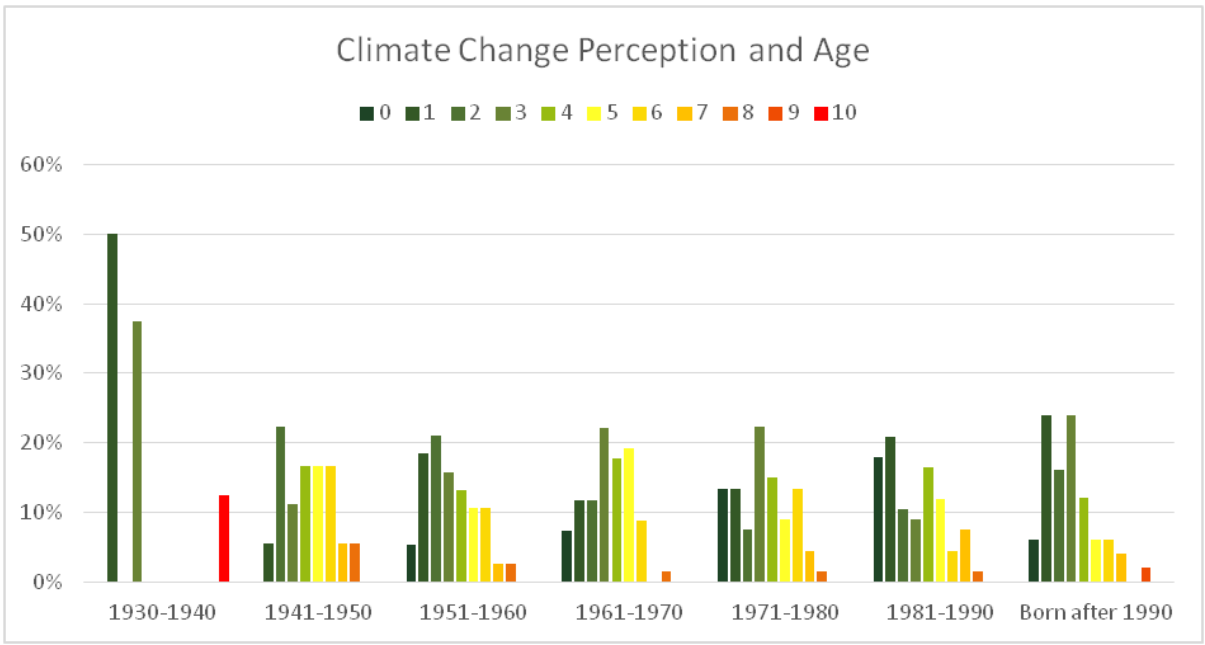


Figure 6.30: Impact on age on CC perception [n=316]

Older persons are more aware of CC in this sample. In detail, the chart shows that the person with the highest score is born between 1930 and 1940 and the person with the second highest score is born after 1990 (Figure 6.30). This statistical result is contrasting with the results from education.

Results: the impact of class, ethnicity and gender on CC perception

Gender, ethnicity and class are influencing the perception of CC, though not with the same level of intensity. The impact of gender, for instance, is weaker than the ones of class and ethnicity. The strongest influence is exerted by class and its two components income and education. Ethnicity is

most influencing regarding origin and migrant background. For religion/ denomination and skin colour, the statistics are not sufficiently explicit, and even the impact of age can only be expressed through tendencies.

For the expert interview's question *"Do you think there is public awareness among the Bahamian population concerning CC and its potential challenges for the Bahamas?"* we mainly gained laughter. Further inquiry resulted in judgements about politicians and political mimicries. CC has been a governmental issue for the last seven years but, the level of awareness and priority of this issue remains vague and unclear. "*The government has been talking about CC for the last maybe seven years, but I do not know whether it is a real awareness about it or if anyone really is doing anything "*(Interview XIII).

The Bahamian society has to deal with a high-income inequality, unemployment and crime. Consequently, priority is given to these issues. Knowing this topic deserves consideration (Interview X), action and priority of this issue this will only be achieved once the impacts of CC and SLR can no longer be ignored (Interview III, XI, XIV & XV).

6.4.5 The impact of geographical location on CC perception

Is the geographical location of the individual's place of residence of importance for the perception of CC? Map 6.1 shows the participants' residential location distributed on a map of NP. Adapted from this map, we developed further maps on the distribution of income, education, skin colour and CC perception, based on the established CCPS. All of these maps are subdivided into districts 1 to 8.

Map 6.3 illustrates the distribution of income. It is striking that there are several noticeable areas with a predominant group of income. District 1 visualizes how the highest income category of '100,001$ & over' is more or less directly connected to the coastline. This circumstance was supported by our expert interviews, stating that it was in the far west of the island where millionaires and celebrities have their homes. The area around Lyford Cay was already an affluent area even in the past (Interview IX & XII). In contrast, a high density of the lowest income group occurs when focusing the central area in the east. This could be described as a cluster which centres up within district 6 and 7. The area contains the inner city and several neighbourhoods where people's income totally differs from other parts of NP: *"So we are one of the richest countries of the world but... I say but... for the residents that live in the inner city communities the wealth is not spread."* (Interview II).

