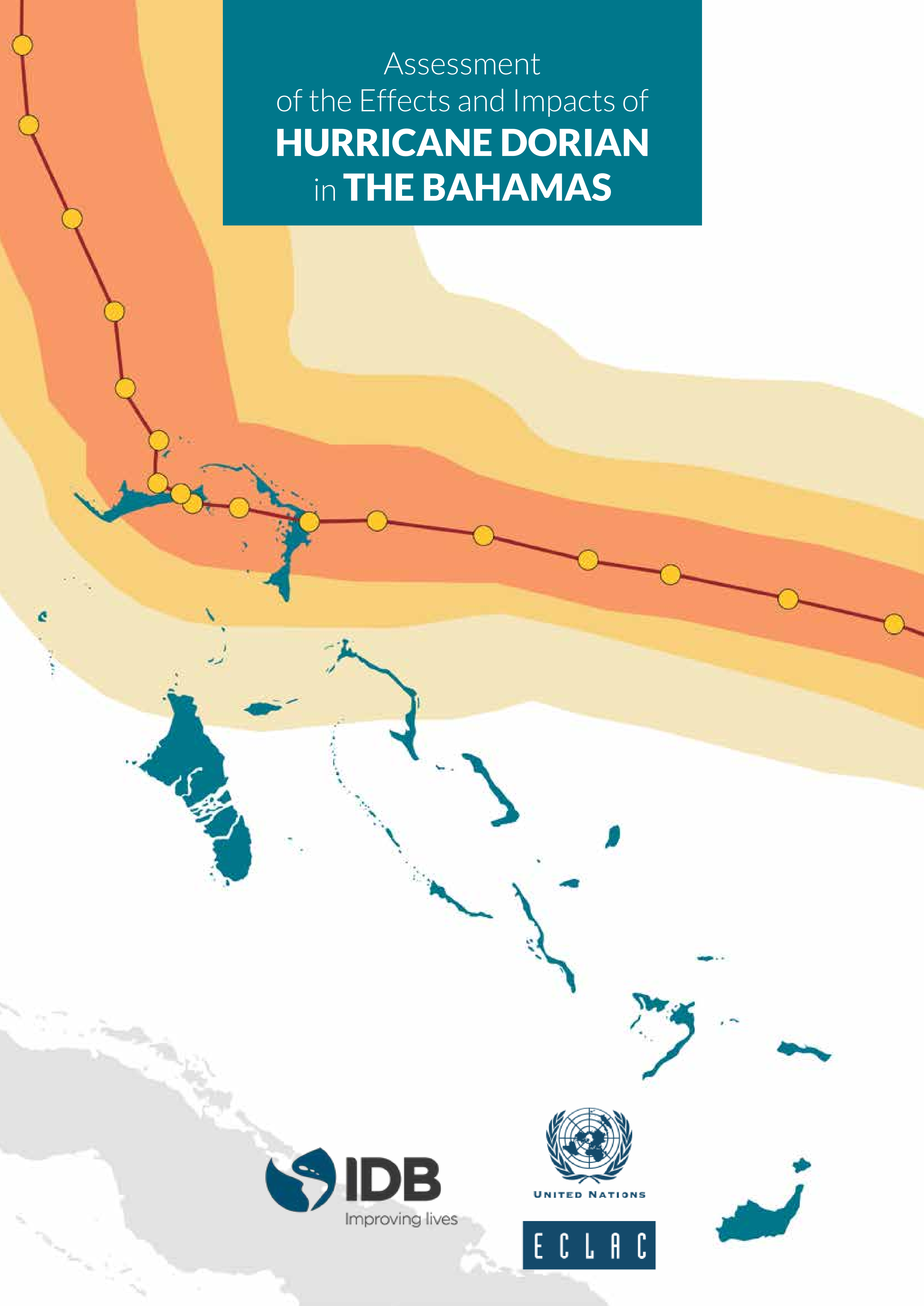
Assessment of the Effects and Impacts of **HURRICANE DORIAN** in **THE BAHAMAS**



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of the Effects and Impacts of
HURRICANE DORIAN in THE BAHAMAS

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Foreword

The threat of climate change presents unique challenges to the Caribbean region, with smaller island nations like The Bahamas particularly vulnerable to the chaos of natural disasters and the impact they have on developing economies.

The Inter-American Development Bank is proud of its long-standing, rich history with the islands of The Bahamas, solidified in meaningful partnerships with the nation's Government, the private sector and its citizenry. During this time, the Bank has witnessed first-hand the increasing intensity of natural disasters and the disruption to lives and the livelihoods within our member country.

In *October 2016*, ***Hurricane Matthew*** passed through the chain of islands, varying between category 3 and category 4 intensity levels that left widespread damage in its path. Nearly a year later, ***Hurricane Irma*** tore through the country as a category 4 storm in *September 2017*, rendering many smaller islands uninhabitable in the short-term and changing daily life in those areas in the long-term. In *September 2019*, the world watched as the category 5 ***Hurricane Dorian*** rained havoc down on The Bahamas islands of Grand Bahama and Abaco and their communities, erasing any evidence of life in some neighborhoods and leaving behind a trail of heartbreak, sorrow and death.

The catastrophic damage to livelihoods and billions of dollars of infrastructure on this archipelago present significant challenges to the preparedness of its tourism-dependent economy and its rescue and recovery capacity.

As the leading multilateral Bank, The IDB committed itself to a restoration effort that would be far-reaching and strengthen the island chain against future natural disasters. Through a partnership with the Economic Commission for Latin America and the Caribbean, the Bank deployed a research team of experts – both local and international – to the affected sites to collect pertinent data that could be integrated in a more sustainable framework for disaster risk management, policy preparedness and reconstruction methods after a natural disaster.

Within this report is a comprehensive overview of the toll Hurricane Dorian had on the islands' economies and an accounting of the losses, broken down throughout the sectors. It analyzes key vulnerabilities and threats and compiles findings from assessments with recommendations to build resilience in a way that honors the nation's past while advancing the present and preserving its future. This report, together with the reports on Hurricane Matthew and Hurricane Irma, provides The Bahamas with data that supports meaningful policy reforms to promote strategic decision making regarding natural disasters.

As we forge ahead, there is a new reality developing and it is that we are now living in uncertain times where climate change and its impacts require us to have tactical plans in place that protect and foster stability in the nation's economic and cultural systems. The Inter-American Development Bank is honored to continue to partner with the Government of The Bahamas and present this Damage and Loss Assessment report to help strengthen national initiatives for a more resilient Bahamas.

Daniela Carrera-Marquis
Country Representative
Inter-American Development Bank
Country Office Bahamas

The Caribbean is among the regions of the world most vulnerable to the impact of extreme weather events, with countries of the subregion experiencing among the highest rates of damage relative to their gross domestic product (GDP). Indeed, considering the ratio of affected population to total population and the damage-to-GDP ratio, Caribbean small island developing States (SIDS) have been more significantly affected than those in other regions of the world. The gravity of this situation is brought into even sharper focus by the fact that SIDS are already bearing the brunt of the impacts of climate change and will face even higher economic and social costs if the projected scenarios of sea-level rise become a reality.

Within the Caribbean subregion, the negative impacts of extreme weather events over the years have been most vividly illustrated in the Bahamas. Since 2015, the Bahamas has been devastated by four large hurricanes, three of which have been classified as category 5 events. Hurricane Joaquin affected the Family Islands in 2015 and Hurricane Matthew hit Nassau and Grand Bahama in 2016. In 2017, the country was not spared the ravages of Hurricane Irma, one of the Atlantic Basin's most powerful storms, which affected primarily Ragged Island, Grand Bahama and Bimini. Most recently, following a brief reprieve in 2018, Hurricane Dorian unleashed devastating force on the beautiful Abacos and Grand Bahama islands in 2019. Dorian left in its wake a swathe of destruction surpassing the loss and damages of the three previous hurricanes combined, costing an estimated US$ 3.4 billion. These events have taken an overwhelming toll on the tourism sector, the country's main engine of growth. As a result, these vulnerabilities significantly diminish the capacity of the Bahamas to finance its recovery and resilience-building.

ECLAC has conducted Damage and Loss Assessments (DaLA) following each of the events mentioned above, measuring their economic, social and environmental impacts on the Bahamas. The assessments were jointly undertaken with the support of the Inter-American Development Bank (IDB) and the Pan American Health Organization/World Health Organization (PAHO/WHO). Great care is taken to ensure the completeness and accuracy of these assessments, given the important role the reports serve in estimating the extent of loss and damage suffered; to describe the critical areas of need for governments in the aftermath of these events; and to guide the country's resilient reconstruction efforts. The DaLA reports have also found wider application in strengthening national policies by integrating key recommendations in the disaster risk management (DRM) policy framework of the Bahamas.

I am very pleased to submit for the judicious use of the Government of the Bahamas the report on the Effects and Impacts of Hurricane Dorian on the Bahamas. It is my hope that this assessment will serve as a valuable guide for decision makers in the design of resilient reconstruction and redevelopment on the affected islands. Such development, however, requires low-cost long-term development finance which is not currently available to the Bahamas because of its income status. The hard evidence in this report should prove to the international community that the Bahamas needs external financial support to strengthen its resilience to disasters and to build back better.

I therefore propose it be used as a robust point of reference and I also encourage DRM experts, international development partners and civil society to embrace its specific recommendations for rebuilding with resilience.

Alicia Bárcena
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ACRONYMS

ARPU	Average Revenue Per User
BEC	Bahamas Electricity Company
BNT	Bahamas National Trust
BPL	Bahamas Power and Light
BTC	Bahamas Telecommunications Company
CARILEC	Caribbean Electric Utility Services Corporation
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CDEMA	Caribbean Disaster Emergency Management Agency
CVI	Coastal Vulnerability Index
DALA	Damage and Loss Assessment
ECLAC	Economic Commission for Latin America
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization
GBPA	Grand Bahama Port Authority
GBPC	Grand Bahama Power Company
GBUC	Grand Bahama Utility Company
GDP	Gross domestic product
GFDRR	Global Facility for Disaster Reduction and Recovery
IDB	Inter-American Development Bank
MEH	Ministry of Environment and Housing
MoEST	Ministry of Education, Science and Technology
MOH	Ministry of Health
MOW	Ministry of Works
MRAG	Marine Resources Assessment Group
NatCap	Natural Capital
NEMA	The Bahamas' National Emergency Management Agency
NGO	Non-government organization
NOAA	National Oceanic and Atmospheric Administration
NPDC	New Providence Development Company
PAHO	Pan American Health Organization
PHA	Public Hospital Authority

EXECUTIVE SUMMARY

INTRODUCTION

Hurricane Dorian is not an isolated occurrence, but the latest example of recurrent extreme climate events that have changed the Bahamian landscape and impacted its economy. The increase in water temperatures is likely to contribute to a tendency for tropical storms to be, on average, stronger than they have been in the past (Bruyere, Holland, 2014; Balaguru, Foltz 2018; Bathia, Vechia et al, 2019; Trenberg, Cheng et all, 2018). Due to its location in the Atlantic hurricane belt and like other Small Island Developing States (SIDS), The Bahamas is extremely vulnerable to the effects of disasters and climate change, as some 80 percent of the landmass is within 5 ft (1.5 m) of mean sea level and coastal areas hold the majority of the population and economic activity. Another relevant vulnerability is access to drinking water, which is made worse by contamination of water resources caused by storm surges. In the upcoming years, the country will face difficult questions of whether to relocate coastal populations and how to smartly invest in more resilient infrastructure. It is, therefore, imperative for The Bahamas, as a country, to establish a comprehensive approach to meeting these challenges and to incorporate considerations for disaster risk management into all features of national development.

Disasters are described as a combination of exposure to hazard and conditions of vulnerability. Greater vulnerability is usually linked to socio-economic and territorial aspects, as poorer populations tend to live in at-risk areas disregarded by formal planning systems, all but ensuring a greater exposure to hazards. This exposure of social and economic assets to hazards can be somewhat balanced with measures to mitigate vulnerabilities, such as investments in early warning and preparedness, and addressing pre-existing social issues such as informal settlements.

Disasters set accomplishments back in social and economic arenas and put a strain on national budgets. This is of concern for The Bahamas, a country not eligible to receive official development assistance (ODA) and where government debt, for example, doubled from 32 percent of GDP in 2007 to 65 percent of GDP in 2014. In this regard, the DaLA assessments of Hurricanes Joaquin, Mathew, Irma and now Dorian offer a historical record of the cumulative effects and impacts on economy, infrastructure and society from recurrent disasters and offers guidance for future decision-making processes.

In The Bahamas, the characteristics of its territory and dispersed population in the Family Islands adds extra challenges for planning and recovery. Settlements are usually dispersed and contain small populations, which increases the costs associated with the provision of public utilities and the development of infrastructure which needs to be extended for long distances to supply communities. Dispersion of population also contributes to inequitable access to social services of varying quality. Additionally, the islands face economic vulnerabilities. Tourism and fishing are, together with public employment, a plurality of the jobs in the Family Islands. Dorian, like other hurricanes, caused widespread damage that directly and indirectly affected these productive activities.

The Bahamas has made important efforts in mitigating risks and improving resilience through instruments such as hard engineering and a modern building code, along with the enactment of the Disaster Preparedness and Response Act from 2006 (amended in 2011). The subjects dealt with in the Act are also reflected in the Vision 2040, the National Development Plan of The Bahamas, which frames the country's development agenda within the Sustainable Development Goals (SDGs). Nevertheless, the effects of Hurricane Dorian brought to light many areas that still require improvement, not only in terms of physical risk, but in social and economic aspects.

Resilience involves identifying these risks and developing measures to reduce them, such as enhancing infrastructure and land-use planning and financial protection. Addressing physical vulnerability must be accompanied by social policies to protect the livelihoods of the most vulnerable groups. Special attention should be given to the particularities and constraints of the Family Islands, such as the challenges to enforce and verify compliance with building codes. Specific policies and programs and possibly additional financial resources should address these. Education and public awareness are also important mechanisms and should be a crosscutting component of any disaster risk management plan. Although a strong system of risk modeling and disaster data management is a must, the population needs to understand the kind of risk they are exposed to and be provided with the tools and capacity to act accordingly at times of emergencies.

On 1 September 2019, the eye of Hurricane Dorian made landfall on the Abaco islands with maximum sustained winds of 185 mph (280 km/h), wind gusts over 220 mph (335 km/h), and central barometric pressure of 911 millibars (26.9 inHg). Abaco and its cays along the eastern side were the most affected areas. According to the trajectory of the hurricane, the central and northern part of the island were affected by hurricane force winds, storm surge and flooding. According to the Bahamas Department of Meteorology, the storm surge provoked storm tide of 20 to 25 ft (6.1 to 7.6 m). Dorian also dropped an estimated 3 ft (0.91 m) of rain over The Bahamas. Therefore, Dorian is considered the strongest hurricane on record to affect The Bahamas, not only because of its wind intensity, but also due to the storm surges. The storm surges provoked extensive damage in the most proximal zones to the coasts and lowlands.

On 2 September, the eye of Dorian moved over the eastern side of Grand Bahama and drifted across the island as a Category 5. The hurricane then stalled over Grand Bahama for another day, finally pulling away from the island on 3 September. According to the descriptions of the Department of Meteorology, storm surge and flooding were the events provoked by hurricane Dorian that caused the most severe damage, especially in the eastern side of the island. The flooding on Grand Bahama began from the north and northeast towards the south of the island, this phenomenon was due to the trajectory of the hurricane and the period that Dorian remained in the northern part of The Bahamas in open ocean.

After hurricane Dorian and the provision of initial emergency services, the government of The Bahamas asked the Inter-American Development Bank (IDB) to assess the resulting damage, losses and Additional costs. The IDB requested the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) for technical assistance with the assessment. This report presents the results of this assessment. It also brings recommendations to guide a resilient reconstruction process that can reduce vulnerabilities and risks for the population and for every sector of the economy. Since 2015, it is the fourth assessment in this kind conducted by IDB and ECLAC in The Bahamas.

The report is divided into two sections. The first section contains the description of event, affected population and detailed explanation of damage, losses and Additional costs in all social, infrastructure and productive sectors. Additionally, this part includes an analysis of environmental effects and the macroeconomic impact. The second part introduces recommendations for resilient reconstruction based on the findings of technical experts and best-practices and is divided in five pillars: risk identification, risk reduction, preparedness, financial protection and resilient recovery. The upcoming section will summarize the main findings and the document and briefly describe the conclusions of each chapter. All monetary estimates are made in Bahamian dollars; to simplify the symbol $ is used.

SUMMARY OF DAMAGE, LOSSES AND ADDITIONAL COSTS

Hurricane Dorian's greatest impact was felt on Grand Bahama and Abaco, although some impact also occurred on the island of New Providence. Damage resulted from high winds and storm surge and was exacerbated by poor construction practices and communities and infrastructure located in vulnerable areas. Given the magnitude of this event, the reconstruction efforts will last many years and it will require major assistance from financing institutions. Reconstruction is expected to be a long-term process, which tests the strength of a country's institutions. However, it is important that those directly affected by the disaster feel the presence and solidarity of the government throughout the process.

The costs consist of three elements: direct physical damage, revenue and other income losses, and Additional costs—chiefly debris removal. Table 1 summarizes estimates of Damage, Losses and Additional costs for the four primary sectors on the affected islands: social, infrastructure, productive and environment. The estimated damage is $2.5 billion, of which nine percent is public and 91 percent private.[1] Abaco suffered 87 percent of the damage and Grand Bahama 13 percent. Losses are estimated as $717.3 million and were sustained primarily in the private sector, which accounted for 84 percent of the total. (Seventy percent of the losses took place on Abaco, 15 percent on Grand Bahama, and nine percent in other islands.) Additional costs add up to $220.9 million, 46.4 percent of those costs were in the environment sector and are associated to the cleaning of the oil spill. A major part of the remainder of the additional costs is related to debris removal and demolition.

Damage in the social sector was $1.6 billion, 85.3 percent took place on Abaco. Ninety-three percent of the damage was in housing, 4.6 percent in education while 2.4 percent occurred in the health sector. Approximately 93.8 percent of the damage in the social sector happened to private property and the remaining 6.2 percent in public property. The productive sector suffered damage estimated to be $620.9 million, most of them in tourism ($529.6 million), followed by commerce ($77.6 million), and fisheries and agriculture ($13.6 million). All damage in the productive sector happened in the private sector. Infrastructure experienced damage amounting to $239.1 million. The power sector represents 54.1 percent of the total. The telecommunications sector suffered damage of $42.1 million, transport accounted for $50.8 million and water and sanitation $14.9 million. Approximately 48.6 percent of the damage in the infrastructure sector was to private property and the remaining 51.4 percent was to public property. 66.8 percent of damage of the infrastructure sector took place on Abaco.

We estimate that about 38 percent of the damages were insured. Note that the damage estimate is based on the replacement cost of the asset. For example, in the commerce sector, in the case of destroyed establishments, our estimate seeks to approximate what is the replacement cost of that infrastructure, not its market value. The latter includes, for example, the value of the land. In general, the amount of insurance is based on market value, not as much as a similar infrastructure is worth replacing. Therefore, our estimates of the insured amount are intended to approximate the percentage of assets whose replacement costs could be financed in this way. In the specific case of the housing sector, it is expected that in the insurance there will be a bias towards those of greater value and that it is influenced by the homes that had a mortgage. In this sense, we estimate that 30 percent of the damages in the housing sector were insured and that 14 percent of the properties were insured.

1 The distinction between public or private is made on the basis of ownership of the asset, not on who will pay for its recovery. For example, many of the airports damaged are privately owned. The damages in these facilities are classified as private, regardless on who ends up paying for its recovery. We know that in this cases, some private infrastructure will get public resources to rebuilt, unfortunately at this point is not possible to precise which infrastructures and to what extent, will get public funding.

Losses for the social sector are estimated to be $93.2 million, of those $65 million were in housing, $21.4 million in health and $6.7 million in education. Losses in the Environmental sector were estimated at 27.5 million. Losses for the productive sector were estimated at approximately $400.3 million. Abaco suffered 83.8 percent of those losses. Tourism accounted for most of the losses (81.2 percent) and suffered the greatest effects. This sector suffered a loss of $325.2 million. The losses in commerce were $65 million and in fisheries and agriculture, $10.1 million. All losses to the productive sector were private. The losses in the Infrastructure sector were estimated at $197.1 million. Most of the losses were in the power sector (35 percent), followed by telecommunication (27.6 percent). The losses in water and sanitation and transportation were near $19 million each. The public losses in the infrastructure sector were smaller (38.8 percent) than the private sectors (61.2 percent). Abaco suffered 60 percent of the losses of the infrastructure sector.

Additional costs were estimated as $220.9 million, 46.4 percent of those costs were in the environment sector associated to the cleaning of the oil spill. The additional costs of the social sector were $82.6 million, followed by the productive sector, $20 million, and infrastructure, $16.2 million. An important part of these costs is related to debris removal and demolition. Costs associated with the emergency response were only partially provided, for example, costs of evacuation were not made available at the time of the finalization of the report.

TABLE 1. SUMMARY OF EFFECTS OF HURRICANE DORIAN

	Damage	Losses	Additional costs
Social	1,597,290,766	93,163,186	82,254,021
Housing	1,487,167,663	65,014,267	57,809,391
Education	72,406,603	6,799,026	19,100,000
Health	37,716,500	21,351,380	5,344,630
Infrastructure	239,135,274	197,136,671	16,236,779
Power	131,355,000	68,924,558	6,335,000
Telecommunications	42,150,000	54,380,149	1,039,960
Water and Sanitation	14,853,000	36,624,014	2,289,200
Transport	50,777,274	37,207,950	6,572,619
Productive	620,650,850	400,285,030	19,954,141
Tourism	529,550,208	325,199,267	15,146,625
Commerce	77,584,545	64,973,002	4,807,516
Fisheries and Agriculture	13,516,097	10,112,761	
Environment	7,146,963	27,435,048	102,473,000
Total	$2,464,223,852	$718,019,935	$220,917,941

Source: Assessment team 2019

In 2019, The Bahamas economy was expected to grow by 2.2 percent. The estimated impact of Hurricane Dorian is one percentage point of the GDP. This implies that post-disaster, the economy is expected to grow 1.2 percent. This will result in a decrease in salaries of $42 million and capital income of $59.9 million. The situation is different when the focus is on local economic activity. In the case of Abaco, the impact was estimated at 7.1 percent of its GDP, which is estimated to be 47 percent and 60 percent decrease of the country's remuneration and capital, respectively. On Grand Bahama, the impact was 1.9 of its GDP.

METHODOLOGICAL APPROACH

The assessment of the effects and impacts caused by Hurricane Dorian follows the Disaster Assessment Methodology developed by the Economic Commission for Latin America and the Caribbean. The methodology allows standardized data collection and analysis on a sectoral basis, applying the same criteria to every sector under study. In this regard, the following concepts are used in the assessment[2]:

(i) Effects: Damage, Losses and Additional costs

- Damage: the effect the disaster has on the assets of each sector, expressed in monetary terms

  Assets may include buildings, machinery, equipment, means of transportation, furnishings, roads, ports, stocks of final and semi-finished goods, among others.

- Losses: goods that go unproduced and services that go unprovided during a period running from the time the disaster occurs until full recovery and reconstruction is achieved

- Additional costs: outlays required to produce goods and provide services as a result of the disaster

  These represent a response by both the public and the private sectors, and may take the form of additional spending or a recomposition of spending.

(ii) Impacts: consequences of the effects on macroeconomic variables, such as GDP, public finance and balance of payments

Based on the information gathered during field visits and interviews, the social sector analysis focuses on affected population, housing, health and education. The infrastructure sector comprises transportation, telecommunications, power and water and sanitation. The productive sectors analyzed are tourism, and agriculture and fisheries. Additionally, the report includes a cross-cutting assessment of the effects suffered by the environmental sector. The Assessment team visited The Bahamas from 31 September to 5 October 2019 to collect data and obtain an overview of the effects of the hurricane on the country. Between 1 and 2 of October, team members visited the most affected areas, including Eastern Grand Bahama, Freeport and Marsh Harbour, as well as the surrounding regions. In addition, the Assessment team held meetings and interviews with representatives from government agencies responsible for each sector under analysis.

The assessment was carried out using official data provided by the government, interviews with the private sector and academia, and observations from the field visits. However, as it will be detailed in each pertinent sector, the main limitation of the assessment was access to information, either due to unavailability during the assessment or because it is not yet collected/produced in the country. This limitation was overcome by creating reasonable assumptions where data was unavailable. Both official information and informed assumptions were used to estimate the effects of the hurricane and are presented in each section.

2 ECLAC (2014), Handbook for Disaster Assessment

SUMMARY OF AFFECTED POPULATION

Most inhabitants of Abaco and Grand Bahama were affected by the passage of Hurricane Dorian in one way or another. The Assessment team estimated that approximately 29,472 persons were affected by the hurricane as a result of some sort of damage to their homes and assets. There were 67 confirmed deaths and 282 persons still missing as of 18 October 2019. The number of related injuries recorded by the health authorities was over 200 a week after the passage of the hurricane.

Approximately 4,861 persons were registered by the Department of Social Services during the evacuation process. However, it should be noted that not all evacuees would have been accounted for, as some used private transport to evacuate to Eleuthera and the United States of America. With the passage of Hurricane Dorian, the government was faced with accommodating thousands of displaced persons in shelters across New Providence, in some cases up to two months after the event. The number of displaced persons in shelters on Abaco and Grand Bahama was comparatively less as most had evacuated to New Providence.

In terms of access to services, most of the population of Abaco and Grand Bahama suffered interruptions in utilities like telecommunications, electricity and water. Approximately 10,546 students were affected as a result of a suspension of primary and secondary school classes in both islands. This created a significant loss in teaching time, as most school facilities were damaged in the affected islands. Furthermore, a great number of the population employed in the commerce and tourism sectors experienced disruptions in employment due to damaged properties.

In addition to the regional and international partners that aided in the early phases of emergency and relief response, the government of The Bahamas, through its various institutions, allocated around $7 million for the attention of the emergency and relief efforts.

SUMMARY OF HOUSING AND PUBLIC BUILDINGS

Housing was the sector most severely affected by Hurricane Dorian. Several residential settlements along or near the coastline suffered heavy damage as a result of the intense force of winds and storm surge or was impacted by falling trees and flying debris. Houses and residences suffered significant damage to the structural elements, roofs, flood damage, and other components of the buildings.

Approximately 9,000 homes and in excess of 11 million square feet of structures have sustained some damage on the two islands. On Abaco more than 75 percent of the dwellings were somehow affected, approximately 57 percent of the houses were severely damaged. Central Abaco (Marsh Harbour), Treasure Cay, and Hope Town were the most affected locations. Vulnerable settlements in Marsh Harbour were also destroyed. Damage to the housing sector on the islands of Abaco and Grand Bahama is estimated at $1.48 billion, 88.9 percent of which took place on Abaco.

Losses in the housing sector are attributed to the interruption of accommodation and rental services due to severe damage or destruction of the house, making it temporarily or permanently uninhabitable. The Assessment team estimated losses at $56.8 million resulting from 2,894 homes left uninhabitable after the hurricane.

Additional costs included in this assessment are refer to the cost of demolition of the most affected dwellings, debris cleaning, and labor and equipment rental cost. Additional costs are estimated at $57.8 million.

In total, 31 public buildings (excluding schools, hospitals/clinics and shelters that were assessed in other sectors) and government offices were affected. Damage to the public building sector is estimated at $10.6 million. Additional costs to demolition and debris removal in public buildings are estimated at $1.0 million. There was no losses related to public buildings.

SUMMARY HEALTH

The hurricane severely affected the infrastructure, equipment, medical supplies and electrical and water supply on Abaco and Grand Bahama. Therefore, the capacity of the healthcare delivery system has been significantly hampered on Abaco and Grand Bahama.

Hurricane Dorian damaged most of the healthcare facilities in both affected islands, with severe damage to the Rand Memorial Hospital (RMH) and four clinics located in the eastern part of Grand Bahama. Additionally, significant damage was also evidenced in medical equipment, furniture, and vehicles from extensive and prolonged flooding, very high humidity and high temperatures during and after the storm. The estimated damage in infrastructure, medical equipment, furniture, supplies and others to the health sector on Abaco and Grand Bahamas attributable to hurricane Dorian has been estimated in $37.7 million.

A total of $21.4 million is the estimated cost of health services operations disruption. The disruption covers three time periods: before, during and after the hurricane.

Additional costs are related to the emergency response and provision of temporary relief and are estimated as $5.3 million

SUMMARY OF EDUCATION

Following the passage of the category 5 Hurricane Dorian, Grand Bahama and Abaco were the two hardest hit islands, incurring widespread damage to most educational facilities. Across the both islands, there were 45 educational facilities experiencing varying levels of damage with 10,546 students and 796 teachers affected. Seven schools were altogether destroyed. On Abaco, there were 23 educational facilities impacted with 3,512 students and 211 teachers affected while Grand Bahama had 24 educational facilities impacted with 7,034 students and 585 teachers affected. At the time of this report and following the registration drive conducted by the Ministry of Education, approximately 1,500 displaced students had been reassigned to alternative schools across the islands of The Bahamas.

The widespread damage to educational facilities amounted to $72 million. Losses in the subsector which comprises the estimated value of lost instruction time along with the value of tuition refunds for students no longer returning for post-secondary level education totaled $6 million. The remaining costs included Additional costs incurred during the recovery efforts, which amounted to $19.1 million. They include the removal of rubble, school furniture to accommodate re-assigned students and teachers, special equipment to conduct classes, fencing, security, school meals, payment of grants, security, psychosocial support to teachers and staff, enrollment fees and costs associated with the enrollment drive conducted by the Ministry of Education for displaced students. The estimated costs across the two islands were equally distributed despite the student and teacher population on Abaco being significantly smaller than that of Grand Bahama; an indication of the magnitude of the damage on Abaco. Public sector institutions incurred the brunt of the costs across the affected islands with a total estimated cost of $74 million. The limited data available on private sector schools across the both islands contributed to the significantly smaller private sector cost.

SUMMARY OF ROADS, AIRPORTS AND PORTS

The transport infrastructure, including roads, ports and airports was damaged on Abaco and Grand Bahama. Structural damage was related to storm surge and high-speed winds and the most affected infrastructures were located near the shore. The airports suffered high operational damage due to flooding and roof failure due to high-speed winds, and seaports were impacted by waves, storm surge, and wind.

The estimated transportation infrastructure damage is approximately $51 million for the whole country, 53 percent of the damage took place on Grand Bahama, where 93 percent was sustained at the Grand Bahama International Airport.

The losses are estimated considering the decrease in tourism and cargo in both Abaco and Grand Bahama and its effects on the collection of port charges and services. The estimated economic losses associated with the interruption of transportation services is $37 million. It is estimated that 44 percent of the losses will take place in 2019, 39.2 percent in 2020 and 16.8 percent in 2021.

Finally, the additional costs associated with the construction of temporary infrastructure and removal of debris are $6.6 million.

SUMMARY OF TELECOMMUNICATIONS

The telecommunications sector suffered considerable damage to infrastructure because of Hurricane Dorian. Gale force winds caused damage to above ground network elements, while flooding caused unexpected damage to various types of ground level telecommunications equipment. Total damage to the telecommunications sector was estimated at $42.1 million. Water damage to electronic systems rendered many parts of the network inoperable during and after the hurricane, whilst the high saline content of the floodwater caused corrosion to various types of wiring and conductors. Due to the high flood levels, buried fiber optic cables and copper wires were damaged to the point where they emerged from the ground to connect to above ground equipment. Heavy winds also caused the more typical type of damage associated with hurricanes, seriously damaging wireless infrastructure such as antennae, base transceiver stations and satellite dishes.

The losses are estimated at $54.4 million and the most significant losses occur on Abaco, where services could not be provided to end users due to widespread destruction. Losses estimates were projected until December 2021, as recovery is expected to take at least this time or even longer to return to normal levels. An estimated loss of $13.7 million was made for the remainder of the year 2019; $16.3 million for the year 2020; and $24.4 million for the year 2021. Losses were primarily as a result of the absence of commercial power, the extended time needed for network restoration, and the loss of clientele. On Abaco, where the effects of the hurricane were the hardest, it is expected that there will be a long road to recovery of the services that require a wired telecommunications network infrastructure.

Additional costs were estimated at approximately one million dollars, mainly reflecting the labor-related costs required to perform repairs, as well as generator fuel burned in the absence of commercial power.

SUMMARY OF POWER

Hurricane Dorian caused extensive damage to the power generation, transmission and distribution systems on the islands of Abaco and Grand Bahama.

Total damage in the power sector was estimated at $131.3 million, of which the largest line-items were $80.4 million in damage to the transmission and distribution networks on Abaco and $21 million in damage to the flooded power generation plant on Grand Bahama.

Total losses were estimated at $68.9 million, reflecting the value of power that was not sold, both because of damage to the transmission and distribution network and because of the reduction in demand for electricity as a result of storm damage. Losses were estimated until December 2021 as recovery is expected to take at least this time or even longer to return to normal levels. An estimated loss of $22 million was made for the remainder of the year 2019; $40 million for the year 2020; and $6.8 million for the year 2021.

Additional costs were estimated at $6.3 million, which mainly reflects extraordinary labor and labor-support costs.

SUMMARY OF WATER AND SANITATION

Damage to facilities and assets associated with water and sanitation are estimated at $14.8 million. The hurricane primarily affected water pumping systems, storage tanks, distribution system and its related damage related to WSC assets that were destroyed in the event.

Losses are related to interruption of piped water service both residential and other economic sectors, losses of volumes of water due to system leaks, sewerage and waste collection and estimated at $36.6 million. The decrease in water demand during the recovery period due to the decline in tourist numbers and commercial activity is considered a loss through the end of 2019 for an estimated period of 28 months on Abaco and six months on Grand Bahama as well as an estimated of loss of demand from 7,339 severely damage houses on both Islands.

Additional costs such as additional labor and construction equipment, emergency power generation and solid waste management is estimated at $2.3 million. These costs also referred to the expense of managing cleaning activities, costs for disaster assessment and recovery teams deployed, and payment to fulfill restoration work.

SUMMARY OF TOURISM

Hurricane Dorian impacted two major tourist destinations of The Bahamas and disrupted the tourist flows for several days before and after the storm in the rest of the Lucayan Archipelago. The hurricane also caused significant damage to tourism infrastructure on Abaco and in East End of Grand Bahama; in some locations the damage was catastrophic. The total damage in the tourist sector was $530 million. A large majority of the damage occurred on Abaco.

In this occasion the forecasted losses are less than the damage and amount to $325 million. They are related to the disruption in the flow of tourists as result of the storm and a changed public perception due to the damaged structures. Most of the losses will be accrued in the high season of 2019 and 2020, tapering off as the recovery is expected to gain momentum.

There were also additional costs for $15 million related to demolition, debris removal and salvaging of sunken ships.

SUMMARY OF FISHERIES AND AGRICULTURE

The impact of Hurricane Dorian in the fisheries and agriculture sector of Abaco and Grand Bahama was significant. All the fishing processing facilities were affected, either by wind damage or storm surge, with all the consequences of water damage. For the agricultural sector, several green houses were decimated, and many perennial crops were damaged by wind and salt-water intrusion. A poultry processing facility was also destroyed on Abaco.

The total damage in fisheries was $11 million including damage to vessels, processing facilities and fishing gear. Considering the seasons for spiny lobster and stone crab, the losses in fisheries will be $7.0 million and will represent a big fraction of the total losses. In agriculture the losses will be $2.0 million, considering perennial and annual crops, and for poultry, over $1.5 million. The total losses for fisheries and agriculture are estimated at $10 million.

SUMMARY OF COMMERCE

The effect on the commerce sector was greater on Abaco than Grand Bahama due to the path of the hurricane, as the eye of the storm passed through the commercial center of Marsh Harbour. The structures that were made of concrete survived with less damage, while those made of lighter materials fared much worse. The total damage was estimated at $77.5 million for the commerce sector: $71.4 million on Abaco, and $6.2 million on Grand Bahama.

The losses to the sector are projected to occur over the expected length of recovery. On Grand Bahama, the losses are expected to accrue over just four months, while on Abaco it is expected to take a full three years. Due to the destruction of property and vital infrastructure, as well as the evacuation of residents, commercial expenditure will fall to zero in the month of the disaster and then gradually make its way back to pre-disaster levels as the recovery goes on. The total losses estimated for the commerce sector are $65 million: $64.5 million on Abaco and $0.5 million on Grand Bahama. Assessing over time, losses will be $22.1 million or 34 percent of the total in 2019, $34.9 million or 54 percent in 2020, $7.2 million or 11 percent in 2021, and 0.8 million or 1 percent in 2022.

The additional costs for this sector comprise debris removal and demolition. At the time of the Assessment team's site visit to Abaco, there was still an extensive amount of debris in Marsh Harbour. Debris removal and demolition of damaged properties will be expensive and will take additional time on Abaco. The total Additional costs for the commerce sector are estimated at $4.8 million: $3.8 million on Abaco and $1 million on Grand Bahama.

SUMMARY OF ENVIRONMENT

Although previous assessments in The Bahamas indicate that ecosystems in the country have adapted over time to become resilient to tropical weather, the intensity and duration of Hurricane Dorian still caused moderate to significant environmental effects. Wave action, storm surge and high winds have produced partial to severe destruction to mangroves, coral reefs, seagrass beds and forests on both Abaco and Grand Bahama. As a result, ecosystems were left in a critical state and pre-existent vulnerabilities were exacerbated with an expected decrease in ecosystem services provision in the short and medium term. These ecosystems are home to a wide variety of species of flora and fauna and provide services that are essential to the development of the country.

Damage to mangroves, coral reefs, seagrass beds and protected areas account for around $7 million. This damage is a product of impacts on coral reefs, seagrass beds, mangroves, beaches and on the infrastructure of protected zones. Due to the inherent difficulty of assigning a price tag to some of these assets, the value reflected in this damage estimation is only based on a global average of the cost of restoration projects. Numbers could go higher depending on factors such as equipment availability, local workforce, planning and monitoring.

The impacts to natural resources are not only expected to cause changes in biodiversity, disappearance of habitats, and displacement of species, but also affect Bahamians who depend on healthy ecosystems to maintain their livelihoods and economies. For example, the damage to seagrasses beds is likely to have short- to medium-term effects (2 to 4 years) on the services they provide to fisheries, which makes the losses represent the most significant public costs. Since ecosystems are crucial to the economy and society in The Bahamas, it is expected that the impacts of the hurricane on their ecosystem services will result in losses of approximately $27 million.

Additional costs entail the costs of future environmental assessments, organic debris removal, fire control measures and a significant private cost related to the oil spill on Grand Bahama. These costs are estimated to be $102 million.

These estimates are based on a limited amount of information available at this time and on initial assessments, long term impact studies will be further required. There are also environmental elements that suffered damage (such as water resources) for which there is no economic quantification due to the limited availability of information.

DESCRIPTION OF EVENT

Hurricane Dorian was the first major hurricane of the 2019 Atlantic hurricane season. The National Hurricane Centre (NHC) originally identified a tropical wave within a monsoon through over Guinea and Senegal in western Africa. This system was disorganized for several days, and on 23 August it consolidated, and thunderstorm activity increased. On 24 August the system was classified as Tropical Depression Five because the system acquired enough organized convection. A deep ridge imparted westward movement of the depression, steering it toward the Lesser Antilles. A small cyclone developed a defined inner core with a 12-mile-wide eyelike feature. Therefore, the system intensified into a tropical storm; it was assigned the name Dorian by the NHC. Rain bands gradually wrapped more around Dorian on 25-26 August though convection remained inconsistent.

Dorian continued moving west and passed close to Barbados, bringing tropical storm-force winds and heavy rain. On 27 August Dorian made landfall on the island of Saint Lucia as a tropical storm and then entered to the Caribbean Sea. The storm underwent a center relocation further north, to the west of Martinique, experiencing tropical storm force winds. Dorian took a more northerly track than expected, passing to the east of Puerto Rico, and hit the US Virgin Islands. On 28 August Dorian intensified into a Category 1 hurricane as it approached Saint Thomas in the US Virgin Islands. On 29 August the system moved north and entered a more favorable environment and it started to rapidly intensify, reaching Category 2 status on the first hours of 30 August. Rapid intensification continued, and the storm eventually reached major hurricane status several hours later, on the same day. The system continued strengthening, and on 31 August Dorian attained Category 4 major hurricane status.

