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Research Article

GLOBAL CHANGE CONCERNS IN SMALL ISLANDS WITH REFERENCE TO THE BAHAMAS

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ABSTRACT

Islands have a coastal zone that is commonly defined as an area covering the surface within 60 to 200 kilometers of the shoreline. This study addresses some general characteristics of the Bahamas to identify environmental concerns, with focus on population, water resources and the anticipated impact of global change, in particular of rising sea level. The population density of the Bahamas has about 39 people km^{-2} and hardly any surface flow contributes to the water resources of the Bahamas, and the southernmost islands are practically arid. The Bahamian economy is based primarily on tourism that is largely responsible for a GDP in the neighborhood of $4 billion. In the Bahamas, the hazards can be demonstrated with intense and frequent hurricanes and the major concern in the Bahamas is the risk related to anticipated impacts of climate change and acceleration of global mean sea level.

Key words: *small islands, climate change, sea-level rise, coastal zone management, population dynamics*

INTRODUCTION

Most small islands are the outcome of larger tectonic events such as seafloor spreading, uplifting and building of volcanic islands. Many small islands are low-lying, and their environmental challenges are similar with respect to resource constraints, population dynamics and exposure to natural disasters and global change. Most small islands are disadvantaged because of their remoteness from major economies and a rather modest resource base, mainly in the coastal zone. The following will address some general characteristics of small islands and will focus on the Bahamas' population, water resources and the anticipated impact of global change, in particular of rising sea level. The Bahamas is located between latitudes 20° and 28°N, and longitudes 72° and 80° W covering a total of 13,940 km^2 and a length of 3,542 km. The terrain is flat and land covers about 10,070 km^2 as part of a limestone plateau that is about 6.5 km thick and is based on two major platforms that comprise the Bahamas, Southern Florida, Northern Cuba and the Turks and Caicos. The Bahamas is part of an archipelago of approximately 700 islands and islets with about 2,400 cays that stretch over a distance of approximately 800 km. The low topography of the Bahamas makes it extremely vulnerable to the impact of hurricanes and as a result, people and property are at risk as well as the infrastructure that supports the tourist industry.

The Bahamas has a tropical climate with a mean temperature that fluctuates between 17°C and 32°C. and has a moderate rainfall with a wet summer and dry winter, and the corresponding mean annual rainfall ranges from about 1470 mm to about 865 mm. The period May to October is considered the wet summer months. The Atlantic hurricane season extends from June to November with the maximum occurrence around July to October. The capital, Nassau, on New Providence and Freeport on Grand Bahama Island, carry the major population whereas the rest of the population is dispersed over approximately 30 other islands. However, not all islands are inhabited and about 70% of the population lives on New Providence and about 16% inhabit Grand Bahama.

MATERIALS AND METHODS

The estimates for the population dynamics in the Bahamas are based on listings of data by the United Nations (United Nations Population Division, 2017) and were graphed for population changes from 1955 to 2018, and a comparison was made with the forecasting of population increase up to the year 2045.

The analysis of surface precipitation flux in parts of the Atlantic and the Caribbean is based on on visualizations with the Giovanni online data system that has been developed and maintained by the NASA GES DISC. The units were graphed as kg m^{-2} s^{-1} and the values are presented in a corresponding color scale.

Salinity measurements were estimated with two salinometers (EXTECH EC 170 and a refractometer that reads the salt concentration over a range 0-100 ppt. The resolution for salinity readings is with some practice close to 1ppt salinity and inter-calibration was performed between the radiometers as well the use of standard seawater samples with varying salinity.

RESULTS AND DISCUSSION

Population

Figure 1 gives the population dynamics of the Bahamas based on the latest United Nations estimates as of June 2017 (United Nations Population Division, 2017), and shows that the current population of the Bahamas is around 397,000 with a total land area of 10,018 $km^{2,}$ giving a population density of about 39 people km^{-2}. Yet, the population is not evenly spread throughout the Bahamas. For instance, the larger number of people is found in New Providence that has an area of about 207 km^2 and using figures from 2010 for the capital Nassau, the estimated population is around 250,000 and gives a density of roughly 1,200 persons km^{-2}.