When looking at a possible connection between the distribution of income and potential prospective threats due to CC, it is especially alarming that many people without financial security live in one of the most vulnerable areas, which is in the south-east portion of NP, an area with several residents of generally lower income: *"They already have issues with flooding and that's expected to increase as we get more precipitation, as we get more intense hurricanes."* (Interview XII).

Map 6.4 shows a clear distribution pattern concerning the residents' educational status. 44.9% of the respondents are holding a senior high school degree and 38.4% a university/college degree. Looking at the distribution of these two categories it is remarkable that university/college graduates are more frequently distributed within the outer districts, especially 1, 2 and 3, whereas senior high school graduates are more frequently distributed on the eastern and the southern part of the island (inner and outer districts). Junior high and primary school graduates are more frequently distributed

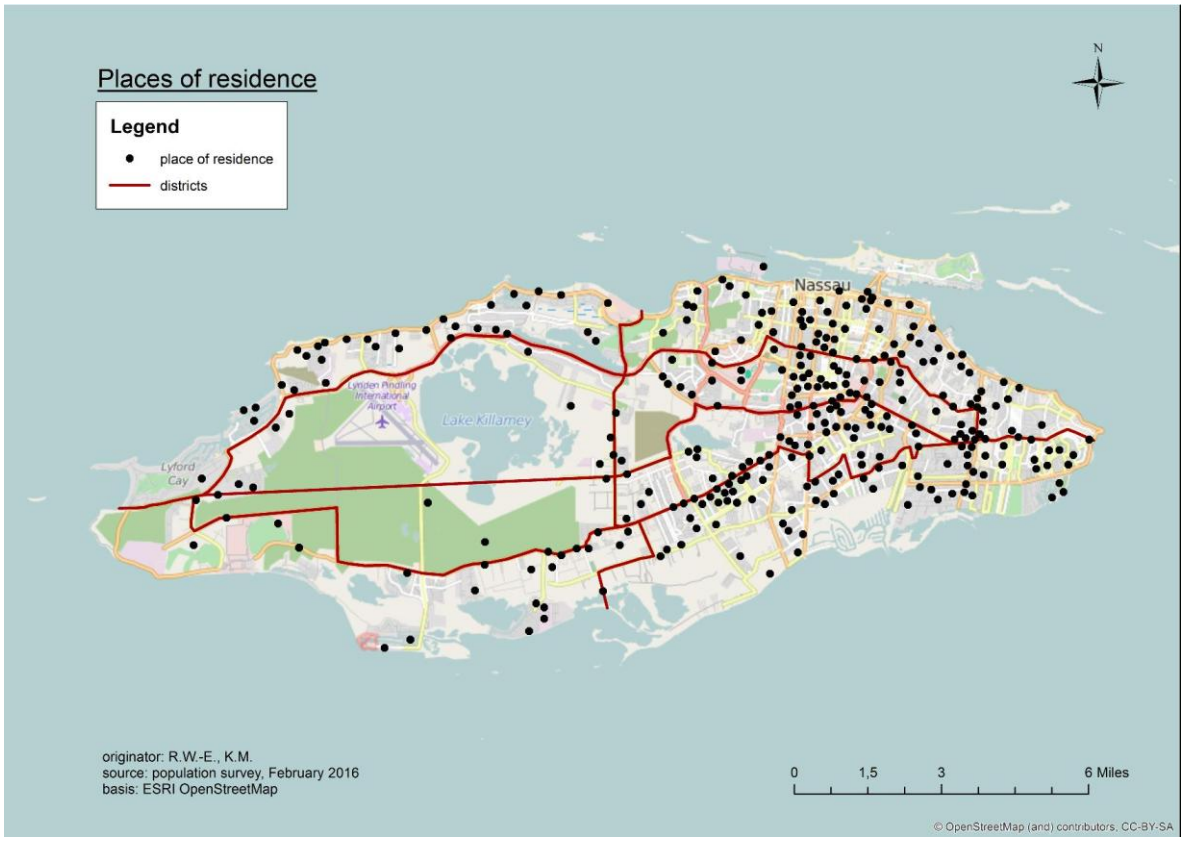
in the eastern part – districts 2, 3, 6 and 7. By comparing the map of income and educational status, a strong relation between both of these aspects becomes visible. This supports the statement made in chapter 6.4.2. When looking in detail at the respondents' perception, which indeed might be influenced by educational status, it could be presumed that a higher perception is prevailing among the districts' residents who are holding a higher educational degree:

> *"I think that the more educated and more wealthy people in the communities would know more about CC because they are more connected to international news and what's going on the global skill and so those people will be more aware of how CC will affect them and be able to* response so […]" (Interview XII).