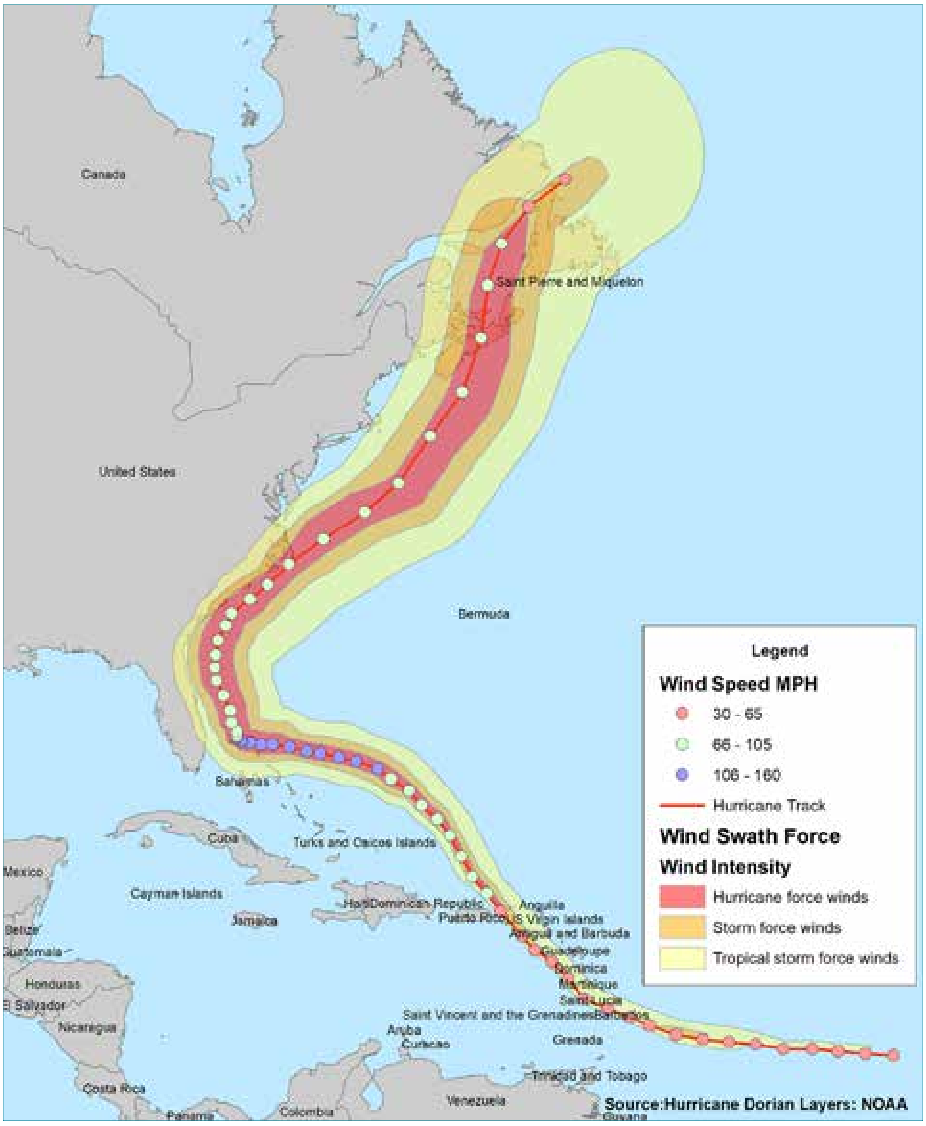
On 1 September, Dorian reached Category 5 intensity and made landfall at 16:40 UTC on Great Abaco Island in the Bahamas, with one-minute sustained winds of 185 mph (280 km/h), wind gusts over 220 mph (335 km/h), and central barometric pressure of 911 millibars (26.9 inHg). The storm´s central pressure bottomed out at 910 millibars (26.87 in Hg) within a few hours, as Dorian reached its peak intensity during landfall as it passed through Marsh Harbour. Hurricane Dorian´s forward speed decreased around this time, slowing to a westward crawl of 5 mph (8 km/h). At 02:00 UTC on 2 September Dorian made landfall on Grand Bahama at near the same intensity. Afterward Dorian´s forward speed slowed to just 1.2 mph (1.9 km/h), as the Bermuda High[3] that was steering the storm westward weakened. Later that day, the storm underwent an eyewall replacement cycle to the north of Grand Bahama; the Bermuda High to the northeast of Dorian also collapsed, causing Hurricane Dorian to stall just north of Grand Bahama. Around the same time, the combination of the eyewall replacement cycle and upwelling of cold water caused Dorian to begin weakening, with Dorian dropping to Category 4 status at 15:00 UTC. Due to the absence of steering currents, Hurricane Dorian stalled north of Grand Bahama for about a day. Hurricane Dorian subsequently weakened to a Category 2 storm on 3 September, before beginning to move north-westward at 15:00 UTC, parallel to the east coast of Florida, with Dorian´s wind field expanding during this time.

On 5 September, Dorian moved over the warm waters of The Gulf Stream and re-intensifying into Category 3 hurricane off the coast of South Carolina. However, several hours later, Dorian encountered high wind shear, causing the storm to weaken to a Category 2 hurricane, and later to Category 1 intensity early on 6 September. At 12:35 UTC, Dorian made landfall in Cape Hatteras, North Carolina as a Category 1 hurricane. Afterward, Dorian began to transition into an extratropical cyclone as it quickly moved north-eastward, completing its transition on September 7. The storm

3 The Bermuda High pressure system sits over the Atlantic spring and summer. Acting as a block that hurricanes cannot penetrate, the size and location of this system can determine where hurricanes go. A normal Bermuda High often leads to hurricanes moving up the east cost of the US and out to sea (NASA, 2006).

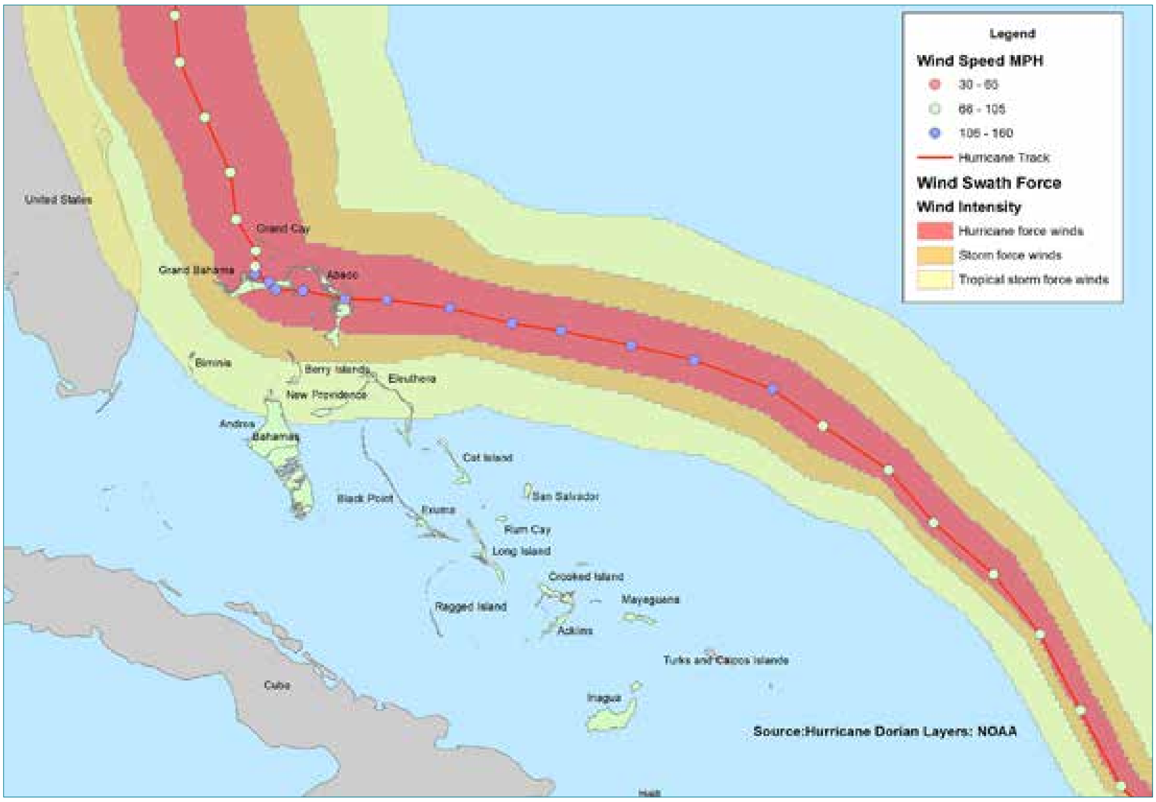
subsequently strengthened, due to baroclinic processes, generating Category 2 hurricane winds. Several hours later, Dorian made landfall on Sambro Creek, Nova Scotia, as a Category 2-equivalent extratropical storm, before making another landfall on the northern part of Newfoundland several hours later. On 8 September, Dorian had moved into Labrador Sea, maintaining tropical storm strength winds. On 10 September, Dorian´s extratropical remnant dissipated off the coast of southern Greenland.

FIGURE 1. PATH OF HURRICANE DORIAN ACROSS THE ATLANTIC



Source: Assessment team, 2019, using data provided by the United States National Oceanic and Atmospheric Administration (NOAA)

FIGURE 2. PATH OF HURRICANE DORIAN IN THE NORTHERN CARIBBEAN AND WESTERN ATLANTIC



Source: Assessment team, 2019, using data provided by the United States National Oceanic and Atmospheric Administration (NOAA)

HURRICANE DORIAN IN THE BAHAMAS

The effects of Hurricane Dorian in The Bahamas were among the worst experienced for any disaster in the country. Hurricane Dorian hit Abaco as a Category 5 hurricane on 1 September, and a day later hit Grand Bahama at the same category. The hurricane then stalled over Grand Bahama for another day, finally moving away from the island on 3 September.

On 31 August, as Hurricane Dorian intensified while approaching The Bahamas, voluntary evacuations were issued on Abaco and Grand Bahama. In low-laying cays, government officials urged residents to move inland. Boats rented by the government shuttled residents of outlying fishing communities to McLean´s Town on Grand Bahama. Most major resorts were forced to close. Nine hurricane shelters were opened on Grand Bahama and fifteen shelters were opened on Abaco. Airports on Abaco, Grand Bahama and Bimini were closed by 1 September. Government workers were ordered to stay indoors once winds outside reached tropical storm force.

On 1 September the Bahamas Department of Meteorology published Alert #27, detailing the track of the storm and the potential threat to the Bahamas and it said:

> "…Extremely dangerous Hurricane Dorian is closing in on Abaco and Grand Bahama…
>
> A hurricane warning remains in effect for portions of the northwest Bahamas which includes: North Eleuthera, Abaco, Grand Bahama, Bimini, The Berry Islands and New Providence.

A hurricane warning means that hurricane conditions could affect the mentioned islands within 36 hours a hurricane watch remains in effect for North Andros.

A hurricane watch means that hurricane conditions could affect the mentioned island within 48 hours.

At 2 AM EDT, the center of Hurricane Dorian was located near Latitude 26.3 degrees north and longitude 75.6 degrees west, about 85 miles northeast of Governor´s Harbour, Eleuthera; 95 miles east of Marsh Harbour, Abaco; 135 miles northeast of New Providence; and 147 miles southeast of East End, Grand Bahama.

Hurricane Dorian is moving toward the west at near 8 mph and a slower westward motion is forecast for the next day or two, followed by a gradual turn toward the northwest. On this track, the core of Dorian should be near or over Abaco and Grand Bahama today.

Maximum sustained winds remain near 150 miles per hour with higher gusts. Dorian is a strong Category 4 Hurricane on the Saffir-Simpson Hurricane wind scale. Some fluctuations in the intensity are likely, but Dorian is expected to remain a powerful hurricane during the next few days.

Hurricane force winds extend outward up to 30 miles from the center and tropical storm force winds extended outward up to 105 miles from the center.

Currently, the feeder bands of hurricane Dorian producing showers over the islands of Eleuthera, Cat Island Abaco, and should hurricane Dorian remain on the latest forecast track through tonight, resident on Abaco will begin to experience tropical storm force winds momentarily and hurricane force winds later this morning.

Meanwhile, residents in East Grand Bahama could begin to experience tropical storm force winds at about 9 am and hurricane force winds at about 7 pm. Tropical storm force winds are forecast to begin in West End, Grand Bahama at about 8 pm and increase in strength through tonight. Tropical storm force winds are to be experienced in New Providence around 9 am this morning. The eye of Dorian is forecast to pass over Treasure Cay, Abaco at about later this morning or early this afternoon. Residents in these areas should not be deceived by the lull in the winds as the eye passes but remain indoors and prepare for the second phase of the hurricane.

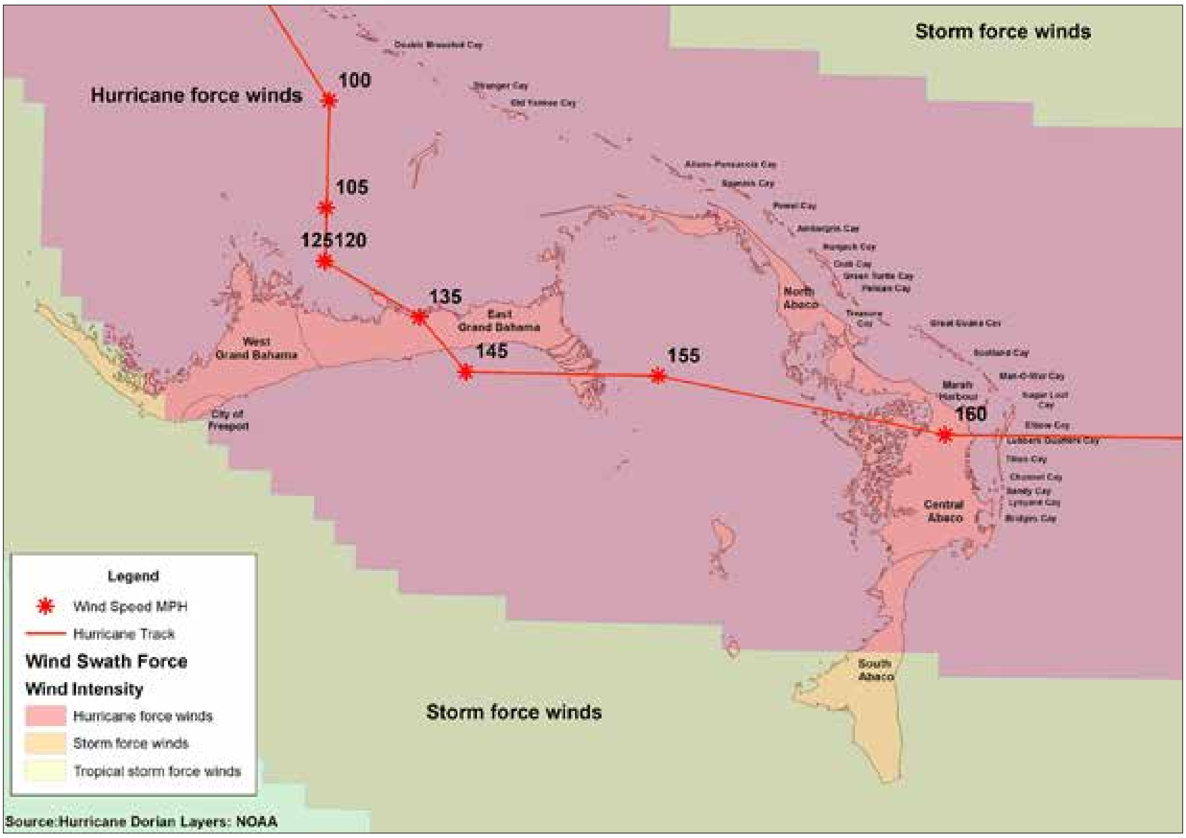
Since Dorian is expected to slow down as it nears the northwest Bahamas, a prolonged period of Life-Threatening storm surge accompanied by large and destructive waves up to 15 feet above normal tide can be expected along the eastern and northern shores of Eleuthera and Abaco today and the northern and southern of Grand Bahama tonight through Tuesday.

Dorian is expected to produce rainfall amounts of 10 to 15 inches ever portions of Abaco and Grand Bahama and 2 to 4 inches over the reminder of the northwest Bahamas and the central Bahamas…"

On 1 September, the eye of Hurricane Dorian made landfall on the Abaco Islands with maximum sustained winds of 185 mph (280 km/h), making it the strongest hurricane on record to affect The Bahamas. The next day, the eye of Dorian moved over the eastern side of Grand Bahama and drifted across the island. According to technical staff from different institutions and people interviewed during the field visits, storm surge provoked storm tide of 20 to 25 ft (6.1 to 7.6 m). Dorian also dropped an estimated 3 ft (0.91 m) of rain over the Bahamas.

Based on these descriptions, assessment reports from different government institutions responsible for civil protection, emergency management entities, and the field assessment conducted by the Assessment team between 30 September and 4 October, it has been concluded that the most affected islands were Abaco and its cays and Grand Bahama. The main effects from Hurricane Dorian to these islands are described below.

FIGURE 3. PATH OF HURRICANE DORIAN THROUGH ABACO ISLANDS AND GRAND BAHAMA



Source: Assessment team, 2019, using data provided by the United States National Oceanic and Atmospheric Administration (NOAA)

ABACO ISLANDS

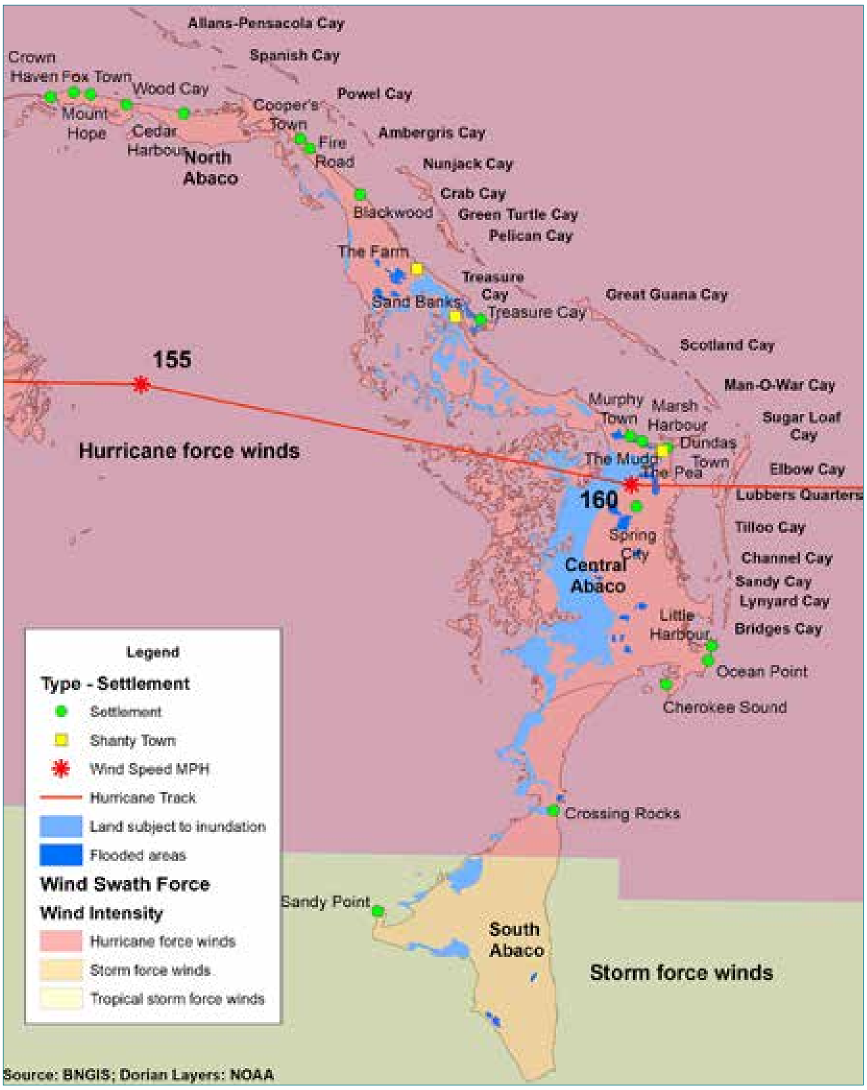
On September 1, Hurricane Dorian hit the island of Abaco as a Category 5. According to the trajectory of the hurricane, the central and northern part of island were under the influence of hurricane force winds. All these areas were severely affected not only by winds but also by storm surge and flooding. The districts and towns affected were:

- In the northern part of South Abaco: Crossing Rocks.
- Central Abaco: Cherokee Sound, Ocean Point, Treasure Cay, Dundas Town, Little Harbour, Marsh Harbour, Murphy Town, Sand Banks (Shanty Town), The Farm (Shanty Town), Spring City, The Mudd (Shanty Town), The Pea (Shanty Town), Behring Point, Bowen Sound, Cargill Creek, Man of War Sound.

- North Abaco: Blackwood, Cedar Harbour, Cooper´s Town, Crown Haven, Fire Road, Fox Town, Mount Hope, Wood Cay.

- Cays: Bridges Cay, Lynyard Cay, Sandy Cay, Channel Cay, Tilloo Cay, Lubbers Quarters Cay, Elbow Cay, Sugar Loaf Cay, Man-O-War Cay, Scotland Cay, Great Guana Cay, Treasure Cay, Pelican Cay, Green Turtle Cay, Crab Cay, Nunjack Cay, Ambergris Cay, Powel Cay, Spanish Cay, Alians-Pensacola Cay.

FIGURE 4. AFFECTED AREAS ON ABACO ISLANDS BY WINDS AND FOOD



Source: Assessment team, 2019, using data provided by the United States National Oceanic and Atmospheric Administration (NOAA) and Bahamas National Geographic Information System Centre

Marsh Harbour was severely affected by Dorian, most of the infrastructure was damaged and observable comparing the satellite images before and after the event below.

FIGURE 5. AFFECTED AREAS MARSH HARBOUR

a- Digital Globe Image: July 13, 2019

b- Airbus Image: September 4, 2019

Source: Google Earth a) Maxar Technologies, 2019; b) Airbus, 2019

Informal communities in the area were mostly destroyed due to the type of vulnerable housing infrastructure. One of the most affected sites was the area named "the Mudd", which was a community located in the eastern site of Marsh Harbour, mostly inhabited by Haitian migrants. Figure 6 shows satellite images before and after the event.

FIGURE 6. AFFECTED AREAS THE MUDD – MARSH HARBOUR

a- Digital Globe Image: October 24, 2018

b- Airbus Image: September 4, 2019

Source: Google Earth a) Maxar Technologies, 2018; b) Airbus, 2019

In North Abaco another vulnerable community located in the western side of Treasure Cay, named Sand Banks, was also destroyed.

FIGURE 7. AFFECTED AREAS SAND BANKS – NORTH ABACO

a- Digital Globe Image: January 28, 2019

b- Airbus Image: September 4, 2019

Source: Google Earth a) Maxar Technologies, 2019; b) Airbus, 2019

Hurricane Dorian impacted the cays along the eastern side of Abaco, the images below present some examples of the areas that were severely affected by the hurricane.

FIGURE 8. AFFECTED AREAS CAYS ALONG EASTERN ABACO

Man–O–War Cay

Digital Globe Image: July 13, 2019

Airbus Image: September 4, 2019

Source: Google Earth a) Maxar Technologies, 2019; b) Airbus, 2019

FIGURE 9. AFFECTED AREAS GREAT GUANA CAY

Airbus Image: July 13, 2019

Airbus Image: September 4, 2019

Source: Google Earth a) Maxar Technologies, 2019; b) Airbus, 2019

GRAND BAHAMA

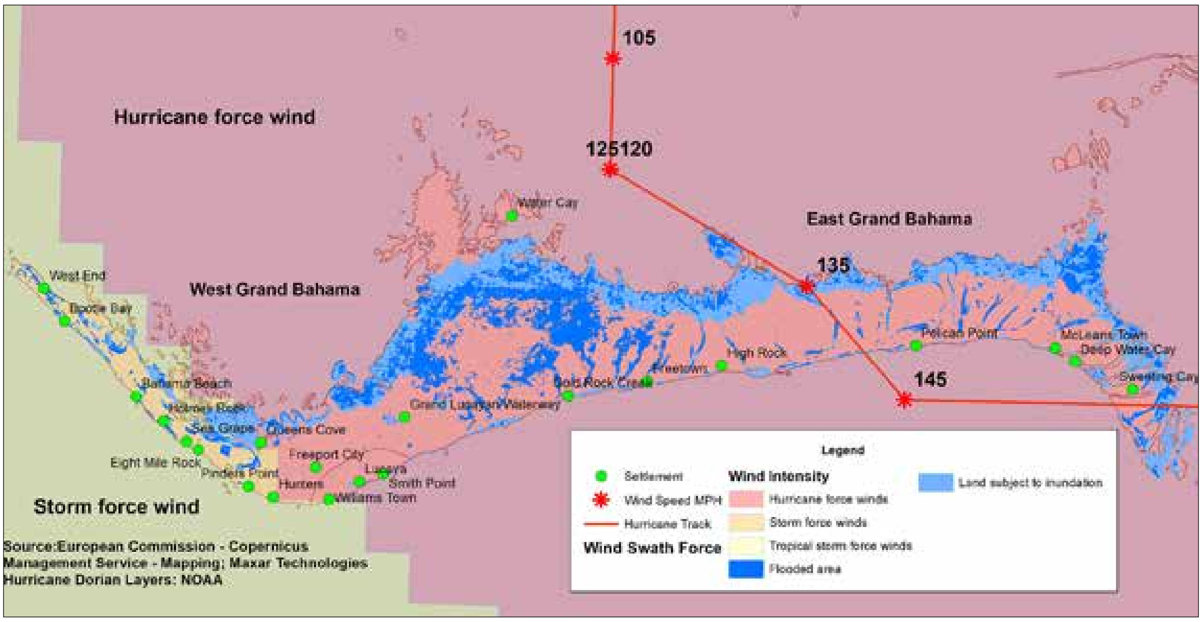
On 2 September, the eye of Dorian moved over the eastern site of Grand Bahama and drifted across the island as a Category 5. The hurricane then stalled over Grand Bahama for another day, finally pulling away from the island on 3 September.

According to the descriptions of the Department of Meteorologist staff interviewed during the field mission, storm surge and flooding were the events provoked by Hurricane Dorian that caused considerable damages, especially on the eastern side of the island. They described that the flooding on Grand Bahama began from the north and northeast and moved toward the south of the island, this phenomenon was due to the trajectory of the hurricane and the period that Dorian remained in the northern part of The Bahamas in the open ocean.

In Freeport the most affected areas were located on the north side of the city. Additionally, based on available geo-information, flooding areas could be identified in the northwestern side of the island around the airport. It is important to mention that according to the analysis done by the staff of the Port Authority of Grand Bahama, the topographic characteristics of the surrounding areas prevented increased flooding across the city.

As mentioned, the eastern part of Grand Bahama was the most affected area, with housing damage observed between Free Town and Deep-Water Cay including: Free Town, High Rock, Pelican Point, McLeans Town, Deep Water Cay and Sweeting´s Cay. In West Grand Bahama district, the impact was not as severe, but the areas that were under the hurricane force winds and storm force winds included: West End, Bootle Bay, Bahama Beach, Holmes Rock, Sea Grape, Queens Cove, Eight Mile Rock and Pinders Points. It is important to mention that the effects of Hurricane Dorian not only impacted settlements, but forest areas were destroyed as well, particularly in the eastern side. Figure 10 shows the track of the hurricane and the flooded areas across Grand Bahama.

FIGURE 10. AFFECTED AREAS ON GRAND BAHAMA ISLAND BY WINDS AND FOOD



Source: Assessment team, 2019, using data provided by the United States National Oceanic and Atmospheric Administration (NOAA) and Bahamas National Geographic Information System Centre

Towns located on the eastern part of Grand Bahama were severely damaged. In the following figures the level of damage can be understood based on satellite images that have been taken before and after the event.

FIGURE 11. AFFECTED AREAS GRAND BAHAMA EASTERN SIDE OF THE ISLAND

Freetown

a- Airbus Image: August 14, 2019

b- Digital Globe Image: September 6, 2019

Source: Google Earth a) Maxar Technologies, 2019; b) Airbus, 2019

FIGURE 12. AFFECTED AREAS GRAND BAHAMA EASTERN SIDE OF THE ISLAND (2)

McLeans Town

Digital Globe / Airbus Image: June 6, 2019 / November 22, 2016

Digital Globe Image: September 5, 2019

Source: Google Earth a) Maxar Technologies, 2019 / Airbus, 2016; b) Airbus, 2019

FIGURE 13. AFFECTED AREAS GRAND BAHAMA EASTERN SIDE OF THE ISLAND (3)

Sweeting´s Cay
Airbus Image: July 13, 2019

Digital Globe Image: September 5, 2019

Source: Google Earth a) Airbus, 2019; b) Airbus, 2019

WEATHER-RELATED EVENTS IN THE BAHAMAS

Historically, numerous hurricanes have hit The Bahamas, since 1990 the country was affected by several tropical storms and at least 28 hurricanes (Table 2). Since 2015 the Bahamas has suffered yearly impacts of severe hurricanes that impacted the archipelago, causing damages, losses and Additional costs to different islands. They were Hurricane Joaquin in 2015, Hurricane Matthew in 2016, Hurricane Irma in 2017 (Hurricanes José and María also passed through the Bahamas on 2017 causing relatively minor damages) and Category 5 Hurricane Dorian in 2019.

TABLE 2. TROPICAL STORMS AND HURRICANES IN THE BAHAMAS (1990 – 2019)

Year	Event	Year	Event
1990	Hurricane Klaus	2005	Hurricane Katrina Hurricane Rita Hurricane Wilma
1991	Tropical storm Fabian	2007	Hurricane Noel
1992	Hurricane Andrew	2008	Hurricane Hanna Hurricane Ike Tropical storm Fay
1995	Hurricane Erin	2011	Hurricane Irene
1996	Hurricane Bertha Hurricane Lili	2012	Hurricane Sandy
1998	Hurricane Georges Hurricane Inez	2014	Hurricane Arthur
1999	Hurricane Dennis Hurricane Floyd Tropical storm Harvey Tropical storm Irene	2015	Hurricane Joaquin Hurricane Kate
2001	Hurricane Michelle	2016	Tropical storm Bonnie Hurricane Hermine Hurricane Matthew
2004	Hurricane Frances Hurricane Jeanne	2017	Hurricane Irma Hurricane Maria Hurricane Jose
		2019	Hurricane Dorian

Source: Assessment team, 2019, based on information from the National Hurricane Centre

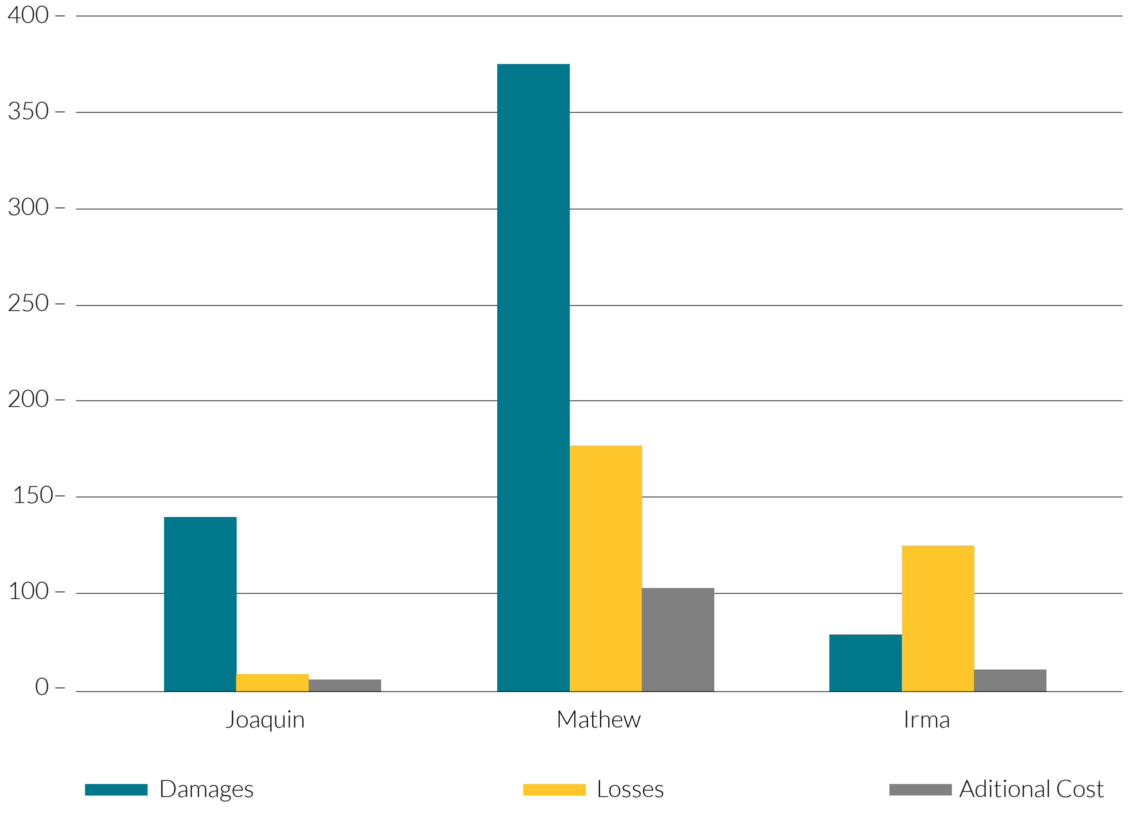
Hurricane Joaquin affected The Bahamas from 30 September to 2 October 2015. It reached category 4 for an extended period on Crooked Island and southern Long Island, causing severe damage, as well as to Acklins, Rum Cay, and San Salvador. According to the United States National Oceanic and Atmospheric Administration (NOAA), Joaquin was the strongest Atlantic hurricane known to have affected The Bahamas since 1866. It was a large hurricane in terms of the area covered, with outward hurricane force winds extending 50 miles (80 km) from the center, and tropical storm force winds reaching as far as 185 miles (295 km). Approximately 5,028 inhabitants of the central and southern Bahamas were affected, mainly on Long Island, the most populated of the islands along Joaquin´s path.

Hurricane Matthew moved across The Bahamas from 5 to 7 October 2016, as a Category 3 and Category 4 hurricane. Hurricane force winds extended outward up to 45 miles (72 km) from the center. According to NOAA, Hurricane Matthew was the deadliest Atlantic hurricane since Hurricane Stan in 2005. Unlike Hurricane Joaquin, Hurricane Matthew´s arrival in The Bahamas had been forecast with extensive lead-time, allowing for the population to prepare. Post-disaster assessment showed that approximately 8,931 people in The Bahamas were affected directly by the hurricane. This hurricane was particularly damaging to the country as it affected the major population centers of New Providence and Grand Bahama. North Andros and the Berry Islands were also strongly affected by the storm. The settlements of Lowe Sound on Andros and West End on Grand Bahama were among the hardest hit, having experienced very high storm surge. The main impact was suffered by the Housing sector.

Hurricane Irma entered The Bahamas as Category 5 storm on 7 September, with sustained winds of 175 miles per hour. The center of Irma passed over Little Inagua on 8 September and continued moving northwest, passing about 30 miles south of Salina Point and Acklins as Category 5. Irma weakened slightly to a Category 4 storm before its center passed over Ragged Island on Friday 8 September. The most affected islands were Acklins, Inagua (Great Inagua) and Ragged Island, located in the southeastern part of The Bahamas, as well as Bimini and Grand Bahama in the north. The effects of Hurricane Irma on the population of the Bahamas were moderate. According to the reports prepared by the government entities responsible for emergency, no fatalities or serious injuries were reported. The greatest damage which directly affected the population of the islands occurred in the Housing sector.

For the three events, in which damage and losses assessments were conducted, Figure 14 shows a summary of the results to each hurricane based on 2017 prices. Hurricane Matthew was the storm that provoked the highest impact to The Bahamas in comparison to the other two. Related to damage, Hurricane Matthew cost the country more than three times as much as Joaquin and more than ten times as Hurricane Irma. The estimated losses show that Hurricane Matthew cost almost two times as much as Irma and fifteen times as much as Joaquin. The additional costs caused by Matthew represents ten times as much as Joaquin and five times as much as Irma.

FIGURE 14. EFFECTS OF HURRICANES JOAQUIN, MATTHEW AND IRMA
($million)



Source: Assessment team based on information from previews DaLa analysis

AFFECTED POPULATION

INTRODUCTION

This section presents an overview of the effects of Hurricane Dorian on the population of The Bahamas with an emphasis on the description and quantification of the affected population. The affected population consists of[4]:

- Primary affected population: People affected directly by the disaster, that is, those who died, were injured or became ill, were disabled (primary trauma victims), were displaced and living in shelters, or suffered material losses as a direct and immediate consequence of the disaster.

- Secondary affected population: People who suffered indirect or secondary effects of the disaster, including deficiencies in the provision of public services, trade, employment, or education, as well as isolation.

Overall, the effects of Hurricane Dorian on the population of The Bahamas were considerable, most notably on Abaco and Grand Bahama, located in the northern part of the country. Based on official reports from government entities responsible for emergency coordination and management, there were 67 confirmed deaths and 282 people still missing, as of 18 October 2019. The number of related injuries recorded by the health authorities was over 200 a week after the passage of the hurricane. The greatest damage occurred in the housing sector as a result of destructive winds, storm surge and the impact from falling trees and flying debris. The Assessment team estimates that approximately 29,472 persons (40 percent of the total combined population of Abaco and Grand Bahama) experienced damage to their homes and assets. Additionally, the quality of life of the population temporarily decreased due to disruptions in telecommunications, electricity and water. Like most Caribbean countries, The Bahamas is relatively small, thus a hurricane of this magnitude will have national implications. The population working in the tourism and commercial sectors were significantly affected, while disruption in the school system affected students and teachers throughout the impacted islands. Subsequent sections analyze these factors in depth.

The baseline information in this section was obtained from the 2010 Census of Population and Housing of the Commonwealth of Bahamas as well as information collected through interviews and field visits by the Assessment team. Supplemental information was also sourced from the National Emergency Management Agency (NEMA), the Ministry of Social Services and various assessment and situational reports from the Caribbean Disaster Emergency Management Agency (CDEMA), the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and the Pan American Health Organization (PAHO). Reports from the Bahamas Red Cross and UKAid were also used to give a snapshot of some of the relief distribution that was targeted to the people mostly affected by the hurricane.

AFFECTED ISLANDS

The effects of Hurricane Dorian were primarily felt on Abaco and Grand Bahama. Based on 2019 population projections, these islands comprise about 73,673 inhabitants, with Grand Bahama

4 Economic Commission for Latin America and the Caribbean (ECLAC). (2014). Handbook for Disaster Assessment LC/L.3691 2013-817. United Nations, Santiago, Chile

being the second most populated island in The Bahamas after New Providence, and Abaco being the third. Not all the population of these islands were directly affected by the hurricane, as its intensity varied among settlements. Based on the reports published by the entities responsible for emergency management and the visits made during the field mission by the Assessment team, the mainly affected settlements due to damaged houses and other assets are:

ABACO

- North Abaco: Blackwood, Cedar Harbour, Cooper's Town, Crown Haven, Fire Road, Fox Town, Mount Hope, Wood Cay
- Central Abaco: Cherokee Sound, Ocean Point, Treasure Cay, Dundas Town, Little Harbour, Marsh Harbour, Murphy Town, Sand Banks, The Farm, Spring City, The Mudd, The Pea, Behring Point, Bowen Sound, Cargill Creek, Man of War Sound.
- South Abaco: Crossing Rocks
- Cays: Bridges Cay, Lynyard Cay, Sandy Cay, Channel Cay, Tilloo Cay, Lubbers Quarters Cay, Elbow Cay, Sugar Loaf Cay, Man- O- War Cay, Scotland Cay, Great Guana Cay, Treasure Cay, Pelican Cay, Green Turtle Cay, crab Cay, Nunjack Cay, Ambergris Cay, Powel Cay, Spanish Cay, Alians-Pensacola Cay

GRAND BAHAMA

- East Grand Bahama (Freetown, High Rock, Pelican Point, McClean's Town, Deep Water Cay and Sweeting's Cay)
- West Grand Bahama (West End, Bootle Bay, Bahama Beach, Holmes Rock, Freeport, Sea Grape, Queens Cove, Eight Mile Rock and Pinders Point)

DEMOGRAPHICS

The demographic profile of the two islands under analysis allows estimating the relative extent of the effects and the population that was potentially affected by Hurricane Dorian. According to the 2019 population projections done by the Department of Statistics, Abaco and Grand Bahama have approximately 73,673 inhabitants.[5] An examination of density by island indicates that Grand Bahama has the third highest population density at 106 people per square mile in an area of 530 square miles, while Abaco has a population density of 27 people per square miles in an area of 649 square miles.

According to the projection of the Department of Statistics, the 2019 figure for total population of Grand Bahama was 56,260, of which 48.7 percent are men and 51.3 percent are women, while it is the opposite on Abaco with more men (51.7 percent) than women (48.3 percent). The total population projection for Abaco was 17,413. It was noted that between 2010 and 2019 the population of Abaco increased 1.1 percent while the population of Grand Bahama expanded by 8.7 percent.

5 According to 2010 Census of Population and Housing, those islands represented about 19.5 percent of the country´s population. The population distribution among these islands, in relation to the national total, is 4.9 percent on Abaco, and 14.6 percent on Grand Bahama.

With regards to the age structure of Abaco and Grand Bahama, both islands have very similar percentages of working age population (15 – 64 years), children (those under 15 years) and the elderly (persons over 64 years). Table 3 below provides a snapshot of the baseline demographics for the affected islands.

TABLE 3. DEMOGRAPHICS OF THE AFFECTED ISLANDS

Demographic	Abaco	Grand Bahama
Total Population	17, 413	56, 260
Female (percentage)	48.3	51.3
Male (percentage)	51.7	48.7
Density (persons per square mile)	27	106
Distribution by age (percentage)		
Under 15 years	27.2	27.1
15 -64 years	66.8	66.9
+ 65 years	6.1	6.0

Source: The Bahamas 2010 Census of Population and Housing and 2019 Population Estimates for Abaco and Grand Bahama

The 2010 Census Disability Report indicated that about 2.9 percent of Bahamians have some form of disability, with the most common form being a lack of mobility, followed by blindness and mental disorders. On Abaco, 2.6 percent of the population have indicated some form of disability, while Grand Bahama registered 3.0 percent. On these islands, the number of males outnumbered afflicted females, accounting for 53 percent of the total population with some form of disability on Abaco, and 52 percent on Grand Bahama.