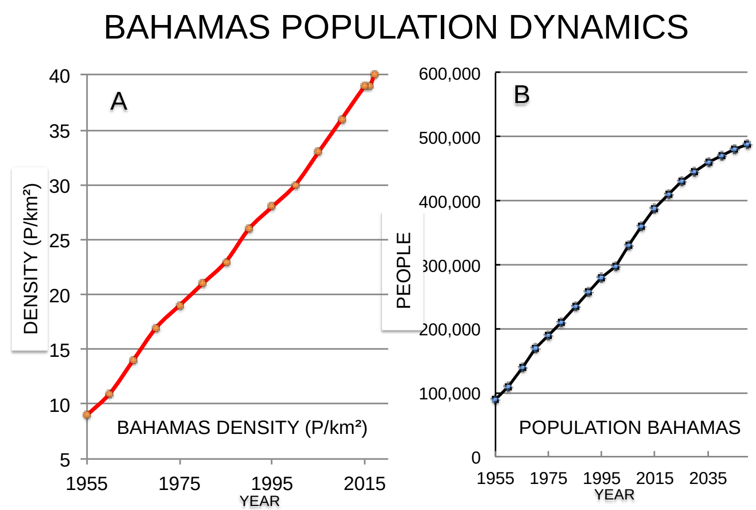

Figure 1: A. Present and past population density for the Bahamas.
B. Population of the Bahamas from 1955 to forecast for 2045.

Resources

The Bahamas is considered as a country with a high level of social, economic, health service and educational development. The GDP per capita in the Bahamas was for 2016 around $24,600 and approximately 60% of the GDP is generated by half of the labor force that is directly or indirectly linked to tourism together with tourism-driven construction and manufacturing. Financial services constitute the second-most important sector of the Bahamian economy and, when combined with business services, account for about 35% of GDP, while the agricultural sector and manufacturing contribute only a smaller fraction. According to the 2016 figures, the poverty rate in the Bahamas is around 12.5 % in 2014, the poverty line in the Bahamas was marked at $4,247. However, poverty rates vary significantly from island to island.

With the increasing population and various developing industries, water plays a key role as a major resource for sustainable development. Natural conditions regulate the amount and rate of rainfall and control the amount of accessible water. This can be demonstrated with the total precipitation flux shown in Figure 2 for the Bahamas. The seriousness in the water deficit in the Bahamas was evident in the past with the necessity of having to barge freshwater from Andros Island to New Providence, although at present this supply of freshwater is now superseded by freshwater production through reverse osmosis.

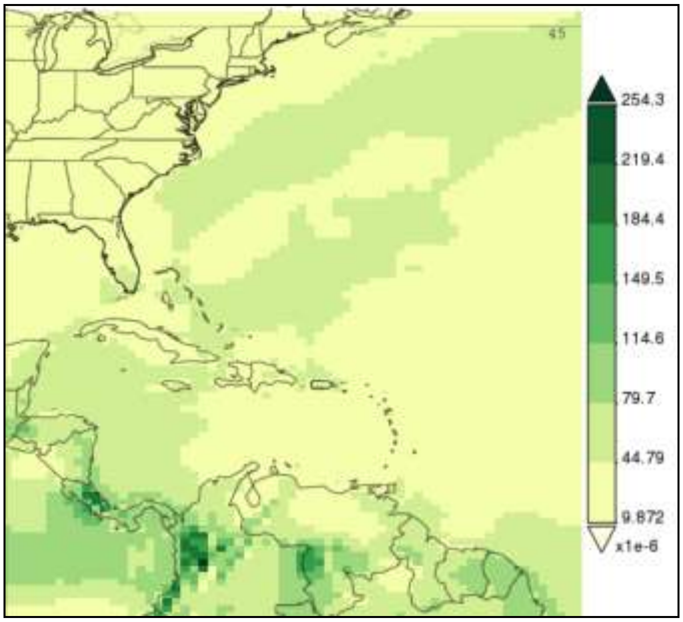

Figure 2: Time averaged total surface precipitation flux.
Units are in kg m^{-2} s^{-1} and show value for parts of the Atlantic and the Caribbean region.