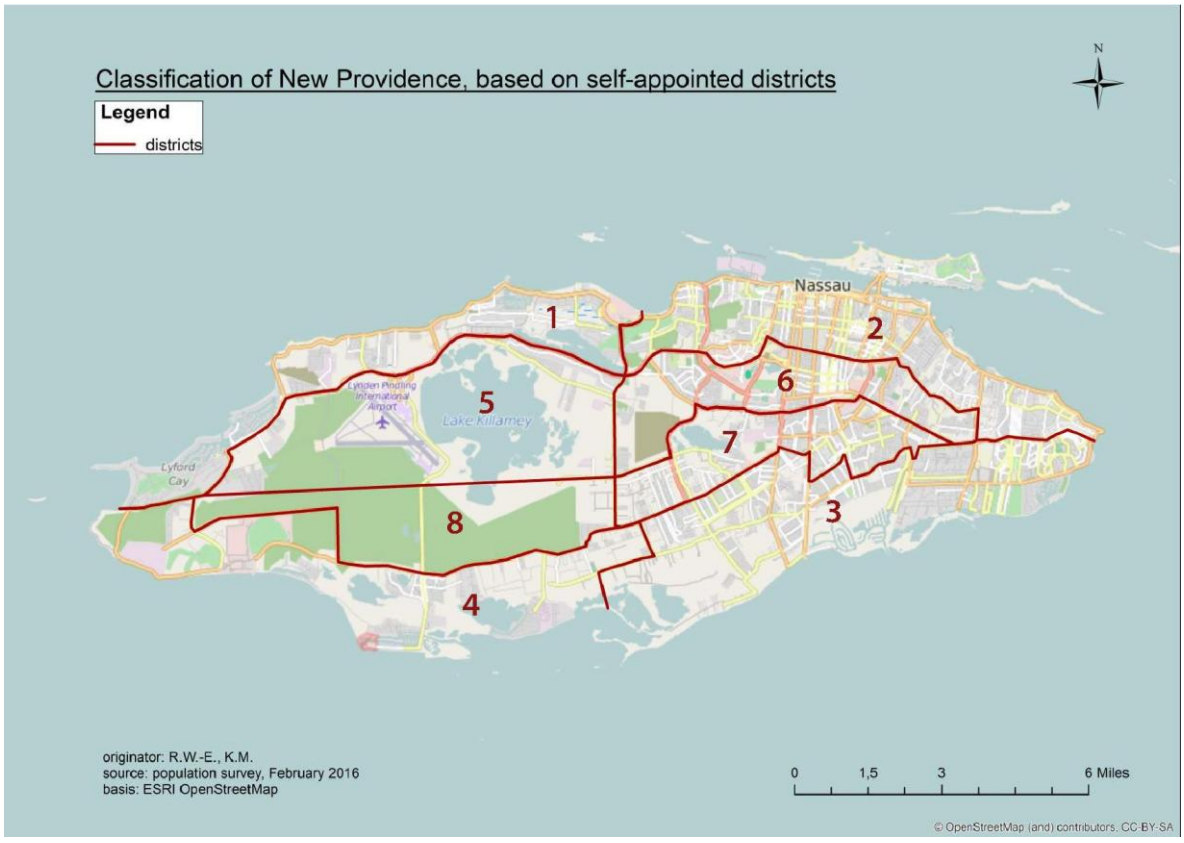
Map 6.5 reveals information about the distribution of skin colour. 78,.2% of the survey respondents identified themselves as black. This majority is distributed throughout the whole island and is, therefore, present in every district. In contrast, when focusing on the proportionate distribution of the minority of 21.8%, it is visible that almost half of the residents in district 1 are white while a very heterogeneous pattern is also found in district 2 and 3. Almost no individual with a skin colour other than black is living in the inner districts 5-8. In addition to that, more than half of the people identifying themselves as 'other' are living in district 2, followed by district 1 and 3.

Finally, Map 6.6 shows the distribution of personally accumulated CCPS. At first sight, the perception of CC is homogenously distributed. When looking at the statistics though, residents with a higher score than 8 are identified to live exclusively in district 3, one of the outer districts. Therefore, it can be assumed that the direct linkage between the own property and the coast line affects and sensitizes people's perception: *"People living on the coast or having their property on the cost, they see coastal erosion and the possible affection by CC and SLR"* (Interview XII).