It should be noted that according to the 2010 Census, 17.3 percent of the population of The Bahamas are citizens of another country, which is an increase of 4.6 percent from 2000 when the non-Bahamian population represented 12.7 percent of the total population. Most non-Bahamians come from Haiti (64.4 percent), Jamaica (9.2 percent) and the United States of America (7.2 percent). Both affected islands had most non-Bahamians from Haiti, followed by the United States of America and Jamaica. On Grand Bahama, there were 2,696 persons of Haitian nationality, 925 persons from the United States of America and 575 from Jamaica. On Abaco, the Haitian population accounted for 4,486 persons of the total population, with 331 persons from The United States of America and 119 persons from Jamaica.

PRIMARY AFFECTED POPULATION

DEATHS

Based on the information by the Royal Bahamas Police Force (RBPF) there are 67 confirmed deaths[6] (56 on Abaco and 11 on Grand Bahama) as of 29 October 2019. Victim recovery and fatality management operations are still ongoing. The RPBF along with the Ministry of Health Medical Examiner's Office, are leading these efforts, and have been working with The United States Agency for International Development (USAID), who deployed a Disaster Assistance Response Team (DART) at the request of The Bahamas Government. This team included 57 search and rescue members and four canines. There has also been the deployment of defense force personnel

6 During the field mission, the Assessment team asked for disaggregated information (by sex and age) on the dead people. At the time of writing this report this information was not received.

from Jamaica (120 officers) and Trinidad and Tobago (100 officers) to assist in the search and recovery efforts. The Assessment team was informed that rescue efforts have been faced with unprecedented logistical challenges in trying to access hard-to-reach areas like The Mudd and Pigeon Pea near Abaco's Marsh Harbour that experienced widespread destruction. These blighted areas are made up of informal settlements with a large population of transient and undocumented Haitians that may not have been accounted for in the official death count.

MISSING PERSONS

Another dynamic of the affected population is the people that have been reported as missing. The Assessment team was informed by several government officials that the death count could increase after taking into consideration those who have been reported as missing. The Department of Social Services and NEMA established a national phone hotline as well as the Missing Persons Help Desk across New Providence and the impacted islands for persons to report relatives, neighbors and friends who were missing. An official registry of missing persons was then developed after all information was cross referenced with those who were registered in shelters. Each week after the hurricane, NEMA would provide updates on the number of missing persons and encourage people to continue to call the Missing Persons Help Desk to update on those who were missing or found. While this system resulted in over 876 persons being found and may continue to change as the list of missing persons is cross-checked against shelter lists and other records of displaced individuals, there are still around 282 persons[7] still unaccounted for based on official figures from the RBPF.[8]

As is possible in an event of this magnitude in the Caribbean, it should be noted that there may also be some underreporting as the Assessment team was informed that many people left The Bahamas to go to other countries, as well as the large number of undocumented migrants that may not have come forward to report missing relatives for fear of repercussions for their irregular status. According to the Ministry of Security, the official missing persons list is the responsibility of the police, as they work with a coroner who must be involved in the process to declare someone dead.[9] Inter-institutional coordination and data sharing as well as the standardization of the registration, is therefore highly encouraged especially when dealing with something as emotionally sensitive as missing persons and deaths after such an event.

INJURED PERSONS

The number of injuries as a result of the hurricane is still being determined, however the Assessment team was informed that there were at least 265 persons on Abaco and about 28 on Grand Bahama that were treated for injuries between 2-11 September after Hurricane Dorian.[10] During that period the Rand Memorial Hospital on Grand Bahama had about 27 patients and it can be assumed that health services would have been rendered to patients who evacuated to New Providence as well. Main pathologies included skin infections, exacerbated chronic conditions, dehydration, minor trauma, puncture wounds and lacerations, and many in need of mental and psychosocial support.

7 During the field mission, the Assessment team asked for disaggregated information (by sex and age) on the missing people. At the time of writing this report this information was not received.

8 Information based on NEMA Hurricane Dorian Daily Brief, Friday 18 October 2019. See: www.bahamas.gov.bs/nema/dailyupdates for the number of people found and information from the Royal Bahamas Police Force on the number of people still missing.

9 The Missing Persons' Help Desk has since been officially transferred to the Missing Persons' Unit located at the Central Detective Unit under the Royal Bahamas Police Force.

10 Information received from PAHO Country Office Report on Patients from Abaco and Grand Bahama after Hurricane Dorian.

Even though there have been no reports of disease outbreaks to date, there could be a significant risk of water and vector-borne diseases as a result of deteriorated sanitary conditions and a lack of access to safe water in the affected communities. There have already been reports of increased infestations of rodents and mosquitoes which may be exacerbated as there is still a lot of standing water and debris to be cleared, which can increase the likelihood of rodent-borne leptospirosis and vector-borne diseases such as Dengue, Zika and Malaria[11]. While it normally takes three to six months to see a full-blown infestation, the Department of Environmental Health Services has been proactive in having an expert in rodent control visit the affected islands to assist in this area to avoid such an infestation.

Other environmental conditions that continue to be serious concerns for the population are the smells from animal carcasses and cadavers under the rubble on Abaco and Grand Bahama. Residents were advised to avoid drinking or consuming ground water following the passage of the hurricane since it has the potential to be contaminated with infectious bacteria, chemicals and other pollutants. There has also been a concern about the potential risk of diseases like cholera and gastrointestinal illnesses brought on by the combination of stagnant floodwater, contamination from sewage, and lack of access to safe water. Public Health announcements on proper waste disposal, hand washing, and prevention notices were advertised in both English and Creole. In early October, IsraAID donated water purification equipment to provide residents of the impacted islands with potable drinking water.

EVACUATED PERSONS

On 30 August, NEMA instituted emergency evacuation orders for the following settlements:

- Abaco: Elbow Cay, Green Turtle Cay, Man-O-War Cay, Great Guana Cay, Grand Cay, Lubbers Quarters, Tilloo Cay.

- Grand Bahama: East Grand Bahama (Sweeting's Cay, Water Cay, Gold Rock Creek North & South, Freetown, Pelican Point, McClean's Town, Grand Cay, Deep Water Cay, Queen's Cove), West Grand Bahama (West End, Bootle Bay, Bahama Beach).

NEMA also issued advisories to other settlements to be alert and move inland on Grand Bahama:

- East Grand Bahama: Gambler Point, Bevan's Town, High Rock, Smith's Point, Mather Town

- West Grand Bahama: Deadman's Reef, Holmes Rock, Seagrape, Jones Town, Russell Town, Martin Town, Pine Dale, Hanna Hill.

The Government advertised that flights from Abaco and Grand Bahama would be increased to facilitate those who wanted to leave the islands before the hurricane. The Prime Minister had a press conference on 31 August and made a final plea to citizens to adhere to the evacuation orders, as many people opted to stay and ride out the storm. Government registered shelters on Abaco, Grand Bahama and New Providence were open to assist those who chose to stay during the hurricane, however the Assessment team did not receive information on the number of persons who voluntarily evacuated before the hurricane or stayed in shelters.

11 Information based on PAHO Country Office Situation Report No.10.

After the passage of Hurricane Dorian, NEMA provided evacuation flights at no cost to residents of Abaco and Grand Bahama to get to New Providence, with priority given to women, children and persons with disabilities. Additional support was also given by private and military air and sea transport to facilitate the evacuation of persons. The Assessment team was informed that the Grand Memorial Hospital on Grand Bahama made evacuation provisions for special needs individuals, as well as PAHO who facilitated a medivac of patients from Abaco to the Princess Margaret Hospital in New Providence. Additionally, others used private means of transport to evacuate to Eleuthera and the United States of America. While the Department of Social Services is still in the process of registering evacuees, there were 4,861 persons registered as of 18 October[12]. Based on information received by the Assessment team, the cost of a direct one-way flight with Bahamas Air from Abaco and Grand Bahama to New Providence averages about $100, which would mean that the government would have absorbed at least $486,100 in evacuation costs.

DISPLACED POPULATION LIVING IN SHELTERS

The damage and destruction of homes caused by Hurricane Dorian on Abaco and Grand Bahama created a massive need for shelter, for those that remained on the impacted islands as well as those who evacuated to New Providence. NEMA activated several shelters: 29 in New Providence, 18 on Grand Bahama and 13 on Abaco.[13] While a lot of people chose not to go to the shelters before the hurricane, officials responsible for emergency coordination and management informed the Assessment team that some persons who evacuated from Abaco and Grand Bahama came to shelters in New Providence.

As seen in Table 4, based on information that was available for the period 8 to 30 September, the number of displaced persons residing in shelters in New Providence exceeded 1,000 which was near or above the recommended capacity. According to the shelter manager for the Fox Hill Community Center, the Haitian population mainly from Abaco comprised about 85 percent of the of the displaced persons staying at that shelter. She also mentioned that the daily operation cost averaged about $1,000 without taking into consideration the cost of utilities such as electricity and water. It should be noted that these figures show a conservative estimate of the number of displaced persons from Abaco and Grand Bahama as official shelter registries are still in the process of being compiled, as well as there have been reports of persons residing in alternative accommodations including staying with relatives and friends, renting apartments, or staying in hotels and condominiums supported by private actors.

12 Information based on NEMA Hurricane Dorian Daily Brief, Friday 18 October 2019. See: www.bahamas.gov.bs/nema/dailyupdates

13 Information based on NEMA's website and social media page.

TABLE 4. NEW PROVIDENCE: POPULATION IN SHELTERS

Shelter	Estimated Number of People												
	8 Sept	9 Sept	10 Sept	11 Sept	12 Sept	13 Sept	14 Sept	15 Sept	17 Sept	19 Sept	21 Sept	23 Sept	30 Sept
All Saints Anglican Auditorium	--	--	--	--	--	--	--	69	63	19	94	94	87
Bahamas Academy Gym	--	--	226	191	191	193	198	198	195	192	192	196	161
Calvary Baptist Church (Haitian)	91	95	85	96	96	86	80	79	80	80	80	80	84
Enoch Backford Shelter	--	--	--	36	36	78	60	DEACTIVATED					
Fox Hill Community Centre	200	202	239	236	236	240	134	135	137	141	134	135	127
Grant's Town Seventh-Day Adventist Church	--	29	DEACTIVATED										
Pilgrim Baptist Church	95	70	64	63	63	69	69	68	64	64	68	105	58
Sir Kendal G. L. Isaacs Gymnasium	520	422	1357	1062	1062	1078	1068	1064	1064	1056	845	845	821
Sir Kendal G. L. Isaacs Gymnasium (Tent A)	--	150	150	150	150	130	120	120	120	120	122	122	122
Sir Kendal G. L. Isaacs Gymnasium (Tent B)	--	144	144	145	145	146	146	146	146	146	83	83	87
Sir Kendal G. L. Isaacs Gymnasium (Tent C)	--	--	--	--	--	0	0	0	0	0	0	0	0
The Salvation Army	25	27	27	27	27	27	27	27	26	DEACTIVATED			
TOTAL	931	1139	2292	2006	2006	2047	1902	1906	1895	1818	1618	1660	1547

Source: Shelter Status Reports based on data from PDC, CDEMA, NEMA & BNGIS

Note: Information was not disaggregated by sex, age or nationality to reflect the differential effects of the hurricane on each segment of the population.

-- Information unavailable

As shelter occupancy increased, so did needs for water, sanitation and hygiene (WASH) supplies, health staff, medical supplies and protection interventions. The Department of Environment Health Services continuously evaluated the shelters to ensure environmental health and food safety standards were being met. Shelters were secured by the RBPF, and the Bahamas Red Cross Society assisted with managing the shelters. Meals were provided principally by the World Food Programme, Salvation Army, the Bahamas Red Cross Society, World Central Kitchen, Samaritan's Purse and various other local and international NGOs and private institutions. The Assessment team was informed that some shelters distributed wristbands for residents of the shelter and for non-residents (those who stayed with friends or family), so that the non-residents were still able to still access meals and clothing, to ease up the burden of additional needs in private homes that accommodated displaced persons.

As most of the displaced persons accessing shelters went to New Providence, the estimate in shelters on Grand Bahama and Abaco were comparatively less (see Table 5 and Table 6). The Assessment team was informed that 45 children from the Grand Bahama Children's Home were evacuated to New Providence where The Ranfurly Home for Children took in 21 children, the Nazareth Center and the Children's Emergency Hostel took in 9 and 15 children respectively. It was also reported that there were 44 displaced persons residing in a privately managed shelter called Camp Symonette in Eleuthera.

TABLE 5. GRAND BAHAMA: POPULATION IN SHELTERS

Shelter	Estimated Number of People			
	5 Sept	12 Sept	21 Sept	23 Sept
Bethel Deliverance Center *	116	--	DEACTIVATED	
Christ the King	--	DEACTIVATED		
Church of the Ascension	--	15	21	28
Grand Lucayan Resort *	800	--	DEACTIVATED	
St. Georges Sr. (Gymnasium only)	--	12	47	47
Total	916	27	68	75

Source: Shelter Status Reports based on data from PDC, CDEMA, NEMA & BNGIS

Note: Information was not disaggregated by sex, age or nationality to reflect the differential effects of the hurricane on each segment of the population.

-- Information unavailable

* Temporary Shelter

TABLE 6. ABACO: POPULATION IN SHELTERS

Shelter	Estimated Number of People			
	2 Sept	4 Sept	5 Sept	6 Sept
Abaco High School	--	--	--	800
Amy Roberts Primary School		35	489	--
Central Abaco Primary School*	--	600	40	--
Faith Walk Church of God Community Center	--	--	100	--
Fox Town Primary (Pre-School)	--	--	60	--
Grand Cay All Age School (Pre-School)	--	30	--	--
Grand Cay All Age (Upper-School)	--	100	--	--
Guana Cay All Age School	--	--	30	--
Marsh Harbour Government Complex**	--	--	1000	--
Marsh Harbour Healthcare Center**	500	--	1000	--
Sandy Point Community Center	--	--	300	--
Total	500	765	3,019	600

Source: Shelter Status Reports based on data from PDC, CDEMA, NEMA & BNGIS

Note: Information was not disaggregated by sex, age or nationality to reflect the differential effects of the hurricane on each segment of the population.

-- Information unavailable

* A Special Needs Shelter that was used as a temporary shelter after the hurricane

** Temporary Shelter

Most shelters on Abaco were deactivated within a couple of days, as most people left the island. The Assessment team was informed that the Bahamas Government Complex in Marsh Harbour was used as a temporary shelter as several shelters were compromised during the hurricane and persons came to the building for safety during the storm.

POPULATION WHO SUFFERED DAMAGE OR DESTRUCTION TO THEIR HOMES

The primary affected population also includes individuals or families who suffered damage or destruction of their homes. The Assessment team confirmed that on both Abaco and Grand Bahama, most of the damage was to frames, walls, roofs, doors, and windows as well as furnishings, appliances, and other equipment. An estimated 6,331 houses on Abaco suffered some type of effects which includes 27.6 percent that had catastrophic damage and 46.6 percent with significant structural damage, while 2,879 houses were affected (8.0 percent with catastrophic damage and 8.5 percent with significant structural damage) on Grand Bahama. Given that the average household size on Abaco and Grand Bahama is estimated at 3.2 persons per household- approximately 29,472 persons would have suffered some type of damage or destruction to their homes and assets (Table 7). In the case of the informal settlements in both affected islands, the Assessment team reported catastrophic failure in 100 percent of the houses.

TABLE 7. AFFECTED POPULATION WITH DAMAGE TO HOMES

Island	Damaged houses	Affected population
Abaco	6,331	20,259
Grand Bahama	2,879	9,213
TOTAL	9,210	29,472

Source: Assessment team, 2019

At the time of this assessment, the Department of Social Services was in the process of evaluating the needs of displaced people still at the shelters to assist them in the identification of appropriate medium- and long-term housing solutions. As of 28 October, there were still 777 displaced persons staying in five shelters in New Providence[14] and a Shelter and Housing Plan has been developed to assist in the relocation of evacuees to return to Abaco and Grand Bahama. The new Ministry of Disaster Preparedness, Management and Reconstruction has also announced that a protocol is being determined for the relocation of individuals back to Abaco, and is in the process of deploying 100 RV trailers as temporary housing for 300 government personnel who will be a part of the rebuilding and recovery efforts on the island. Sixty RV trailers will be placed at the primary school, and 40 at the high school in Marsh Harbour, and assigned to various government agencies, including 15 to the Ministry of Health, eight to airports, 20 to security forces, six for Ministry of Works, and one as a workspace for senior government officials.[15] According to the Ministry of Finance the cost of the RV trailers are around $1,934,359. A land site next to the Spring City subdivision on Abaco is also being prepared to create a Family Relief Centre, which will serve as temporary housing accommodations for families affected by the hurricane. The Family Relief Centre will comprise of 250 dome structures that each can accommodate four to five people, and will include plumbing, drainage, a sewer system and electricity. The estimated cost for this facility is $6.4 million.

In terms of psychosocial support, the Assessment team was informed that there were various initiatives to help communities cope with and adapt to the impacts of the disaster. In the first week after the hurricane, a roster of volunteers who were trained in counseling by the Bahamas Red Cross Society were utilized to provide support to affected people who had been evacuated to New Providence. These services were coordinated by the Bahamas Psychological Association and the

14 Information based on NEMA Hurricane Dorian Daily Brief, Monday 28 October 2019. See: www.bahamas.gov.bs/nema/dailyupdates

15 Information received from NEMA broadcast updates on social media. See https://www.facebook.com/NEMA242/photos/a.1662093044060169/2460012187601580/?type=3&theater

Ministry of Health and involved counseling, psychoeducation on coping, normative treatment, and referrals to other facilities to treat with health or mental health issues. As of the 13 of October, this service reached a total of 782 people (227 males, 455 females, 79 children, and 21 adolescents)[16]. On Grand Bahama, a team of 40 counselors called Team Restoration provided services throughout the island to assess the mental health of residents. In addition to counseling, Team Restoration also set up a 24-hour hotline for residents to call should they feel overwhelmed and need to talk. They also partnered with the Haitian community to provide counseling services to the residents. Other psychosocial support services included the work of UNICEF who supported child protection services for 1,200 children in shelters and a training-for-trainers on psychosocial support. UNFPA led gender-based violence prevention and response activities, including development of long-term strategies with State officials. IsraAID, PAHO and several other NGOs were also very strategic in counseling and support services to many people who were severely traumatized by this event.

With regards to relief efforts for the affected population, the Government of The Bahamas has received about $5 million in monetary donations as of 30 September.[17] In addition to the regional and international partners that provided assistance in the early phases of emergency and relief response, the Government of The Bahamas, through its various institutions, has also allocated around $7 million for the attention of the emergency and relief efforts. The Department of Social Services also reported that up to the end of October, about 2,611 persons affected by the hurricane were provided with $100 food coupons.[18] Information was also received from the Bahamas Red Cross, U.S. Embassy and UKAid on relief distribution to the affected population after Hurricane Dorian. According to the General Director of the Bahamas Red Cross, there are 3,921 families on both affected islands who have been assisted through relief distributions as of 10 October (Table 8). Relief items were mainly tarpaulins, hygiene kits, jerry cans, aqua tabs, solar lights and blankets.

TABLE 8. RED CROSS RELIEF DISTRIBUTIONS TO AFFECTED ISLANDS

Islands	Total Beneficiaries [a]
Abaco	600
Grand Bahama	1,138
New Providence	2,183
TOTAL	3,921

Source: The Bahamas Red Cross Society 2019

Notes: a Beneficiaries represent single households.

According to the American Embassy in The Bahamas, the United States provided $16,284,726 to disaster relief efforts channeled through several organizations (Table 9). Moreover, the USAID Food For Peace (USAID/FFP) contributed to a total of $1,000,000 for food security through the UN World Food Program. Additionally, the Department of Defense provided $8,490,000 for logistics support and non-monetary contributions including U.S. Hardware Assets such as helicopters, fixed wing aircraft, ships and personnel from U.S. Coast Guard, Drug Enforcement Administration, DHS/CBP Air and Marine Operations. The operations resulted in the rescue of individuals and pets, relocation of personnel and equipment, collection of imagery and video, provision of transportation for Bahamian government officials, personnel, equipment, and supplies, contacting outer cays for security and health concerns, and evacuating adults and children with non-life-threatening injuries.

16 Based on information received from the Bahamas Red Cross Society.
17 Information received from the Ministry of Finance.
18 Information based on NEMA Hurricane Dorian Daily Brief, Monday 28 October 2019. See: www.bahamas.gov.bs/nema/dailyupdates

TABLE 9 – U.S RELIEF DISTRIBUTIONS TO AFFECTED ISLANDS

Implementing Partner	Activity	Location	Amount
The Bahamas Red Cross Society	Shelter and settlements, WASH	Countrywide	$200,000
Fairfax County Fire and Rescue Departments	Urban Search and Rescue	Abaco	$3,639,351
International Federation of Red Cross and Red Crescent Societies	Economic recovery and market systems, health, protection, shelter and settlements, WASH	Countrywide	$2,340,000
International Medical Corps	Health, Protection, WASH	Grand Bahama	$2,691,000
International Organization for Migration	Humanitarian coordination and information management, shelter and settlements	Countrywide	$1,500,000
	In-Kind Relief Commodities	Countrywide	$219,350
Pan American Health Organization	Health, WASH	Countrywide	$2,600,000
U.S. Coast Guard	Humanitarian coordination and information management	Grand Bahama, New Providence	$141,135
UN World Food Program	Logistics Support	Countrywide	$1,064,186
	In-Kind Relief Commodities	Countrywide	$324,935
	Logistics support	Countrywide	$1,157,434
	Program support		$407,335

Source: The Bahamas Red Cross Society 2019

Information from UKAid showed that emergency relief donations were received by approximately 3,430 persons on Abaco that were affected by the hurricane. Donated goods ranged from shelter kits, collapsible water containers and bottled water, hygiene kits, ration meals, engineer stores, generators, fuel and medical supplies. The emergency response was delivered by helicopter on 5 September to Coopers Town, Elbow and surrounding Cays, Marsh Harbour, Treasure Cay Farms, on 7 September to Cedar Harbour and Fox Town, on 8 September to Grand Cay and on 9 September to Cedar Harbour. MexiFloat in Coopers Town delivered further emergency assistance to Marsh Harbour and Fox Town. Assistance was delivered by HADR to Treasure Cay and Black Wood Village (Table 10). The number of beneficiaries reached by distribution will change following cross-checking of datasets as time goes by.

TABLE 10. UKAID RELIEF DISTRIBUTIONS TO AFFECTED ISLANDS

Settlement	Quantity	Items
Grand Cay	336	Bottles 500 ml water
	160	24h. ration meals
	8	Shelter kits
Fox Town	168	Bottles 500 ml water
	80	24h. ration meals
	544	Shelter kits
	196	Hygiene Kits
	20 tonnes	Water incl. 1000 DFIF x 10l collapsible water cubes
Black Wood Village	6	Shelter Kits
Treasure Cay Farms	168	Bottles 500 ml water
	4	Shelter kits
	80	24h. ration meals
Cedar Harbour	168	Bottles 500 ml water
	80	24h. ration meals
	4	Shelter kits
Treasure Cay	10	Shelter kits
Coopers Town	984	Bottles 500 ml water
	225	24h. ration meals
	1	Generator and fuel
	204	Shelter kits
	687	Hygiene kits
Elbow and surroundings Cays – Hope Town	984	Bottles 500 ml water
	225	24h. ration meals
Marsh Harbour	-	Fuel and medical supplies
	196	Shelter kits
	104	Hygiene Kits
	1250	124h. ration meals
	6912	Bottles 500 ml water

Source: information received from the UKAid

The Bahamas experienced an overwhelming amount of support in response to Hurricane Dorian from international, regional and local organizations, which emphasizes the importance of coordination especially in the recovery and relief phases. At a time when all national disaster and coordination systems can be overwhelmed, a large amount of interests with sometimes competing mandates tend to be more counterproductive as it can lead to duplication of efforts as well as leave vulnerable communities and populations behind.

SECONDARY AFFECTED POPULATION

The secondary affected population are those persons who suffer indirect or secondary effects of the disaster, such as interruptions in public services, trade, employment, and from isolation.

Regarding access to services, the entire population on Abaco and Grand Bahama experienced a disruption in electricity, water and telecommunications for a period immediately following the impact from Hurricane Dorian. In fact, at the time of this assessment, only portions of Abaco had electricity restored. Access to clean potable water was also an issue as the ground water was contaminated from the storm surge. Additionally, there were disruptions in the flight and ferry services that facilitated the easy transport to and from other islands within Bahamas.

The hurricane did not only result in widespread damage to homes, but also to those properties which make up the tourism sectors in the affected islands. Tourism is one of the main contributors to the economy of both Abaco and Grand Bahama and is also the main driver for many of the other sectors like commerce, restaurants and transportation. The tourism sector is also fundamental for employment, and as such the hurricane impacted the jobs of many of the residents that were employed in these sectors resulting in a loss or decrease in income.

Approximately 10,546 students were affected as a result of a suspension of primary and secondary school classes for about eight weeks and counting. At the time of the assessment some students were still not in school yet. This created a significant loss in teaching time, as many schools were destroyed on Abaco and needed significant repairs on Grand Bahama. The Ministry of Education is awaiting advice from the Ministry of Works on the scope of work and costs for the 16 schools needed to be repaired on Grand Bahama.

PART ONE:
ASSESSMENT OF EFFECTS

SOCIAL SECTORS

HOUSING AND PUBLIC BUILDINGS SECTOR

INTRODUCTION

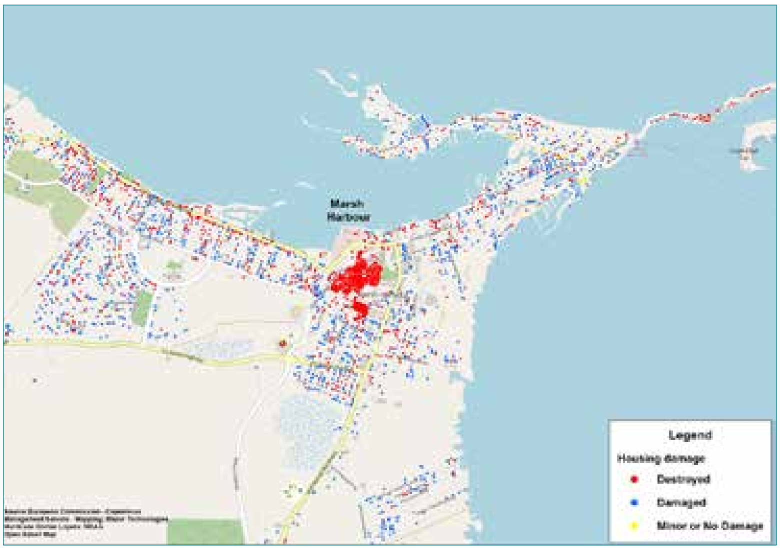
Housing was the sector most severely affected by Hurricane Dorian. Several residential settlements along or near coastlines sustained heavy damage as a result of the intense force of winds and storm surge of a Category 5 hurricane or were impacted by the effects of falling trees and flying debris. Houses and residences throughout Abaco and parts of Grand Bahama suffered significant damage to the structural elements, roofs, and other components of the building. According to official data provided by the authorities and field inspections, 31 public buildings including government offices were affected. Schools, hospitals, clinics, and shelters are considered as part of other sectors for the purpose of this assessment.

Approximately 9,000 homes and over 11 million square feet of structures sustained damage on Abaco and Grand Bahama due to Hurricane Dorian. On Abaco more than 75 percent of the dwellings were affected, approximately 57 percent of the houses were severely damaged. The most affected locations were central Abaco (Marsh Harbour), Treasure Cay, and Hope Town. It is also important to mention that several blighted areas were completely devastated.

Data for the assessment was provided by the authorities of The Bahamas, field inspections, meetings with personnel from different ministries of the government and other institutions, and the use of the geo-information based on data available by The European Commission's Copernicus Programme, specifically the Emergency Management Service-Mapping component, as well as Maxar Technologies and OpenStreetMap.org.

Damage to the Housing sector on the islands of Abaco and Grand Bahama is estimated at $1.48 billion. The estimated Losses are $65 million resulting from 2,894 homes left uninhabitable after the hurricane. Additional costs are estimated at $57.8 million. Damage to the Public building sector of The Bahamas is estimated at $10.6 million. Additional costs are estimated at $1.0 million. There were no losses reported related to public buildings. Figure 15 and Figure 16 present the GIS report in housing damage to Marsh Harbour and East Grand Bahama.

FIGURE 15. MARSH HARBOUR: HOUSING DAMAGE REPORT



Source: Assessment team, 2019

FIGURE 16. EAST GRAND BAHAMA: HOUSING DAMAGE REPORT

Source: Assessment team, 2019

BASELINE INFORMATION

For the year 2019, Abaco and Grand Bahama have an estimated population of approximately of 17,413 and 56,251 respectively. The projected number of dwellings was estimated using the data from the GIS analysis and population projections established by the Assessment team (Table 11 and Table 12).

TABLE 11. ABACO: NUMBER OF DWELLINGS

Island / Supervisory District	Number of Dwelling Units	Number of Occupied Dwelling Units	Number of Vacant Dwelling Units
Total Abaco	8,202	5,254	2,948
North Abaco	4,239	2,710	1,529
South Abaco	3,963	2,544	1,419

Source: Assessment team, 2019

TABLE 12. GRAND BAHAMA: NUMBER OF DWELLINGS

Island / Supervisory District	Number of Dwelling Units	Number of Occupied Dwelling Units	Number of Vacant Dwelling Units
Total Grand Bahama	22,270	16,579	5,691
West End	1,772	1,384	388
Eight Mile Rock	3,673	2,961	712
Pineridge	3,122	2,550	572
Lucaya	5,719	3,643	2,076
Marco City	2,906	2,572	334
High Rock	5,078	3,468	1,610

Source: Assessment team, 2019

The tables show a difference between the two islands in the percentage of vacant dwellings at the time of Hurricane Dorian. On Abaco 35.9 percent of the housing units were unoccupied or vacant, compared to 25.6 percent on Grand Bahama. Inferentially, a larger segment of the houses on Abaco are owned by people that are not living on Abaco. According to the 2010 Census, 39.1 percent of the houses in the two islands were fully owned. Abaco had a greater percentage of houses fully owned, registered at 48 percent, where Grand Bahama showed 36.3 percent of homes fully owned. In the case of mortgaged houses, this figure was 28.1 percent on Grand Bahama while on Abaco it was 15.9 percent. In our estimates we assume those parameters remain the same. Insurance penetration in The Bahamas is very low for properties that do not have any mortgage, and in many cases the owners of homes are not insured. Most of the damaged structures reported in this chapter were uninsured.

DAMAGE

The destruction caused by Hurricane Dorian was generalized in the Housing sector. Of the 6,331 estimated dwellings and public structures affected on Abaco, an estimated 27.6 percent were decimated, while 46.6 percent had significant structural damage, 15.5 percent had minor damage, and 10.3 percent showed minimal damage. In the case of Grand Bahama, out of 2,879 dwellings and structures affected, an estimated 8.0 percent presented catastrophic damage, 8.5 percent with significant structural damage, 50.1 percent showed minor damage, and 33.4 percent proved to have minimal damage. In the case of the blighted areas, catastrophic failure occurred in 100 percent of the dwelling units. The Housing sector sustained an estimated damage of $1.476 billion (Table 13), of which 88.9 percent took place on Abaco. The furniture and equipment estimate includes damage related to vehicles.

TABLE 13. HOUSING SECTOR: DAMAGE

Area	Non-Damaged Houses	Damaged Houses (number)	Structures (million $)	Furniture and Equipment m.$	Damage (millions$)
Abaco	1,871	6,331	1,216.7	96.7	$1,313.4
Grand Bahama	19,391	2,879	140.1	23.1	$163.2
Total	21,262	9,210	1,356.8	119.8	$1,476.6

Source: Assessment team, 2019

Most damage sustained by houses on Abaco was catastrophic, for structural elements as well furnishings, appliances, and other equipment. Damage to dwellings was estimated considering two factors:

I. Average house value, based on average house size, building class, and consideration of outer walls and roofing materials, and an average depreciation based on usage and age of the house.

II. Level of damage assigned to each house (Table 13 and Table 14)

- Level 1- No significant damage. Structure is usable and can be occupied. Repairs required are minimal.

- Level 2- Minor damage. Structure is usable and can be occupied after urgent temporary measures are taken. Assistance will probably be required for repairs.

- Level 3- Major damage. Structure is not usable and cannot be occupied until repairs are completed.
- Level 4- Destroyed. Structure is not usable and cannot be repaired. Must be cleared and rebuilt.

TABLE 14. ABACO: DAMAGED HOUSES

Area	Houses with no Damage	Level of Damage				
		Level 1	Level 2	Level 3	Level 4	No. of Damaged Houses
Treasure Cay	200	56	84	270	126	536
Central Abaco	127	315	472	1,446	1,125	3,358
North Abaco	854	65	97	137	90	389
Hope Town	614	187	281	934	614	2,016
South Abaco	77	-	-	31	-	31
Totals	1,871	623	934	2,819	1,955	6,331

Source: Assessment team, 2019

TABLE 15. GRAND BAHAMA: DAMAGED HOUSES

Area	Houses with no Damage	Level of Damage				
		Level 1	Level 2	Level 3	Level 4	Damaged Houses
Freeport Area	7,675	263	394	29	2	689
West Grand Bahamas	10,135	687	1,030	176	21	1,914
East Grand Bahamas	1,581	12	18	40	207	276
Total	19,391	962	1,443	245	230	2,879

Source: Assessment team, 2019

The Assessment team field mission verified that most of severely affected dwellings are old construction structures that presented deficiencies in building materials and a lack of application of the building codes which creates vulnerability for the structure to withstand events like Hurricane Dorian.

The type of buildings that performed better during Hurricane Dorian were made of concrete and block walls, with a concrete roof and a stronger roofing solution. This is an important aspect for a resilient solution in reconstruction.

LOSSES

Losses in the Housing sector are related to the interruption of accommodation and rental services due to severe damage or destruction of the dwellings, making them temporarily or permanently uninhabitable. According to the 2010 Census, 26 percent of Abaco houses are rented and 30 percent of houses on Grand Bahama are rented. This data has been used for estimating the losses related to units that are potentially uninhabitable, damage level 2 and up on both islands. There are 7,339 houses in this condition. Table 16 and Table 17 show estimated losses for each island by town. The Assessment team assumed a timeframe for recovery between 6 and 28 months. The total losses associated to Hurricane Dorian on Abaco and Grand Bahama is estimated at $56.3 million, 92.8 percent of these losses taking place on Abaco. Some of the costs of the vacation residential facilities have been incorporated in the tourism sector for the purpose of this report.

TABLE 16. ABACO: LOSSES

Island	Qty. of Houses	Ave. Monthly Rent $	Monthly Cost $	Period (months)	Total Cost
Treasure Cay	480	1,800	224,762	28	6,293,337
Central Abaco	2,757	1,400	1,003,713	28	28,103,971
North Abaco	324	1,000	84,352	28	2,361,844
Hope Town	1,829	1,800	855,952	28	23,966,662
South Abaco	31	1,000	8,004	28	224,121
Total	5,422		2,176,783		$60,949,937

Source: Assessment team, 2019

TABLE 17. GRAND BAHAMA: LOSSES

Island	Qty. of Houses	Ave. Monthly Rent ($)	Monthly Cost ($)	Period (months)	Total Cost
Grand Bahama	426	1,800	229,873	6	1,379,239
West Grand Bahama	1,228	1,000	368,262	6	2,209,575
East Grand Bahama	264	1,000	79,253	6	475,517
Total	1,917				$4,064,330

Source: Assessment team, 2019

ADDITIONAL COSTS

Additional costs included in this assessment refer to the cost of demolition of the most affected dwellings, debris removal, as well as the cost of labor and equipment rental. Additional costs related to the Housing sector is approximately $57.8 million (Table 18 and Table 19). It is estimated that 2.5 million cubic yards of debris needed to be removed from the affected areas. The cost to fill and transfer each truckload of debris of approximately 13 cubic yards is estimated to be $200 per truckload, without considering the management of the landfill. The cost of demolition was estimated at $40 per cubic yard, labor and equipment rental included.

TABLE 18. ABACO: ADDITIONAL COSTS

Island	Y3	Truckloads	Cost per Truck/ Demolition ($)	Estimated Cost (1)
Debris Cleaning	2,145,453	165,035	200	$33,006,963
Demolition	321,818		40	$12,872,715
Total	2,467,270			$45,879,678

(1) Including Labor and Equipment Rental

Source: Assessment team, 2019

TABLE 19. GRAND BAHAMA: ADDITIONAL COSTS

Island	Y3	Truckloads	Cost per Truck/ Demolition ($)	Estimated Cost (1)
Debris Cleaning	510,605	39,277	200	$7,855,454
Cost of demolition	76,591		40	$3,063,627
Total	587,195			$10,919,081

(1) Including Labor and Equipment Rental

Source: Assessment team, 2019

PUBLIC BUILDINGS

BASELINE INFORMATION

Public buildings are associated with government services; public safety such as police and fire stations, postal services, among others. Hurricane Dorian caused different levels of damage to public buildings. Abaco has five police stations, four fire stations, two postal service offices, a courthouse and central government building with various offices. Grand Bahama has five police stations, a fire station, and two postal service stations, in addition to various government buildings.

DAMAGE

The estimated damage in this sector is $10.6 million (Table 20), of which 76 percent took place on Abaco. Abaco was clearly the most affected island, which corresponds with the hazard intensity that each island faced.

Eighteen public buildings were damaged on Abaco, including the destruction of three police stations, a fire station and a post office. The structures that were catalogued as moderately damaged were two fire stations, the natural history museum and some government offices. Finally, a police station located in Marsh Harbour, a postal service station, the courthouse, and three buildings associated with government agencies were catalogued to have minor damage.

Thirteen public buildings were damaged on Grand Bahama. Two post offices were shown to have moderate damage, while three police stations, a fire station, a vehicle inspection building and three government buildings were listed with minor damage.

TABLE 20. PUBLIC BUILDINGS: DAMAGE

Location	Buildings	Buildings	Furniture and Equipment	Vehicles (units)	Vehicles ($)	Damage ($)
Abaco	18	5,468,066	2,304,682	12	200,410	$7,973,159
Grand Bahama	13	1,528,303	764,152	20	302,050	$2,594,505
Total	31	6,996,370	2,995,600	32	502,460	$10,567,663

Source: Assessment team, 2019

TABLE 21. PUBLIC BUILDINGS: LEVEL OF DAMAGE

Island	Level 1	Level 2	Level 3	Level 4	No. of Damage Buildings
Abaco	5	7	-	6	18
Grand Bahamas	2	1	2	8	13
Totals	7	8	2	14	31

Source: Assessment team, 2019

ADDITIONAL COSTS

Additional costs related to the Housing and Public buildings sector is approximately $1 million (Table 22). It is estimated that 24,820 cubic yards of debris are needed to be removed from the affected areas, and another 20,684 cubic yards from demolition will also need to be cleared from the area.

TABLE 22. PUBLIC BUILDINGS: ADDITIONAL COSTS

Island	CY	Truckloads	Cost of Trucks	Estimated Cost
Abaco Debris Cleaning	18,096	1,392	200	$278,396
Abaco Cost of demolition	15,080		30	$458,426
G. Bahama Debris Cleaning	6,725	517	200	$103,454
G. Bahama Cost of demolition	5,604		30	$170,355
Total				$1,010,632

Source: Assessment team 2019

HEALTH SECTOR

INTRODUCTION

Hurricane Dorian severely affected the Health sector, with significant destruction of infrastructure, equipment, medical supplies and electrical and water supply on Abaco and Grand Bahama. Therefore, the capacity of the healthcare delivery system has been impacted. Access to health services and medical care delivery has been significantly hampered in the most affected areas. Several important health care facilities were impacted, and some are still inoperable, due to important physical damage, with loss of cold chain and many other supplies destroyed.

The number of related injuries recorded by the health authorities was over 200 a week after the passage of the hurricane. Over 2,000 people with the need of basic health services, health screening, and disease surveillance were placed in temporary shelters in New Providence, Abaco, Grand Bahama and other neighboring islands.

The main hospital on Grand Bahama, also the second largest in The Bahamas, is the Rand Memorial Hospital. It suffered severe damage and loss of equipment and supplies from storm surge and flooding. The biggest concern was the mold growth throughout the facility, which forced health authorities to close operations to over 80 percent of the institution. Some services have been offered in a field hospital supported by an international Emergency Medical Team (EMT). All nine other primary health clinics suffered some type of damage ranging from destruction to minor external damage.

The ten health facilities on Abaco suffered relatively less damage. The main clinic at Marsh Harbour experienced some external damage, and although it incurred extensive internal damage it served as a temporary shelter for over three days in the middle of the storm for a significant number of the affected population.

It was necessary to seek assistance from international EMTs, volunteers, and a rotation of health workers from other unaffected neighboring family islands, which forced the MOH to incur in important Additional costs. These include surgeons, anesthesiologists, pathologists, midwives, family physicians, psychiatrists, psychologists, emergency services, and public health nurses. Mental health and psychosocial support were also needed to assist victims to deal with the consequences of the event.

In addition, a health sector cluster was activated to coordinate humanitarian support to the affected population under the co-leadership of the Ministry of Health and PAHO. Along with common critical medical and other supplies, health personnel and specialists arrived in The Bahamas to help tackle the immediate needs from the emergency. Currently, the MOH is trying to coordinate the reception of all type of donations and support from various sources to help the recovery and reconstruction of the affected sector.

BASELINE INFORMATION

The public health infrastructure of Grand Bahama is composed of one inpatient hospital and nine public clinics under the administration of the Public Hospital Authority (PHA). On Abaco there are eight public clinics, all managed by the Department of Public Health (DPH) from the Ministry of Health. Abaco also has one reference clinic located in Marsh Harbour. All the clinics provide ambulatory health care services across the two islands.