In the Bahamas, as in many other islands, especially coral islands, aquifers are almost at sea level, and the concern is that with increasing sea level, access to potable water will be reduced due to inundation as well as to population increase and industrialization. The Intergovernmental Panel on Climate Change **(**IPCC) has reported potential impacts of sea level rise with increase of salinity in freshwater aquifers, inundation of wetlands and lowlands and intensified storm flooding (IPCC, 2013). In addition, the increase in tourism intensifies the demands for water, and groundwater resources that have been extracted beyond their recharge capability, are hard to replenish (US Corps of Engineers Mobile District and Topographic Engineering Center, 2004).

In particular, limestone islands like the Bahamas, atolls and coral islands in tropical latitudes have moderate elevation, and accessibility to freshwater is critical and to be taken into account when projecting the impacts of global warming on water management.

The freshwater in the Bahamas is mainly controlled by meteorological conditions that show the constraint of supply for some islands because precipitation decreases from north to south and the southernmost islands are practically arid. Amid the sparse water condition all over the islands, the surface water is mainly brackish. Estimates for the fresh water resources in the Bahamas showed that available water would decrease with time because of the increased demands from industry, agriculture, and because of population growth (The Bahamas National Report, 2012). In this report, it was pointed out that a daily availability of less than one half of a cubic meter per head in New Providence was already a critical shortage.

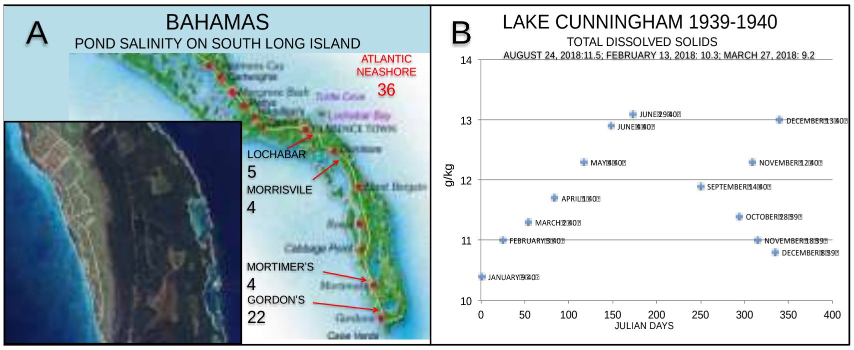

Figure 3A: Pond salinity in selected areas of Long Island, Bahamas. The Atlantic near-shore water has a salinity of 36 (in red). 3B: Salinities in Lake Cunningham, New Providence Island showing the yearly cycle. The diagram also gives the salinity for some measurements in 2017 and 2018. Diagram 3B is based on measurements by Peggs (1941) and surveys by the author in 2017 and 2018.

Tourism

The Bahamian economy is based primarily on tourism concentrated mainly in Nassau, New Providence and Grand Bahama. Tourism and construction are largely responsible for a real GDP that is in the neighborhood of $4 billion and its financial services place the country as one of the world's leading financial centers. The tourism industry accounts for over 60% of the Bahamian GDP and provides jobs for more than half the country's workforce. The Bahamas attracted 5.8 million visitors in 2012, more than 70% of whom were cruise visitors.

Vulnerability to Hurricanes and Environmental Change

A disadvantage of most small islands is not only their geographic remoteness but also the fact that they are facing major impacts of climate change that may consequently hinder their sustainable development, as underlined by Kelman and West (2009) and Mukhopadhyay et al. (2012) who related climate change to vulnerability and adaptation. The dramatic outcome from hurricanes in the Bahamas can be demonstrated with the 2015 Hurricane Joaquin that was estimated to be US$ 100 in damage, and the destruction especially affected the islands of Acklins, Crooked Island and Rum Cay, San Salvador and Mayaguana. Additionally, as reported by The Bahamian Tribune (Hartnell, 2018) in referring to a report by the Inter-American Development Bank (IADB Country Program Evaluation: Bahamas (2018), hurricanes Matthew in October 2016 and Irma in 2017 caused a combined $710 million in economic damages and loss. Matthew alone in 2016 impacted the highly populated islands of New Providence and Grand Bahama with an estimated total of $580 million in physical damage, revenue and other economic losses and clean-up costs. In 2017, Hurricane Irma resulted in an estimated total damage of about $129.4 million.