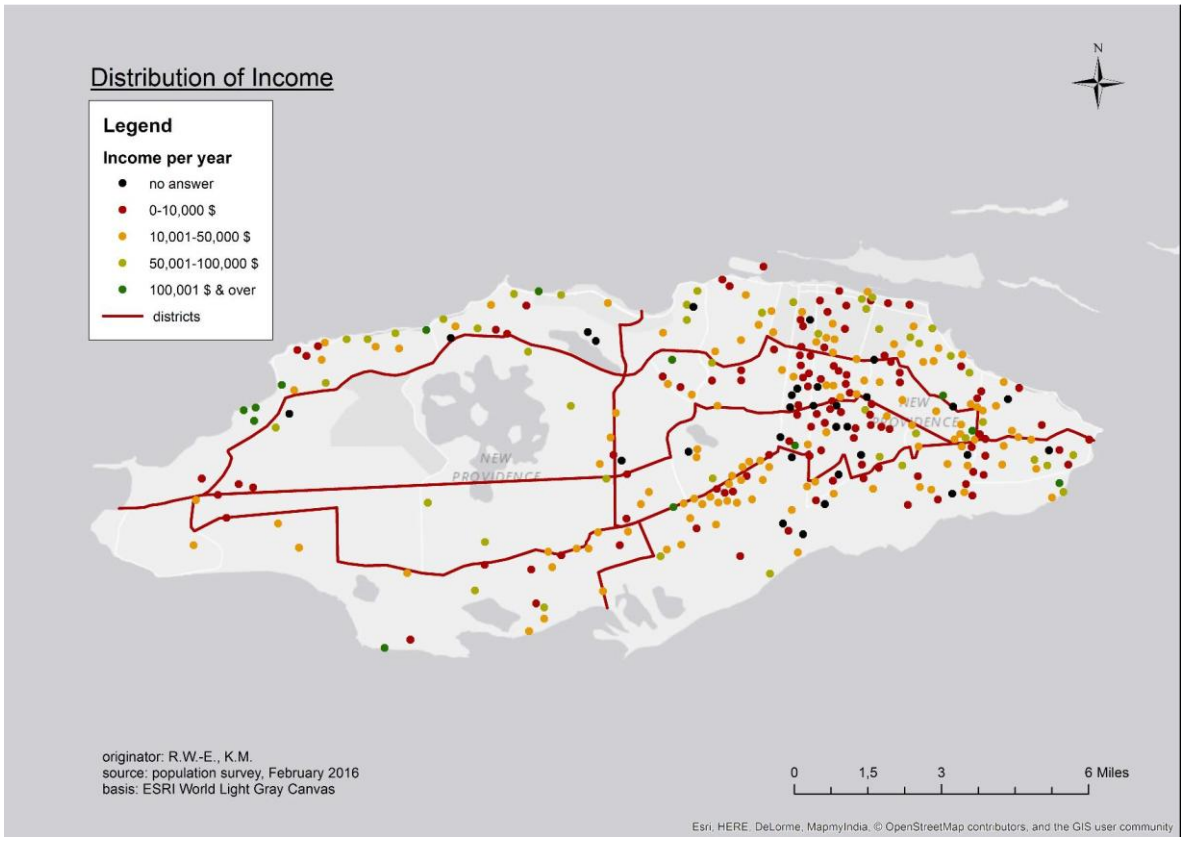
Remarkably, the inner city represents an area where most of the CCPSs remain relatively low. By connecting this circumstance to educational status and income, interplay between all three aspects becomes clearly visible. It is nevertheless questionable whether only these attributes affect the CCPS, or whether there are several more influences on the individual perception. It must be added that residents from all over the island living directly at the coastline hold different CCPS, which means that no consistent pattern can be identified. Therefore, it might also rely on whether a resident has already experienced impacts of CC or not.



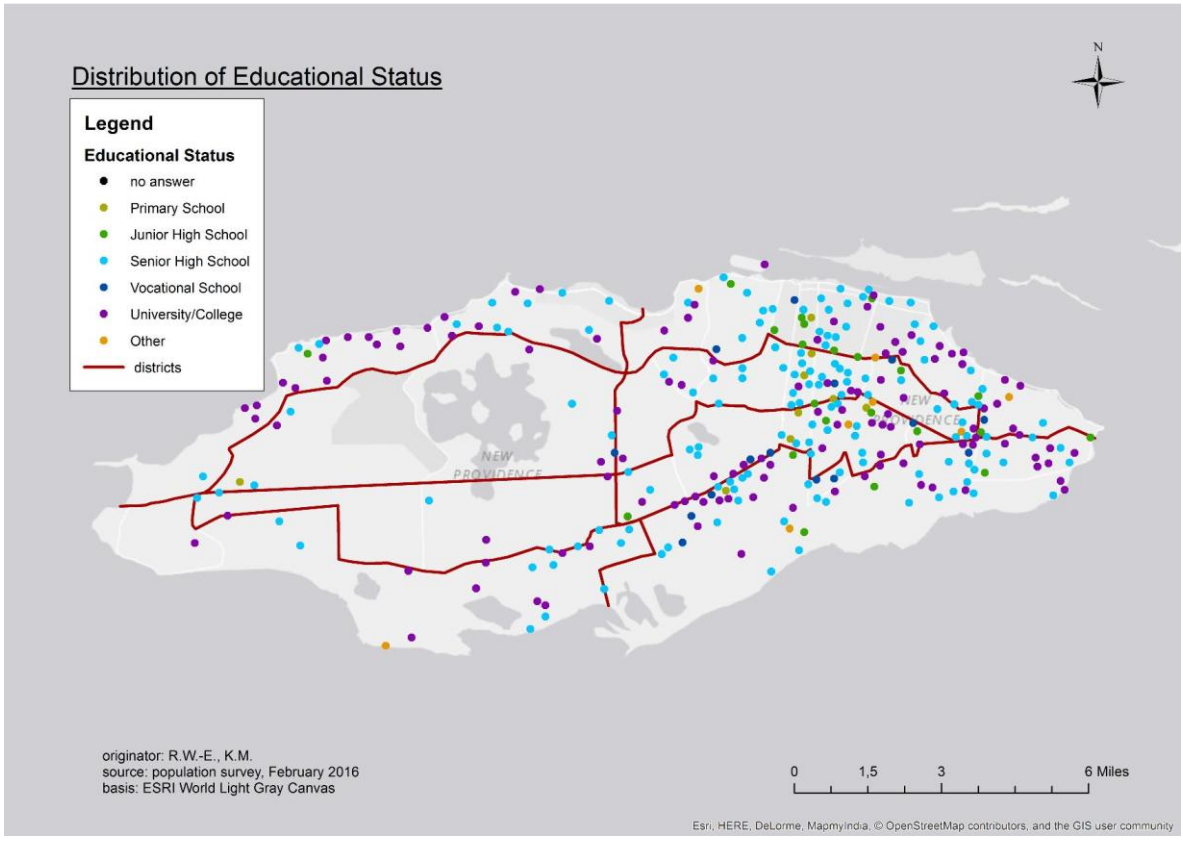
Map 6.1: Places of residence of the respondents [n=315] (Source: Own illustration)