The Princes Margaret Hospital (PMH) is the main reference hospital located in Nassau, New Providence, and has supported all the evacuated patients affected by hurricane Dorian from both islands.

TABLE 23. HEALTH CARE FACILITIES IN THE AFFECTED ISLANDS

Grand Bahama	Abaco
High Rock Clinic	Moore's Island Clinic
Rand Memorial Hospital (RMH)	Marsh Harbour Clinic
Mc Lean Clinic	Hope Town Clinic (satellite)
Pelican Point Clinic	Man-o-War Cay (satellite)
Sweeting's Cay	Fox Town (satellite Clinic)
Eight Mile Rock	Green Turtle Cay Clinic (satellite)
Free Town (rental)	Sandypoint Clinic (satellite)
Hawksbill Clinic	Cooper's Town Clinic
West End	
Grand Cay	
Davies House Clinic (private)	
East Sunrise Medical (private)	
Treasure Cay Clinic (private)	

Source: Assessment team, 2019 PHA and MOH information and estimates

There are several private clinics on both islands that provide mainly specialized care. Some clinics from Grand Bahama were not considered in this assessment due to lack of information or no reports of relevant damage.

Several sources of information were used to compile de data for this chapter:

- Data collected by the Emergency Operations Centre (EOC) of the Bahamas Ministry of Health (MOH) and Public Health Authority (PHA) during and after the impact of Hurricane Dorian
- Data provided by the Public Hospital Authority (PHA), including estimations from Rand Memorial Hospital, and the Grand Bahama Health Clinics
- Data obtained from direct assessments of clinics on Abaco and Grand Bahama inspected by PAHO and ECLAC staff

DAMAGE

Hurricane Dorian damaged most of the healthcare facilities on both affected islands, with severe damage to the Rand Memorial Hospital (RMH) and four clinics located in the eastern part of Grand Bahama, mainly due to the storm surge and wind gusts that reached 220 mph. The other clinics received lesser damage, mainly roof and external damage, water leakages and medical equipment and furniture damage from flooding, humidity and intense heat. See Table 24.

TABLE 24. GRAND BAHAMA: HEALTH CARE INFRASTRUCTURE DAMAGE

Health Care Facility	Description
High Rock Clinic	Destroyed
Rand Memorial Hospital	Damaged over 50%
Mc Lean Clinic	Damaged over 50%
Pelican Point Clinic	Damaged over 50%
Sweeting's Cay	Damaged over 50%
Eight Mile Rock	Partially damaged - 25%
Free Town (rental)	Partially damaged - 25%
Hawksbill Clinic	Partially damaged - 25%
West End	Partially damaged - 25%
Grand Cay	Partially damaged - 25%
Davies House Clinic (private)	Partially damaged - 25%
East Sunrise Medical (private)	Partially damaged - 25%
Treasure Cay Clinic (private)	Partially damaged - 25%

Source: Assessment team, 2019 PHA and MOH information and estimates

TABLE 25. ABACO: HEALTH CARE INFRASTRUCTURE DAMAGE

Health Care Facility	Description
Moore's Island Clinic	Damaged over 50%
Marsh Harbour Clinic	Partially damaged - 25%
Hope Town Clinic (satellite)	Partially damaged - 25%
Man-o-War Cay (satellite)	Partially damaged - 25%
Fox Town (satellite Clinic)	Partially damaged - 25%
Green Turtle Cay Clinic (satellite)	Partially damaged - 25%
Sandypoint Clinic (satellite)	Partially damaged - 25%
Cooper's Town Clinic	Partially damaged - 25%

Source: Assessment team, 2019 PHA and MOH information and estimates

During the site visit, the more severely damaged health care buildings were observed to be at high risk locations at nearly sea level and without design specifications to help withstand a hurricane. In addition, crucial equipment such as power generators, air conditioning units, water pumping equipment for potable wells, and septic tanks are exposed to these same risks. Equipment should be properly protected with barriers made from forged steel that can prevent these assets from being damaged during these events.

Significant damage was evidenced in medical equipment, furniture, and vehicles, also due to the extensive and prolonged flooding, very high humidity and high temperatures during and after the storm. The Rand Memorial Hospital in Freeport, Grand Bahama was the facility where most of the important medical equipment and furniture was damaged because of this storm.

The damage to infrastructure, medical equipment, furniture, supplies and others to the health sector on Abaco and Grand Bahamas attributed to hurricane Dorian has been estimated at $37.7 million.

TABLE 26. HEALTH SECTOR: DAMAGE

Description	Public	Private	Total
Health care Infrastructure - Grand Bahama	25.966,500	787,500	26,784,000
Health care Infrastructure – Abaco	2,441,250		2,441,250
Medical equipment, furniture, vehicles, others - Grand Bahama	6,381,750	350,000	6,731,750
Medical equipment, furniture, vehicles, others – Abaco	1,789,500		1,789,500
Total	$36,579,000	$1,137,500	$37,716,500

Source: Assessment team, 2019 based on PHA and MOH information and estimates

LOSSES

This section outlines losses incurred due to disruption in health services including corporate operations at PHA and MOH. Estimated losses are summarized in Table 26. A total of $21.4 million is the estimated cost of the disruption to health services operations. The disruption covers before, during and after the hurricane.

Pre-hurricane disruption of normal operations included the reassignment of human resources to prepare health facilities and services, stocking of medicine and basic supplies to all warehouses, and personal preparations undertaken by health staff. Preparations began three days prior to the storm for the islands of Abaco, Grand Bahama, Berry Islands, and New Providence.

The second period of disruption was during the hurricane's passage. Three days of services disruption for all clinics on Abaco and Grand Bahama were observed. The third disruption period was the time during which a facility's normal operations remained unrestored after the departure of the hurricane. Clinics with minor damage had three additional days of service disruption. The Rand Memorial Hospital, High Rock Clinic and Pelican Point on Grand Bahama suffered extensive damage and have not restored services in their premises at the time of the report, with no clear date estimated for a return to operations. As for now, it is planned that international EMT will provide some of the health services. High Rock Clinic and RMH estimate the third period of disruption will occur for six months. For the remaining clinics with partial damage, the services were restored gradually as clean-up, restoration of water and electricity and availability of health staff were available, which took four to eight days on average.

TABLE 27. HEALTH SECTOR: LOSSES

Description	Public	Private	Total
Losses to disruption in Hospitals	20,863,750	N.A.	20,863,750
Losses to disruption in Clinics	487,630	N.A.	487,630
Total	$21,351,380		$21,351,380

Source: Assessment team, 2019 based on PHA and MOH information and estimates

ADDITIONAL COSTS

The Additional costs to the Health sector relate to the emergency response and provision of temporary relief. Additional costs include the operation of emergency operation centers at the MOH and PHA, and the cost of operating emergency medical services in PMH on the island of New Providence. Also considered are the expenses incurred for the provision of health services in temporary hospitals by EMTs, procurement of medical supplies, medicine, per diem for health and administrative staff that were used as relief staff, temporary housing (procurement of containers and temporary toilets, sinks and showers), surveillance and vector control supplies. Several PAHO experts were deployed to support the MOH, PHA and NEMA in Nassau and some were deployed to the disaster zone for health emergency coordination, epidemiological surveillance, vector control, civil and military logistics and supplies. Additional costs also includes communication and media, information management, as well as the costs of health screening and delivery of health services for the evacuees, including psychosocial support. Finally, there were the costs for increased storage capacity, demolition and debris removal. Additional costs were estimated at $5.3 million (Table 28).

TABLE 28. HEALTH SECTOR: ADDITIONAL COSTS

Description	Public	Total
Health services provided to hurricane victims	959,530	959,530
Services provided by EMTs	0	0
Relief staff deployment	350,000	350,000
Experts support	320,000	320,000
Temporary housing for staff	612,000	612,000
EOC operation	100.000	100.000
Demolition and debris removal	2,113,000	2,113,000
Others	990,000	990,000
Total	$5,344,630	$5,344,630

Source: Assessment team 2019 based on PHA and MOH information and estimates

EDUCATION

INTRODUCTION

Due to the passage of the category 5 Hurricane Dorian, Grand Bahama and Abaco incurred widespread damage to most educational facilities. Across both islands 45 educational facilities experienced varying levels of damage with 10,546 students and 796 teachers affected. Seven schools were altogether destroyed. On Abaco, there were 23 educational facilities impacted with 3,512 students and 211 teachers affected, while Grand Bahama had 24 educational facilities impacted with 7,034 students and 585 teachers affected. At the time of this report and following the registration drive conducted by the Ministry of Education, approximately 1,500 displaced students had been reassigned to alternative schools across the islands of The Bahamas. However, assignments remain ongoing as several students remained unassigned. A total of approximately 120 teachers from Abaco were reassigned to schools across The Bahamas while 39 teachers remaining on Abaco continue to provide part-time unofficial instruction to approximately 541 students at the preschool, primary and high school levels. Approximately 171 high school students are being instructed through virtual classroom instruction on a full-time basis.

All public schools in The Bahamas and post-secondary institutions were closed on 30 August 2019, and the majority were reopened by 9 September 2019. The University of The Bahamas reopened on 5 September and The Bahamas Technical and Vocational Institute (BTVI) was reopened on 9 September. All public schools on Grand Bahama were re-opened on 17 October 2019 while all schools on Abaco remained officially closed as of the writing of this report. Although the Grand Bahama campus of the BTVI remained closed, classes restarted at alternative locations on 7 October 2019 for approximately 250 of the 400 originally enrolled students. The University of Bahamas- North campus was also unable to be reopen because of the extensive damage, therefore some students were either accommodated at the Nassau campus with classes commencing on 30 September 2019, relocated to alternative US universities to complete their studies, or withdrew from their programs.

Widespread damage to educational facilities amounted to $72 million. Losses in the sector, which comprises the estimated value of lost instruction time along with the value of tuition refunds for students no longer returning for post-secondary level education, totaled $6.8 million. The remaining Additional costs incurred during the recovery efforts amounted to $19.1 million. The estimated costs across the two islands were equally distributed despite the student and teacher population on Abaco being significantly smaller than that of Grand Bahama; an indication of the magnitude of the damage on Abaco. Given more information on privately managed schools in the affected islands, the totals would likely be larger than currently estimated. The limited data available on private sector schools across both islands contributed to the significantly smaller private sector cost was.

Three of the most critical vulnerabilities that were severely impacted in the Education sector by Hurricane Dorian include maintenance of school premises and securing of special equipment to minimize destruction, lack of access to potable drinking water at schools, and the significant loss in school time. In many instances, damage to schools resulted from poorly attached windows, doors and roofs. It is important to conduct regularly scheduled maintenance across educational facilities as neglect can worsen damage sustained to important educational facilities. Special equipment can be expensive to replace and as such should be securely stored in waterproof containers in locations with minimal vulnerabilities. Following a natural disaster, access to potable drinking water is often a major limitation to restoring normalcy to the masses. This was certainly the case for many educational facilities, and it limited the ability of these schools to be reopened despite some incurring otherwise minor damage. Therefore, priority should be given to the provision of a timely supply of drinking water at educational facilities and this will in turn allow for schools to be reopened in a timely manner.

It should be noted that this section assesses Hurricane Dorian's impact primarily on public education and few private institutions with available data across The Bahamas. Data for this analysis was provided by the Ministry of Education.

TABLE 29. EDUCATION SECTOR: DAMAGE, LOSSES AND ADDITIONAL COSTS

	Damages	Losses	Additional costs
Abaco Islands	36,330,052.7	1,240,191.3	9,601,260.5
Grand Bahama	36,076,549.8	3,426,073.1	9,498,739.5
Unaffected facilities	0.0	2,132,762.0	-
Total	$72,406,602.5	$6,799,026.4	$19,100,000.0

Source: Assessment team, 2019

Note: Undamaged facilities are all remaining educational facilities not damaged but were closed for 4 days in the case of the University of The Bahamas, 5 days for public schools and 6 days for BTVI

BASELINE INFORMATION

The Education sector of the report falls under the purview of the Minister of Education, with responsibility for over 57 thousand primary and secondary level students in approximately 175 educational institutions throughout 14 districts. The management of pre-primary, primary and secondary schools, including buildings, staffing and the provision of tuition and other supplies is designated to the Department of Education (DOE). According to the Education Act, access to education is available freely and mandatory for all residents of The Bahamas between the ages of 5 - 16 years. Post-secondary and tertiary institutions are operated by both the public and private sector; however, the state only provides funding for two post-secondary institutions: The Bahamas Technical and Vocational Institute (BTVI) and The University of the Bahamas.

The education system is structured in a 6-3-3 format with students from age five to eleven undergoing primary education for six years. This is followed by junior high school from ages 11 to 14 and senior high school from ages 14 to 17. Secondary schools educate students through both junior high and senior high levels. The Bahamian education system also possesses a range of preschools and tertiary level institutions; however, attendance is not mandatory (Bahamian Education System, 2017). Though 57 percent of public schools are located on the Family Islands, this accounts for only 17 percent of the country's students and 23 percent of the teachers. The categories of schools in The Bahamas are shown in Table 30.

TABLE 30. CATEGORIES OF SCHOOLS IN THE BAHAMAS

Category	Age Group
Pre-school	3 to 5 years
Primary	5 to 11+ years
Junior High	11+ to 14+ years
Senior High	14+ to 16+ years
All-Age	5 to 16+ years
Special schools	Various ages, students with severe learning disabilities

Source: Assessment team, 2019

The school calendar is organized from August to June, and students normally attend school from 08:45 to 15:00 hours. Students should receive 180 days of education per year. For the University of The Bahamas the academic calendar is organized from August to May while BTVI is organized from August to June.

TABLE 31. DATA ON PUBLIC SECTOR EDUCATION FACILITIES, AND STUDENTS

School type	Count	Total
Pre-school	13	670
Primary	94	23700
Secondary	42	17871
All-Age	21	1272
Tertiary	5	13722
Total	175	57,235

Source: Assessment team, 2019

DAMAGE

Table 32 lists the 45 public and private schools that were affected by Hurricane Dorian on the islands of Abaco and Grand Bahama with a brief description of damaged incurred. Damage to these facilities ranged from minimal, requiring minor repairs, to destroyed. Most of the damage involved roof damage, blown windows, flood damage from storm surge and mold accumulation. The estimated damage to educational facilities on both affected islands was $72.4 million (Table 33). Also included in this estimate were costs for damage to school furniture, special equipment, and fencing which amounted to over $1.5 million. Altogether there were seven educational facilities that were destroyed; four in East End and Grand Cay of Grand Bahama and three in Marsh Harbour and Treasure Cay of Abaco. The estimated damage of destroyed educational facilities totaled $29.3 million; $13.6 million for Grand Bahama and $15.7 million for Abaco Islands. Across both islands damage in the public sector ($51.2 million) outweighed that observed in the private sector ($21.2 million). However, limited data for privately managed educational facilities prevented the full analysis for this category.

TABLE 32. DESCRIPTION OF DAMAGE OF AFFECTED EDUCATION FACILITIES AND ENROLMENT BY ISLAND

Affected school	Island	Number of students	Number of teachers	Description of damage
Amy Roberts Primary	Abaco	42	4	Minor damage
Central Abaco Primary	Abaco	832	35	Major damage, severe roof damage, windows blown out
Cherokee Sound Primary	Abaco	19	2	Minor - few shingles blown
Coopers Town Primary	Abaco	124	8	Partial damage, office roof damage, windows blown out
Crossing Rock Primary	Abaco	33	3	Minor - few shingles blown
Fox Town Primary	Abaco	79	7	Minor damage, fans a ceiling destroyed in one class, office roof blown off
Guana Cay Primary	Abaco	4	1	Minor - few shingles blown

Affected school	Island	Number of students	Number of teachers	Description of damage
Hope Town Primary	Abaco	60	4	Major damage, severe roof damage, leaks, sheetrock down, playground damage
James Pinder Primary	Abaco	44	4	Minor damage
Man-O-War Primary	Abaco	13	2	Partial damage, major roof damage in the back
Treasure Cay Primary	Abaco	145	6	Major damage, severe roof damage, windows blown out, severe flooding and wall damage
Angel´s Academy	Abaco	60	11	Major damage
Agape Christian School	Abaco	265	11	Partial, roof damage
Forest Heights Academy	Abaco	151	12	Partial, roof damage
Long Bay School	Abaco	148	6	Major damage - roof damage
Smith´s Memorial Academy	Abaco	68	3	Major damage - roof damage
St. Francis De Sales	Abaco	317	19	Major damage - roof damage, walls collapsed
Every Child Counts	Abaco	98	13	Major damage
Patrick J. Bethel High School	Abaco	574	29	Major damage, severe roof damage, windows blown out, severe flooding poles down, offices flattened and wall damage
Scherlin Bootle High	Abaco	236	20	Major damage, severe roof damage, poles down and trees
Welsey College	Abaco	22	1	Major damage - roof damage to two classrooms, internal damage
Moore's Island All-Age	Abaco	118	11	Partial damage, multimedia room major leaks, sheetrock down in all classrooms
Bahamas Technical and Vocational Institute, Abaco	Abaco	60	3	Severely damaged
Bartlett Hill Primary School	Grand Bahama	225	23	Mold, mild roof damage
Beacon School	Grand Bahama	98	23	No flooding, minimal damage
East End Primary	Grand Bahama	45	8	Interiors destroyed, non-operational
East End Preschool	Grand Bahama	11	2	Interiors destroyed, non-operational
Freeport Primary School	Grand Bahama	493	37	Roof shingles blown off, mold
Holmes Rock Primary School	Grand Bahama	141	8	Minor roof damage, mold
Hugh Campbell Primary School	Grand Bahama	633	40	Major cleaning, walls down and mold
Lewis Yard Primary School	Grand Bahama	128	18	Utility pole down, mold, roof damage on four classrooms

Affected school	Island	Number of students	Number of teachers	Description of damage
Martin Town Primary School	Grand Bahama	219	23	Roof damage, mold, windows out in room 9
Maurice Moore Primary School	Grand Bahama	570	42	Roof shingles blown off, major cleaning, mold
Program Sure/PACE Center	Grand Bahama	11	6	Water damage, mold
Walter Parker Primary	Grand Bahama	667	38	Covering for walkway down, roof shingles off, mold
West End Primary	Grand Bahama	92	9	Four rooms down, major roof damage, mold
East End Junior High	Grand Bahama	10	6	Interiors destroyed, non-operational
Eight Mile Rock High	Grand Bahama	406	64	20 rooms damaged, 11 ceilings down, minor roof damaged, mold
Jack Hayward Junior High	Grand Bahama	461	36	Fence and poles down, mold
Jack Hayward Senior High	Grand Bahama	476	62	Ceiling damage, mold and pressure cleaning
Saint Georges Senior High	Grand Bahama	763	72	Mold and ceiling damage
Sister Mary Patricia Jr High	Grand Bahama	629	44	Minimal roof damage, mold, library and music labs damaged
Sweetings Cay All Age	Grand Bahama	6	1	Interiors destroyed, non-operational
Bahamas Technical and Vocational Institute, Grand Bahama	Grand Bahama	450	5	Major damage on Grand Bahama campus
University of The Bahamas, North on Grand Bahama	Grand Bahama	500	18	Severe damage to Northern campus

Source: Assessment team, 2019

TABLE 33. EDUCATION SECTOR: DAMAGE

Category	Total facilities	Facilities damaged	Total damage
Abaco Islands	23	23	36,330,052.7
Grand Bahama	24	22	36,076,549.8
Public	36	34	51,242,716.2
Private	11	11	21,163,886.3
Total	47	45	$72,406,602.5

Source: Assessment team, 2019

On Abaco, of the 23 educational facilities damaged, three were destroyed. Among the three schools destroyed by the impact of Hurricane Dorian there was one private school, St. Francis de Sales, and two public schools, Patrick J. Bethel High and Treasure Cay primary. Both St. Francis de Sales and Patrick J. Bethel High are in Marsh Harbour, which incurred catastrophic damage. Treasure Cay Primary is, however, located in the cays to the south of Abaco. Most of the damage in the Abaco islands centered around blown roofs and windows and, in some instances, collapsed walls and severe flooding from the storm surge. In the instances where exterior walls of educational facilities collapsed, this resulted in immense damage to the interior of many classrooms accompanied by destroyed documents, furniture and equipment .Figure 17 illustrates the contrast between overhead mapping of Abaco Central Primary before and after the storm.

On Grand Bahama, there were 24 educational facilities damaged, four of which were destroyed. The four destroyed schools include East End Pre-school, East End Primary, East End Junior High, and Sweeting Cays All Age school also located in the east of Grand Bahama, the hardest hit region of the island. Recent upgrades in the technological infrastructure at several public schools was destroyed, valued at approximately $1 million. Damage at the Grand Bahama campus of BTVI stemmed from blown roofs and windows, along with flooding reaching as high as 8ft which severely impacted the lower levels, floors, and building structures. This was like the destruction observed at the University of The Bahamas-North, which is in a flood zone. Special technological equipment located on the ground floors and valued at $1 million was destroyed because of flooding.

FIGURE 17. BEFORE AND AFTER IMAGES OF THE DAMAGE AT ABACO CENTRAL PRIMARY SCHOOL

Source: Maxar Technologies and European Commission - Copernicus Management Service – Mapping

LOSSES

Losses in the Education sector refers to affected flows like the reduction in hours or days of classes taught, along with refunds to students withdrawing from paid institutions. All schools throughout The Bahamas were closed starting 30 August 2019. All schools on Grand Bahama were officially opened as of 17 October 2019. The extensive damage experienced on Abaco resulted in public and private educational facilities remaining officially closed at the time of this report. For this analysis, it was assumed that the entire term was lost for privately managed primary institutions on Abaco. However, informal classes have been conducted for 541 students remaining on the island supported by 39 part-time teachers with an estimated start date of 16 October 2019. The start date for reassigned teachers from Abaco was estimated to be on 16 October 2019. For the BTVI Abaco campus severely affected by the hurricane, the start date for reassigned students was 7 October 2019 while the start date for reassigned students at the University of The Bahamas-North was 30 September 2019. Table 34 outlines the opening dates for the 42 schools remaining closed beyond 9 September 2019.

TABLE 34. LISTING OF SCHOOL CLOSURES BEYOND 9 SEPTEMBER 2019

Island	School	Number of students	Number of teachers	Re-opening date
Abaco Islands	Amy Roberts Primary	42	4	Officially closed
	Central Abaco Primary	832	35	Officially closed
	Cherokee Sound Primary	19	2	Officially closed
	Coopers Town Primary	124	8	Officially closed
	Crossing Rock Primary	33	3	Officially closed
	Fox Town Primary	79	7	Officially closed
	Guana Cay Primary	4	1	Officially closed
	Hope Town Primary	60	4	Officially closed
	James Pinder Primary	44	4	Officially closed
	Man-O-War Primary	13	2	Officially closed
	Treasure Cay Primary	145	6	Officially closed
	Angel´s Academy	60	11	Officially closed
	Agape Christian School	265	11	Officially closed
	Forest Heights Academy	151	12	Officially closed
	Long Bay School	148	6	Officially closed
	Smith´s Memorial Academy	68	3	Officially closed
	St. Francis De Sales	317	19	Officially closed
	Every Child Counts	98	13	Officially closed
	Patrick J. Bethel High School	574	29	Officially closed
	Scherlin Bootle High	236	20	Officially closed
	Moore's Island All-Age	118	11	Officially closed
	Bahamas Technical and Vocational Institute, Abaco	60	3	Officially closed

Island	School	Number of students	Number of teachers	Re-opening date
Grand Bahama	Bartlett Hill Primary School	225	23	October 17th
	Beacon School	98	23	October 17th
	East End Primary	45	8	October 17th
	Freeport Primary School	493	37	October 17th
	Holmes Rock Primary School	141	8	October 17th
	Hugh Campbell Primary School	633	40	October 17th
	Lewis Yard Primary School	128	18	October 17th
	Martin Town Primary School	219	23	October 17th
	Maurice Moore Primary School	570	42	October 17th
	Program Sure/PACE Center	11	6	October 17th
	Walter Parker Primary School	667	38	October 17th
	West End Primary School	92	9	October 17th
	Eight Mile Rock High School	406	64	October 17th
	Jack Hayward Junior High School	461	36	October 17th
	Jack Hayward Senior High School	476	62	October 17th
	Saint Georges Senior High School	763	72	October 17th
	Sister Mary Patricia Junior High School	629	44	October 17th
	Sweetings Cay All Age	6	1	October 17th
	Bahamas Technical and Vocational Institute, Grand Bahama	450	5	October 7th
	University of Bahamas, Grand Bahama	500	18	September 30th

Source: Assessment team 2019

An average value of $40,500 per year was used for preschool and primary school teachers, an average of $43,928 was used for secondary school teachers and an average of $63,816 was used for post-secondary instructors and professors. The number of hours of education lost was estimated using a school schedule of 8:30 to 15:00 hours. The losses incurred by the 135 unaffected educational institutions stood at approximately $2.1 million. On Abaco, total losses in the Education sector amounted to $1.2 million, of which $41 thousand was attributed to estimated tuition refunds at BTVI's Abaco campus. For Grand Bahama, total losses totaled $3.4 million, of which $1 million was attributed to refunded tuition at BTVI's Grand Bahama campus and University of The Bahamas-North campus. Educational institutions that received damage had estimated losses of $4.7 million (Table 35). There was, therefore, overall losses of $6.8 million to the sector.

TABLE 35. EDUCATION SECTOR: LOSSES

	Total facilities	Facilities damaged	Tertiary level tuition loss	Total Loss
Abaco Islands	23	22	$41,562.5	$1,240,191.3
Grand Bahama	24	23	$997,500.0	$3,426,073.1
Unaffected facilities	135	0	$0.0	$2,132,762.0
Total	182	45	$1,039,062.5	$6,799,026.4
Public	171	34	$0.0	$3,962,264.3
Private	11	11	$1,039,062.5	$2,836,762.1
Total	182	45	$1,039,062.50	$6,799,026.43

Source: Assessment team 2019

ADDITIONAL COSTS

The total estimate for Additional costs is $19.1 million (Table 36). These costs consider expenses to restore education services as soon as possible. They include the removal of debris, security, school meals, payment of grants, psychosocial support to teachers and staff, enrollment fees, and costs associated with the registration drive conducted by the Ministry of Education for displaced students. Debris removal costs were reduced as voluntary assistance was provided by NGOs, teachers and staff. Given the degree of devastation across the two islands, the need for immediate and ongoing psychosocial support for teachers and staff was of great importance.

TABLE 36. EDUCATION SECTOR: ADDITIONAL COSTS

Description	Abaco	Grand Bahama	Total
Debris removal	68,000	32,000	100,000.0
School feeding	9,533,260.5	9,466,739.5	19,000,000.0
Payment for grants			
Security			
Psychosocial support			
Fees for enrolling			
Registration drive			
Total	9,601,260.5	9,498,739.5	19,100,000.0

Source: Assessment team 2019

INFRASTRUCTURE SECTORS

ROADS, AIRPORTS, PORTS AND OTHER INFRASTRUCTURE

INTRODUCTION

The section analyzes the effects and consequences of Hurricane Dorian on infrastructure such as roads, ports, and airports on the affected islands of Abaco and Grand Bahama. Transportation infrastructure is crucial for The Bahamas' economy since it provides connectivity and mobility between and within islands, and in the context of disasters, it provides an essential role for the reconstruction of other infrastructures and provides access to other critical services such as medical services, power generation facilities, and shelters, among others. Roads provide ground transport, which is essential for connectivity within the islands and allows the distribution of resources within them. Marine transport fulfills a function related to tourism and provides a network for resources between islands. Finally, air transport provides connectivity with other islands of The Bahamas, and with other countries in the case of international airports.

According to reports and field visits, it was observed that the main causes of structural damage were storm surge and high-speed winds. The most affected infrastructure was located near the shorelines. In terms of roads, the infrastructure sustained effects related to asphalt raveling, and suffered the complete rupture of the asphalt layer in some cases. The airports saw high operational damage due to flooding, and roof problems due to high-speed winds. Ports suffered high damage due to flooding.

The estimated transportation infrastructure damage is approximately $51 million for the whole country (Table 37), and 53 percent of the damage took place on Grand Bahama, of which 93 percent was incurred at the Grand Bahama International Airport. The estimated losses associated with the interruption of transportation services is estimated at $37 million. It is forecasted that 44 percent of the total losses will take place in 2019, 39.2 percent in 2020, and 16.8 percent in 2021. Finally, the Additional costs associated with reconstruction and removal of debris are $6.6 million. The information in this report was obtained from field visits to Abaco and Grand Bahama and provided by the Ministry of Public Works, Ministry of Transportation, Ministry of Tourism, National Emergency Management Agency (NEMA), Airport Authorities, Airlines associations and Port Authorities.

TABLE 37. TRANSPORT SECTOR: DAMAGE, LOSSES AND ADDITIONAL COSTS

Description	Damage	Losses	Additional costs
Roads	8,747,991	-	3,405,794
Bridges	2,862,160	-	58,800
Airports	36,926,085	24,377,244	2,571,316
Ports	2,241,038	12,830,706	536,710
Total	50,777,274	37,207,950	6,572,619

Source: Assessment team 2019

BASELINE INFORMATION

ROAD NETWORK

According to information provided by the Ministry of Transportation, Abaco has a road network length of about 1,929 kilometers (1,198 mi) of paved and unpaved roads. Grand Bahama has a road network extension of 2,374 kilometers (1,475 mi).

The structural pavement designs on both islands consist of mostly two-lane roads, approximately 6.5 meters wide with asphalt treatments less than five centimeters thick. Unpaved roads consist of stabilized granular treatments with an approximate width of 4.5 meters and with low quality standards.

AIRPORTS

The Bahamas airport network is essential for the transport of passengers and merchandise between the islands of the archipelago and different countries. Hurricane Dorian had a considerable effect on the three airports on Grand Bahama and Abaco, rendering them inoperative for some time and caused permanent structural damage to their infrastructure.

Grand Bahama and Abaco are the second and third largest economies of the Bahamas, respectively, and the recipients of a large flow of tourists. The Grand Bahama International Airport, located in Freeport, has an international terminal with US Customs and Border Control Pre-clearance, a domestic terminal, modern firefighting capabilities, a cargo and freight handling area, and an 11,000 ft × 150 ft runway.

Abaco has two airports that suffered structural and operational damage. The main airport of the island is the Leonard M. Thomson International, located in the city of Marsh Harbor. It has one runway of 6,100 ft × 98 ft. The new 51,000 sq. ft. terminal with an investment of $38 million opened in 2014. The terminal has 22 counter positions, a luggage scanning system, pilot briefing room, two restaurants, one lounge, shops, and a public parking area. The Treasure Cay airport has one runway which measures 7,000 ft × 15 ft, one terminal building with departures in one room and arrivals in another, a small store, and the check-in desks.

PORTS

The Bahamas ports are essential for the tourism and commercial sectors. They are a major source to receive passengers and supplies, food and beverages, construction materials, and merchandise, both between the islands of the archipelago and many other countries.

The port of Freeport on Grand Bahama is the main cargo port of The Bahamas, it moves an annual sea load equivalent to one million 20-foot containers. The port of Marsh Harbor on Abaco is a smaller port but in recent years it has increased its volume supporting economic growth on the island. Due to Abaco's growth, The Bahamas government, in partnership with the Republic of China, recently invested $39 million in a new cargo port in the north of the island. In 2018 Grand Bahama and Abaco reported over 600 thousand and 400 thousand tourists respectively, and more than half came in through their ports.

DAMAGE

Hurricane Dorian caused widespread damage to the transportation infrastructure on Grand Bahama and Abaco. Both islands suffered damage to roads and airports. Abaco also suffered damage to its port infrastructure. The varying damage can be explained by the physical vulnerability of certain infrastructure, especially evidenced was the coastal infrastructure being highly exposed to natural hazards. Although port facilities are located on the coast, it was observed that the damaged infrastructure does not meet standards required to handle flooding and high-speed winds.

For the estimation of airport and port infrastructure, the reports provided by the respective authorities and the field visits were essential. The methodology followed was to register all the elements that suffered some level of damage, categorize the damage status and quantify the cost with the corresponding depreciation rate. The damage to airport infrastructure was caused mainly by flooding, with wind causing effects in structures such as hangars. The airports that suffered damage were the Leonard M. Thomson International Airport in Marsh Harbor, Treasure Key Regional Airport and the International Airport of Freeport. Additionally, on Abaco there were several ports that suffered damage, such as in Cooper's Town and Marsh Harbor, and on different cays around the island. The port located in Freeport suffered minor damage according to the field observations and the reports provided by the respective authorities.

ROADS

On Abaco, 71 kilometers (44 mi) of the road network suffered some level of damage as a result of Hurricane Dorian, which corresponds to 3.6 percent of the road network of the island. In addition, a concrete bridge collapsed. Damaged roads were observed on inter-urban routes and within the urban area in Marsh Harbor. On Grand Bahama, 27 kilometers (17 mi) suffered some damage, which is 1.1 percent of the total road network of the island. Structural damage on the roads of the eastern part of the island regards asphalt layers. In general terms, Grand Bahama was less affected than Abaco. In the field mission to the affected areas, certain conditions were observed in the structural and functional performance of the transport system. The main ones are described below:

I. Proximity of roads to coastlines- It was observed that certain roads were highly exposed to surge flooding as they were close to the coastline and essentially at sea level (Figure 18)

II. Low thickness in asphalt mixtures (Figure 19)

III. Lack of tack coat in some roads, resulting in an absence of cohesion between the granular and asphalt layers (Figure 20)

IV. Little uniformity in subbase aggregates (Figure 20)

V. Lack of proper transverse draining channels

FIGURE 18. ROAD CLOSE TO SHORELINE

Source: Assessment team, 2019

FIGURE 19. DEFICIENT ASPHALT MIXES

Source: Assessment team, 2019

FIGURE 20. LACK OF TACK COAT AND NOT UNIFORM GRANULAR SUBBASE

Source: Assessment team, 2019

The damage to the roads can be categorized in two different forms. First, structural damage to the asphalt layer or the granular base was observed and requires repair. Secondly, operational damage was observed, where the road access was interrupted for a limited time due to the level of water (light vehicles cannot pass through) but without immediate structural deterioration. The second case may have an indirect effect in the road durability produced by water saturation of the granular layers and potential loss of material, but the potential costs of which are not considered in this study. Table 38 summarizes only the estimated structural damage associated to the roads on both islands. Notice that approximately 80 percent of this damage took place on Abaco.

TABLE 38. ROADS: DAMAGE

Island	Affected kilometers	Damage
Abaco	71	6,960,322
Grand Bahama	27	1,787,669
Total	98	$8,747,991

Source: Assessment team, 2019

Abaco suffered the collapse of one concrete culvert bridge valued for a total of $2,862,160. Figure 21 presents the collapse of the bridge located in north Abaco. The cost for a temporary embankment was estimated at $16,800.

FIGURE 21. COLLAPSED BRIDGE IN NORTH ABACO

Source: Assessment team, 2019

AIRPORTS

Airports were severely damaged by the hurricane and the main causes were storm surge, flooding, and winds of more than 170 miles per hour to which they were subjected.

In the Grand Bahama International Airport damage was observed on the runway lighting, perimeter fencing, several hangars including private airlines like Western Air and Cherokee Aviation, the baggage belt, electronic trace detector, customs doors, fire station, and control tower. Structural damage to both the domestic and international terminal was observed. The damage resulted in a temporary interruption in all commercial flight operations. On Abaco both airports had severe damage to their infrastructure. The runway, terminals and engine rooms at Leonard M. Thomson International were flooded during the Hurricane. Additionally, damage was seen in hangar structures (Figure 22), to the roofs of the international and national terminals (Figure 23), and to the perimeter fence. The fire station was severely damaged. The Treasure Cay Airport had damage to runway lighting, the perimeter fence, and destroyed the terminal building and fire station. The estimated damage to airports was approximately $37 million (Table 39) and 68 percent took place on Grand Bahama.

TABLE 39. AIRPORTS: DAMAGE

Island	Airport	Damage
Abaco	Marsh Harbour	9,829,616
Abaco	Treasure Cay	2,025,060
Grand Bahama	GB International	25,071,409
Total		$36,926,085

Source: Assessment team, 2019

FIGURE 22. AIRPORT HANGARS DAMAGED IN MARSH HARBOUR

Source: Assessment team, 2019

FIGURE 23. ROOF DAMAGE IN MARSH HARBOUR INTERNATIONAL AIRPORT

Source: Assessment team, 2019

PORTS

The infrastructure at Marsh Harbour Government Port was severely damaged by the hurricane and needs to be replaced. Damage was observed in all the buildings, the perimeter fence, security systems, material handling systems, among others. The port is currently inoperative. The port in Coopers Town, Abaco, suffered minor damage to the main building, perimeter fence, and security booth. The Freeport port did not report considerable damage and is operating regularly. The estimated damage to ports is approximately $2.2 million (Table 40), where 87 percent of the damage took place in the Marsh Harbour port.

TABLE 40. PORTS: DAMAGE

Island	Port	Cost
Abaco	Marsh Harbour	1,950,341
Abaco	Coopers Town	290,697
Total		$2,241,038

Source: Assessment team, 2019

LOSSES

Losses to airports and ports are estimated at $37 million, while there are no losses related to roads (Table 41). The losses consider the decrease in tourism and cargo in both Abaco and Grand Bahama, and the effect this has on the collection of port charges and port services.

Once the structure and operability of the ports and airports are recovered, this does not guarantee that the volume of tourists previously managed will be recovered immediately since the infrastructure necessary to receive these tourists will take longer to recover and load requirements will be lower due to this decrease in visitors. For this reason, losses include expected reduced movement of passengers in the port of Freeport which received only minor damage and is operational.

Although the Nassau airport was not directly affected by the hurricane, losses due to temporarily canceled flights are included, as the decrease in the flow of tourists affected Abaco and Grand Bahama as a result.

TABLE 41. TRANSPORT SECTOR: LOSSES

Description	2019	2020	2021	Total
Abaco Airports	3,190,731	4,852,570	2,426,285	10,469,586
Abaco Ports	2,024,000	3,036,000	1,518,000	6,578,000
Grand Bahama Airports	2,638,336	3,566,639	1,426,656	7,631,631
Grand Bahama Ports	2,233,109	3,126,353	893,244	6,252,706
Nassau Airport	6,276,027	-	-	6,276,027
Totals	$16,362,203	$14,581,562	$6,264,185	$37,207,950

Source: Assessment team, 2019

ADDITIONAL COSTS

Additional costs are estimated at approximately $6.6 million. These costs mainly related to debris removal and demolition of infrastructure with severe structural damage. In the case of road infrastructure, it also considers the cost of temporary infrastructure like the embankment that was necessary in North Abaco due to the collapse of a bridge. Table 42 details the costs for each type of infrastructure.

TABLE 42. TRANSPORT SECTOR: ADDITIONAL COST

Description	Abaco	Grand Bahama
Roads	2,768,225	637,568
Bridges	58,800	-
Airports	606,004	1,965,312
Ports	536,710	-
Total	$3,969,739	$2,602,880

Source: Assessment team, 2019

TELECOMMUNICATIONS

INTRODUCTION

The Telecommunications sector suffered considerable damage and a long recovery is expected, especially on Abaco. Gale force winds caused damage to aboveground network elements, while flooding caused unexpected damage to various types of ground level telecommunications equipment. Losses were primarily a result of the absence of commercial power, the extended time needed for network restoration, and the loss of client base.

Total damage to the Telecommunications sector was estimated at $42.1 million. The losses were estimated at $54.4 million and the most significant losses occurred on Abaco, where services could not be provided to end users due to widespread destruction. Losses were projected until December 2021, as an estimated loss of $13.7 million was made for the remainder of the year 2019, $16.3 million for the year 2020, and $24.4 million for the year 2021. Additional costs were estimated at approximately one million dollars, mainly reflecting the labor-related costs required to perform repairs, as well as generator fuel burned in the absence of commercial power.

Information for this estimate was collected through field visits and interviews with representatives of the Bahamas Telecommunications Company (BTC), Cable Bahamas Limited (CBL) and the mobile carrier ALIV. The information related to the hurricane's effects on the BTC was limited and, as such, some estimations were made based on past reports.

BASELINE INFORMATION

There are three primary telecommunications service providers in The Bahamas– Bahamas Telecommunications Company (BTC), Cable Bahamas Limited (CBL), and ALIV. As the first service provider on the island, BTC provides the widest range of telecommunications services, including fixed telephone, broadband internet, Internet Protocol Television (IPTV), and mobile services. Alternatively, ALIV and Cable Bahamas Ltd. each provide a narrower range of services, with ALIV focusing on mobile cellular services while CBL focuses on fixed telephone, broadband internet, and IPTV.

BTC is 49 percent owned by the Government of The Bahamas, 49 percent owned by Cable and Wireless, and two percent owned by a charitable trust called The BTC Foundation. Many BTC products are provided under the FLOW brand name. BTC is obligated by the terms of its license to provide telecommunications services throughout The Bahamas. Operating on 18 islands, BTC has roughly 70,000 customers for fixed-line telecommunications services that use a combination of fiber optic and copper wire infrastructure. BTC also has about 284,000 mobile subscribers.

The Bahamas is connected through an underwater fiber-optic cable network called The Bahamas Domestic Submarine Network (BDSNi), which has 14 landing points on the islands and an additional spur that connects to Port-au-Prince, Haiti. This submarine cable is owned and operated by BTC.

Cable Bahamas Limited is a Bahamian-owned public converged communications services provider. Initially a cable television service provider, CBL expanded to incorporate broadband internet in 2000 and telephone service in 2011. CBL also holds a 48 percent stake in the mobile operator ALIV, which motivates a strong partnership between the two companies. The remaining stake in the ownership of ALIV is held by a holding company that is controlled by the Government of The Bahamas. ALIV reported a total of 110,000 mobile subscribers to their mobile cellular 3G and 4G LTE services. Their system spans across fifteen islands and is supported by 234 cellular towers.