When considering long term projections, a major concern in the Bahamas is the risk related to anticipated impacts of climate change in the regions with low topography. This is based on observations that the estimated climate change–driven acceleration of global mean sea level is about 0.084 ± 0.025 mm y^{-1} (Nerem et al., 2018). Coupled with the global average climate change–driven rate of sea level rise over 25 years of 2.9 mm y^{-1}, global mean sea level could rise 65 ± 12 cm by 2100. The IPCC predicted that during the 21st century, sea level rise is expected to be the reason for many small islands to lose significant portions of their land and that sea level rise is very likely to increase during the 21st Century (IPCC, 2013), relative to the period 1971–2010 (Nurse et al., 2014). In the Bahamas, the anticipated sea level rise would have an impact on the infrastructure with inland inundation and increasing salinity intrusion into the groundwater level. At present, sea level increase seems to be almost steady; however, predictions over extensive and various time frames are made with a large margin of error, and the magnitude presents greater uncertainties. Nevertheless, predicting a one-meter rise in sea level could bring about flooding in many coastal regions and would inundate many populated areas not only of the Bahamas but also all low-lying islands and atolls (Warrick and Oerlemans, 1990).

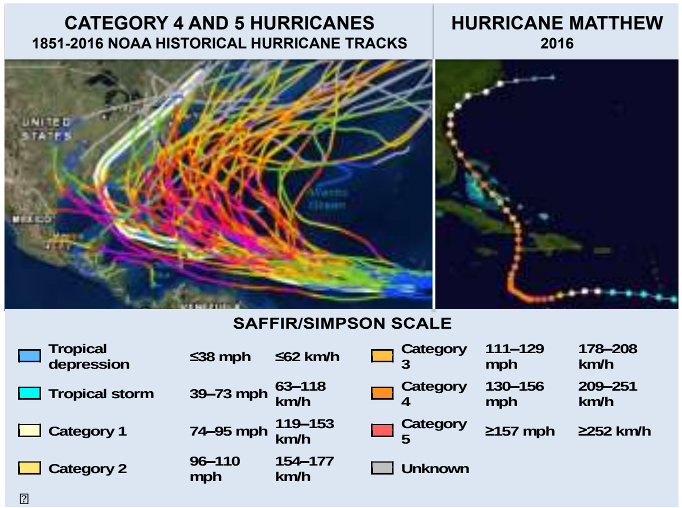

Figure 4: Historical tracks of hurricanes from 1851 to 2016 and selected pass of hurricane Matthew in 2016. Adapted from NOAA data.

International Aspects

Cooperation between SIDS is mainly based on political and legal issues to control internationally the exploration and exploitation of marine resources. The advantage of grouping and cooperation amongst SIDS is best documented with the creation in 1990 of the Alliance of Small Island States (AOSIS) under the aegis of the United Nations. To partially overcome the dependence of small islands on larger developed economies, efforts have been undertaken to form alliances for cooperation at a regional level and to use international platforms to communicate their concerns. This move was accelerated during the 1992 United Nations Conference on Sustainable Development under "Agenda 21" with the inclusion of the item on Sustainable Development of Small Islands (UNCED, 1992). The formation by small island states of an alliance having a common position contributed to the strengthening of the capacity to negotiate in international forums, primarily within the United Nations system. This is important in connection with the challenges of small island states with respect to their vulnerability and concerns impacted by global changes. The formulation of a political image for SIDS is manifested with the adoption of the Barbados Programme of Action (BPoA) in 1994, and in 1999 the United Nations General Assembly reviewed, assessed and called for concerted efforts to support implementation of the BPoA. Furthermore, the special character of SIDS was reaffirmed by the World Summit on Sustainable Development (UN Sustainable Development Platform 1994; 1999; 2002).