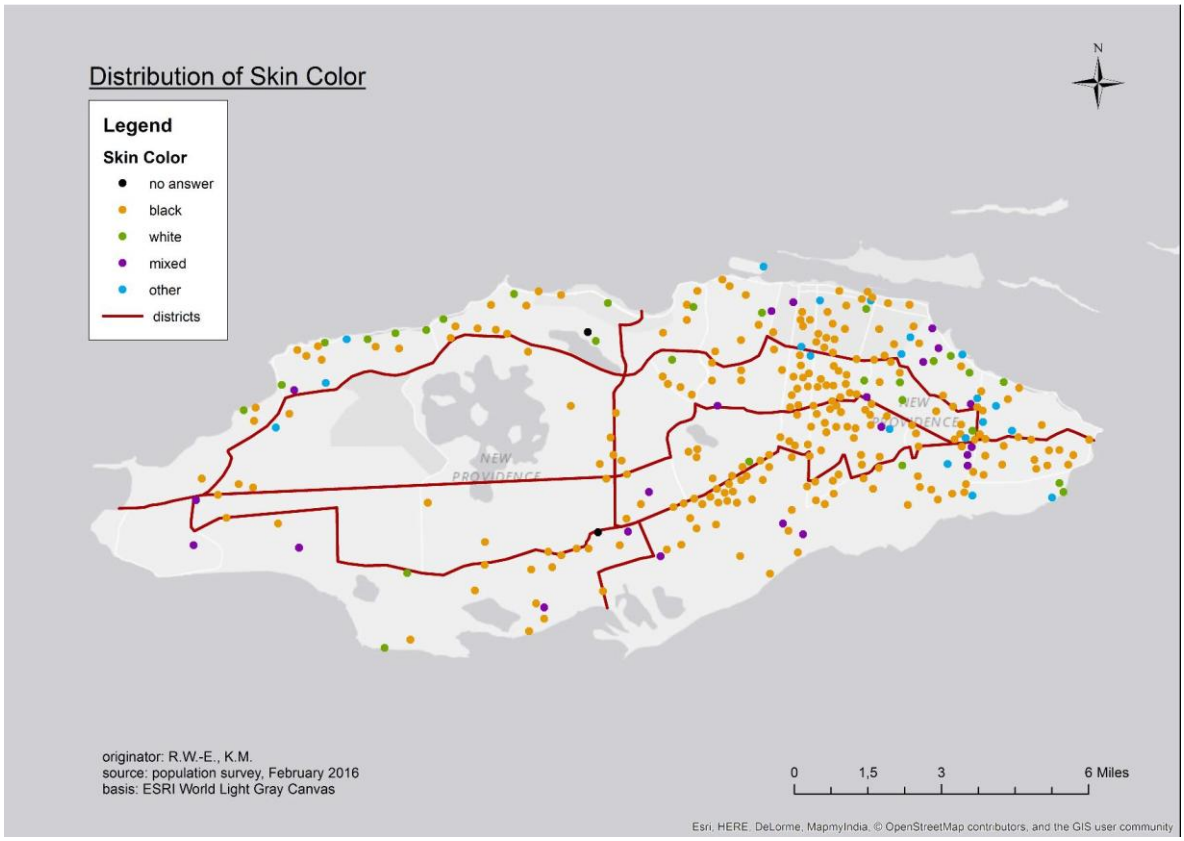
Map 6.2: Classification of NP, based on self-appointed districts (Source: Own illustration)