DAMAGE

Damage to the Telecommunications sector was different in nature to those caused by previous hurricanes and were especially catastrophic. Flooding damage on Abaco and Grand Bahama caused damage to both wired and wireless infrastructure. Water damage to electronic systems rendered many parts of the network inoperable during and after the hurricane, while the high saline content of the flood water caused corrosion to various types of wiring and conductors that defend well against more typical exposure to moisture. Due to the high flood levels, buried fiber optic cables and copper wires were damaged to the point where they emerged from the ground to connect to above ground equipment. Heavy winds also caused typical damage to wireless infrastructure such as antennae, base transceiver stations, and satellite dishes.

On Abaco, damage was widespread as many cellular towers were damaged or completely devastated. Damage to the electricity grid in the form of downed poles also caused significant damage to telecommunications cables and fiber optics across the island. This is expected to require significant financial and human resources to restore and as such will have a large impact on the amount of losses sustained.

The most significant damage on Grand Bahama came in the form of flooding. The administrative and operations center of one of the service providers was completely flooded by up to seven feet of water, causing a complete loss of equipment, which must be replaced for recovery of service. Total damage is estimated at $42.1 million.

TABLE 43. SUMMARY OF DAMAGE IN THE TELECOMMUNICATIONS SECTOR

Description	Public	Private	Total
Buildings and Equipment			
Abaco		11,000,000	11,000,000
Grand Bahama		2,300,000	2,300,000
Wired Infrastructure			-
Abaco		20,000,000	20,000,000
Grand Bahama		2,250,000	2,250,000
Wireless Infrastructure			-
Abaco		5,600,000	5,600,000
Grand Bahama		1,000,000	1,000,000
Total	-	$42,150,000	$42,150,000

Source: Assessment team, 2019

LOSSES

Losses have been calculated based on the number of customers lost for each type of telecommunications service, the average amount of time these services were unavailable, and the average revenue per user for each service (ARPU). The severity of the damage on Abaco is likely to delay the provision of any type of services for an extended period.

Most of the wired infrastructure on Abaco will need to be replaced due to wind damage, water damage or corrosion caused by saltwater. Restoration of wired services on Abaco is likely to continue well into the second half of the year 2020. Furthermore, the losses include the client base that will need to rebuild their homes and businesses before engaging with any telecommunications provider. This factor is expected to contribute to service loss up until the year 2021 as Abaco gradually returns to a state of normalcy and productivity.

Grand Bahama was seriously impacted as flood damage caused the interruption of services at both wired and wireless network nodes. Furthermore, the lack of commercial power caused a disruption to services. Wireless cellular services are a major source of income and account for losses of $15 million.

The losses on Grand Bahama are estimated based on a recovery of approximately four months (up to December 2019), while the losses on Abaco is estimated based on a time of two years and four months (up to December 2021). The total value of losses is estimated at $54.4 million.

TABLE 44. SUMMARY OF LOSSES IN THE TELECOMMUNICATIONS SECTOR

Island	Total
Abaco	41,943,917
Grand Bahama	12,436,232
Total	54,380,149

Source: Assessment team, 2019

ADDITIONAL COSTS

Additional costs in the Telecommunications sector included the cost of fuel used by backup generators for cellular sites and other facilities, the cost of transportation of equipment and materials for making repairs to telecommunications networks after the storm, and the value of contracted labor hired under the extraordinary circumstances to help with recovery efforts. Total Additional costs were estimated at approximately one million dollars.

TABLE 45. TELECOMMUNICATIONS: ADDITIONAL COSTS

Island	Total
Extra labor Costs	
Abaco	500,000
Grand Bahama	25,000
Temporary Power Generators	-
Abaco	6,000
Grand Bahama	8,960
Cellular on Wheels	-
Abaco	300,000
Grand Bahama	200,000
Total	1,039,960

Source: Assessment team, 2019

POWER SECTOR

INTRODUCTION

Hurricane Dorian caused extensive damage to the power generation, transmission and distribution systems on the islands of Abaco and Grand Bahama. On Grand Bahama, severe flooding caused damage to the power generation plant located at Pill Street, whilst strong winds destroyed the major transmission line to the eastern end of the island, seriously inhibiting the restoration of service. Also, major destruction to the properties on the eastern part of Grand Bahama may have implications for losses to the power sector as customers gradually rebuild and reconnect to the power grid. On Abaco, there was extreme damage to the power generation plant at Marsh Harbour caused by both wind and flooding, while the transmission and distribution systems throughout the island suffered wind damage. Significant losses are expected from the level of destruction on Abaco, which has a marked reduction in the number of clients receiving service. Complete restoration of the power sector on Abaco will likely be a long-term process.

Total damage in the Power sector was estimated at $131.3 million, of which $8.4 million was from damage to the transmission and distribution networks on Abaco, and $21 million in damage to the flooded power generation plant on Grand Bahama.

Total losses were estimated at $68.9 million, reflecting the value of power that was not sold, both because of damage to the transmission and distribution network and because of the reduction in demand for electricity as a result of storm damage. Losses were estimated until December 2021 as recovery is expected to take at least this time or even longer to return to normal levels. An estimated loss of $22 million was made for the remainder of the year 2019; $40 million for the year 2020; and $6.8 million for the year 2021.

Additional costs were estimated at $6.3 million, which mainly reflect labor and labor-support costs. Information for these estimates was collected through field visits, interviews with representatives of the Bahamas Power and Light (BPL) and the Grand Bahama Power Company (GBPC), and various publicly available documents.

BASELINE INFORMATION

Many of the islands of The Bahamas, including Abaco, receive a supply of electrical power from Bahamas Power and Light (BPL). In the case of Grand Bahama, the service provider is Grand Bahama Power Company (GBPC), a subsidiary of Emera Limited, a utility company from Halifax Canada. There also exist a few Authorized Public Electricity Suppliers (APES) in The Bahamas which include St. George's Cay Power Company, and Baker's Bay power company. Total Commercial Generation Capacity installed throughout The Bahamas is about 645MW, serving approximately 142,000 consumers, split 80 percent residential and 20 percent commercial, and the sector directly employs approximately 1350 people (Utilities Regulation and Competition Authority, 2018). The last report of revenues of the power sector made by the Utilities Regulation and Competition Authority (URCA) was $513 million in 2016. With respect to electricity rates on the affected islands, BPL charges between 10.95 and 14.95 cents per kWH, while GBPC charges between 17.56 and 26.06 cents per kWH. Electricity prices in The Bahamas also include an additional varying fuel surcharge based on the cost of the fuel used in generating power during the relevant period. The last surcharge reported was 17.77 cents in April 2019 (Rachel Knowles, 2019).

ABACO

BPL serves 108,000 customers in New Providence and most of the Family Islands, of which 93,424 are residential customers (Rachel Knowles, 2019). The total population of Abaco is estimated at 25,000 residents, which makes an estimated 8,000 customers (Abaco CARES, 2010). Abaco is served by two power generating plants. The plant at Marsh Harbour is relatively old and contains two generators with 4 MW capacity (total 8 MW), while the plant at Wilson City is relatively new, containing four generators each with a 12 MW capacity (total 48 MW). Major power demands come from the main settlement at Marsh Harbour, with other major demands coming from the commercial area and the resorts located in Treasure Cay. Abaco's peak load is about 28 MW with the average load standing at around 22 MW.

GRAND BAHAMA

GBPC serves approximately 19,000 customers across Grand Bahama, with approximately 15,500 residential customers, 2500 commercial customers and approximately 1000 unclassified (ICD Utilities Limited, 2016). Power is generated at two major power plants by two slow-speed and seven medium-speed diesel engine generators, with an overall peak generation capacity of about 100 MW (50 MW at each plant). GBPC has a transmission and distribution network that includes eight substations, 153 km of transmission lines and 860 km of distribution lines. Most of GBPC's customers and power demands are located on the western part of the island of Grand Bahama and around the primary settlement of Freeport. Grand Bahama's typical load is about 60 MW.

DAMAGE

The greatest damage to Abaco occurred in the northern part of the island, whose power generation plant at Marsh Harbour was destroyed from heavy winds and strong flooding. Located at the same Marsh Harbour plant was a major substation and storage yard for materials – all of which received significant damage. The power plant at Wilson City remained operational after receiving only minor damage. Due to the heavy impact of the hurricane on Marsh Harbour, the two 4 MW power generation units there require major repairs. BPL plans to relocate these units to the Wilson City power plant as all the buildings at the Marsh Harbour power generation plant were destroyed.

There was serious damage to the support poles of two large transmission lines (34.5kV) connecting the Wilson City power plant to the Marsh Harbour substation facility for voltage management. Transmission lines that carry power to Treasure Cay and the northernmost end of the island were also damaged, cutting off the power supply to these areas. Approximately 1000 transmission or distribution poles were destroyed or seriously damaged, also damaged was all the accompanying pole-mounted equipment such as transformers and switches, as well as the equipment at five substations. The condition of electrical infrastructure on the populated cays around Abaco was still under investigation at the time of this report. Some of the cays are linked to the maon Abaco island by a submarine cable, however, the conditions of these submarine cables were unknown.

The Government of The Bahamas expects to rebuild Abaco to the standard that existed before the effects of the hurricane. As such, BPL provided a plan for the rebuild and restoration of the Abaco electricity grid from Wilson City to Crown Haven, including the Abaco Cays. The plan included the following key items to deal with major damage:

I. Reconstruction of the transmission line from Wilson City to Crown Haven

II. Reconstruction of the distribution network in Marsh Harbour and Treasure Cay

III. Reconstruction of substations that were destroyed during Hurricane Dorian

On Grand Bahama, widespread flooding caused damage to one of the power plants as well as four of the substations used to service the island. The severe destruction on the eastern end of the island caused serious damage to electrical infrastructure as well as customer properties. Furthermore, the hurricane destroyed the only transmission line which connected the eastern end of the island to the main settlement of Freeport and the western part of the island. East End has therefore been completely disconnected from the main power grid. Additionally, a major crude oil storage facility owned by Norway's Equinor has also been disconnected from the main grid. Other major damage includes 76 vehicles such as bucket trucks and vans which were lost due to flooding and general damage to assets.

Significant efforts were ongoing to restore power as there were 15,000 customers in the affected areas receiving power by the time the DaLA team had arrived for this assessment. The East End area of the island is expected to pose a significant challenge to power restoration as the cost to restore power to approximately 300 customers in that area is an estimated $8 million. The total length of transmission and distribution lines to the eastern area is estimated to be well over 100 km, excluding any distribution infrastructure that may exist on Sweeting's Cay and Lightbourne Key. Table 46 breaks down the damage to the Power sector by island.

TABLE 46. POWER SECTOR: DAMAGE ($)

Description	Public	Private	Total
Damage to Power Generation			
Abaco	920,000	-	920,000
Grand Bahama	-	21,000,000	21,000,000
Damage to Transmission and Distribution			
Abaco	80,435,000	-	80,435,000
Grand Bahama	-	16,000,000	16,000,000
Buildings and Equipment			
Abaco	3,000,000		3,000,000
Grand Bahama	-	10,000,000	10,000,000
Total	$84,355,000	$47,000,000	$131,355,000

Sources: Assessment team 2019 and Abaco rebuild and restoration plan 2019.

LOSSES

Losses in the power sector represent sales of electricity that did not occur because of damage to the network. Abaco has a significant challenge for power restoration which is complicated by three major elements: 1) destruction throughout the transmission and distribution grid slows the progress of reconnection; 2) widespread damage to property has caused a temporarily decreased population which reduces the demand for power across the island; 3) the power generation plants available are too large to operate for such a drastically reduced demand for electric power and therefore less efficient machines will have to be utilized.

BPL's first step toward power restoration involved reconnecting the power grid in the southern part of Abaco to the power generation plant at Wilson City. Next, a 1.5 MW backup generator was used to supply power to this area as the peak load was still quite low. The next step will involve reconnecting essential infrastructure such as the airport, port, and hospital to the main power supply as well as reconnecting the main transmission lines across the island. Reconnection across the island should provide a more significant load, which can then be serviced by one of the larger 12 MW power generation units at the Wilson City plant. In the interim BPL plans to procure five 1.5 MW generators for temporary use in locations across Abaco. These smaller generator units are for powering each of the disconnected parts of the power grid during the time it takes the team from BPL to unite the entire grid. Reconnection of the entire power grid is likely to take up to six months. The expected average load after the entire grid is reconnected is expected to be about 10 – 12 MW, less than half of the average load before Hurricane Dorian.

On Grand Bahama, BPL was able to gradually restore power to about 80 percent of customers within a two-week period after the passing of the hurricane. The remaining 20 percent are expected to be restored by the end of October 2019. There is no projected time for the recovery of customers lost from East End of Grand Bahama – about 300 of them. Finally, GBPC is likely to recover only 80 percent of the original customer base as around 20 percent of clients will be unable to receive a safe power supply or may not return altogether. The largest client that has been cut off, Norway's Equinor, is likely to install their own diesel generation system, however, no specifics of this arrangement have been discussed with the DaLA team. The average load on Grand Bahama is expected to remain at about 45 MW for the next six months to a year.

The value of Losses was calculated based on a retail price of $0.13 per kilowatt-hour (kWh) for Abaco and $0.22 per kilowatt-hour (kWh) for Grand Bahama, shown on Table 47. The losses on Grand Bahama are estimated based on a time for recovery of one year and four months (up to December 2020), whilst the losses on Abaco is estimated based on a timeframe of two years and four months (up to December 2021).

TABLE 47. POWER SECTOR: LOSSES ($)

Island	Public	Private	Total
Abaco	24,714,816	-	24,714,816
Grand Bahama		44,209,742	44,209,742
Total	$24,714,816	$44,209,742	$68,924,558

Source: Assessment team, 2019

ADDITIONAL COSTS

Additional costs include the extra labor deployed to perform restoration work, and support services such as meals, lodging and transportation required to maintain the workforce in the field. As part of the response to this disaster, repair crews were mobilized from throughout The Bahamas, with crews from less affected islands being transported to more affected parts of the country. In addition to linesmen, all available staff at BPL were mobilized to work toward the restoration. The total costs of these efforts are shown in Table 48 Furthering efforts, BPL plans to engage the Caribbean Electric Utility Services Corporation (CARILEC) to provide international crews from elsewhere in the Caribbean including Barbados, Belize, British Virgin Islands, Cayman Islands, Dominica, and Grenada to come to The Bahamas to help with the restoration of Abaco. In the case of Grand Bahama, approximately 80 persons were hired along with an unspecified number of trucks and other equipment to assist GBPC in restoring power in a timely fashion.

TABLE 48. POWER SECTOR: ADDITIONAL COSTS ($)

Island	Private	Public	Total
Extra labor Costs			
Abaco	-	1,955,000	1,955,000
Grand Bahama	3,000,000	-	3,000,000
Temporary Power Generators			-
Abaco	-	1,380,000	1,380,000
Grand Bahama	-	-	-
Total	$3,000,000	$3,335,000	$6,335,000

Source: Assessment team 2019.

WATER AND SANITATION

INTRODUCTION

The Bahamas has serious obstacles related to the availability of water and the capacity to supply water due to its geographical spread, population size, remote locations, topography and climatic conditions. Water sources, treatment, storage and distribution on Abaco are managed by the public company, Water & Sewerage Corporation (WSC). In the case of Grand Bahama, services are provided by a third-party private entity Grand Bahama Utility Company (GBUC).

Field visits to Abaco and Grand Bahama by the Assessment team confirmed that water and sewerage infrastructure suffered moderate to major damage and losses and face serious challenges to restore water service throughout the affected areas. Most of the major damage to the system was observed in the areas of Central Abaco and Treasure Cay. According to the information supplied in meetings with GBUC most of the damage on Grand Bahama occurred in the water wells and the water distribution system in the island. Also, the interruption of power on both islands prevented the normal operation of water wells, treatment plants and the distribution system for long periods of time, affecting the supply of service to the residences and businesses.

Damage to facilities and assets associated with water and sanitation is estimated to be $14.8 million. Due to the interruption of water distribution service into dwellings, losses are expected to be $36.6 million. Additional costs such as additional work force and construction equipment, emergency power generation, and solid waste management are estimated at $2.3 million. This also includes the expenses of managing cleaning activities, disaster assessment and recovery teams deployed, and payment to fulfill restoration work.

This assessment was based on the information received from the public and private institutions involved in the activity, interviews during the Assessment team mission and the field visits, as well as some public information available.

BASELINE INFORMATION

WATER

Water is provided to about 94 percent of the population in The Bahamas by piped services (Table 49). It is provided to most of the islands by WSC except for Grand Bahama which is provided by GBUC.

TABLE 49. HOUSEHOLDS' ACCESS TO WATER

Type of access	Households (2010)	Percentage
Public piped into dwelling	63,438	62%
Public piped into yard	1,749	2%
Private piped into dwelling	31,763	31%
Private not piped	2,920	3%
Public standpipe	1,036	1%
Public well or tank	93	0%
Rainwater system	1,111	1%
Other	648	1%
Total	102,758	100%

Source: 2010 Census

ABACO

The water infrastructure on Abaco consists of several standalone systems, most of which include pumping stations, storage tanks, mains and pipes, and some also include pressure tanks. The two water suppliers used by WSC are well fields and Reverse Osmosis (RO) plants. In addition to the water supply system, storage, and distribution network, WSC also handles all commercial aspects related to billing and collection. Presented in Table 50, based on the 2010 census, is the private dwelling data sorted by the source of water and type of sewerage systems used.

TABLE 50. ABACO: PRIVATE DWELLING BY TYPE OF FACILITIES AND SOURCE OF WATER

Type and Use of Toilet Facilities	Total	Main Water Source							Other
		Public Piped into Dwelling	Public Piped into Yard	Private Piped into Dwelling	Private not Piped	Public Standpipe	Public Well or Tank	Rainwater System	
Sewerage	338	313	1	22	-	-	-	1	-
Septic	4,599	3,519	44	534	37	1	-	442	21
Pit Latrine	177	8	4	2	70	73	-	5	15
Other	112	7	-	-	80	1	12	-	12
None	26	3	-	1	4	6	-	4	8
Not Stated	-	-	-	-	-	-	-	-	-
Totals	5,252	3,851	50	559	191	81	12	452	57

Source: 2010 Census

In the central areas of Abaco all water sources are from water wells. In the more remote areas and cays of the island, it comes from reverse osmosis plants where seawater and brackish wells are treated. According to the Strategic Report- Preparation of a Water Supply Development Strategy for Utility and Non-Utility Service Areas in the Family Islands, March 2019, WSC serves an estimated 6,900 customers (2017 data) and produces over two million gallons of treated water per day. Information about the water source, number of customers, and estimated production is presented in Table 51.

TABLE 51. SYNTHESIS OF THE DATA COLLECTED ON THE INFORMATION SHEETS (DATA FROM 2017)

System	Source	Age	Nr. of customers	Production (IGPD)
Cherokee Sound	RO	>30	136	31,000
Marsh Harbour	WF	>30	3,536	1,301,000
Casuarina Point	WF	>30	97	10,000
Cedar Harbour	WF	>30	476	83,000
Blackwood	WF	>30	344	85,000
Moore's Island	RO	>30	306	29,000
Grand Cay	RO	>30	136	19,000
Sandy Point	WF	>30	240	55,000
Crossing Rocks	WF	>30	57	23,000
Treasure Cay	WF	>30	1,575	526,000
Totals			6903	2,162,000

Source: Strategic Report - Preparation of a Water Supply Development Strategy for Utility and Non-Utility Service Areas in the Family Islands, March 2019

Field visits revealed that water well facilities have insufficient infrastructure and lack necessary maintenance to support the population needs. In their current state they cannot meet the demands of a potential tourism infrastructure growth on Abaco. The affected parts of the water distribution process include the desalination and chlorination, which are necessary in order to meet the standards for human consumption. The average tariff used to bill customers in the different areas of Abaco is shown in Table 52.

TABLE 52. ABACO: AVERAGE TARIFF PER AREA

System	Avg. price ($/1,000 IG)
Cherokee Sound	7.4
Marsh Harbour	7.9
Casuarina Point	7
Cedar Harbour	7.1
Blackwood	7.3
Moore's Island	7.9
Grand Cay	7.5
Sandy Point	6.8
Crossing Rocks	10.1
Treasure Cay	8.4

Source: WSC, 2017

GRAND BAHAMA

As mentioned above, the water supply system on Grand Bahama is managed by GBUC. GBUC is responsible for the supplying, storing, and distributing of the water, as well as billing and collection to the final customer. Most of the water comes from water wells. In Freeport they operate three main water wells which accounts for 60 percent of total production. In East End they produce in three main areas- Pelican Point, McLean's, and High Rock, who combine for 30,000 gallons per day. The potable water production on Grand Bahama is over seven million gallons per day, and they also produce over six million gallons of saline water that is supplied to the population at no charge but has a production cost associated with them. GBUC distributes piped water island-wide, except to isolated zones where it is economically difficult to justify any extension of the grid. GBUC currently serves an estimated 11,300 customers and delivers most of its water via pipeline, but trucks supply to outlets beyond the network. On Table 53 we see the breakdown of water sources on Grand Bahama and other sanitation aspects according the 2010 census.

TABLE 53. GRAND BAHAMA: TYPE OF FACILITIES AND SOURCE OF WATER FOR PRIVATE DWELLINGS

Type and Use of Toilet Facilities	Total	Main Water Source							Other
		Public Piped into Dwelling	Public Piped into Yard	Private Piped into Dwelling	Private not Piped	Public Standpipe	Public Well or Tank	Rainwater System	
Sewerage	1,754	1,715	5	32	-	-	-	-	2
Septic	14,721	13,333	131	1,151	53	-	-	4	48
Pit Latrine	25	9	2	1	12	-	-	-	1
Other	27	-	4	-	13	3	-	-	7
None	19	5	7	-	1	3	-	-	2
Not Stated	-	-	-	-	-	-	-	-	-
Totals	16,546	15,062	150	1,184	79	7	-	4	60

Source: 2010 Census

As per information gathered in meetings on Grand Bahama with GBUC the average tariff for water supply and service is $5.50 per 1000 gallon of water.

SEWERAGE

Almost 75 percent of Bahamians are not connected to public sewage, and WSC currently has no wastewater treatment facilities in the Family Islands. On Abaco, according to the 2010 census (Table 50), 87 percent of the dwellings manage sewage using septic tanks, which is then collected by vacuum trucks. The event most affected Treasure Cay and Spring City whose waste collection and pumping systems suffered severe damage. On Grand Bahama 10 percent of dwellings are connected to a sewerage system and 88 percent use septic tanks (Table 53).

SOLID WASTE

Solid waste is a major challenge for most Caribbean islands and represents a critical factor that correlates to the development and management of the main economic activities of the islands. The Bahamas is no exception, and solid waste can become a significant barrier to not only the growth of tourism, but more importantly to maintain a sustainable equilibrium with the environment, natural areas and shorelines.

DAMAGE

The overall impact of Hurricane Dorian in Water and Sanitation sector is summarized on Table 54. Total damage in the water and sanitation sector is estimated at $14.8 million, primarily consisting of damage to water pumping systems, storage tanks, distribution system and WSC assets that were destroyed in the event. No detailed information was received related to Grand Bahama.

TABLE 54. WATER AND SANITATION: DAMAGE[1]

	Damage
Storage Tanks	2,775,000
Repair in Pumping Stations	975,000
Buildings Repairs	180,000
Distribution systems Repairs	620,000
Service Laterals Replacement	2,000,000
Reparation of distribution lines (3)	-
Fences Repair at RO Plants	70,000
Treatment / RO plants	2,040,000
Replacement of Generators	475,000
Underwater HDPE Pipeline (Repairs and/or Replacement)	1,500,000
Spring City Sewage Operations	200,000
Treasure Cay Sewage Operations	2,923,000
Fleet Replacement	735,000
Commercial Offices Recovery	300,000
IT Equipment	60,000
Totals	$14,853,000

Source: Assessment team, 2019

1- No data available for Grand Bahama

As per the Assessment team meetings with representatives of WSC, significant damage occurred during the impact of Hurricane Irma and are still present today, with most of said damage in Central Abaco and Treasure Cay. Both the water supply and waste collection systems presented failures and breaks across the network to connection points and tie-ins to the households.

Damage to several storage tanks was observed, with the Marsh Harbour and Treasure Cay stations seeing the worst effects of Hurricane Dorian. This represents the major component to the cost of damage on Abaco. Several of the water pumping facilities were affected by wind and flooding and presented severe to moderate damage in all electromechanical systems. Some systems require major repairs, while most require a replacement.

WSC assets such main offices, operation buildings, and operation fleets were affected. Moderate damage was observed to the roofs and structures of the buildings due to water surge and high winds. Several vehicles and other equipment were suffered severe damage. Field visits verified that some components, namely exposed surface lines, water piping, and the distribution system, are vulnerable to weather events, and as such experienced damage from flooding and high winds. Many collection systems also sustained damage. In addition, there was minor damage to fences, pipes, pump stations at plant sites, ground wells, and the main production and treatment facilities.

According to the discussions held with GBUC most of the damage on Grand Bahama occurred in the water wells and the water distribution systems. The interruption of power to both islands prevented to normal operation of water wells, treatment plants, and the distribution system for longer periods of time, affecting the supply of service to the population and businesses. Underground storage and pumps were damaged, distribution lines and residential connections were affected generating leaks in the system, and water service buildings were affected.

A long recovery is predicted due to the overall damage occurred, the level of displaced population, and the collapse of tourist activities. For Abaco's full recovery nothing is more urgent than having a fully operative water and sanitation system.

LOSSES

Losses in the Water and Sanitation sector, presented in Table 55, are estimated to reach $36.6 million, and are related to the interruption of piped water service both to residential and commercial sectors. Losses of volumes of water due to leaks, as well as losses from sewerage and waste collection are also included. The decrease in water demand during the recovery period from the decline in visitors and commercial activity is considered in the losses through the end of 2019. Abaco and Grand Bahama combine for an estimated loss of demand to 7,339 severely damaged houses.

TABLE 55. WATER AND SANITATION: LOSSES

	Losses
Loss of Income	36,567,822.4
Losses of Water (leaks)	56,191.7
Totals	$36,624,014

Source: Assessment team, 2019

Power services were also interrupted, which reduced the production of water through desalination plants and pumps, requiring use of diesel generators. The estimation in Table 55 was based on rates and annual revenues provided during meetings with WSC and GBUC. Field visits and interviews were used to verify dates and levels of interruptions to the water supply.

ADDITIONAL COSTS

Additional costs for the Water and Sanitation sector are estimated at $2.3 million (Table 56). Special action on temporary power generation and overtime hours to personnel were used to replace power service to the water desalination plants.

The costs include the expenses associated with diesel generators used to operate pumps, acquisition and rental of emergency generators to manage the emergency, machinery needed to remove debris, demolition work required, and hiring and contracting workers are the main activities associated with managing the event and ensuing emergency actions.

TABLE 56. WATER AND SANITATION: ADDITIONAL COSTS

	Additional costs
Emergency Generation	500,000.0
Fuel for power generator	79,200.0
Extra cost associated with Personnel	431,000.0
Demolitions	200,000.0
Debris handling	350,000.0
Temporary RO and distribution Systems	229,000.0
Sewerage / Waste collection services	200,000.0
Rental Tools / Equipment	100,000.0
Other Cost (contingency)	200,000.0
Totals	$2,289,200

Source: Assessment team, 2019

Field visits to both islands showed the use of temporary reverse osmosis plants and distribution systems (Figure 24) donated by different international organizations like IsraAID to support The Bahamas during this event emergency, whose cost is included in Table 56.

FIGURE 24. RO PLANTS AND WATER DISTRIBUTION SYSTEMS

Source: Assessment team, 2019

PRODUCTIVE SECTORS

TOURISM SECTOR

INTRODUCTION

Hurricane Dorian directly impacted two major tourist destinations of The Bahamas and disrupted the tourist flows in the rest of the Lucayan Archipelago for several days before and after the storm. Hurricane Dorian caused significant damage on Abaco and Grand Bahama, and in some locations the damage was catastrophic. The total damage in the tourist sector was estimated at $530 million. A large majority of the damage was sustained on Abaco. The forecasted losses are less than the damage and are estimated to amount to $325 million. The Additional costs were estimated to be $15 million.

The information for this section comes from field mission observations and interviews from official institutions like the Ministry of Tourism, Ministry of Finance, Freeport Port Authority, The Department of Statistics of The Government of The Bahamas, as well as private associations like the Bahamas Insurance Association.

BASELINE INFORMATION

After being impacted three years consecutively by a major hurricane, The Bahamas saw 2018 pass with no major disruptions in tourism. It was a positive year, according the Market Update Report from the Bahamas Ministry of Tourism, the number of arrivals (air and sea) were 6.6 million. This represented an increase of 7.9 percent with respect to 2017. The estimated total spending by tourist visitors during 2018 was $2.9 billion, up 11.8 percent from the previous year.

This increase in visitors was the result of several factors. First, much better arrival numbers than 2017, as a result of the absence of any major tropical storm. In September 2018, total arrivals were over 400 thousand, up 62.4 percent with respect to the same month in 2017. The second factor was the addition of new properties in 2017 and 2018, particularly the long-awaited opening of Baja Mar. Joint marketing efforts of the Bahamas Ministry of Tourism and industry partners also contributed to the increase in visitors.

During the first eight months of 2019, the positive tendency continued. The Bahamas received a total of 1.4 million stopover visitors in this time, up 17.6 percent from the same period in 2018. There are, however, significant differences. While New Providence increased the number of visitors by 22.8 percent, Grand Bahama suffered a decline of 16.2 percent. The Out Islands experienced an increase in stopover visitors of 19.1 percent. For Grand Bahama, the lack of recovery from the Grand Lucayan hotel has weighted negatively in its recovery since Matthew, highlighting once again the importance to bring back anchor properties to speed up recovery.

There was a marked improvement in cruise visitors during the first eight months of 2019. The total cruise arrivals measured at third point of entry was 5,561,269 visitors, up 10.2 percent above the same period of 2018. Most of this increase was in New Providence with 12.5 percent, followed by The Out Islands with 9.6 percent and Grand Bahama with 3.2 percent.

In general terms the Tourism sector prior to hurricane Dorian was in good shape, particularly in New Providence. The only point of concern was Grand Bahama, which has been still suffering the effects of Matthew. This is particularly clear from the number of stopover visitors. The year before Matthew the total stopover visitors for Grand Bahama was over 246 thousand. Without a full recovery, by 2018 this number was down 32.1 percent. However, there are promising's signs for the island in coming years, with the planned reopening of the Grand Lucayan and other important investments related to the cruise sector.

DAMAGE

Hurricane Dorian impacted the second and third most popular Bahamas destinations measured by air arrivals. Unlike Hurricane Irma, the amount of tourist infrastructure destroyed in the path of Hurricane Dorian was considerable, particularly on Abaco.

The methodology for assessing tourism infrastructure damage considers both the structural and non-structural damage for each hotel facility. The damage is assessed through reports provided by the authorities and field visits. The damage assessment was divided into 5 different groups: roofing, rooms, common areas, equipment and landscaping. The hotel establishments that suffered the greatest damage are those located on the coastline. While it is natural that large hotels are located near the coastline, great damage was observed due to this high exposure.

The analysis concluded that the infrastructure was most affected by flooding and high-speed wind forces to roofs, windows, equipment, marinas, and structural elements. Hotel establishments that had a marina were affected by the high exposure to the hazard. The material of the infrastructure played an essential role in its fragility. Hotel infrastructure built with lightweight materials and close to the coastline suffered higher damage from Hurricane Dorian. On the other hand, facilities built with concrete had better structural performance because they have a greater resistance to external solicitations.

The total estimated damage in the tourism infrastructure of Abaco is $512 million. The most affected area was Central Abaco with $260 million, followed by North Abaco with $150 million. The estimated damage in Marsh Harbour was $66 million, while the damage for South Abaco was $37 million. Most of the damage on Abaco was to landscape and facilities estimated at $188 million, with marinas included in this category. The damage to rooms is estimated at $140 million, while the figure is $133 million for common areas. The damage in roof and ceilings was $22 million, with roughly the same amount in equipment, while other damage totaled about $8 million. The damage on Abaco was considerable, some smaller business may never fully recover, and the recovery process will take many years.

The total estimated damage for Grand Bahama was $17 million (Table 57). This was significantly less than Abaco. Most of the touristic infrastructure is in Freeport and the West End, where the impact of Hurricane Dorian was less considerable. The East End of Grand Bahama suffered catastrophic damage, more in line with what happened in some parts of Abaco. The estimated damage in Freeport was $12 million, and for West End $334 thousand. Compared to the total infrastructure present in these areas, the damage was minor. Conversely, the small touristic infrastructure present in East End was completely devastated, the damage in this area is estimated to be $5 million. Most of the damage on Grand Bahama was concentrated in the common areas of the touristic facilities with $8 million. In rooms the estimated damage amounted to $4 million, and $2 million in landscape and facilities, and another $2 million in equipment. There was damage in roof and ceilings of $1 million and about half that in other damage.

The total damage in the tourism infrastructure, not included in the infrastructure section, is $530 million. This figure is significantly higher than the damage as a result of Hurricanes Irma and Matthew. Hurricane Dorian devastated a big portion of the touristic infrastructure of Abaco. The damage was significantly less for Grand Bahama, excluding East End. Abaco bore the brunt of the storm and suffered about 97 percent of the total damage. As a result of this, the recovery process will be very different between the two affected islands.

TABLE 57. TOURISM: DAMAGE

	Roof/Ceiling	Rooms	Common areas	Landscape & facilities	Equipment	Others	Total
Abaco Total	21,976,543	140,106,272	132,933,315	187,811,131	21,562,332	7,980,272	512,369,865
North Abaco	6,616,411	42,545,406	39,686,714	52,533,468	6,260,301	2,344,546	149,986,846
Marsh Harbour	2,391,782	14,645,597	18,027,331	27,099,200	2,968,009	1,020,035	66,151,955
Central Abaco	11,462,490	78,459,338	65,401,244	89,769,664	10,564,173	4,064,893	259,721,800
South Abaco	1,505,859	4,455,931	9,818,027	18,408,800	1,769,850	550,798	36,509,264
GrandBahama Total	1,028,634	4,152,314	7,665,646	1,906,986	1,891,350	535,412	17,180,343
Freeport	581,906	3,067,951	4,427,497	1,726,486	1,361,096	443,175	11,608,111
West Grand Bahama	16,668	35,909	92,786	134,869	48,890	5,181	334,304
East Grand Bahama	430,060	1,048,454	3,145,363	45,632	481,364	87,055	5,237,928
Total	$23,005,177	$144,258,586	$140,598,961	$189,718,118	$23,453,682	$8,515,684	$529,550,208

Source: Assessment team, 2019

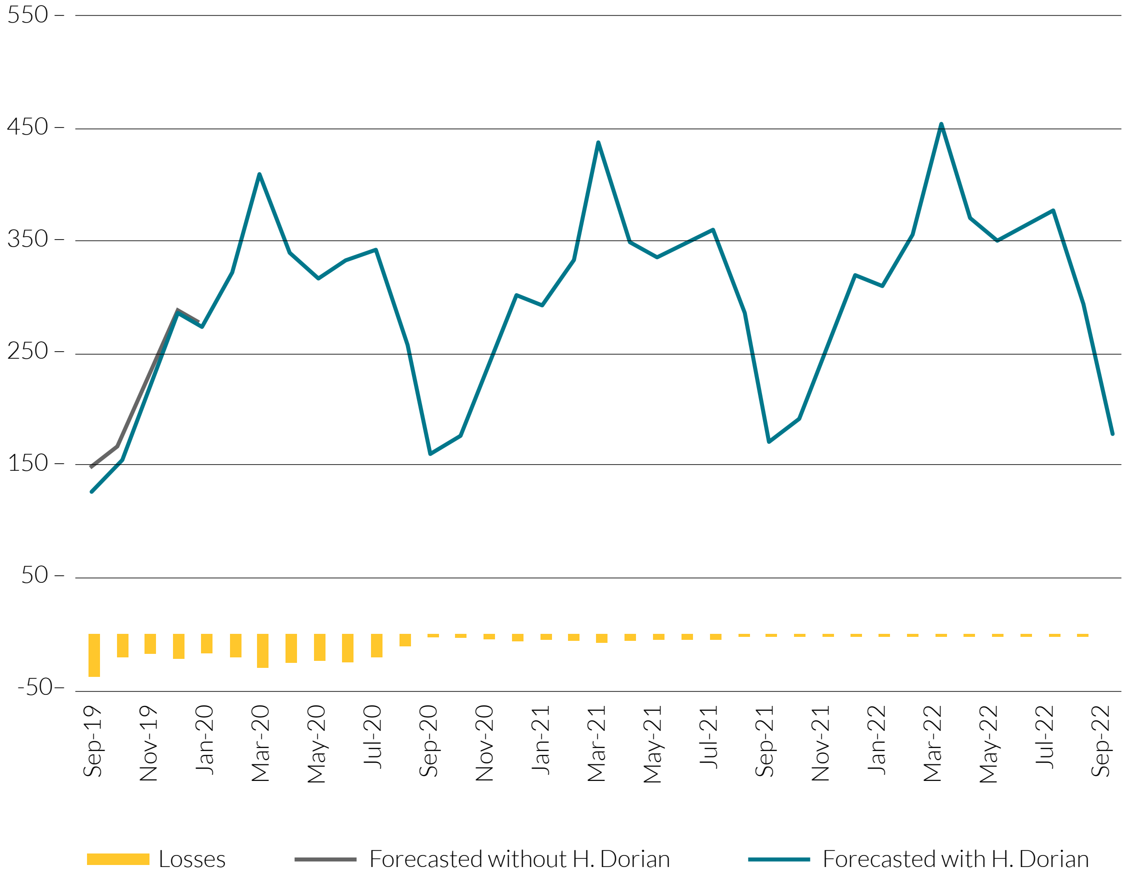
LOSSES

The losses in the tourism sector have two different fundamental causes. The first one is the disruption in the flow of tourists as a result of the passing storm. These losses can be considerable depending on the amount of traffic affected. The second cause is related to the damage and the direct impact of the storm on the tourist infrastructure and the perception of tourists about the location. Hurricane Dorian disrupted the flow of tourists from a few days before the storm made landfall to the end of September, particularly for the cruise sector. Hurricane Dorian did ample damage to the tourist infrastructure throughout Abaco and East End of Grand Bahama.

For the estimation of Losses, we employed official figures up to August 2017 that were provided by the Ministry of Tourism, as well as public information about cruises and other information gathered in our fieldwork. We made some plausible assumptions about the flow of air and sea tourists before and after the storm, and we use time series analysis to make a forecast about these flows. The assessment assumes the full recovery for Abaco will take three years, while the recovery for the key infrastructure on Grand Bahama will take much less, around six months. The recovery for the rest, including New Providence, will only take weeks.

The monthly forecast of the three-year expenditure for the recovery is displayed in Figure 25. This is the baseline scenario for estimating the losses, and then we adjust that forecast using our assumptions. The monthly losses are the differences between these two series. Full recovery is assumed to occur by September 2022, even though some of the infrastructure destroyed may never recover, particularly those uninsured small properties. The assessment of losses assumes that there will be significant efforts to bring back anchor properties.

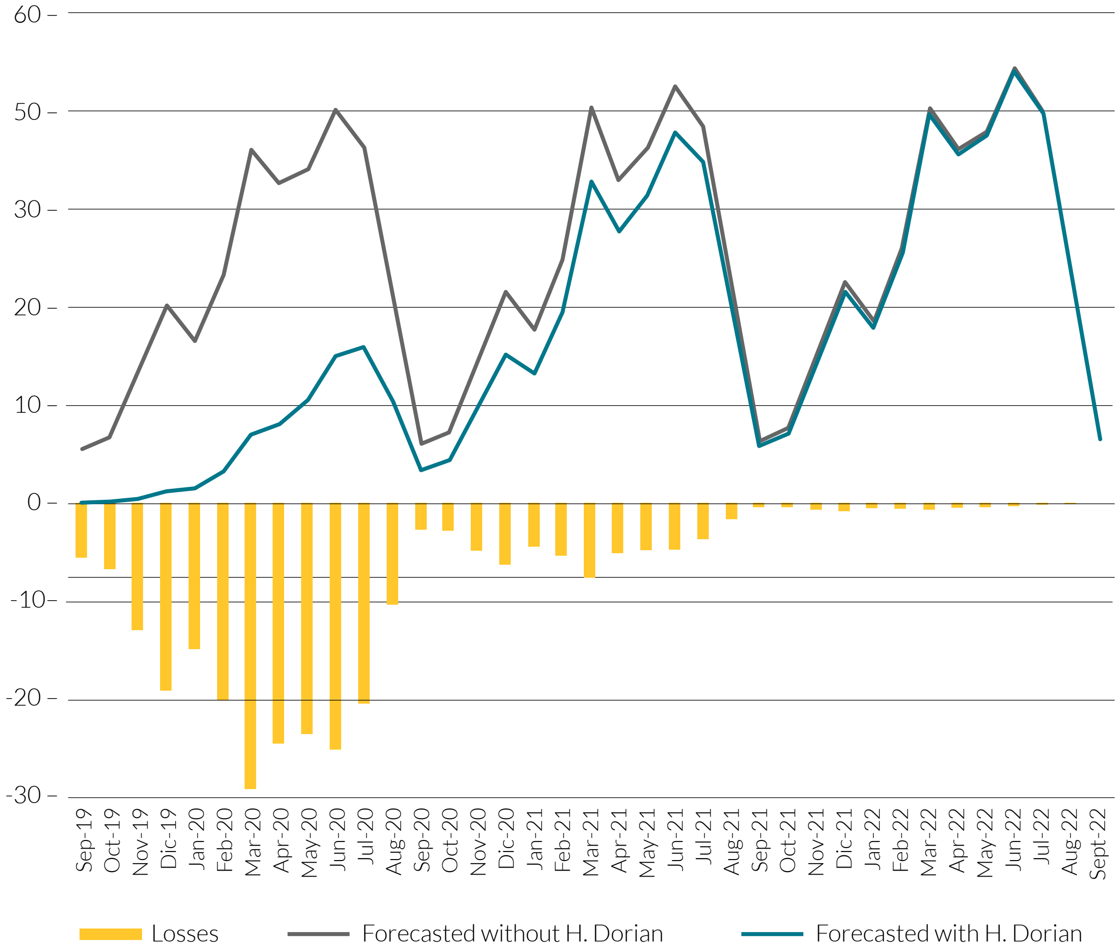
FIGURE 25. BAHAMAS: FORECASTED STOPOVER INCOME AND LOSSES (MILLIONS)



Source: Assessment team, 2019

As shown in Figure 25, even for a catastrophic hurricane like Dorian, the losses are relatively small compared to the total forecasted income. The reason for this is that tourist income in The Bahamas is highly concentrated in New Providence, where the impact was negligible; also, Hurricane Dorian disrupted tourist flows in low season. However, it is instrumental to put these losses in a better perspective, as shown in Figure 26. In order to do this, we present the same information for Abaco only, regarding stopover losses. The picture that emerges is very different. The losses for Abaco are considerable, both in magnitude and in time, as we can see in Figure 26. The losses in the cruise sector of Castaway Cay was considered in the rest of the Out Islands.