With regards to boundary issues of the Bahamas, the Bahamas in 2011, established its maritime boundary agreement with Cuba but has not yet concluded maritime boundary agreements with the United States, Haiti, and United Kingdom (boundary with Turks and Caicos Islands). The Bahamian Government introduced "The Bahamas' Archipelagic Waters and Maritime Jurisdiction (Archipelagic Baselines) Order" that took effect with the establishment of coordinates for the archipelagic baselines. This Act addresses the situation of the outer limits of the Exclusive Economic Zone of the Bahamas that extend to the median line that is defined as a "line every point of which is equidistant from the nearest points of the baselines from which the breadths of the territorial sea of the Bahamas and of any neighboring state are measured". Therefore, the outer limits of the EEZ of the Bahamas towards the United States is considered to the median line between the two countries (Figure 5, US Department of State, 2014).

Figure 5: Illustrative map of the archipelagic baselines of the Bahamas. US Department of State (2014). The United States Government does not necessarily reflect an acceptance of the limits claimed.

Territorial and marine boundaries can be negotiated through bilateral or multilateral means. However, small islands have less control on any major decision with respect to environmental changes due to anthropogenic alterations on a global scale. Provisions to reflect on this shortcoming are anchored in the adopted Paris 2015 agreement for an effective and progressive response to the present threat of climate change and the vulnerabilities of food production systems (UNFCC, 2015). In particular, Article 11 of the Agreement pays attention to countries with the least capacity to take appropriate action. Furthermore, islands are included because they are particularly vulnerable to the adverse effects of climate change. It also pointed out that increasing threats from climate change, natural disasters and unplanned economic growth have harmful implications for tourism and agriculture, as well as for food security and nutrition. The reduction of available living areas and diminished natural resources brought about by an increase in population and an anticipated rise in sea level have drawn the attention of governments, in particular in those islands with low elevation regions where about 10 per cent of the world's population live (McGranahan et al., 2007). Whatever means are taken to mitigate the social, institutional, and political dimensions of coastal ecosystem change, consume the financial resources of coastal managers (Olsen and Christie, 2000). Unfortunately, as documented by the Organization for Economic Cooperation and Development (2015), the support through Official Development Assistance (ODA) has decreased while total required assistance on a global scale increased. In 2013, SIDS received around US$ 4.3 billion in ODA that corresponds only to a small fraction of total ODA. However, compared to a proportion on a per capita basis, they are bigger recipients in the financing for development because they received about 5.7% of total development. Foe example, in 2013, SIDS on average received US$ 447 per capita in ODA while low-income countries received on average US$ 59 per capita aid for that year (OHRLLS, 2015). The numbers show that the share of total official assistance to SIDS decreased from around 3.5% in 2000 to less than 2% in 2013. The peak in ODA in 2010 was largely caused by aid-relief to Haiti, but finance to SIDS has remained fairly constant before its decrease in 2011. Nevertheless, funding for mitigating environmental changes and for disaster prevention is rather limited in most small island states, and financing has been mainly secured through loans and bilateral grants (Olsen and Christie, 2000).

Conclusions

Governments of islands have long been concerned about the emission of greenhouse gases but have debated internationally the fact that small islands play a minor role with respect to their emission of greenhouse gases and therefore contribute only marginally to the effects of climate change (Tisdell, 1993). The risk profile and vulnerability differ from island to island, and therefore, response to drivers of climate change has to be dealt with separately. Small islands are left with few alternatives. Public awareness and education on coastal threats are direct initiatives that can be taken for reducing future disasters. Resettlement from the coast is a mitigation alternative that on the national level is valid for islands with elevated topography but may be difficult in the mobilization of high numbers of people. A rough estimate with respect to the situation of the future population and associated environmental concerns can be given for the Bahamas where about 0.4 million have to retreat from the low elevated coastal zone. Those estimates are affiliated with a large margin of error, but it shows the dimension with which planners have to deal with. The mitigation to predicted changes progress at a slow rate, and Bahamas' neighboring countries could possibly absorb migrants, with the US probably being the major recipient. Similar conclusions can also be derived for many other islands. External support for migration however can be foreseen only if smaller groups of population can be shifted and integrated into supporting recipient countries. On the other hand, if millions of people from islands with high populations are engaged in migration, most challenging will be the political willingness at the national and international levels and having to face as well socio-economic needs.

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