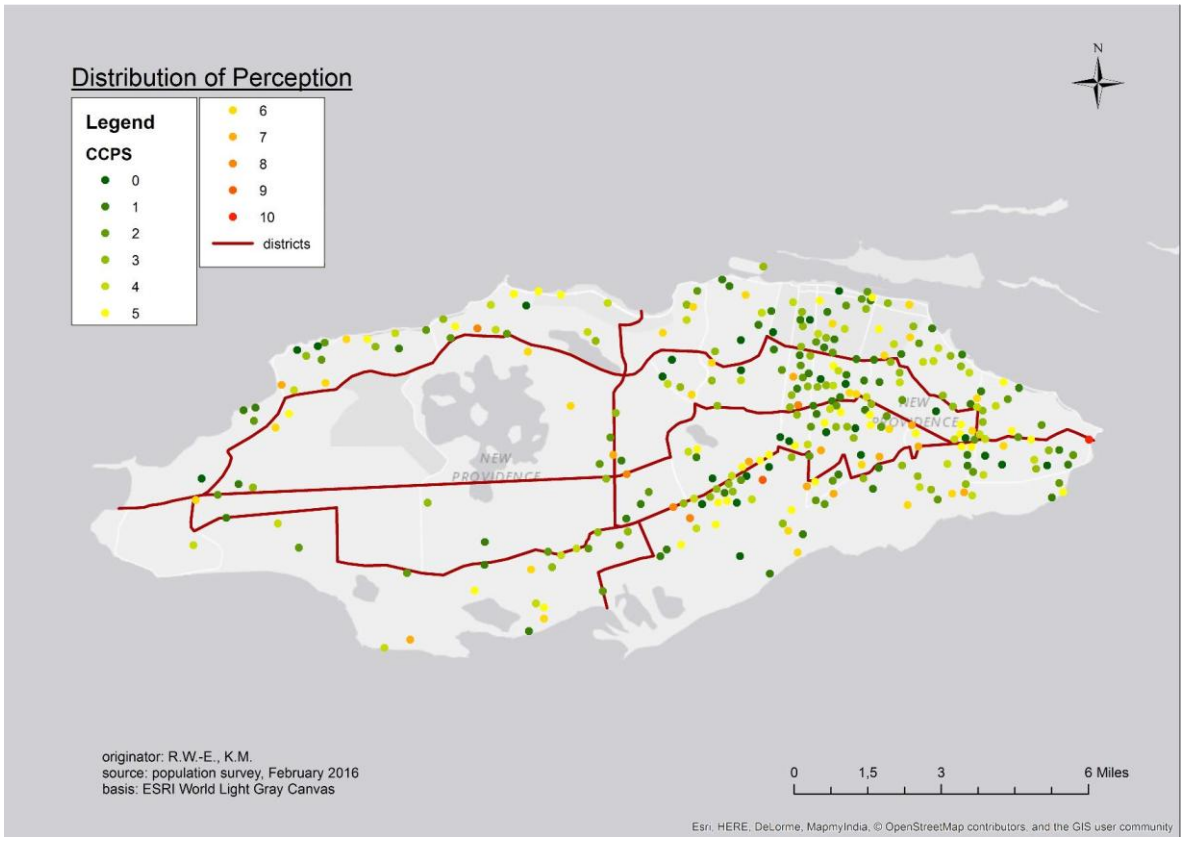
Map 6.3: Distribution of income [n=285] (Source: Own illustration)



Map 6.4: Distribution of educational status [n=314] (Source: Own illustration)



Map 6.5: Distribution of skin colour [n=313] (Source: Own illustration)



Map 6.6: Distribution of perception [n=315] (Own illustration)

6.5. Conclusions

There is a significant relation between class affiliation, ethnic background and gender. The empirical study undertaken on NP reveals a strong impact of class affiliation on CC perception, whereby persons who hold higher levels of education and income tend to have a stronger awareness of CC and SLR than those who hold lower levels of education and income. Gender and age of a person apparently do not play a role regarding CC perception (see chapter 6.4.4).

The impact of a person's place of residence on its CC perception remains unclear. The study reveals a trend that persons who live in a coastal district of NP generally have a higher level of perception, however, the geographical distribution of high CCPS values is predominantly congruent with the geographical distribution of high levels of education and income on the generated maps (see chapter 0). Therefore, there is no evidence that location plays an actual role or if the distribution of different levels of CC perception only reflects class affiliations of a person. However, the geographical analyses visualize the socio-economic segregation of Nassau into more wealthy coastal areas and the socio-economically weak developed, partly impoverished, inner city areas (Interview II, IV & XIII).

Furthermore, the analysis indicates a correlation between a person's migrant background and his CC perception – however, reflecting the results about the relation of class and ethnicity, it becomes obvious that specific migrant groups only represent the CC perception of their class affiliation. More specifically, an illegal migrant has generally limited access to education, job market and higher levels of income and therefore automatically slides into lower class segments which statistically stand for a lower perception of CC, while a migrant from a high-income country tends to represent the stronger CC perception of higher class segments.