FIGURE 26. ABACO: FORECASTED STOPOVER INCOME AND LOSSES (MILLIONS)



Source: Assessment team, 2019

Table 58 presents the total losses sorted by type of visitor for New Providence, Grand Bahama and the Out Islands. The total losses over a three-year period starting in September 2019 are $235 million. These losses are heavily concentrated in stopover visitors to Abaco, representing about 85,2 percent of total losses. The losses in New Providence amount to $28 million, while the losses for Grand Bahama are forecasted to be $19 million. The remainder of the losses will be accrued in the rest of the Out Islands, which is the result of the disruption in the flow of tourists. These islands can expect to see a minor positive impact due to the diversion of tourists that otherwise would have gone to Abaco. Most of the losses will be accrued in the high season of 2019 and 2020, tapering off as the recovery is expected to gain momentum. It is crucial to bring back anchor properties as soon as possible. After the recovery of the key infrastructure and services, room capacity will be the limiting factor in tourism recovery.

TABLE 58. TOURISM: LOSSES BY TYPE OF VISITOR

	Stopover	Cruise	Day	Total
New Providence	23,562,685	4,601,358	27,859	28,191,902
Grand Bahama	10,450,550	8,694,576	115,799	19,260,924
Out islands	277,053,402	664,981	28,057	277,746,440
Abaco	271,090,647			
Rest Out islands	5,962,755			
The Bahamas	311,066,637	13,960,914	171,715	$325,199,267

Source: Assessment team, 2019

TABLE 59. TOURISM: LOSSES BY TYPE OF VISITOR AND YEAR

	2019	2020	2021	2022
Stopover	82,934,979	185,578,173	39,405,745	3,147,740
Cruise	11,915,522	2,045,392	0	0
Daily	139,237	32,478	0	0
Total	$94,989,739	$187,656,043	$39,405,745	$3,147,740

Source: Assessment team, 2019

Below, Table 60 presents the losses by type of expenditure and type of visitors. The major component is accommodation where the losses amount to $193 million, about 59.4 percent of total losses. The next category is meals and drinks, with losses of $39 million. In shopping the losses will be $32 million, while in activities losses are estimated at $30 million. The transportation services related to tourism will experience losses of $22 million. The remaining losses will be accrued by casinos estimated at $3 million and by other expenses amounting to almost $7 million.

TABLE 60. TOURISM: LOSSES BY TYPE OF EXPENDITURE

	Stopover	Cruise	Day	Total
Accommodation	193,248,449	0	0	193,248,449
Meals and Drinks	37,751,660	1,686,859	20,597	39,459,116
Activities	24,721,976	4,753,397	60,514	29,535,887
Shopping	25,069,247	6,458,459	78,554	31,606,260
Transportation	21,421,967	709,595	8,577	22,140,139
Casino	2,384,544	253,075	1,532	2,639,151
Other	6,468,795	99,531	1,940	6,570,265
Total	$311,066,637	$13,960,914	$171,715	$325,199,267

Source: Assessment team, 2019

There was no significant damage reported in the tourism infrastructure in New Providence. The only effect was the disruption in the flow of tourist due to the storm, before and after. These losses are concentrated in a few weeks of August, September and October. The total losses for New Providence are estimated in $28 million and its disaggregation is presented in Table 61. About 47 percent of the losses are accounted for in accommodation. Meals and drinks will register losses of $4 million, and shopping will experience similar losses. The losses in activities will reach above $2 million; while in casinos expected losses are near $3 million. The remainder of the losses are distributed between transportation related to tourism, and other expenditures.

TABLE 61. NEW PROVIDENCE: LOSSES BY TYPE OF VISITOR

	Stopover	Cruise	Day	Total
Accommodation	13,374,180	0	0	13,374,180
Meals and Drinks	3,543,828	579,771	3,510	4,127,109
Activities	1,222,903	1,242,367	7,522	2,472,792
Shopping	1,753,064	2,268,469	13,735	4,035,268
Transportation	895,382	257,676	1,560	1,154,618
Casino	2,384,544	253,075	1,532	2,639,151
Other	388,784	0	0	388,784
Total	$23,562,685	$4,601,358	$27,859	$28,191,902

Source: Assessment team, 2019

Grand Bahama was impacted directly by the storm; however, the damage is far less than that from Hurricane Matthew. The total expected losses are $19 million, about $10.5 million due to the loss of stopover visitors, and $9 million from cruise visitors; there are also some minor losses due to day visitors. A large fraction of the visitors to Grand Bahama comes from cruises. Many cruises were diverted or canceled, and in some occasions the cruise ships were used to provide relief. Even if the impact was not as severe, there were facilities that experienced some damage due to wind and storm surge. The recovery faces an important challenge regarding the recovery of the Grand Bahama International Airport which suffered severe damage.

In this case the major losses will occur in accommodation, estimated at $5 million, followed very closely by losses in shopping, most of them due to the drop in cruise visitors. Also related to the fall in this type of visitors, the losses in activities are forecasted to be U$4 million. The losses for meals and drinks are estimated to reach $3 million, while the losses in transportation and other losses are forecasted to be close to $1 million each.

TABLE 62. GRAND BAHAMA: LOSSES BY TYPE OF VISITOR

	Stopover	Cruise	Day	Total
Accommodation	5,297,384	0	0	5,297,384
Meals and Drinks	1,825,711	1,025,960	13,664	2,865,335
Activities	917,558	3,295,244	43,888	4,256,690
Shopping	1,279,147	3,877,781	51,646	5,208,574
Transportation	552,834	417,340	5,558	975,732
Casino	0	0	0	0
Other	577,915	78,251	1,042	657,209
Total	$10,450,550	$8,694,576	$115,799	$19,260,924

Source: Assessment team, 2019

A large majority of the losses in the Tourism sector are concentrated on Abaco. In accommodation the losses are expected to reach $171 million. This is the biggest category of spending in the Out Islands, and particularly in a place like Abaco with relatively high-end visitors. The losses in meals and drinks are estimated at $32 million, followed by the losses in activities at $22 million. Among the most important water activities are flats sport fishing, deep sea sport fishing, and sailing. Tourism related shopping losses would total $22 million, where a big portion of them will come from the mentioned boating visitors. Transportation related to tourism will suffer losses estimated to near $20 million. Other losses are calculated to be around $5 million.

TABLE 63. ABACO: LOSSES BY TYPE OF VISITOR

	Stopover	Cruise	Day	Total
Accommodation	170,819,634	-	-	170,819,634
Meals and Drinks	31,685,191	-	-	31,685,191
Activities	22,095,514	-	-	22,095,514
Shopping	21,562,754	-	-	21,562,754
Transportation	19,543,875	-	-	19,543,875
Casino		-	-	0
Other	5,383,679	-	-	5,383,679
Total	$271,090,647	-	-	$271,090,647

Source: Assessment team, 2019

The remaining faction of the Out Islands did not suffer significant direct impact from Hurricane Dorian. The negative impact was exclusively derived from the disruption in tourist flows. There is however a positive impact assumed from future tourists diverted from Abaco, which will end up visiting the rest of the Out Islands. Many visitors to The Bahamas are repeat visitors, in many occasions changing locations within The Bahamas. More than half of the expected losses are accrued in accommodation ($4 million), closely followed by meals and drinks, shopping, and activities with roughly the same amount in each category. The losses in transportation are estimated to be close to $0.5 million dollars, while those in other expenditures only amount to $141 thousand.

TABLE 64. REST OUT ISLANDS (INCLUDING CASTAWAY CAY): LOSSES BY TYPE OF VISITOR

	Stopover	Cruise	Day	Total
Accommodation	3,757,251	0	0	3,757,251
Meals and Drinks	696,929	81,128	3,423	781,480
Activities	486,000	215,786	9,105	710,891
Shopping	474,282	312,208	13,173	799,663
Transportation	429,876	34,579	1,459	465,914
Casino		0	0	0
Other	118,416	21,279	898	140,594
Total	$5,962,755	$664,981	$28,057	$6,655,793

Source: Assessment team, 2019

ADDITIONAL COSTS

The cost of demolition, debris removal and salvage of sunken ships are all considered in the Additional costs. The methodology to evaluate the Additional costs of cleanup and demolition consider the analysis of each hotel infrastructure to obtain the total volume to be removed and transported. The methodology considers the status of damage of each hotel, the category of each hotel and its location.

The Additional costs are estimated to surpass $15 million (Table 65); of those $8 million are associated with demolition costs, $2 million to debris removal and $5 million to salvage costs.

TABLE 65. TOURISM: ADDITIONAL COSTS

	Cost
Demolition	8,088,943
Debris removal	2,410,182
Salvage	4,647,500
Total	$15,146,625

Source: Assessment team, 2019

FISHERIES AND AGRICULTURE

INTRODUCTION

The impact of Hurricane Dorian on the Fisheries and Agriculture sector of Abaco and Grand Bahama was significant and generalized. Every fishing processing facility was affected, either by wind damage or storm surge. In the agricultural sector, several green houses were devastated, and many perennial crops were damaged by the wind and salt-water intrusion. A poultry processing facility was devastated on Abaco. The total damage in fisheries was $11 million, while the estimated losses are $7 million. For agriculture the total damage was $3 million, and the losses $4 million. The information for this section comes from field mission observations, interviews from official institutions like the Ministry of Agriculture and Marine Resources and The Department of Statistics of The Government of Bahamas, as well as fieldwork and interviews with stakeholders.

BASELINE INFORMATION

Fishing is an important activity in The Bahamas. It is a source of employment for many Bahamians, one of the major goods exported, and a fundamental source of food for the local population as well as for the many tourists that visit the archipelago. The main catch is spiny lobster, followed by conch and lane snapper.

According to the Ministry of Agriculture and Marine Resources, The Bahamas total catch for 2018 was 3,028 tons. Of those, about 64 percent were spiny lobster (1,938 tons), followed by 537 tons of conch and 176 tons of lane snapper. The value for the total catch was $57 million. The value for spiny lobster as a fraction of the total catch is even larger, amounting to 82 percent. During 2018 the total value of fishery products and exports was $75 million, of those $68 were spiny lobster, either frozen or live. The next export in value was conch with $4 million, followed by stone crab with $2 million. Abaco was responsible for about $8 million of the total catch (13.5 percent) and Grand Bahama for $4 million (6.3 percent). The major destination for these exports is the United States of America.

DAMAGE

Fishing activity is particularly vulnerable to tropical storms because the infrastructure and equipment in proximity to water or directly in it. Dorian had a profound impact in the fishing sector of Abaco and Grand Bahama because it also affected the processing facilities.

The total estimated damage in fisheries amounted to $11 million. Seven processing facilities, five of them non-seasonal, were affected. The total damage to fishing processing facilities is estimated to be $5 million, shown in Table 66. Within the facilities a total of $2 million in inventory was damaged. The damage to vessels amounted to $2 million, while the damage to outboard engines was close to $0.4 million. Finally, fishing gear lost or damaged totaled $2 million.

TABLE 66. FISHERIES: DAMAGE

Assets	Value
Processing facilities	4,744,500
Inventory	1,645,150
Vessels	1,841,100
Outboard engines	359,032
Fishing gear	2,047,631
Total	$10,637,413

Source: Ministry of Agriculture and Marine Resources.

The damage in the Agriculture sector totaled just under $3 million. Most of the damage is associated to the poultry facility located on Abaco. In this facility the estimated damage to infrastructure was $0.8 million. Also linked to this facility the damage in animal property was $1 million. The damage in green houses is estimated to be over $187 thousand while the damage in perennial plants is estimated in $0.66 million. A total of $197 thousand is the estimated damage to agriculture-related equipment.

TABLE 67. AGRICULTURE: DAMAGE

Assets	Value
Green houses	187,382
Other facilities	800,000
Animals	1,037,951
Plants	655,874
Equipment	197,476
Total	$2,878,684

Source: Assessment team, 2019

LOSSES

To estimate the Losses to fisheries, the yearly total catch was broken down to a monthly amount for Abaco and Grand Bahama. A full recovery should occur in eight months, with such relative quickness due to the important nature of this activity. In order to estimate losses, the seasons for spiny lobster and stone crab where also considered. Special attention in the recovery should be paid to the processing facilities. Agriculture activity considered crops divided between perennials and annuals. The annual crops should recover by midyear 2020, while the perennials can take between three to eight years to recover. For the poultry factory, the recovery is assumed to take a year, although at this point there is uncertainty whether the business will return to its operations.

The losses in fisheries are estimated to be $7 million and represent many of the total losses. In agriculture the losses will be $2 million, and for poultry, over $1.5 million. The total losses for fisheries and agriculture are estimated at $10 million.

TABLE 68. FISHERIES AND AGRICULTURE: LOSSES

Sector	Losses
Fishing	6,570,623
Agriculture	1,985,212
Poultry	1,556,926
Total	$10,112,761

Source: Assessment team, 2019

COMMERCE SECTOR

INTRODUCTION

The effects from Hurricane Dorian on the Commerce sector was much greater on Abaco than Grand Bahama due to the path of the hurricane. The eye of the storm passed through the commercial center of Marsh Harbour and missed the business center of the Freeport City. Generally, the structures that were made of concrete survived with less damage, while those made of lighter materials fared much worse. The total damage was estimated at $77.5 million, of which $71.4 million was attributed to Abaco, and $6.2 million to Grand Bahama.

The losses to the sector are projected to occur throughout the expected length of recovery. On Grand Bahama, the losses are expected to accrue over just four months, while on Abaco it is expected to take a full three years from the time of the event. Due to the destruction of property and vital infrastructure, as well as the evacuation of residents, commercial expenditure will fall to zero in the month following the disaster and then gradually make its way toward pre-disaster levels as the recovery goes on. The total losses estimated for the commerce sector are $65 million: $64.5 million on Abaco and $0.5 million on Grand Bahama. Assessing over time, losses will be $22.1 million or 34 percent of the total in 2019, $34.9 million or 54 percent in 2020, $7.2 million or 11 percent in 2021, and 0.8 million or 1 percent in 2022.

The Additional costs for this sector are comprised of debris removal and demolition. At the time of the Assessment team's site visit to Abaco, there was still an extensive amount of debris in Marsh Harbour. Debris removal and demolition of damaged properties will be expensive and will take additional time on Abaco. The total Additional costs for the Commerce sector are estimated at $4.8 million, $3.8 million on Abaco and $1 million on Grand Bahama.

The information for this assessment was collected from official interviews and reports and data from Openstreetmaps.com. The Damage and Loss Assessment team also conducted site visits to Abaco and Grand Bahama.

BASELINE INFORMATION

The Commerce sector, as defined in national accounts as activity such as "wholesale and retail trade, motor vehicle repairs", accounted for 12.0 percent of the Bahamas' GDP on average from 2012 to 2018. It was the second largest sector in The Bahamas' economy, behind real estate at 15.6 percent. This number almost certainly includes a high degree of tourist activity. In tourism-dependent economies like of The Bahamas, it is often difficult to separate tourism activity from domestic business activity.

According to the Department of Statistics 2017 Labor Force Survey Report, the size of the labor force in The Bahamas in 2017 was 222.0 thousand. Of this, 80.5 thousand were in New Providence, while the labor forces on Grand Bahama and Abaco were 15.3 thousand and 6.7 thousand respectively.

In New Providence, over 18 thousand, or 15 percent of total employed persons worked in wholesale and retail trade, while 18 percent worked in hotels and restaurants. On Grand Bahama and Abaco, the labor statistics are not as detailed, and therefore wholesale, retail, and hotels and restaurants are grouped as one. Nevertheless, the distribution of workers is similar. On Grand Bahama 28 percent of employed workers work in this group, while this number is 34 percent on Abaco. More women than men work in this sector on all three islands. The ratio of female to male workers in the wholesale and retail and hotels and restaurants sector was 1.6 on Grand Bahama and 1.3 on Abaco.

Commerce is of particular importance to Abaco, with most businesses located in the commercial center in Marsh Harbour. The Abaco Chamber of Commerce lists 175 members in their online directory. For the purpose of this report 34 of these members, which were hotels and resorts, marinas, agricultural producers, and telecommunications companies, will be addressed in their respective sectors of this report. The other 141 members were considered part of the Commerce sector. The geographic data identified 98 structures as commerce-related on Abaco. There were 43 members who were not identified in the GIS data.

The Grand Bahama Chamber of Commerce lists 218 members in their online directory. As on Abaco, 28 members fit into other sectors and were not considered to be part of the Commerce sector, while the remaining 190 were. The geographic data identified 82 structures as commerce-related on Grand Bahama. Another 108 members were not identified in the GIS data.

Restaurants, while usually counted as tourism activity, were included in the Commerce sector for this report. The GIS data used included 23 restaurants on Abaco and 21 on Grand Bahama. However, restaurants within hotel and resort properties were not included.

The Bahamas Department of Statistics provided the Assessment team with an annual household consumption expenditure for Grand Bahama and Abaco. The categories of household expenditure that were included were food and non-alcoholic beverages, alcohol beverages, tobacco and narcotics, clothing and footwear, furnishing, household equipment and routine household maintenance, and recreation and culture. Average household expenditure in 2017 for Grand Bahama was $42.6 thousand or 95.9 percent of the national average, while on Abaco average expenditure was $39.6 thousand or 89.1 percent of national average. Total household consumption expenditure on Grand Bahama and Abaco was $639 million and $239 million respectively.

DAMAGE

The damage suffered by this sector varied by island. On Grand Bahama damage was not that significant, while on Abaco, the damage was much greater. In structural terms, most damage was caused by high-speed winds and flooding. This caused severe damage to structural elements such as beams and walls, and caused limitations and interruptions to operations from flooding and the failure of non-structural elements. From the field visit, a direct relation between constructive quality and the structural performance was observed. There is little regulation in terms of urban planning, therefore varying degrees of damage were incurred throughout the commerce sector. Wood structures have much lower resistance to the stress caused by a hurricane and suffered the most damage, while concrete structures were mainly damaged in roofs and exterior windows, as shown in Figure 27.

FIGURE 27. DAMAGE IN NON-STRUCTURAL ELEMENTS

Source: Assessment team 2019.

The high exposure of some structures exacerbated the damage. Many structures close to the coastline were exposed to greater solicitations and consequently had greater structural damage. Figure 28 shows that a Standard Hardware company facility suffered structural damage to its walls and ceiling. Structures like hangars with low resistance cladding and large walls were highly affected by hurricane winds. In sum, inadequate building codes and building materials, and the location of the structure, were the main causes of damage.

FIGURE 28. DAMAGE CAUSED BY WIND FORCE

Source: Assessment team, 2019

To help estimate the total damage, GIS data from Openstreetmaps.com was utilized. This data, which estimates the aerial area of buildings from satellite and aerial photography, also classifies individual buildings as damaged, destroyed or with minor or no damage. The buildings were attributed a damage factor based upon this classification. The damage factor and aerial surface area, along with an estimated number of floors, were used to estimate a damage value for the structure, roof, furniture and equipment of each building in the GIS dataset. The methodology to estimate the damage considers the materiality, the size and type of commercial premises and the state of damage after the effects of the hurricane. An analysis was made for each of the premises to estimate the structural damage and the associated costs. These were summed to calculate the total damage for the sector. The Chamber of Commerce on each of the two islands is in the process of preparing an additional damage report for their members at the time of the DaLA team assessment.

Total damage to the Commerce sector was estimated at $77.5 million. The majority of the damage, $71.3 million, occurred on Abaco, while Grand Bahama incurred damage of $6.2 million. This corresponds with the path and intensity of Hurricane Dorian, which was more severe on Abaco and affected the main city Marsh Harbour. Damage in the Commerce sector is summarized by island and damage component in Table 69 below.

TABLE 69. COMMERCE: DAMAGE

Description	Abaco	Grand Bahama	Total
Structures	44,565,125.7	3,637,502.1	48,202,627.8
Roof	9,131,339.0	762,059.3	9,893,398.3
Furniture	5,853,942.8	436,655.6	6,290,598.4
Equipment	11,835,803.3	1,362,116.9	13,197,920.3
Total	71,386,210.8	6,198,334.0	77,584,544.8

Source: Assessment team, 2019

LOSSES

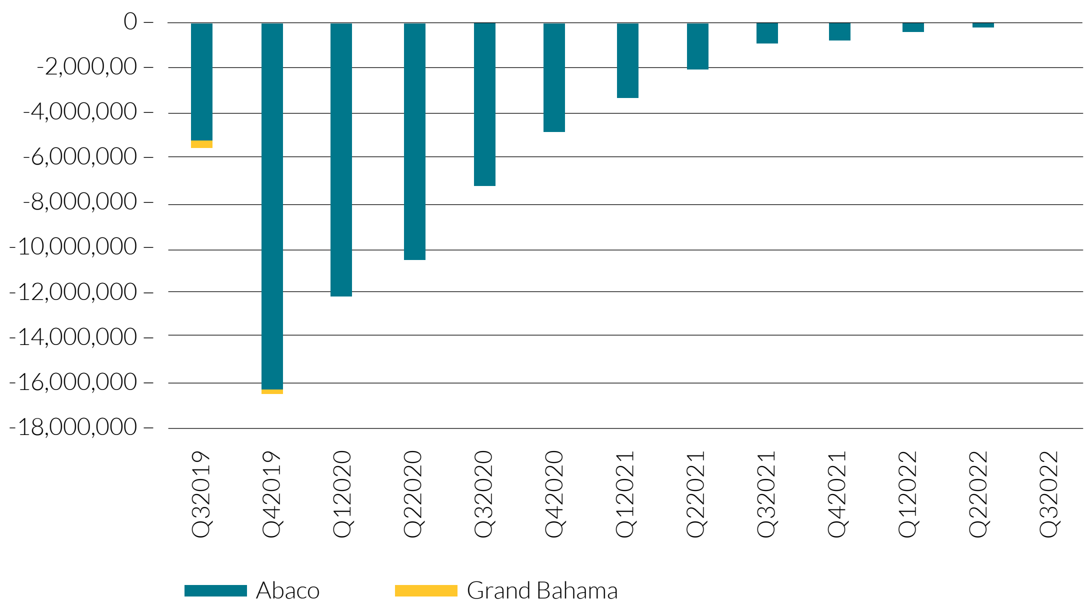
The losses resulting from the hurricane varies by island. Business activity will be limited by damage to properties both owned and rented, and by loss of inventory. The cleanup process on Abaco is ongoing and will be extensive, and many buildings will require significant repairs and even demolition. A lot of debris needs to be cleared before the flow of goods and customers can return to normal. Also, the population of the island was temporarily reduced following the storm as persons were evacuated to New Providence and other islands. The slow return of residents will impact the recovery time for the sector. In these islands, domestic expenditure is often linked to tourism activity, as a portion of tourist expenditure ends up in the hands of residents. The return of tourists to the island will contribute to the domestic commercial performance. By comparison Abaco was much more affected and its return to normalcy will be much more protracted, and as such it will incur far greater losses.

A baseline forecast of average household expenditure by category was created using data from the Department of Statistics Household Expenditure Survey and GDP growth forecasts from the International Monetary Fund's World Economic Outlook April 2019 database. Annual expenditure by category was forecasted up to 2022. Using average quarterly GDP growth rates, the annual expenditure was distributed on a quarterly basis, which produced a baseline of average quarterly expenditure forecasted until the third quarter of 2022.

To calculate the Losses, a forecast of household expenditures following the hurricane was produced for both Grand Bahama and Abaco. For Grand Bahama it was assumed that in September and Q4 2019 expenditure would be reduced by a factor equal to the average damage factor for businesses on that island. On Abaco it was assumed that commercial expenditure would fall to zero in September 2019, and then gradually normalize over the next 12 quarters. The recovery would occur slowly at first over the first few quarters, then more rapidly, and then slowly return to baseline levels over the last few quarters. However, some reallocation of expenditure in the recovery period is expected. The expenditure category of furnishing, household equipment and routine household maintenance is expected to see levels greater than the baseline for seven quarters starting in Q1 2020. This increase will mitigate the total losses in the sector. The baseline forecast was subtracted from the post-Dorian forecast to calculate the losses by quarter.

The figure below depicts the quarterly losses from Q3 2019, up until Q3 2022. As the event occurred in the last month of Q3 2019, the losses in this quarter are much smaller. In Q4 2019, the losses are much greater, and they gradually decrease in size over the next three years as the recovery continues and more businesses begin to re-open and activity normalizes.

FIGURE 29. LOSSES BY QUARTER IN THE COMMERCE SECTOR



Source: Assessment team, 2019

Losses in the Commerce sector are summarized in Table 70 below. The total losses on Abaco are estimated to be $64.5 million, while the total losses on Grand Bahama will be just $0.5 million, for a total in Losses of $65 million.

TABLE 70. COMMERCE: LOSSES

Description	Abaco	Grand Bahama	Total
Food and non-alcoholic beverages	53,295,751.3	787,715.9	54,083,467.2
Alcohol beverages, tobacco and narcotics	2,703,444.5	47,640.2	2,751,084.7
Clothing and footwear	3,884,187.8	106,937.5	3,991,125.3
Furnishing, household equipment and routine household maintenance	-71,574.8	-589,911.7	-661,486.5
Recreation and culture	4,713,087.7	95,723.6	4,808,811.3
Total	$64,524,896.4	$448,105.5	$64,973,001.9

Source: Assessment team 2019.

Table 71 below depicts the losses in the Commerce sector by year. Most of the losses will occur in 2019 and 2020, at $22.1 million and $34.9 million respectively. For the following two years losses will be considerably less at $7.3 million and $0.8 million.

TABLE 71. COMMERCE: LOSSES BY YEAR

Description	2019	2020	2021	2022	Total
Food and non-alcoholic beverages	15,451,699.7	31,233,441.8	6,755,410.1	642,915.6	54,083,467.2
Alcohol beverages, tobacco and narcotics	791,475.6	1,584,326.6	342,670.4	32,612.1	2,751,084.7
Clothing and footwear	1,175,646.8	2,276,289.4	492,333.5	46,855.6	3,991,125.3
Furnishing, household equipment and routine household maintenance	3,260,426.9	-3,004,449.3	-917,464.1	0.0	-661,486.5
Recreation and culture	1,392,499.4	2,762,057.9	597,399.2	56,854.8	4,808,811.3
Total	22,071,748.4	34,851,666.5	7,270,349.0	779,238.0	64,973,001.9

Source: Assessment team, 2019

ADDITIONAL COSTS

Based on the available data for this assessment, Additional costs were stemmed mainly from debris removal and demolition of buildings.

Debris removal first considers the type of business, since there is a direct relation with the volume of debris generated. Secondly, it considers the state of damage to the infrastructure and the size of the establishment. The cost for debris removal begins with the volume to be removed and from there an estimate of the number of trucks needed, which was then calculated to include the unit cost of each truck in the context of each island.

For the estimation of demolition costs, a statistical analysis is made based on past events where the damage state, debris volume, and volume to be demolished are related, which is calculated based on its size and its damage state according to the reports provided and the field visits.

Additional costs in the Commerce sector are summarized in Table 72 below. The total was estimated at $4.8 million, with $3.8 million on Abaco and $1 million on Grand Bahama.

TABLE 72. COMMERCE: ADDITIONAL COSTS

Description	Abaco	Grand Bahama	Total
Debris removal	2,940,633.9	786,959.0	3,727,592.8
Demolition	845,440.8	234,482.3	1,079,923.1
Total	3,786,074.6	1,021,441.3	4,807,515.9

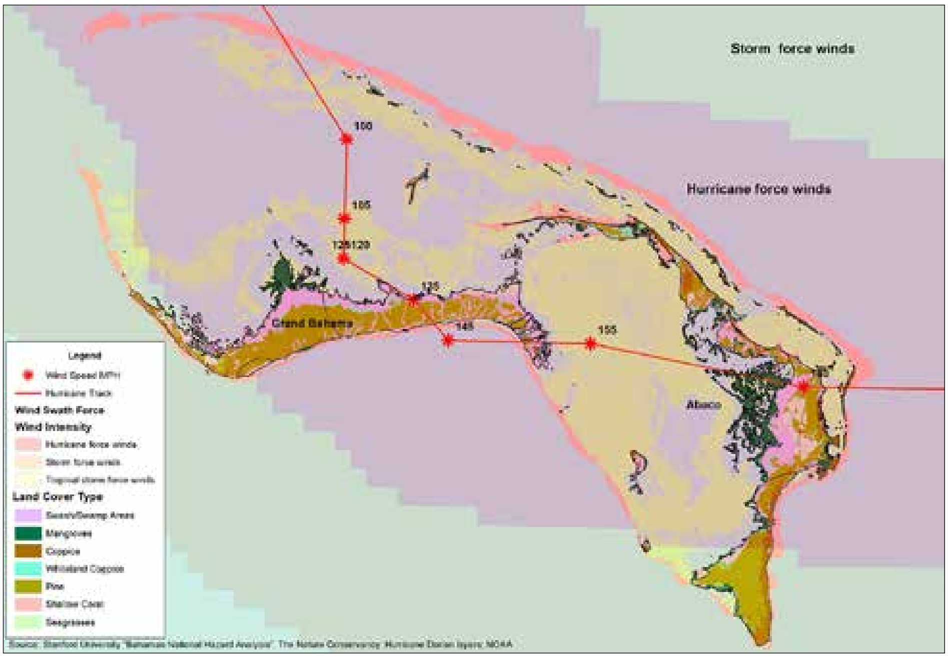
Source: Assessment team 2019.

ENVIRONMENTAL SECTOR

INTRODUCTION

This section evaluates Hurricane Dorian's effects on natural resources. The type and temporal extent of impact varies according to the storm's speed, size, intensity, and amount of precipitation in each area and will be classified into minimal, moderate or significant impact. Although previous assessments indicate that ecosystems in the Bahamas have adapted over time to become resilient to tropical weather, the intensity and duration of Hurricane Dorian caused moderate to significant impacts on several ecosystems (Figure 30).The results presented in this report offer a partial and preliminary overview of what has been formally evaluated a month and half after the event. Long-term environmental impacts of the event on Grand Bahama and Abaco will require detailed studies and long-term monitoring of ecosystems on both islands.

FIGURE 30. ECOSYSTEMS ON ABACO AND GRAND BAHAMA AND HURRICANE DORIAN TRAJECTORY



Source: Assessment team, 2019

The effects to natural resources are not only expected to cause changes in biodiversity, disappearance of habitats, and displacement of species, but also to affect Bahamians who depend on healthy ecosystems to maintain their livelihoods. These benefits are referred to as ecosystem services[19], as they result in increased revenues for the government, fishermen and from tourism, and they reduce the costs to homeowners and businesses offering natural protection from continuous impacts from storms.

19 The Millennium Ecosystem Assessment (MA) report from 2005 defines Ecosystem services as benefits people obtain from ecosystems and distinguishes four categories of ecosystem services: regulating services, provision services, cultural services and supporting services.

In The Bahamas, several studies have assembled considerable information about the economic value of its ecosystems and Marine Protected Areas (MPA) (Hargreaves-Allen 2010, 2011, 2016, Micheletti 2016). These studies will be used as a reference for ecosystems services valuation since primary estimation methods are constrained by data availability. For services that do not have a market price but where data is available, the restoration costs will be used as the reference value.

An assumption has been made that before Hurricane Dorian the health of the natural resources in the affected areas was generally good, except where previous environmental problems were reported and documented. It is further assumed that other threats to the health of natural habitats existed before the hurricane including climate change, sea-level rise, development, and over-fishing.

The environmental assessment is based on information and interviews provided by the Ministry of Environment and Housing, BEST Commission, the port authority, the Bahamas National Trust (BNT), site visits and through interviews of members of these organization that have visited the affected areas[20] (Table 73). Baseline data was collected from online sources, ministry reports, and information obtained from NGOs that conducted environmental operations on the affected resources. The separation of damage and losses in the environmental sector by islands is challenging, as ecosystems are connected, and their damage and the interruption of the services provided have transboundary implications. Therefore, some of the results will be presented as an overall estimation.

TABLE 73. OBSERVED AND EXPECTED QUALITATIVE IMPACTS OF HURRICANE DORIAN

Resource	Qualitative observed impacts
National reserves and non-protected areas	Severe defoliation of areas of pine forests on Grand Bahama and Abaco, with moderate to severe tree uprooting and tree breakage in certain areas Destroyed trees that may act as a fueling agent to fires Storm surge and wind transported saltwater, sediment, and other organic matter inland Severe destruction of national reserves infrastructure, especially in the recently constructed facilities at Lucayan National Park Expected lost eco-tourism revenue resulting from closure and damage of protected areas, especially Lucayan park, which is one of the main attractions on Grand Bahama Losses in non-timber forest products Soil and forest contamination due to oil spill on Grand Bahama Increased risk of invasive species
Coastal ecosystems	Partial/total destruction of portions of seagrass meadows Partial/total destruction of the mangrove forests Expected reductions in the ecosystem services that seagrasses/mangroves provide, such as habitat for commercial and non-commercial fish and shellfish species, and improving water clarity Beach erosion/dune destruction observed in several areas, most severe impact reported in Gold Rock Beach in Lucayan National reserve

20 As more detailed assessments are conducted by Bahamian stakeholders, estimates would be adjusted to reflect the updated data sets. Undertaking comprehensive surveys in both the protected and non-protected areas in the near-term future will be beneficial to the Government of Bahamas, as it will help understand future damage, and the recovery or restoration requirements of their resources.

Wildlife (non-commercial species)	Destruction of forest canopy causing changes in the light, temperature, and humidity levels with expected implications for birds, lizards, and other animals, especially with regards to food availability and predation Potential impact to sea turtle nesting sites Expected high nutrient loading and subsequent periods of hypoxia (low oxygen levels) with alterations in the distribution, abundance, and movement of mobile aquatic species Flooding of unusual areas and stranding of fish and other aquatic animals observed in some areas after water levels recede Expected impact over oyster reefs through physical disturbance (waves pounding into the reefs cause breakage), sedimentation, and extreme salinity changes Possible extinction of the subspecies of the Bahamian nuthatch
Marine ecosystems	Physical damage to coral reefs Accumulation of sediment and rubble, which is unstable and less suitable for coral settlement
Water resources	Potential long-term impact to access to clean water because of damaged forests and greenspaces Expected contamination of fresh-ground water resources by residuals (testing still on-going)
Others	Economic losses in coastal properties from damage to mangroves, seagrass and beaches Expected loss of eco-tourism revenue resulting from damage to dive shops and boats, coral reefs, commercial and recreational fish habitat, forest habitat for birds and endangered species, etc.

Source: Assessment team, 2019 observations and information from preliminary assessments and interviews

TABLE 74. ENVIRONMENTAL: DAMAGE, LOSSES, ADDITIONAL COSTS

	Damage	Losses	Additional costs
Grand Bahama	1,160,781	2,182,688	99,795,000[1]
Abaco	945,483	3,275,130	2,678,000
Marine transboundary areas	5,040,699	21,977,230	
Total	$7,146,963	$27,435,048	$102,473.000

Source: Assessment team, 2019

[1] $94.9 million in Additional costs are private costs.

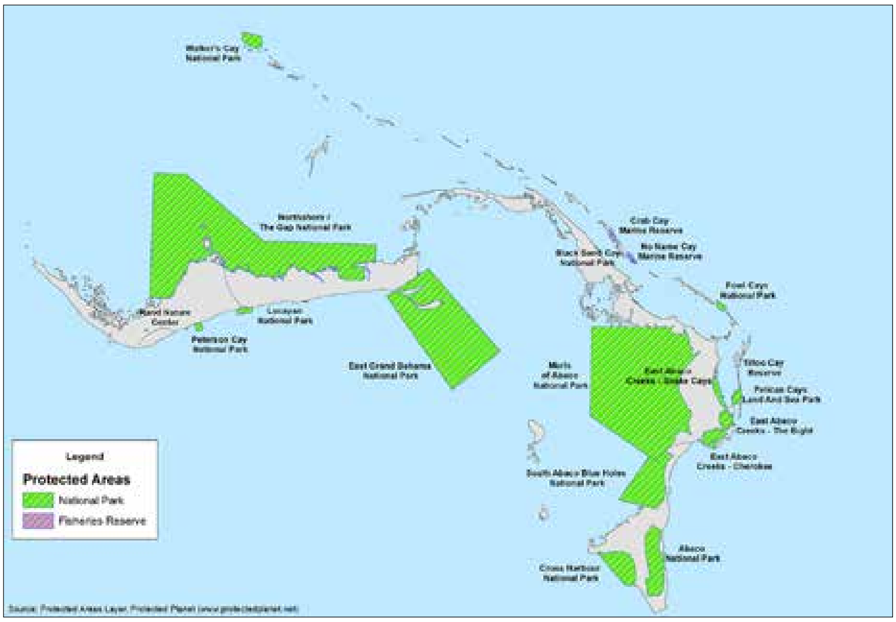
BASELINE INFORMATION

Baseline information on ecosystems of The Bahamas has long been collected by non-government organizations (NGOs), academic institutions and the government. Most of these studies focused on protected areas or localized groups of islands, as they are sources of interest and revenue for tourism and operators. Although some of these studies have adopted an ecosystem services valuation approach, as observed in other locations across the Caribbean, many natural resources in The Bahamas are still only valued and studied for their contributions as commodities, which poses a challenge for the proper economic valuation of losses.

The islands in The Bahamas have been historically divided according to the vegetation type. Northern Bahamas pine forests are found on Abaco, Andros, and Grand Bahama; Central Bahamas broadleaf hardwood forests, commonly known as coppice, including mahogany and brasiletto are found on islands such as Cat Island; and Southern Bahamas have drought-resistant woodlands (SENES Consultants Limited, 2005). Historically, forests were cut for timber to build boats and houses, for fuel wood, and particularly to clear land for cane cultivation until the 1970s. However, no large-scale commercial logging activity were observed or reported in the assessed areas.

The islands are typically flat with elevations of less than ten meters. A higher coastal ridge may occur, usually located along the exposed side of most islands. Islands of the southeast and central Bahamas are generally of higher elevation than the Northern Bahamas. The Bahamas may be classified as a marine tropical climate dominated by Atlantic southeast trade winds in the summer and cool dry North American high-pressure systems in winter. Most rainfall occurs during the warm summer months from May to October, but annual rainfall totals vary significantly due to the influence of tropical storms and hurricanes. Ninety percent of The Bahamas' freshwater lenses are within five feet of the land surface. Fresh groundwater as a resource is fragile and highly vulnerable to contamination and overexploitation (ICF Consulting/ US Army Corps of Engineers, 2004). Abaco and Grand Bahamas are home to several endemic species and national reserves as mapped in Figure 31 below.

FIGURE 31. MAP OF NATIONAL PARKS ON ABACO AND GRAND BAHAMA.



Source: Assessment team, 2019

ABACO

The Abaco group of islands is in the northern section of the Bahama Archipelago. Surrounding Great Abaco are several smaller islands known as cays, many of which are popular with tourists visiting the islands. Some of the native forest on Abaco has been previously cleared and human-altered. Still, Abaco is home to several national parks, including six official national parks and three under the auspices of BNT and others that have not been designated yet. Combined they protect an area of approximately 122,787 hectares of marine and terrestrial environment.

Crawfish, queen conch and scalefish are the three main fisheries in the affected islands, and are significant contributors of such species to the Bahamas fisheries economy. Mangroves, wetlands, and seagrass provide critical nursery habitat for different land and sea species of The Bahamas. The pine forest on Abaco National Park is the major habitat of the Bahama parrot. Additionally, there are four endemic bird species of The Bahamas found on Abaco: swallow, warbler, woodstar hummingbird, and yellowthroat.

Abaco Island possesses good freshwater resources from the Lucayan limestone aquifer lenses. Very large to large quantities of water are available from four relatively large freshwater lenses: Normans Castle, Marsh Harbour – Lake City, Lake City – Crossing Rocks, and Crossing Rocks – Hole in the Water (ICF Consulting/ US Army Corps of Engineers, 2004).

An ecosystem service valuation of two protected areas on Abaco - East Abaco Creeks (Snake Cay, Bight of Old Robinson, Cherokee Sound) and Cross Harbour - was carried out in 2013 and is used as the main source for baseline information and valuation of resources (T. Clavelle and Z. Jylkka., 2013).

GRAND BAHAMA

Grand Bahama is the fourth largest island in area in The Bahamas, around 530 square miles, situated in the most northwestern portion of the archipelago. Being the closest to Florida, it is an important tourist destination and is home to the second largest city in The Bahamas, Freeport. The island has vast beaches, extensive cave systems, wetlands and both pine and coppice forest (BNT). It is home to three national parks under BNT, and other non-designated protected areas that comprise approximately 144,672 hectares of marine and terrestrial environment.

Lucayan National Park is internationally recognized as an Important Bird Area (IBA), supporting three restricted range birds; the Thick-billed vireo (Vireo crassirostris), Bahama swallow (Tachycineta cyaneovifidis) and the Olive-capped warbler (Dendroica piyophila). The park contains two sinkholes that open into large limestone caverns which are part of one of the largest underwater cave systems in the world with over six miles of tunnels charted. Peterson Cay comprises extensive seagrass beds, fringed reefs, patch reefs, sandy bottom, and seabird nesting habitats. The Rand Nature Centre comprises foot trails through pine barrens, native and exotic coppice, and a freshwater watchable wildlife pond and a native plant arboretum and an education center that houses an exhibit room and art gallery (BNT).

Second only to Andros Island, Grand Bahama has the most extensive and plentiful ground water reserves of the Bahamian islands. Large to enormous quantities of freshwater are available from limestone lenses on Grand Bahama, and the water table is between 0 to 6 m (0 to 20 ft) of the surface (ICF Consulting/ US Army Corps of Engineers, 2004). It was reported to the Assessment team that Freeport usually has good quality potable water from these natural sources.

To this date, no valuation of ecosystem services has been carried out on Grand Bahama, therefore, considering the similarities between the ecosystems in the two islands, Abaco valuation will be used for reference value.

DAMAGE

The damage to Bahama's natural habitats has been identified as sustaining varying levels of impact ranging from moderate to severe depending on the habitat type, location within, or proximity to the swath of Hurricane Dorian. Assessing the damage in ecosystems at this stage is challenging, since most of the post-hurricane surveys are still ongoing and baseline data is limited.

The damage estimations rely on the publication by Bayraktarov et al., 2016, which compiles on the costs of restoration projects around the world for coral reefs, seagrass, mangroves, saltmarshes and oyster reefs. Estimates are provided for the United States, developed countries, and developing countries.

Damage in the environmental sector is estimated at $7.1 million (Table 75), with damage sustained in the infrastructure of protected areas and monitoring equipment, coral reefs, water resources, mangroves, seagrass and forests. The most visible effects were debris from collapsed infrastructure, erosion in the coastline and defoliation and uprooting of trees. The damage to different assets was estimated considering restoration costs based on available studies. No damage to the private sector was assessed at this stage.

TABLE 75. ENVIRONMENTAL SECTOR: DAMAGE

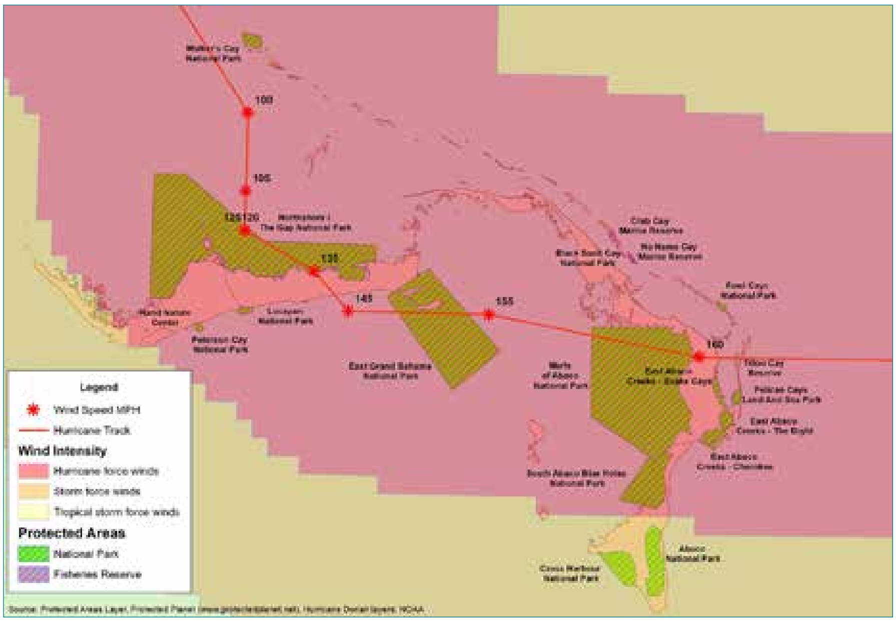
Damage	Public
Grand Bahama	
Monitoring equipment	1,000,000
Mangrove restoration	82,031
Coastal areas restoration (Gold Rock Beech)	78,750
Total Grand Bahama	$1,160,781
Abaco	
Seagrass restoration	742,237
Mangrove restoration	203,246
Total Abaco	$945,483
Marine transboundary areas	
Coral reefs restoration	5,040,699
Total transboundary areas	5,040,699
Total	$7,146,934

Source: Assessment team, 2019

NATIONAL RESERVES AND NON-PROTECTED AREAS

A complete assessment of national reserves has not been concluded yet on either island. Preliminary assessments by park staff have reported extensive damage to both parks' vegetation and infrastructure. Considering the hurricane trajectory and wind force in relation to the location of national parks, moderate to severe damage can be expected in nearly all national parks on both islands (Figure 32).

FIGURE 32. NATIONAL PARKS AND HURRICANE DORIAN TRAJECTORY



Source: Assessment team, 2019

Extensive damage has been verified and reported in Lucayan National Park on Grand Bahama. Reported damage includes one pavilion and boardwalk, two vehicles and the contents of one office. The coastal landscape has also been reengineered in Lucayan National Park due to severe sand loss in Gold Rock Beach. Recent rehabilitation of sand dunes before the hurricane damage was already estimated at $63 thousand, which is expected now to increase. The park charges a small fee for visitors but has remained officially closed a month after the hurricane. The park is one of the main attractions on the island, therefore its recovery is considered vital for bringing tourists back to the island (Figure 33).

Rand Nature Center, the home base of Bahama National Trust, has also suffered minor infrastructure damage with some leakage reported in the building. The main office complex houses natural history exhibits, an art gallery and gift shop which was left structurally intact but experienced about three feet of flooding during the storm with loss of furniture, appliances and other contents. Park trails have also been blocked by fallen trees and debris. Trees in the native arboretum need to be replaced and the pergola that connects the pond and arboretum requires rebuilding. Abaco National Park has sustained minor damage according to preliminary reports, but a full assessment has not been carried out as local staff were affected and had to relocate.

FIGURE 33. DAMAGE IN NATIONAL RESERVES ON ABACO (1) AND GRAND BAHAMA (2, 3)

Source: BNT website

Considering that the national reserves comprise terrestrial and maritime areas that have been not fully accessed yet, the estimation of the damaged area is based on a conservative percent of the extended area affected by hurricane winds according to satellite imagery and the hurricane path. Impact has been graded as severe, moderate and minimal.

TABLE 76. GRAND BAHAMA: PROJECTED DAMAGE TO THE NATIONAL RESERVES (SQUARE METERS)

Reserves	Extension	Estimated damaged area
Rand Nature Centre	397,943	37,805
Peterson Cay National Park	4,412,479	419,185
East Grand Bahama National Park	487,436,716	60,929,590
Northshore/ The gap National Park	946,637,452	118,329,681
Lucayan National Park	7,838,031	979,754
Total	1,446,722,620	180,696,014

Source: Assessment team, 2019

TABLE 77. ABACO: PROJECTED EXTENSION OF DAMAGE TO THE NATIONAL RESERVES

Reserves	Extension	Estimated damaged area
Abaco national park	85,093,545	4,254,677
Walkers' Cay National Park	18,732,200	1,779,559
Pelican Cay Land and Sea Park	8,725,992	828,969
Fowls Cay National Park	4,997,897	474,800
Tilloo Cay Reserve	40,264	3,825
Cross Harbour National Park	61,438,980	3,071,949
Marls of Abaco National Park	866,421,102	108,302,638
East Abaco Creeks - The Bight	16,437,706	1,561,582
East Abaco Creeks – Cherokee	23,882,833	2,268,869
East Abaco Creeks - Snake Cays	13,277,886	1,659,736
South Abaco Blue Holes National Park	128,822,879	12,238,174
Black Sound Cay National Reserve	5,721	543
Total	1,227,877,004	136,445,321

Source: Assessment team, 2019

In the field visit to Grand Bahama it was observed that many trees were uprooted or broken. Remaining trees have been partially to totally defoliated (see Figure 34). Pines have proven to be very sensitive to wind damage and storm surge. Although they might show no immediate visible damage after high winds, they can die slowly over a period of six months to two years after the event. Broad-leaved forests had already started to appear to regenerate on Abaco (Figure 35).

FIGURE 34. STATUS OF PINE FOREST ON GRAND BAHAMA

Source: Assessment team, 2019

FIGURE 35. STATUS OF PINE FOREST ON ABACO

Source: Assessment team, 2019

In non-protected areas like Crown Land on Abaco initial findings estimate that 39 thousand acres of forest have been impacted, with moderate to severe damage. On Grand Bahama, especially East End, 55 thousand acres of forest have been damaged and more than fifteen thousand acres on eastern cays. An overall estimate of 109 thousand acres of forests in public lands have sustained damage. There are no formal primary forest industries in The Bahamas since forest exploitation ceased in the late 1970s, therefore, forests will be valued by the loss in ecosystem services they provide and not as terms of market value of lost timber.

During a field visit to Eastern Grand Bahama, several points of fire were observed. Some in the proximity of the road, which suggests that they might have been started by human activity, while others were found further inside the pine forest, which suggests natural combustion. Anticipatory measures for forest fire control have been taken in preparation for the dry season (Figure 36).

FIGURE 36. FOREST FIRES OBSERVED ON GRAND BAHAMA

Source: Assessment team, 2019

WETLANDS (MANGROVES / SEAGRASS)

Serious mangrove and seagrass damage is expected on both islands, but especially on Grand Bahama, where the health of the mangrove was already compromised by invasive species. Estimations of damage in these areas range from moderate to severe based on preliminary reports.

There has been no survey or ground-truthing activities related to mangroves in this report. For the purpose of this report, the assumption was made based on satellite images and the hurricane path. Over 28 thousand hectares covered by dense and sparse mangrove, which experienced hurricane force winds, was moderately to severely damaged. For the purpose of this report, the assumption was made that five percent of the impacted area was damaged to the point where recuperation is unlikely. Costs associated with mangrove restoration average $202 per acre. Considering the natural regeneration processes in most of the affected area and an active restoration of five percent, the damage is estimated to be $285 thousand (Table 78).

TABLE 78. ESTIMATED DAMAGE TO MANGROVES

	Area of expected moderate to severe impact (ha)	Damage
Abaco	20,123	203,246
Grand Bahamas	8,121	82,031
Total	28,245	$285,277

Source: Assessment team, 2019

Damage estimates to submerged aquatic vegetation (SAV) are unknown at this time, as there have been no official reports of damage and very little anecdotal evidence of the extent of damage occurred at this stage. SAV can be damaged by hurricanes, intense wave energy, and by significant sediment deposits Although no survey has been carried out at this stage, it is unlikely that there were zero impacts on the SAV beds. Based on satellite imagery and the hurricane path, the area of seagrass impacted by hurricane force wind is estimated to be to over 452 thousand hectares. Typically, damage to SAV will result in reduced catch of lobster and conch in the upcoming years, since larvae of these species depend on SAV for a nursery habitat. Seagrass and coral restoration projects are among the most expensive type of marine habitat restoration activities, and seagrass restoration has a low success rate as studied in many projects (Bayraktarov et al., 2016). It is possible that the damaged SAV will recover within 3-5 years without any human enhancement or intervention. However, to not ignore any potential damage to SAV, this report is assuming that an area equivalent to five percent of Fowl Cays National Park, the location of the most seagrass beds on Abaco, will be actively recovered totaling a little over $742 thousand. The cost of restoration is based on the most cost-effective seagrass restoration project reported in the research, which involves the transplantation of seagrass cores or plugs ($29.749/ha).

COASTAL AREAS

Significant loss of sand at beaches on Grand Bahama and Abaco has been reported but not yet quantified. Improper construction observed near sand dunes may have exacerbated the erosion and loss of protective buffer between the ocean, and the inland areas and may suffer delayed recovery from storm damage.

Based on the reported damage on Gold Rock Beach on Grand Bahama and the estimated value of recovery of the sand dunes before the hurricane with a 25 percent increase in price, the estimated damage in this area is over $78 thousand in sand fill. This is the minimum value, considering the recuperation of only a single beach.

WILDLIFE (NON-COMMERCIAL SPECIES)

Birds and turtles in the Bahamas depend on various marine and terrestrial habitats for nesting, reproducing and feeding. Specifically, many bird species utilize mangroves as rookeries, and use coral reefs, broadleaf forests and beaches for feeding and nesting.

The cumulative effects of the damage to these habitat types, and the associated impacts to bird species are extremely difficult to estimate given the lack of baseline data that exists at this time. The post-hurricane situation needs to be further evaluated. Preliminary reports fear that some species may have become extinct or brought close to extinction, specifically the Bahamian nuthatch, already considered an endangered species. Sea turtles depend on areas above mean-high water, in mostly unlit, unobstructed sandy beaches for nesting. Beach erosion and buildup of debris from storm surge is expected to affect the nesting habitat of sea turtles and may require preventive measures.

DOMESTIC ANIMALS

Hurricane Dorian forced many residents on Abaco and Grand Bahama to evacuate at short notice, leaving their pets behind. Moreover, for health reasons, many emergency shelters cannot accept animals. A lot of these animals were killed by the storm or trapped inside homes for weeks. The Assessment team did not get quantitative information about this issue. Government guidelines on how to deal with domestic animals in preparation for a disaster would be helpful. For example, recommending the usage of ID tags, opening temporary boarding facilities and advising owners to confine pets to a safe area with plenty of food and water and not chain them up, or placing notices outside the house advising where the animal is located to facilitate rescue.

CORAL REEFS

Reefs can immediately start to recover through the regeneration of surviving corals, attachment and growth of viable coral fragments, and from the colonization of new substrate (which could include those areas afflicted by the hurricane). The vulnerability of colonies to hurricane forces is a function of their shape, strength of their skeletons and anchor positions, as well as their orientation, so it can vary from destruction to no effects.

Preliminary reports expect moderate to extensive damage to coral reef and coral nurseries. Good baseline data has been collected by BNT in collaboration with the Perry Institute for Marine Science (PIMS) on the coral reefs at 70 different sites around Grand Bahama and Abaco, which may be used to guide future recovery efforts and analyze long term impacts and recovery. The Perry Institute for Marine Science has also begun conducting post-hurricane surveys on sites on Grand Bahama and the Abaco islands, but the results have not been made available at this stage.

For the purpose of this report, the assumption was made based on satellite image and the hurricane path that about 93 thousand hectares covered by shallow reef which experienced hurricane force winds were moderately to severely impacted. Considering the natural regeneration processes of most of the area and an active restoration of 0.5 percent of potentially affected area the damage is estimated in approximately $5 million (Table 79). Private damage has also been reported to the infrastructure and activities of coral farms, but not yet quantified.

TABLE 79. DAMAGE TO CORAL REEFS

	Area of expected moderate to severe impact (ha)	Restoration costs ($- per ha)	Damage
Coastal areas	92,907	10,851	$5,040,699

Source: Assessment team, 2019

WATER RESOURCES

Severe weather is a very significant agent of pollution, especially in combination with anthropogenic sources such as solid waste, sewerage, agriculture, and coastal tourism. As previously stated, more than 90 percent of all freshwater resources in The Bahamas are to be found within 1.5 meters of the surface. Past hurricanes have shown significant effects due to coastal inundation by sea water in the form of storm surges, localized flooding due to heavy precipitation, and the possibility for contamination of soil and ground water due to sewerage, petroleum products, pesticides, and other substances not secured or stored.

Although no current assessment of ground water resources has been carried out at this time, damage to freshwater lenses were reported after Hurricane Floyd, Frances, and Jeanne, and are expected to be reported from Hurricane Dorian. Contamination of the aquifer by sewerage due to flooding and storm surge can be assumed, but further testing is necessary to determine the scope.

The potential contamination of already fragile freshwater lenses may require larger environmental restoration investments and will result in longer recovery periods.

MONITORING EQUIPMENT

Hurricane Dorian resulted in the destruction of Atmospheric Observation instruments (AO systems) and synoptic instruments on Grand Bahama to an approximate cost of $1 million, as reported by The Bahamas Department of Meteorology. This equipment is usually replaced by the World Meteorological Organization at no cost for the country, as they are required to be kept in place to collect data during the event. The meteorology office on Grand Bahama has also been compromised and a trailer will be used in the meantime until a new space is organized. The loss of this equipment and office space sharpen the deficient condition of the hydrometeorological surveillance networks, substantially reducing the capacity to monitor threats.

LOSSES

Ecosystems in The Bahamas have endured tropical storm damage over thousands of years. The effects of Hurricane Dorian on these ecosystems are largely unknown, but it is noteworthy to consider the contribution of ecosystem services to the Bahamian economy. To name a few examples, mangroves and seagrass are important habitats for commercial species including lobster, conch, grouper, and other scalefish. Ecosystems within the existing marine protected areas (MPA) network in the Bahamas are valued in more than $23.5 million annually as nursery habitats for spiny lobster. Mangroves and seagrass within the MPA network also store 400 million tons of carbon, worth $5 billion in avoided emissions globally. Coral reefs dissipate wave and storm surge, help to filter water and assimilate CO_2, and are also one of the main local attractions. Pine forests provide a range of market services (timber and non-timber forest products) and non-market services (landscape, carbon sequestration, watershed protection, protection of soil erosion and biodiversity). In addition, ecosystems in the network reduce the risk of coastal hazards like flooding associated with hurricanes to nearly 40,000 people living along the coastline throughout the country, saving $806 million in annual income by reducing damage from storm events. (BNT, 2018).

According to the Millennium Ecosystem Assessment (Reid et al., 2005), an ecosystem service is defined as any benefit that humans derive from an ecosystem. It can be divided into four categories: provisioning services (water, food and forest products), regulatory services (climate regulation, moderation of extreme weather events, erosion prevention, maintenance of soil fertility), cultural services (aesthetic, spiritual or recreational benefits) and services support (the nutrient cycle, photosynthesis). Assigning value to ecosystem services require the collection and analysis of a significant amount of monitoring and observation data over an extended period. Ecosystem losses are a result of the interruption or decrease in the services resulting from damage to the ecosystem that will require an extended recovery time. Ecosystem service losses will be related to a temporary decrease in provisioning, regulatory cultural and support services based on the assessed values of these services to the economy of The Bahamas.

In this report, the value for the ecosystem services was calculated using the Ecosystem Service Valuation of Proposed Protected Areas on Abaco (T. Clavelle and Z. Jylkka., 2013). Due to the lack of specific studies the same values were extended to Grand Bahama. This approach has its limitations and may lead to underestimation, as economic values of ecosystem services vary spatially with differences in ecological, social, and economic factors. The average value of the ecosystem service was multiplied by a fraction of the total affected area (5 percent), considering the rate of natural recovery and to avoid duplication of services already calculated in other sectors, totaling losses of over $27 million.

TABLE 80. LOSSES: ECOSYSTEM SERVICES

Ecosystem Service	$/ha/yr	Losses
	Grand Bahama	
Mangrove	2,692	1,093,087
Pine Forest	718	1,089,601
Eco. services losses on Grand Bahama		2,182,688
	Abaco	
Mangrove	2,692	2,708,556
Pine Forest	718	566,574
Eco. services losses on Abaco		
	Marine transboundary areas	
Seagrass	820	18,553,607
Coral Reef	737	3,423,623
Eco. services losses in transboundary areas		21,977,230
Total expected losses in ecosystem services		$27,435,047

Source: Assessment team, 2019

ADDITIONAL COSTS

Additional costs related to Hurricane Dorian on Abaco and Grand Bahama is substantial, nearing $96 million. This considers the costs associated with debris removal, fire control measures, the management of the oil spill and price of future necessary, more detailed technical assessments of damage to existing ecosystems.

DEBRIS REMOVAL

The total amount of debris might be roughly estimated at 2 million cubic meters. It is not clear whether these initial estimates already consider the green waste generated. Contracts for cleanup on a time/material/equipment basis have been granted, but no invoice has been submitted at the final date of this report. Private citizens have been requested to place rubble in common areas to facilitate the collection by government. The material will be sorted and the Ministry of Housing and Environmental will be responsible for disposing the material. Five dump sites have been identified. Several boats and cars sank on both islands. The costs of salvaging vessels and vehicles is evaluated in the tourism sector.

Considering a conservative estimation of 20m3 of wood per hectare in the affected areas, the cost of transportation, disposal of organic waste, and the parameters already established of $200 per approximately 13 cubic yards truckload, without considering the management of the landfill, Table 81 shows the costs related to organic debris removal are $6.8 million.

TABLE 81. ORGANIC DEBRIS REMOVAL: COST

Island	Y3	Truckloads	Cost of Trucks per load	Estimated Cost
Abaco	157,820	12,140	200	2,428,000
Grand Bahama	283,270	21,790	200	4,358,000
Totals				$6,786,000

Source: Assessment team, 2019

The large amount of debris generated will shorten the expected lifetime of the existing landfills, imposing costs for the future. New landfills should follow strict management procedures to avoid environmental risk of contamination of aquifers.

FIRE CONTROL MEASURES

The Bahamian pineyards are fire-maintained, meaning they depend on a specific fire regime for their persistence and characteristics. On the other hand, coppice vegetation usually occurs in areas that are protected from fire (Nature Conservancy 2004). Wildfires tend to become widespread during the dry season, which runs from November through April. The large quantity of dry wood resulting from damage to the trees in the area poses a high fire hazard. During the field visits to Eastern Grand Bahama, small fire outbreaks have been observed and the smoke resulting from fires has reported to reach Florida. Removal of materials, issuance of temporary logging permits, prescribed burning and reinforcement of firebreaks along the roads and other measures for fire control, especially around the oil spill area as Lucayan National Park is in its proximity, are urgent measures to be considered. Costs associated with fire control measure on Grand Bahama are based on previous assessment done in the Bahamas and listed in Table 82 below.

TABLE 82. GRAND BAHAMA: FIRE CONTROL MEASURES

Measure	Estimated price
Fire Control Equipment	75,000
Fire Activities	150,000
Total	$225,000

Source: Assessment team, 2019

OIL SPILL MANAGEMENT

The oil spill in the Norwegian-based Equinor South Riding oil terminal on Grand Bahama is an issue of great concern (Figure 37). A National Oil Spill Contingency Advisory Committee, consisting of a cross-section of industry stakeholders, has been appointed to address the issue. The committee is supposed to conduct site visits and convey meetings every fortnight to closely monitor the area. More than 250 people and large equipment are engaged in oil recovery efforts, including nine vessels.

FIGURE 37. GRAND BAHAMA – OIL SPILL AT EQUINOR SOUTH RIDING OIL TERMINAL

Source: Assessment team, 2019

The costs associated with cleaning up an oil spill are influenced by the circumstances surrounding the spill, including the type of product spilled, the location and length of the spill, sensitive areas affected or threatened, liability limits in place, local and national laws and cleanup strategy. A study on the average costs of oil-spill cleanup in the US in 2010 was approximately $19 per gallon as a 2019 equivalent (Cohen 2010/ Ethikin 2004).

The initial estimated volume of the oil spill at the South Riding Point terminal after the impact of Hurricane Dorian is 119 thousand barrels or around six percent of the total 1.88 million barrels stored, which puts a conservative estimate of the total cost as $94 million. According to the company information around 30 percent of this has already been recovered and the clean-up continues.

This estimate, however, reflects only the immediate remediation activities, which includes containment and recovery of the spilled fuel and oil. It does not account for total remediation, monitoring, and addressing the longer-term implications of chronic oil spills such as polluted soil and groundwater, storm water runoff, and damage to adjacent marine habitats including sandy shorelines, coral and other public and private facilities adjacent to the affected area. Per satellite image, the oil spill affected an estimated minimum area of 39 hectares of coppice and pine forest, which is accounted for in the overall losses (Figure 38).

FIGURE 38. GRAND BAHAMA – OIL SPILL (AREA: 398,537 SQM)

Source: Image Owner: dtindle.dhhc

FUTURE ASSESSMENTS

In meetings with government officials it was mentioned that future environmental assessments will be required. Preliminary estimations put the costs of such assessment as $500 thousand for both islands, not including water analysis. These assessments will help direct further studies and restoration project potential for The Bahamas. Overtime for employees working on emergency support from The Ministry of Environment and Housing has not been estimated yet and should also be included as Additional costs.

TABLE 83. ENVIRONMENTAL SECTOR: ADDITIONAL COSTS

Additional costs	Public	Private	Total
Grand Bahama			
Fire Control	225,000		
Comprehensive environmental assessment	250,000		
Organic debris	4,358,000		
Management of oil spill		94,962,000	
Total Grand Bahama	4,833,000	94,962,000	99,795,000
Abaco			
Comprehensive environmental assessment	250,000		
Organic debris	2,428,000		
Total Abaco	2,678,000		
Overall cost			$102,473,000

Source: Assessment team, 2019

MACROECONOMIC IMPACT

INTRODUCTION

The Bahamian economy improved its recovery in 2018 with growth firming to 1.6 percent compared with 0.1 percent in 2017. Growth was driven mainly by the strong performance of the tourism sector, as it was mentioned in the Tourism sector chapter. The Bahamas recorded the largest increase in visitor arrivals in eight years, largely supported by small and medium-sized construction projects financed by foreign direct investment (FDI). It is worthy to mention that 2018 was the first year since 2014 that the country was not affected by any disaster.

Activity in the offshore financial services sector remained stable as the authorities continued to adjust to increased international regulation that has contributed to some consolidation in the sector. Inflation picked up to 2.0 percent in 2018, from 1.8 percent the year before, on the heels of the increase in the value added tax (VAT) rate and in international fuel prices. An increase in employment was offset by the growth of the labor force, so that the rate of unemployment rose to 10.4 percent in 2018, up from 10 percent in 2017.

In 2019, the Bahamas economy was expected to grow by 1.9 percent. The estimated impact of Hurricane Dorian is one percentage point of GDP. This implies that post-disaster, the economy is expected to grow 0.9 percent. This will result in a decrease in salaries of $51.3 million and capital income of $60.9 million. The situation is different when we focus on local economic activity. In the case of Abaco, the impact was estimated at 7.3 percent of its GDP. As a result, the island saw a 47 percent and 60 percent decrease of the country's remuneration and capital, respectively. On Grand Bahama, the impact was 2.0 percent of its GDP.

ECONOMIC ACTIVITY AND REMUNERATIONS

BASELINE SCENARIO

Before Hurricane Dorian, the expectations for the performance of The Bahamas' economy were positive. Tourism and construction were the key leading sectors on that dynamic. In the first eight months of the year, tourism activity continued to grow, driven by demand from the United States and additional room capacity. The high value-added stopover-tourism segment was expected to continue to recover, producing a positive multiplier effect on distribution, transportation and other sectors. This will be further supported by growth in cruise tourist arrivals. Construction is bolstered by varied-scale projects, including the development at The Pointe and the cruise port being built by the Carnival Cruise Line on Grand Bahama.

As a first step to estimate the impact of the disaster on the GDP, a baseline scenario of the sector GDP for 2019 is constructed, both at current prices and constant prices. For this, the total GDP expanded with the expected growth rate for 2019. In the absence of more specific information, the 1.9 percent was distributed among the sectors according to their shares in the Gross Value Added (GVA) of 2018. In the case of prices, the deflators of each activity for the year 2019 were estimated using the simple average of its evolution during 2017 and 2018.

The second stage of the procedure consists of transforming the losses obtained in each sector to aggregate values. In the case of Additional costs, two considerations have to be made; first, that the Additional costs imply an increase in the intermediate consumption (IC) of the sector affected by the disaster; and secondly, the Additional costs imply an increase in the production of the sector that sells the service. All this is done using the Supply and Use Table (SUT). In the specific case of this exercise, we use the most recent one published in 2012 by the Bahamas Department of Statistics of the Bahamas. By multiplying the estimated losses for each activity by the technical coefficients of SUT, it is possible to obtain the lost GAV for each of the activities (and over the total GDP for the year 2019, expressed at current prices), less the salary and lost capital income due to the disaster of each of the affected sectors.

The SUT describes the components of gross production (GP[21]) of a country by economic activity: IC and GAV[22], as well as its breakdown in remuneration of employees (Re), other net taxes on production subsidies (To), mixed net income (MY), Capital Income (KI) and fixed capital consumption (FCC).

The third stage consists of subtracting each activity, the lost GVA, and the increase in the IC from the GDP, and adding the Additional costs incurred to deal with the emergency. The result is post-disaster GDP. The only sector that we did not include in this estimation was Environment, because it is not in the national accounts.

Given the magnitude of the disaster and that Abaco and Grand Bahama were the islands directly affected by the storm, it was considered pertinent to estimate the economic impacts on their GDP.

IMPACT ON ECONOMIC ACTIVITY

GDP growth of 0.9 percent is expected instead of 1.9 percent as projected before the event. This estimate was made considering only the sectors evaluated in this report and under a moderate response scenario. As a result of the disaster, salaries of $51.3 million and capital revenues of $60.9 million will be lost. With regard to remuneration, we do not have disaggregated data on employment, but given the effects of the disaster in the tourism sector, where many of the employees are women, we suggest that in the compensation policies that are implemented, special attention should be given to women heads of households that stopped receiving any form of remuneration.

Unemployment is expected to rise to 13.5 percent for the remainder of 2019 through 2020. This short-term setback is related to the severity of the destruction to The Abaco tourism and business infrastructure, as well as Grand Bahama, even though to a lesser extent.

With respect to the economic activity of Abaco and Grand Bahama, the estimated impact on their GDP is -7.3 percent and -2.0 percent, respectively. In the case of Abaco, the result is a consequence of almost null economic activity during the last four months of the year. Estimates are an indicative exercise seeking to highlight the local dimension of the disaster, which may require allocating greater financial resources to the Department of Statistics to calculate and publish annually the GDP for all the major islands of The Bahamas.

FISCAL IMPACT

Fiscal policy was contractionary in 2018, as the government implemented spending containment measures to facilitate the orderly reduction of public debt. The deficit declined from 5.6 percent of GDP in fiscal year 2016/17 to 3.4 percent in fiscal year 2017/18, although this still exceeded the budgeted target of 2.6 percent of GDP. The reduction in the deficit resulted from cuts in both capital and current expenditure, as government prioritized fiscal consolidation. Capital spending

21 GP = IC+GAV
22 GAV= Re + To + MY + KI + FCC

contracted by 31.1 percent, reflecting a near halving of spending on infrastructure, which returned to trend following exceptional outlays for post-hurricane Irma rehabilitation in 2017. Meanwhile, current expenditure fell by 6.8 percent, representing 17.9 percent of GDP, with a sharp fall in spending on goods and services, which normalized after hurricane-related outlays in 2017. By contrast, spending on wages and salaries rose by 2.0 percent, partly reflecting arrears payments.

Total revenue contracted marginally, by 1.4 percent, owing largely to declines of 0.3 percent and 10.4 percent in taxes and non-tax revenues. Proceeds from taxes on international trade fell due to lower receipts from excise and import taxes. This was only partly offset by an increase of 6.6 percent, or $42.3 million, in VAT revenues. The decline in non-tax revenues, to $200.6 million, was due to a 50 percent fall in income from dividends and other sources.

Public sector debt edged up to 66.2 percent of GDP, from 64.9 percent in 2017. Central government debt rose by 4.4 percent. The debt of public corporations increased by 4.2 percent, reflecting government guarantees for loans extended to two utility companies.

During fiscal year 2018/19, the government implemented key measures to entrench fiscal consolidation, including an increase in the VAT rate from 7.5 percent to 12.0 percent and the enactment of the Fiscal Responsibility Act in October 2018. At the end of fiscal year 2018/19, the primary balance was positive for the first time in more than a decade, 0.9 percent of GDP and the central government deficit was 1.8 percent of GDP.

In the short term, Hurricane Dorian implies a fall in tax revenues and an increase in fiscal expenses to deal with the emergency and to initiate the reconstruction effort. In relation to the former, the Ministry of Finance estimated that these would fall by approximately $168 million. In relation to the latter, as it is explained below, these could be financed with the payment of CCRIF SPC and with the IDB contingent line. Important to note that, the funds of this contingent line must be spent in the six months following the disaster.

The mixture of the fall in tax revenues with the increase in expenses makes it difficult for the government to continue reducing the fiscal deficit that it had in fiscal year 18/19 which was partially possible because in 2018 the government incurred no concurrent expenses from a disaster. The central government fiscal deficit is expected to reach 5.9 percent of GDP for the fiscal year 2019/20. The primary balance is expected to be -2.9 percent of GDP. The central government debt-to-GDP ratio is expected to increase by four percentage points, to 66 percent of GDP in fiscal year 2019/20.

Unlike the previous disasters caused by Hurricane Joaquin (2015), Matthew (2016) and Irma (2017), in 2019 The Bahamas has two financial instruments that allow financing the needs of the emergency response without affecting the fiscal accounts. These instruments are:

a. IDB´s Contingent Credit Facility. On September 3, the Ministry of Finance of The Bahamas requested IDB to verify the eligibility of Hurricane Dorian for disbursements from their Contingent Loan for Natural Disaster Emergencies (BH-O0003), signed in April 2019. Based on information obtained from the National Oceanic and Atmospheric Administration (NOAA), both the track and wind swath of Hurricane Dorian were analyzed to determine the event eligibility and its impact on The Bahamas. Based on the analysis performed, in accordance with the methodology established in the Terms and Conditions of Coverage included in the Operating Regulations for Loan BH-O0003, the IDB determined Hurricane Dorian was eligible event for a disbursement of resources from the loan and the maximum amount to be made available for disbursement is US$100 million (total coverage provided by the loan).

b. Parametric insurance. The Bahamas has three tropical cyclone policies and three excess rainfall policies with the (Caribbean Catastrophic Insurance Facility Segregated Portfolio Company (CCRIF SPC) – each covering a section or zone of the archipelago: North West, South East and Central.

On 11 September, the government of The Bahamas requested the disbursement of a first installment of US$25 million which was made available by IDB on 13 September. The government of The Bahamas announced that these resources will be allocated primarily to public utilities as well as immediate emergency relief.

On Tuesday, 17 September, an IDB mission landed in The Bahamas to work with IDB country representatives and the government on the allocation of CCF resources. The Ministry of Finance, NEMA and other sectorial ministries have presented requests with specific needs. During the last 3 weeks, IDB worked on assessing the country's overall necessities, verifying procedures, holding meetings with the Treasury Department and the Ministry of Finance and various entities. The main sectors and activities identified include supporting the Ministry of Public Works on the removal of debris, working with the electric companies– work that is being coordinated with IDB's Energy Team, providing the necessary resources and supporting the relevant entities in the assistance to victims, and supporting the activities of companies involved in water and sanitation – work that is being coordinated with IDB's WSA Team.

CCRIF has made two payouts to the government of The Bahamas totaling US$12.8 million in the aftermath of Hurricane Dorian. The government received US$11 million when its tropical cyclone policy was triggered and US$1.3 million from its excess rainfall policy for the North West zone, which includes Abaco Islands and Grand Bahama. CCRIF's payouts are normally made within 14 days of an event, but in this case, CCRIF made an advance payment of 50 percent of the preliminary estimated payout for tropical cyclone within seven days to allow the government to begin to address its most pressing needs. The remaining 50 percent was paid within the 14-day window for CCRIF payouts.

In addition to this $112 million, the country has received $7.9 million to date in cash donations. Also considered are donations in kind, both goods and labor force, by international cooperation institutions.

In relation to medium-term expenses, these will increase associated with the reconstruction effort on Abaco and Grand Bahama. The reconstruction financing should not be based on the total damage, but on the total damage of the public sector plus other areas that the government prioritizes. According to our estimate of damage, $2.5 billion, public sector assets are appximately $229 million.

The reconstruction process will have to be financed in several budgetary years and with assistance of funds provided by multilateral agencies. It is recommended to elaborate a multi-year reconstruction plan with clear objectives, responsibilities, communication and leadership channels, accountability measures, resources, and revision periods to assess progress and adjust activities.

PART II
RECOMMENDATIONS FOR A RESILIENT RECOVERY

INTRODUCTION

As observed through field visits and interviews, and considering the estimations of the DaLA Assessment team, Hurricane Dorian had greater consequences than Hurricanes Joaquin, Matthew and Irma. With that said reconstruction after major disasters is not something to be completed in a year and requires major investments in terms of time, as well as and financial and institutional resources. The complexities of such process must be kept in mind by policymakers and clearly communicated to the population, which is anxious for quick answers. In short, reconstruction is expected to be a long-term process, which tests the strength of a country's institutions. However, it is important that those directly affected by the disaster feel the presence and solidarity of the government throughout the process.

The recovery process takes place in two stages. The first involves attending to the affected population and seeking to restore the functionality of existing infrastructure and normalize productive activities. The second involves upgrading strategic infrastructure in accordance with a vision of local development that considers all aspects of disaster risk reduction. If the decision is made to undertake reconstruction, this should entail a master plan that sets out the criteria for the location and resilient reconstruction of the affected settlements and structures, and the economic viability criteria and social cost-benefit assessment of the territory affected by the event.

Lessons learned in Hurricane Dorian should serve as an impetus for further improvement. Data availability and information management among different government agencies are strengths in this process. Training and awareness campaigns are also fundamental. For example, storm surge is not a risk easily understood by the public, as small and moderate storm surges often happen and seldom lead to disaster. The need to rebuild across so many sectors of the economy and increased public interest present an important opportunity for the country to reconsider its development prospects to assure that long-term recovery and future growth is conducted in a resilient and sustainable way.

This section provides recommendations for the resilient reconstruction of the affected areas in the Bahamas. It builds upon the five pillars of the GFDRR as an organizational framework and considers the findings of the DALA team during its mission to the affected areas in October 2019. The recommendations provided herein are issue-specific and are intended to act as the seeds of ideas that can be further developed to inform future interventions in the country. They are based on the inputs of local stakeholders and the analysis of experts to the sectors under consideration: affected population, social, infrastructure, productive and the environment. These should be read as complementary recommendations to add to internal analysis made by local stakeholders. In that sense, even as the recommendations derive from the analysis of experts during the field visits, policy makers in each sector should undertake a more comprehensive assessment of the risk factors they face, the opportunities for reducing these risks, and means of managing the up-front cost of this risk mitigation. This assessment requires a multisector consultative process that should be framed in the context of a progressive national strategy to enhance resilience to natural hazards.

The GFDRR has been developed as an instrument that can inform countries about how to address this challenge. It provides a roadmap consisting of five cross-cutting pillars—risk identification, risk reduction, preparedness, financial protection, and resilient recovery—that can be applied in every sector (Table 84). Taken together, these pillars provide a framework that can apply not only to the recurring threat of tropical cyclones, but also to the country's long-term objectives of mitigating and adapting to the effects of climate change, including sea-level rise.

TABLE 84. PILLARS OF ACTION FOR DISASTER RISK REDUCTION

Pillar 1: Risk identification	Improved identification and understanding of disaster risks through building capacity for assessment and analysis.
Pillar 2: Risk reduction	Avoided creation of new risks and reduced risk consideration in policy and investment.
Pillar 3: Preparedness	Improved capacity to manage crises through developing forecasting and disaster management capacities.
Pillar 4: Financial protection	Increased financial resilience of governments, private sector and households through financial protection strategies.
Pillar 5: Resilient recovery	Quicker, more resilient recovery through support for reconstruction planning.

Source: GFDRR, 2012.

Table 85 summarizes the main recommendations for each pillar. It should be noted that many proposals are repeated throughout previous assessments, as many challenges remain unresolved. Beyond sector-specific recommendations, these issues remain relevant and should be addressed urgently:

I. Building code- Enforcement is the main persisting challenge; however, it is also important to establish revision periods and review it considering the damage profile caused by all assessed disasters in order to find adequate materials and methods that suit the characteristics of the islands. It is also suggested to analyze the pertinence of establishing special safety standards for public infrastructure. Training and sensitization of the population must accompany technical improvements.

II. Zoning- Absence or disregard of spatial planning strategies is the other main contributor to severe damage. It is recommended to develop these plans before any large-scale reconstruction projects take place. It is also an opportunity to consider relocation of settlements and agglomeration of communities to improve service delivery and optimize the use of public resources. Zoning strategies must consider location of businesses and touristic infrastructure. In addition, protection and recovery of ecosystems must be included in land use plans.

III. Data and information- Although some data gaps remain, the government of The Bahamas has improved the availability of sectoral data. It is recommended to improve sharing practices to take full advantage of it and avoid duplication of efforts. Better data would simplify DRM activities and allow sectoral leaders to make better decisions.

IV. Planning- In addition to spatial planning, the magnitude of the reconstruction efforts needed calls for a sober analysis of how to better use scarce financial, technical and institutional resources. Before undertaking reconstruction activities, it is recommended to carefully draw long term development plans that reimagine sustainable and resilient communities.

Hurricane Dorian caused unseen levels of destruction but now provides a great opportunity to reimagine SIDS communities. The Bahamas has an opportunity to reconfigure the setup of its communities and become a leader in resilient reconstruction.