The study revealed that social inequality has significant impacts on CC perception on NP. Especially class affiliation, which is influenced by the ethnic background and gender, affects the individual level of awareness about a changing climate and a rise in sea level. Nevertheless, the interviewed experts agreed that CC perception on NP is generally low (see chapter 6.4.4).

One reason for the lack of CC awareness among the population is probably the limited knowledge transfer from an institutional level into the public sphere. Other reasons are probably the widespread socio-economic challenges among many citizens:

> *„[...] the average Bahamians, all they're thinking about right now is how we gonna pay this bill at the end of the month. So these are the major concerns here in the Bahamas, climate change is the last. We worry about will my child finish school, will he find a job and these are the needs we are looking at now."* (Interview XIV)

Especially lower class members face serious social problems in their daily struggle for survival such as high rates of unemployment, poverty, the marginalisation of minorities as well as high levels of crime and violence. For many people on NP, there is simply no room to address relatively abstract issues such as CC and SLR in their daily lives. Awareness-building especially among socio-economically disadvantaged people, however, is crucial because those are the most vulnerable social groups regarding expected hazardous effects of CC such as SLR and an increase of extreme weather events.

Adaptation strategies, therefore, cannot ignore the significant impacts of social inequality on CC perception on NP. Only if the basic socio-economic needs of a population are sufficiently covered, a solid foundation can emerge which allows for a broader development of CC awareness. A broader awareness of CC and SLR among the public and in the political sphere, are essential preconditions for building adaptive capacity and resilience, not only to CC but also for a sustainable development of the society as a whole:

"There is no realization that by the end of this century sea-level is likely to be 2 meters higher than it is now. And that will mean that on this island, where more than 60% of our people live, easily 70% of the housing stock will be sitting in water and that the airport will be unusable. So although all these huge hotel buildings might still function, there is no way to get people here anymore. So we will go out of the tourist business. […] If we go out of the tourist business we will be fishermen again." (Interview XI)

This instructive statement of one of our interview partners illustrates the enormous vulnerability of NP and its socio-economic system. The vulnerability to CC could also be reduced by the development of other income sources including the expansion of sustainable agriculture and fisheries which would simultaneously reduce the country's high dependence on imports and contribute to reducing social inequalities. As this study reveals, successful adaptation to CC is not only based on a broad awareness about these processes but also inseparably connected to the sustainable development of a society as a whole. The Bahamians have always been highly adaptive people – the recent challenges need new proofs of this capacity.

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Appendix: Interview list Chapter 6

Interview I: Former Assistant Professor at the Department - History, Philosophy & Religion (COB), 27/01/2016.

Interview II: Community activist, Lewis Street, Bain Town/Grants Town, 13/02/2016.

Interview III: Environmental activist, ReEarth – Save the Bays, 19/02/2016

Interview IV: Board Member, Hands for Hunger, 11/02/2016.

Interview V: Haitian/Bahamian translator, Haitian community activist, 15/02/2016.

Interview VI: Baptist pastor, 17/02/2016.

Interview VII: Banker, former member of the Rotary Club of East Nassau, 18/02/2016.

Interview VIII: Anglican pastor, 16/02/2016

Interview IX: Civil servant, Department of Social Services, 11/02/2016.

Interview X: Driver of a food truck, Hands for Hunger, 16/02/2016.

Interview XI: Chair Person, Bahamas National Reparations Committee, 17/02/2016.

Interview XII: Assistant Professor of Geography (COB), 12/02/2016.

Interview XIII: News editor, The Tribune, 10/02/2016.

Interview XIV: Research consultant, Antiquities Monuments & Museums Corporation, 10/02/2016.

Interview XV: Entrepreneur and human rights activist, Community project Bain Town, 13/02/2016.

Interview XVI: Member of the BEST Commission, 12/02/2016.

7. Executive summary

Coastal regions and small islands are particularly affected by the consequences of climate change, in particular by rising sea levels. Low-lying Small Island Developing States (SIDS), such as the Bahamas, need to find sustainable adaptation solutions to future sea-level rise. On a field trip of the Institute of Geography of the University of Hamburg to New Providence, we pursued the question: what role can social actors play in adapting to sea-level rise in a post-colonial Caribbean island small island state, dominated by tourism?

The project is part of the Cluster of Excellence Integrated Climate System Analysis and Prediction (CliSAP) at the University of Hamburg, Germany, and addresses the issue of social responses to climate change, with a focus on impacts and adaptation to sea-level changes. With the example of the Bahamas we intended to collect and analyse elements of local vulnerability, understand how social institutions and people respond to sea-level rise and assess the potential to build social resilience for climate change adaptation. For this purpose, we applied a mixed methods approach of qualitative and quantitative research methods and undertook a two-week field trip to New Providence, in February 2016, for collecting empirical data. We greatly benefitted from the help and openness of the local population, authorities and the cooperation with the College of the Bahamas (COB), for which we express our sincere thanks.

Four working groups were set up with a distinct research focus each involving different stakeholders that play a role regarding adaptation to climate change on the Bahamas:

1. Coastal erosion and coastal protection
2. Water resources supply
3. Fishery development
4. Social inequality and societal perception of climate change

The main findings of our research are presented along the four guiding questions of the thematic group work in the following:

a) In how far is New Providence affected by coastal erosion and how is coastal protection realised?

The erosion analysis of coast of New Providence revealed a strongly affected coastline by a diverse range of erosion processes. Along with the noticeable impacts on infrastructure and beach extensions, there could be identified an increasing awareness of the need for more suitable coastal protection measures. Accordingly, future projected climate change issues and the sea-level rise particularly are getting increasing attention on the political level as well as NGOs and activists are getting more engaged.

Current coastal protection is characterised by a vast amount of small and smallest efforts scattered across the island and realised by individual committees, investors and individuals. No obvious integrated coastal protection scheme for the entire island is noticeable. There appears to be a rather piecemeal approach of single projects and small patches, partially resulting in further increasing processes of erosion. The lack of coordinated or organised efforts in coastal protection may raise further problems.

The future challenge is to improve and coordinate the communication between the involved committees, ministries and agencies as well as to apply concentrated and joint efforts to reduce erosion along the island's coasts while at the same time providing protection from flooding and future rising sea-levels.

b) Which impact does climate change have on the availability, supply security and use of water resources on New Providence?

Natural water resources on New Providence are likely to be negatively influenced by climate change and sea-level rise, although there is a lack of reliable data on the magnitude and time frame of potential water stress. However, compared to other SIDS in the Caribbean Region, there is no serious fresh water issue on the Bahamas yet, as desalination already replaces the natural water resources. The switch to reverse osmosis (RO) for water supply is currently, in fact, the only response option to climate change identified and so far about 30% of the population are provided with fresh water by two local private companies in this way.

Within the population, there is little awareness regarding the impacts of climate change on water supply resulting in a low degree of water saving means at home. Political campaigns have not been able to create a significant change in consumer behaviour yet. However, there are further attempts to secure water resources by an increased turn of water supply to reverse osmosis and to increase the national awareness of the sustainable use of fresh water through national adaptation plans and education campaigns.

c) How does climate change influence fish stocks and the fishery sector on the Bahamas?

The consequences of climate change will be of major concern for the fishery sector in the future, for instance, due to shifting species compositions. However, no relevant negative impacts on the fishery sector have been observed yet. Only individual events like single strong storms or hurricanes have had measurable negative impacts on the fishery sector. Direct impacts of changes in fish stock on fisheries due to global warming are difficult to notice due to insufficient monitoring and lack of reliable data. Moreover, direct anthropogenic influences always have to be considered, too, when talking about changes in fish stocks and fisheries. Hence, climate change and its potential future impacts on fisheries do not seem to be valued as important as short-term economic benefits by the public at large.

Nevertheless, environmental agencies are willing to adjust to the noticeable impacts of climate change in many projects by raising awareness and improving cooperation among the stakeholders involved. A sustainable use of marine resources – also in consideration of developing mitigation and adaptation measures regarding possible impacts of climate change – will ensure their existence in the future and the livelihood of future generations.

d) What is the impact of social inequality on climate change perception on New Providence?

Based on the population survey results, general awareness of climate change among the population appears to be low. Social inequality shows significant impacts on the perception of climate change

on New Providence. Especially class affiliation, which is influenced by the ethnic background and gender, affects the individual level of awareness about climate change and rising sea levels.

Suitable adaptation strategies should not disregard the significant impacts of social inequality on perception and awareness of climate change. Only if the basic socio-economic needs of a population are sufficiently covered, a solid foundation can emerge which allows for a broader development of sustainable adaptation measures and help to increase social resilience.

In summary, climate change affects the Bahamas on different levels of society and implies challenges for various stakeholders. Despite a general awareness among certain stakeholders that climate change and sea-level rise, in particular, will be a major issue for New Providence, specific suitable adaptation measures and their implementation could not be identified. A lack of reliable data, not only regarding changes in sea level but also regarding associated consequences for coastal protection, water resources, the fishery sector and local populations, was noticed.

Nonetheless, scientific consensus about the potential impacts of climate change for SIDS calls for action also on the Bahamas. Albeit without certainty about the magnitude of impacts of climate change, coordinated strategic action is needed and at the same time, developments and policies that potentially conflict with adaptation measures should be avoided. The challenge is to identify technical and political options as well as to understand the various perceptions, interests, motivations and capacities of the different stakeholders on the local, national and international level. Only if existing contradictions and obstacles to sustainable adaptation pathways for the benefit of the island community are recognised, the question of responsibility for adaptation can be clarified and socially just strategies can be implemented.