TABLE 85. SUMMARY OF RECOMMENDATIONS BY PILLAR

Risk identification	Establish data management and sharing protocols to optimize access and use of data in times of disaster Establish action protocols with clear leadership roles, sectoral activities, and communication and accountability channels
Risk reduction	Enforce the application of the building code and incorporate revision periods Revise and adjust safety standards for essential infrastructure Identify adequate materials and construction methods Schedule and budget maintenance programs and post-disaster infrastructure revision drives Incorporate a DRM in public investments Elaborate zoning strategies Protect and promote healthy ecosystems as first defense mechanisms
Preparedness	Elaborate sectoral preparedness checklists and provide training Elaborate evacuation procedures Standardize shelter management and safety assessment Revise, upgrade and repair infrastructure prior to hurricane season Request private operators of public services and utilities to elaborate DRM plans
Financial protection	Elaborate a multi-year reconstruction plan with revision periods Consider mandatory insurance of public infrastructure, including utilities and other public services provided by private operators Allocate post-disaster sectoral funds for minor repairs Revise utilities tariffs to include DRM activities Request international financial organizations to include DRM considerations in credit lines and any other assistance provided
Resilient recovery	Ensure that all minor and major reconstruction efforts consider safe location; application of the building code; and use of adequate construction materials Avoid disbursement of public funds for works that could reproduce disaster risks, especially in the housing sector Empower communities and promote local networks as first action line Transition to decentralized utilities and boost the use of renewable energy, especially in the power, telecommunications and water and sanitation sectors Recover and promote healthy ecosystems as first defense mechanisms

Source: Assessment team, 2019

PILLAR 1: RISK IDENTIFICATION

Pillar 1 entails the development of a broadly understood societal recognition of disaster risk and the development of specialized institutional knowledge concerning the hazards, exposure, and vulnerabilities faced by the country and its territories. The process of risk identification focuses on two aspects. First, it considers the assessment of multiple hazards including their frequency, intensity and magnitude. Second, it identifies exposed infrastructure, services, communities and other elements, as well as their vulnerabilities. Identifying risks makes it possible for a country to foresee potential effects and impacts of a disaster on its society and economy. Implementations of programs for mapping, modelling and cross-institutional data sharing are needed to contribute to this process. Furthermore, it is necessary to implement mechanisms to ensure that the outputs of such activities are incorporated into the construction of national and local development plans and are publicly shared.

The main recommendations presented under this pillar are related to two main issues: data sharing and management, and process standardization. Regarding process standardization, it is important to establish action protocols so that the wide variety of public and private organizations that intervene in disaster preparedness, response and reconstruction activities know how to act in each phase. Standardized processes reduce uncertainty and ad hoc reactions, establish clear communication channels and improve accountability. It would also allow to strengthen and consolidate the role of sectoral leaders, specifically the Ministry of Disaster Preparedness, Management and Reconstruction and NEMA.

In general, and across sectors, important data gaps were observed. These gaps include inexistent data, inconsistent compilations, use of incomparable methodologies, lack of sharing and dissemination procedures, and competing collection schemes. Hence, these recommendations highlight the importance of establishing data and information sharing protocols in general, but notably for disaster periods. The organization of existing information and clarity in the management of new data, combined with clarity in the role and leadership of the Ministry of Disaster Preparedness, Management and Reconstruction and NEMA should streamline DRM procedures and optimize the use of existing platforms and other institutional capabilities.

A. STANDARDIZATION AND PROTOCOLS

DISASTER MANAGEMENT NETWORKS

The Bahamas experienced an overwhelming amount of support in response to Hurricane Dorian from international, regional and local organizations which emphasizes the importance of coordination especially in the recovery and relief phases. At a time when all national disaster and coordination systems were overwhelmed, competing interests and mandates tend to be counterproductive as they can lead to duplication of efforts, hinder accountability and leave vulnerable communities and populations behind. As was recommended after Hurricane Joaquin, a network of public and private organizations should be established with clearly defined roles and responsibilities in times of disasters. The new Ministry of Disaster Preparedness, Management and Reconstruction in collaboration with NEMA should establish response protocols for each stakeholder to follow, which should also take into consideration the accountability in the management of public funds for the attention of the emergency. Furthermore, having strong governance frameworks could allow Bahamian governmental entities to improve cooperation between partners and to gradually strengthen their capacity to manage and respond to disasters.[23]

23 See for example these two documents from the OECD: https://www.oecd.org/gov/risk/Critical-Risks-Recommendation.pdf and http://www.oecd.org/daf/fin/insurance/DFR_Public-Consultation.pdf

SHELTER OPERATION

It is recommended to establish shelter management protocols and procedures to ensure consistent attention of the residents. These protocols must include basic safety issues, such as infrastructure revision and maintenance; provision of security; distribution of food and water; and compliance with hygiene standards. In addition, it is important to establish specific care guidelines for certain populations, including: accessibility for the elderly and persons with disabilities; provision of information in different languages for migrant populations; planning of leisure and education activities for children and teenagers; ensuring privacy and hygiene conditions for girls and women; response and prevention of domestic violence; protection of LGBTI populations, among others.

B. DATA AND INFORMATION MANAGEMENT

SHELTER INFORMATION

The assessment of the effects of disasters on a population can be substantially improved by having detailed and updated baseline demographic information to facilitate response and relief efforts during an emergency. The Department of Social Services and the Bahamas Red Cross are to be commended for having a database for persons with special needs (persons with medical needs; the elderly and persons with disabilities) and facilitating their evacuation before the hurricane. However, it is recommended that other departments and agencies be included in the evacuation of other vulnerable groups of the population, including single female-headed households, all people receiving government social transfers/subsidies, migrants regardless of their migratory status, and non-residents that make up informal settlements, communities and shanty towns. Improved cross-sector and inter-agency coordination with the Departments of Social Services, Women's Affairs, Health, Housing, Statistics, NEMA and the newly implemented Ministry of Disaster Preparedness, Management and Reconstruction is key in the formalization of a database of beneficiaries for there to be an effective evacuation and emergency response, prioritization of interventions and allocation of sufficient welfare resources.

Standard shelter procedures must include the registration of every person being sheltered, which should include information disaggregated by sex; age; location; nationality; disability and/or medical need and number of family members. In addition, it is possible to collect information on affected individual or family assets, and livelihood and employment. This type of information is relevant to know where the affected population is and to determine their most urgent needs. This information was collected by Shelter Managers with the assistance of the Department of Social Services and the Bahamas Red Cross, but in some cases the information collected was not standardized across all shelters. It is advisable to develop a unique form to be used in the country to capture this information, preferably digitalized, and to provide training for the adequate use of the forms. This information should be sent to a central database that can be accessed by the relevant institutions including the administration of the shelter. Considering that power is one of the most widely affected and interrupted sectors after a disaster and its effects on the telecommunications sector, it is recommended to establish guidelines for distribution, completion and sharing of the forms, both digitally and manually or offline. The elaboration of these forms and the ensuing training process could be informed by the country's experience using the Displacement Tracking Matrix (DTM) developed by the International Organization for Migration (IOM). The Assessment team was informed that the IOM provided training in the use of the matrix to assist with registration and documentation of persons being housed in the shelters.[24] The DTM has been proven to be highly effective as a preparedness tool, as well as to support the recovery and transition phase of the response after a disaster, and so it is encouraged that technical capacity in the use of this matrix be enhanced.

There should also be the standardization of the registration of missing and deceased persons. The Assessment team received different official figures of the number of persons unaccounted for and the number of deceased persons, as the Department of Social Services had different reports to the Royal Bahamian Police Force. It was understood by the Assessment team that the Department of Social Services instituted a missing persons phone hotline and missing persons help desk across New Providence and the impacted islands, but the figures coming out of this process were different to police records. According to the Ministry of Security, the official missing and deceased persons list is the responsibility of the police, as the latter requires a coroner's declaration. Inter-institutional coordination and data sharing is therefore highly encouraged especially when dealing with something as emotionally sensitive as missing people and deaths after an event. In such sensitive cases, it is commendable to have several input points to collect information, but it is highly recommended to establish cooperation and interoperability protocols to channel all the information into one coherent and official database.

NATIONAL STATISTICS

The Department of Statistics has made significant improvements in recent years, including the quarterly GDP publication and the Supply-and-Use Table update from 2007 to 2012.The assessment of disasters such as hurricane Dorian could be substantially improved by having detailed and updated economic statistics and national accounts. This requires the allocation of more financial resources to the Department of Statistics. Challenges encountered during the assessment process allow suggesting improvements in four areas:

1. As a country that depends primarily on tourism, it is essential to have an updated Tourism Satellite Account (TSA), the latest available is from 2003. This is especially important as this sector is usually affected by a disaster. An inter-institutional platform could be created to develop a new TSA with involvement of the Ministry of Tourism, the Department of Statistics, the Central Bank (mainly for the detailed measurement category "travel"), the tourism business sector and the academia.

2. It becomes increasingly pertinent to publish quarterly accounts by economic activity with more timely frequency, both at current and constant prices, not only to assess the effects of economic disasters with better tools, but also to analyze the economic evolution of the Bahamas economy and eventual turning points of economic activity.

3. The Supply-and-Use Table is a fundamental instrument in the process of annual and quarterly compilation of national accounts, so its permanent incorporation into the process of compiling the Bahamas national accounts is recommended, with the purpose of eliminating the statistical discrepancies and strengthen the consistency of the results.

4. It is advisable to compile sub-national (or regional) accounts. In the case of multi-island countries, such as Bahamas, this is important for better monitoring of economic activity.

24 The DTM is a system to track and monitor displacement and population mobility. It is designed to regularly and systematically capture, process and disseminate information to provide a better understanding of the movements and evolving needs of displaced populations. See https://www.globaldtm.info/

> Regarding disaster assessment, this is also important, because the typical hurricane affects only some of the islands of this country, not all. For the correct measurement of the impacts in terms of GDP and employment, it would be ideal to have sub-national statistics.

The availability of economic data must be accompanied by appropriate metadata as the only way to ensure transparency and better use of information by decision makers in the public and private sectors, planners, analysts and civil society.

GEOSPATIAL INFORMATION

It is evident that geo-information and spatial databases are fundamental for planning processes and to make decisions in emergency times and disaster scenarios. Although there are geographical databases of The Bahamas, they are not available for public use and not easily shared between State entities. For example, The Bahamas National Geographic Information System Centre (BNGIS), which is the technical agency specialized in the subject, does not have a web geoportal to upload the official geo-information of The Bahamas. Therefore, it can be challenging to search, find and download data to perform any analysis related to spatial planning or risk assessment.

Consequently, it is recommended that the Government of The Bahamas initiate a process to establish legislation regarding geographic information management. This legal instrument can allow the definition and distribution of responsibilities and competences for the production, management and dissemination of geo-information at different territorial levels.

At the same time, the BNGIS can lead a process to construct the Spatial Data Infrastructure (SDI) of The Bahamas to oversee the collection of technologies, polices and institutional arrangements that facilitate the availability of and access to spatial data. It is recommended that BNGIS prepare and propose a project to structure the SDI at national level considering:

- The government structure
- The identification of key stakeholders, which produce and provide geo-information of the country
- The definition of a core data set that should include basic and thematic layers that are necessary for different analysis
- The SDI architecture and the feasible SDI techniques, including web access tools such as geoportals
- Polices and legislation that are needed to develop the SDI
- Standards to produce, manage and disseminate geo-information[25]

This proposal could be presented to government authorities and non-government organizations for funding and technical support.

25 It is suggested to follow the standards stabilized by the Open Geospatial Consortium (https://www.opengeospatial.org/).

INFRASTRUCTURE INFORMATION AND INVENTORIES

As recommended in previous assessments, it is suggested to elaborate detailed infrastructure maps for power, telecommunications, roads, water and sanitation, education and health facilities, government-provided housing, and any other relevant infrastructure for the provision of public goods and services. Detailed maps would contribute to a proactive approach to risk management by providing decision makers with a complete inventory of assets and would improve monitoring and maintenance. This inventory would identify infrastructure located in risk-prone areas, such as close to the shoreline or in flood-prone areas. A full understanding of exposed assets would improve the quality of new investment decisions and promote retrofitting or relocation of exposed assets. After a disaster, the maps would help prioritize attention to vulnerable areas and provide detailed information on the damage and losses caused by the event. It should also be noted that some of these maps currently exist, but information is not readily shared with the public; hence, the importance of establishing data management and sharing protocols to avoid duplication of tasks and inefficient use of resources.

Two experiences could inform and enrich this process. First, the ongoing project NatCap – discussed below – could be expanded to incorporate specific public infrastructure, especially those affecting ecosystems or built in protected areas. Second, supported by the IDB, Belize City has developed several studies as part of the Emerging and Sustainable Cities initiative.[26] The methodology has also been used in Nassau. The action plan proposed aims to revitalize Downtown Nassau through economic diversification, better productive usages for land, with inclusion of green spaces to increase livability, improving the city connectivity and energy efficiency and reducing crime with community engagement and technology usage. ESC's methodology seeks to apply data and studies for the development urban development strategies that are well-planned, integrated, and cross-sectoral.

Besides increasing the quality and availability of pre-disaster data, it is also recommended to compile an inventory of past events and their effects on public infrastructure. Given the high recurrence of hazards in The Bahamas, it is essential to analyze and identify the specific causes of structural failures and to propose appropriate solutions and regulations depending on the location, type and importance of each infrastructure. According to the observations from the field mission, it is concluded that the damage to infrastructure was caused by high-speed winds and hydraulic force. In both islands there were important floods and infrastructure remained under water for some time, especially on Grand Bahama, so it is also recommended to make an evaluation of possible hidden damage that may appear as for example the effect on the useful life of the roads. The compilation of such an inventory and the elaboration of damage profiles should inform maintenance strategies – discussed below.

ECONOMIC ACTIVITIES

In terms of commercial activities, an issue of concern in conducting the assessment was the availability of data. The Department of Inland Revenue only collects tax receipt data for firms with annual revenue of $100,000 or more. This cut off point excludes most if not all microenterprises on Grand Bahama and Abaco. It is highly recommended to expand data collection to micro, small and

26 The Emerging and Sustainable Cities initiative is a technical assistance program that provides direct support to national and subnational governments in the development and execution of city action plans, using a multidisciplinary approach to identify, organize and prioritize urban interventions to tackle identified challenges. The programmed focus in three general dimensions of sustainability: environmental, urban, and fiscal/governance The full document for Nassau and more information on the programmed can be accessed here: https://www.iadb.org/en/urban-development-and-housing/emerging-and-sustainable-cities-program medium enterprises (MSME) to allow for a deeper analysis after an event such as Hurricane Dorian and design support measures for these companies – especially considering that MSME account for 98% of all registered companies in the country and are important contributors to employment. This is a crucial issue because MSME are usually not insured, so their recovery process is more challenging. Any government intervention would be better if it has baseline statistics about these specific firms.

ENVIRONMENTAL DATA

Having a robust baseline of environmental data is essential for ecosystem management and analyzing long-term impacts of storms on the ecosystems in The Bahamas. Currently, there appears to be no mechanism or procedure in place for ensuring information transfer between departments and coordination between agencies for joint submission of information. Technical institutions with geospatial information and environmental data should be well coordinated and have operational guidelines to ensure that the data they collect and analyze are turned into accessible and useful information for planning and decision-making pre and post-disaster.

To facilitate the collection and analysis of baseline data, the country might consider establishing an "ecosystem service accounting", which is a structured way of measuring the economic significance of nature that is consistent with existing macro-economic accounts. The ecosystems service accounting allows for a quantification of the importance of ecosystems services to society and the comparison with other sectors of the economy. There are several on-going initiatives that aim to develop recommendations for integrated natural capital accounting and the incorporation of ecosystem service values in national accounts that should be carefully reviewed and considered. The System of Environmental-Economic Accounting (SEEA), for example, provides detailed methodological guidance on how to prepare environmental-economic accounts. E-learning tools and technical assistance from UN Agencies and SEEA implementation partners are readily available. In November 2018, ECLAC jointly organized with the United Nations Statistics Division (UNSD) and the Brazilian Institute for Geography and Statistics (IBGE) a SEEA Experimental Ecosystem Accounting (SEEA EEA) workshop for Latin America and the Caribbean (LAC), such initiatives can be repeated under demand. The organization of such accounts will require the country to have a program and a regular budget for repeated compilation and publication. South-South cooperation is also recommended to take advantage of national experiences, such as Mexico's environment national account, which interacts with the tourism national account to obtain information on the state of ecosystems, the pressures posed by tourism and opportunities for improved multisectoral management.

Promoting ecosystem evaluation studies, such as the one existing for areas on Abaco, and amplifying its scope is also useful for valuing a suite of services provided by different habitats and raising awareness about the importance of these ecosystems for supporting the economy of The Bahamas and well-being of its people. This type of study is part of the larger Natural Capital (NatCap) project led by Stanford University and partially funded partly by the Inter-American Development Bank. The project, initiated in Andros, analyses the value of environment services to the people and considers how natural and human ecosystems will respond to climate change in combination with different types of economic development. One output of the project is a Coastal Vulnerability Index (CVI) that can be used to understand the areas at elevated risk. The incorporation of the findings from this project into the Andros Master Plan, the first island-wide plan to explicitly account for natural capital, can be replicated in the reconstruction plans of the affected islands.

Technical assistance and funding for the development of mapping/modelling (flood plain and storm surge) should be further pursued as well as for establishing and maintaining tide stations. The recuperation of damaged meteorological equipment should be prioritized, and a denser observation network is recommended. As per received information, existing models can only predict that a severe storm surge is expected, but not its elevation and where it is going to reach, a SLOSH model (Sea, Lake and Overland Surges from Hurricanes), or other existing models are useful tools. A SLOSH model, for example, can help to analyze how various hurricane conditions would affect a coastline. This data combined with probabilistically simulated hurricane paths could be used to find specific locations at risk for this type of surge event. However, SLOSH models require high quality data on basins and coastlines. In summary, to deal with storm surges, accurate forecasting, storm surge prediction and effective warning should be tightly connected.

To quantify contributions of ecosystem services, it is also advisable to take advantage, whenever available, of non-traditional sources of information: drones, satellite images and collaborative applications (Pathfinders). Developing a geo-referenced environmental data and information system with the support of academic institutions, NGOs and government stakeholders would be greatly beneficial in the long-term, as observed by the assessment team, mapping of environmental resources is not readily available.

ENVIRONMENTAL MONITORING PROGRAMS

A general recommendation is to implement monitoring programs and compile existing data that could add to the process of analysis of long-term impacts of hurricanes on the different ecosystems. For example, using tree inventories combined with wind exposure models to enable a better understanding of risk susceptibility of different tree species to severe storms. Storms have cumulative effects on the environment that may severely impact economic activities and increase future costs of recovery. Regular and comprehensive monitoring of the impacts of Hurricane Dorian is important to help to predict the future of ecosystems under the constant threat of hazards and plan accordingly. Monitoring the condition and quality of ecosystems would also provide information on the effectiveness of existing natural barriers and should inform recovery plans to restore the capacity of such ecosystems, most notably coastline, mangroves and reefs.

PILLAR 2: RISK REDUCTION

When risk exposure and its potential harmful effects are identified, it is then possible to take actions to reduce such risk. In this pillar, instruments such as policies and investment programs are critical to reducing existing risks and preventing new ones from arising. Depending on the type of risk, it could reduce the exposure of a community or to a particular threat. Therefore, structural and non-structural prevention and mitigation measures are core components of this pillar. Non-structural measures include the amendment or creation of national laws, ordinances and other long-term planning instruments, as well as investment policies and programs. In the Caribbean, this pillar is generally based on three core elements- spatial planning, incorporation of a risk reduction module into national public investment systems, and modification and enforcement of building codes.

Although a proposal for the incorporation of DRM analyses in public investments is presented, planning and enforcement of the building code remain the two most pressing issues for The Bahamas. All previous assessments indicate that inadequate or inexistent spatial planning and weak enforcement of the building code have caused most damage and losses. In contrast, it has also been observed that infrastructure located in safe zones and built up to code tends to be unaffected by disasters or bare its effects better. Hence, recommendations in this regard remain relevant as challenges persist.

Furthermore, several settlements must be completely rebuilt, providing an excellent opportunity to design resilient spaces through adequate land use and zoning schemes. In these cases, it is advised to design zoning maps before reconstruction takes place. Public support must also guarantee compliance with building standards and respect zoning strategies. It is also an excellent opportunity to draft code compliance and information strategies and test them on the ground to then expand them to the rest of the country.

A. DISASTER RISK MANAGEMENT IN PUBLIC INVESTMENTS

Disaster risk reduction can be mainstreamed by incorporating a specific DRM component on every public investment undertaken by the country. It is recommended to adapt public investment procedures, so that any new public development incorporates disaster risk reduction from its feasibility or pre-design studies to its completion and maintenance. The analysis of projects should use a multi-hazard approach to address all identified risks. This task should be undertaken by the entity responsible for approving public investments and should be done in coordination with the Ministry of Finance. The assessment of the effects and impacts of disasters—regardless of the magnitude—would be an important input to demonstrate the impacts of disasters on public finances, and hence, justify the need to incorporate disaster risk reduction in every public investment.

It is worth mentioning that the United Nations Office for Project Services (UNOPS) could aid in the development and implementation of projects. Considering financial constraints, the use of public-private partnerships, such as the concessions model, could be explored. In this regard, UNOPS provides project management, infrastructure and procurement services with a focus on sustainability and national capacity development. The private sector arm of the IDB group, known as IDB Invest, also provides financing for private sector projects to advance clean energy, modernize agriculture, transportation system and expand access to financing. Additionally, the public sector arm of the IDBG possesses a special public-private-partnerships (PPP) unit which can advise governments in the design and implementation of bankable bidding processes, including the financial, legal, and socio-environmental structure of tender documents and PPP contracts, as well as provide support during the entire bidding processes.

B. SPATIAL PLANNING

The deficiencies in construction and maintenance practices are exacerbated by absent or incipient territorial planning. To enhance resilience, it is recommended that exposed communities and flood prone areas be identified. By collecting data and mapping all low areas with risk of flooding, a zoning system can be generated. This system could be the determinant factor for allowing future construction developments.

The risk identification pillar identifies a variety of opportunities for the compilation and use of existing and new data. The importance of data lies on how it is used to improve public policies and interventions. Therefore, it should be used to design resilient settlements through the identification of risk-prone and safe areas; adequate land uses; and location of public services.

Given the exposure of the country to natural hazards and the repeated damage to infrastructure located close to the shoreline or in flood-prone areas, it is imperative to design zoning plans. Although this action is socially, culturally and economically costly, it can no longer be postponed. The opportunity should especially be seized in settlements that were completely or almost destroyed and must be rebuilt, as they provide the right conditions to pilot the design and construction of resilient communities. Spatial planning plans must also consider the role of ecosystems as first defense barriers and should encourage ecosystem protection and recovery.

In sum, it is highly recommended to elaborate Master Plans for each island and consider adequate settlement location within them according to safety and resilience standards. It should be noted that the Government of The Bahamas has collaborated with the IDBG already in this area for a few select islands. For example, the Andros Master Plan was developed incorporating the quantified values and spatial location of the natural capital (ecosystem-based methodology) of the future development planning of the island. In San Salvador (BH-T1052), ecosystem-based and climate-adaptation studies have been developed and are to be incorporated in the Master Plan for the island. In New Providence, the Sustainable Nassau Action Plan (SNAP) developed under the Emerging and Sustainable Cities Initiative (BH-T1045), incorporated both sea-level rise and natural disaster-related scenarios into the urban planning process. Therefore, expanding the geographic scope of similar interventions across the archipelago can play a key role in determining appropriate settlement locations that will save lives in the event of a natural disaster.

C. ENVIRONMENTAL REGULATIONS

The Bahamas National Development Plan and the National Policy for the Adaptation to Climate Change already include provisions for the protection and conservation of the environment, as well as the preparation of environmental impact assessments for certain projects. Considering that the national legislation is already in place, political and institutional commitment to observe these commitments should be now reinforced, establishing clear accountabilities, including roles and reporting structures for different stakeholders. The results of environmental impact assessments previously undertaken on Abaco and Grand Bahama should also be fed into policies and strategies for reconstruction.

Reconstruction in coastal zones that provide hurricane resistance/buffer zones are to be avoided. Implementation of protected areas in selected zones, as part of the existing plan of expanding the MPA network in the country, should be followed through as are a nature-based solution to harmonize different land uses in the reconstruction plan. Moreover, enforcement of legal measures should discourage the continued destruction of mangroves for tourism development activities, as they provide natural coastal defenses, and should be combined with protection programs to encourage the regrowth and protection of damaged areas.

NATURAL PROTECTION

In affected areas to be reconstructed, natural defenses may be considered as an alternative to traditional shoreline protection. These structures also support ecosystem restoration and conservation. Some of these measures may require higher initial investments that are compensated by their durability, lower long-term maintenance cost and ecological benefits. Other planned mitigation projects such as reinforcement of sea walls or other physical structures should, wherever possible, guarantee that community members are a part of the process to ensure community ownership and maintenance skills. Local enterprises should also be an important component of these efforts.

D. FLOODING MITIGATION MEASURES

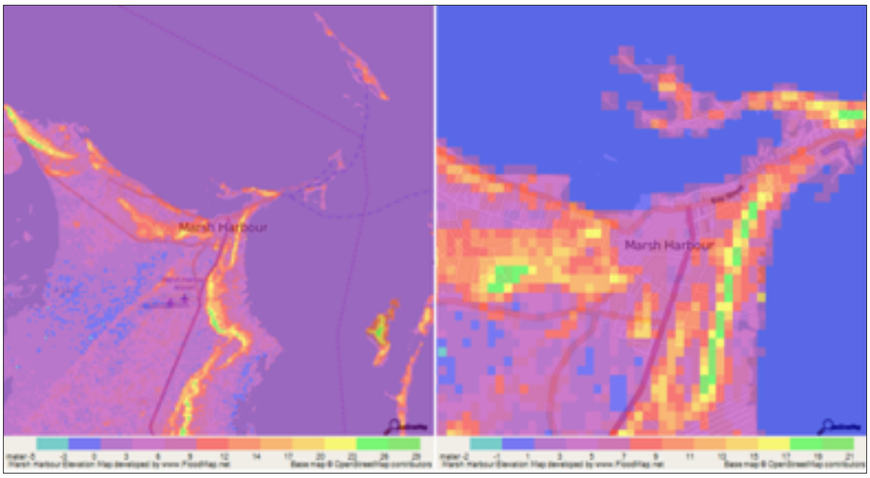
In The Bahamas 88 per cent of the population lives less than 10 meters above sea level, and most of its critical infrastructure is also located near the coast (McGranahan et al., 2007). Hurricane Dorian generated extreme conditions due to flooding associated with the water surge. Grand Bahama (Figure 39) experimented high level of flooding in the populated areas, impacting housing, buildings and other infrastructure.

FIGURE 39. GRAND BAHAMA BEFORE AND DURING HURRICANE DORIAN

Source: Copernicus Sentinel data 2019 (accessed via Planet Labs Inc), ICEYE

A cohesive urban planning / zoning system should be based on the mapping of all low areas with risk of flooding. In Figure 40, there is a sample of an elevation map of Marsh Harbour using two different zoom resolutions and displaying elevation in different colors. Matching this information with the recorded events on Grand Bahamas and Abaco Islands will support efforts of risk reduction by planning future flood mitigation projects. Further evaluation of the registered data must include Hurricane Dorian recorded information on water surge and flood levels.

FIGURE 40. MARSH HARBOUR ELEVATION AREAS



Source: This Marsh Harbour, Bahamas Elevation Map is licensed under CC BY-SA.

Some recommendations to minimize flooding damage due to water surge include:

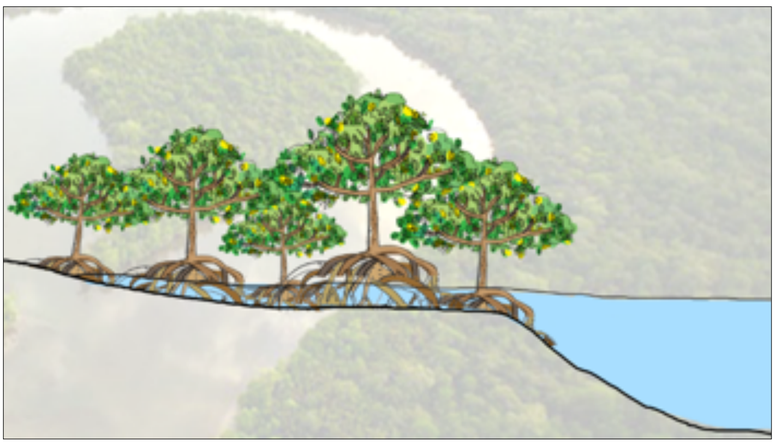
- Mapping of low elevation areas with risk of flooding and generating a zoning system for construction in non-risk areas.

- Planning future projects for flooding mitigation in areas that are considered vulnerable.

- As part of the spatial planning and mapping efforts of risk areas, the construction of seawalls might be considered, as they are less invasive than other coastal defenses. This should be planned in conjunction with other recreational and tourism requirements and consider existing limitations. It should include a detail evaluation of the coastal perimeter levee, one of the most used techniques in terms of flood mitigation.

- Another option is to use mangrove for coastal protection of populated and low elevated areas that are not adjacent to the beaches used for touristic purposes (see Figure 41). In this regard, the government might consider securing the support from specialized institutions and organizations to create a cohesive plan integrated and in harmony with other sectors such as tourism and fisheries.

FIGURE 41. MANGROVE COASTAL PROTECTION SCHEME

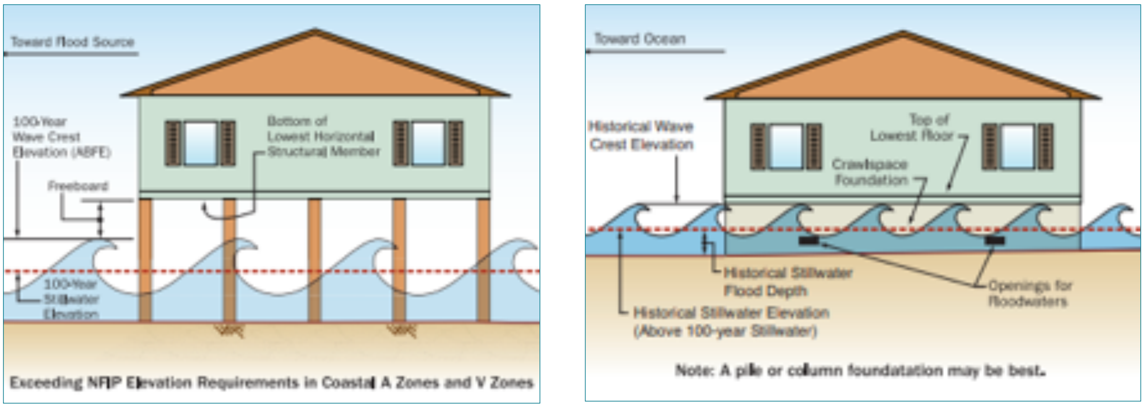


Source: mangrovectionproject.org

All exterior elements like water tanks, pumps, generators, gas bottles, and air conditioning units should be sufficiently affixed and protected considering the effects of hurricane force winds and sea level rise. Potential flooding areas should consider elevated construction techniques allowing the building or structure to remain above flood waters. It is widespread practice in coastal construction to include structural solutions using wood / concrete columns, piles or pre-engineered solutions like multipoint foundation systems.

There are several organizations, such as FEMA, who have recorded significant statistical information regarding establishing criteria and guidelines to mitigate and reduce flood risk that may be applicable to The Bahamas. Figure 42 illustrates the recommended elevated construction in different coastal zones to protect the asset against the potential water surge produced by tropical storms. Figure 43 describes FEMA Foundations Requirements and Recommendations for Elevated Homes, as an effort for the recovery from Hurricane Sandy.

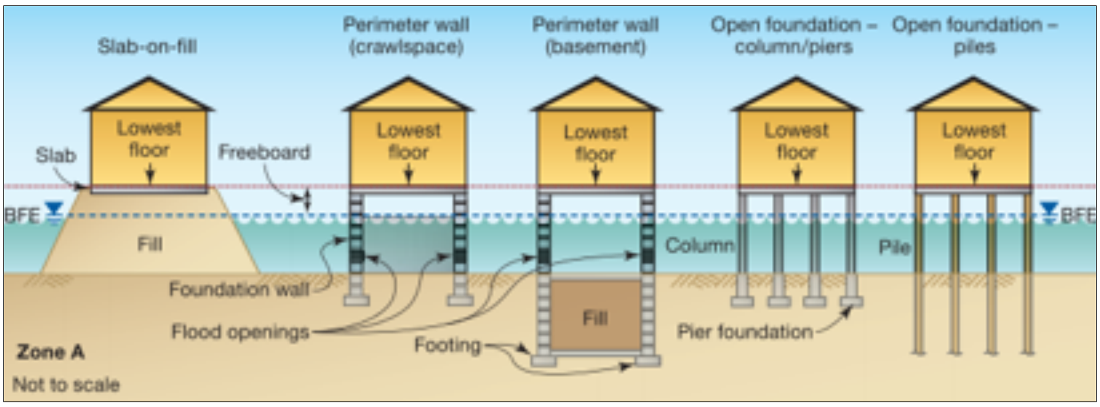
FIGURE 42. FEMA DESIGNING FOR FLOOD LEVELS ABOVE THE BFE, HOME BUILDERS GUIDE TO COASTAL CONSTRUCTION



Base Flood Elevation – The elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year.

Text & Image source: FEMA Home Builder's Guide to Coastal Construction Technical Fact Sheet No. 1.6, "Designing for Flood Levels Above the BFE"

FIGURE 43. FEMA FOUNDATION REQUIREMENTS AND RECOMMENDATIONS FOR ELEVATED HOMES



Source: Hurricane Sandy Recovery Fact Sheet No. 2 May 2013

E. ENFORCEMENT OF THE BUILDING CODE AND MAINTENANCE

Infrastructure throughout the country varying levels of damage due to three main reasons: (i) lack of compliance or deficiencies in the application of the building code, (ii) use of inadequate and/or hazardous materials, and (iii) lack of continuous maintenance schemes, especially for public infrastructure.

Geographical conditions and dispersion, and lack of resources result in limited availability of construction materials, discretional construction practices, and varying levels of compliance with standards. Therefore, compliance with the building code is one of the most salient and urgent recommendations of this report.

It was also observed that an important number of public structures had been affected by previous storms or hurricanes and presented varying levels of deterioration. Although there are some maintenance efforts in place, these tend to be cosmetic or inconsistently implemented. It is recommended to establish annual sectoral maintenance programs, especially for essential infrastructures such as health, education, water and sanitation, power and telecommunications facilities and equipment. Inspections of public infrastructure should be mandatory and scheduled before hurricane season every year, as well as after passage of tropical storms and hurricanes. This will assist in the identification and removal of threats. In addition, and regardless of the frequency of storms and hurricanes, routine maintenance schemes must be developed to supervise the condition of these facilities.

REVISION OF BUILDING CODE

In the evaluation of the information gathered from housing sector authorities, it was observed that The Bahamas has improved, updated and published a reasonably integrated, comprehensive and rigorous building code that is aligned with the goal of protecting the population and the physical assets of the country. However, the magnitude of Hurricane Dorian and subsequent observed damage exposed gaps in the enforcement of existing regulations and the potential need to undertake an extensive building code review.

Most of the houses assessed with significant signs of damage were not complying with the building code, especially in remote areas. It is worth noting that this situation repeats itself in every assessment conducted since 2015. During the assessment mission, government representatives conveyed the challenge of establishing a management / supervisory program to assure the correct application of the code due the geographical spread of the houses and lack of financial and human resources. Correct application of the norms requires appropriate compliance and enforcement mechanisms, which includes training for public officials responsible for approving construction permits, establishment of accountability measures and sensitization of the population.

In areas such as Marsh Harbour and Treasure Key some houses resisted the effects of Hurricane Dorian while others were destroyed, as shown in pictures below. It is highly recommended (with house owners' permission) to execute a random verification and inspection of houses with zero to minimum damage in order to create a statistical sample to identify the common factors presented in these houses to create a cause and effect diagram. The findings would serve as a tool to categorize potential causes of damage, as well as common traces in houses that resisted the hurricane. This method may help the authorities to focus the efforts on identified gaps to better target the norms that need revision in the existing code.

FIGURE 44. HOUSES NEXT TO EACH OTHER IN TREASURE KEY

Source: Assessment team, 2019

It was also observed that some of the houses in Treasure Key and other areas constructed with specific standards, materials and methods presented a significantly more robust and resilient structure. Most of the houses destroyed in Marsh Harbour (Figure 45) had a total collapse of the wooden roof structure. These aspects must be carefully evaluated by the authorities involved in the revision of the building code. Hurricane Dorian is part of an unusual trend of major tropical storms affecting The Bahamas in the recent years, the wind forces and water surge might have been underestimated in the parameters and suggested design requirements of the existing building code. Therefore, it is recommended to contemplate the use of new construction methods, techniques and materials.

FIGURE 45. HOUSES (STRUCTURE / ROOF) BUILT IN WOOD

Source: Assessment team, 2019

As a rule of thumb less populated, low-income and isolated communities (very common in archipelago countries such as The Bahamas) have challenges in the application of the building code due to lack of quality or quantity of construction contractors, construction supervision and appropriate inspection to guarantee the enforcement of the building code. As a recommendation to improve level of compliance with the build code in the low-income and isolated areas, it is suggested to:

- Design of a simplified house building manual. The objective of this handbook will be to detail, step by step, the principles and methods needed to build a house in compliance with the building code. Construction specialists can use it regardless of their educational level as well as people of the community with the appropriate training. It should include typical and standard construction drawings and specifications to ease the execution process. Also, it should comprise a list of suitable materials to build a safe and affordable home as well as include explanations to guide the construction process and indicate when permits or approvals are required.

- Develop standards and revisions to current building codes with the aim of making construction processes safer, more affordable, simpler and a more flexible. Complex building codes and complex approval procedures can de-legitimatize new housing, and by extension lead to non-compliance.

- The Ministry of Infrastructure and Public Works should work in the design and promotion of technical training programs to develop capable local contractors with knowledge of building techniques. For this task, the Ministry will need a specific budgetary allocation.

- Reinforce, inspect and supervise the building process and procedures. The Bahamas authorities shall have an appropriated surveillance mechanism in all phases of the building process from design to construction. This process could be improved through some of the actions listed below:
  - Evaluate the required resources (supervisors/ inspectors) for on-site supervision on all the stages of the process.
  - Execute a competency assessment and associated training programs to fill the gaps in technical capability and limited resources. Expand the resources availability in all islands and locations avoiding centralization of the effort.
  - Create a responsibility matrix in the building process including designers, contractors, developers and any other relevant stakeholders to ensure compliance with standards and rules throughout the construction process.
  - Create an engineer, architects and construction contractor's certification, and a performance indicator registry.
  - Involve other stakeholders in the Housing Sector such as Bahamian Contractors Association, Bahamian Insurance Association, Engineering Schools and Association, to integrate an "Ad-Hoc" committee to follow up guidelines towards these and other aspects related to the housing sector.

MATERIALS AND METHODS

In general, concrete, masonry and steel reinforcements are the recommended materials to be used during reconstruction and any new developments. These materials have shown higher structural performance, better respond to wind solicitations and resist water intrusion and damage. In contrast, wooden structures are less resistant to wind and water damage and are subject to humidity and mold.

It is also important to consider the materials used to build storage facilities and structures housing special equipment, such as power generators, gas tanks and electronic equipment, as well as public information, databases and other documents. If the structures are not deemed suitable to protect the integrity of the equipment, it is recommended to establish relocation guidelines to be applied prior to any storm.

Table 86 shows specific materials and methods recommended for each subsector – a detailed analysis of these recommendations is presented in the Annex.

TABLE 86. SUBSECTOR SPECIFIC MATERIALS AND METHODS RECOMMENDATIONS

Subsector	Observations and recommendations
Education	Recommended materials for main structures: masonry and steel reinforcement Proper bracing and fixing of roofing to a metal structure to avoid being blown off and allow water intrusion Aluminum shutters protect windows and doors from wind, excess rainfall and debris Inadequate fixing of shingles favors water intrusion Observed risks when using sheetrock materials on main structures Wooden beams and other wooden materials show reduced resistance to humidity and mold
Health	Recommended materials for main structures: masonry and steel reinforcement Wood, sheetrock and similar materials are not recommended for locations with high humidity or prone to flooding
Power	Steel reinforced concrete walls tend to be more resistant than sheet metal Concrete to protect equipment and electronics rooms High category poles proven resistance Installation of storm guy wires to the transmission system for additional support and hardening of essential components Standardization of the distribution network through the consistent use of equipment that supports one voltage level: simplify stockpiling and training
Telecommunications	Reinforcement of cellular antenna, retrofit antennas with additional bracing Standardize resilience and protection measures Analyze options to protect wired and wireless infrastructure, including grounding, pole upgrade and fiber to the node
Tourism	Concrete has higher structural performance and better responds to wind solicitations Use species resilient to tropical storms in landscaping, avoiding species with superficial roots Replant trees in clusters as groups withstand strong winds better
Agriculture and fisheries	Consider stilts and other mitigation structures for infrastructure that must remain close to coast Identify adequate materials for greenhouses given crystal-s vulnerability to wind damage
Commerce	Lightweight material structures presented more damage to roofs, walls, beams, non-structural elements and foundations

Source: Assessment team, 2019

SECTORAL RECOMMENDATIONS

Although each sector's characteristics and performance demand specific risk reduction measures, it is possible to identify several cross-cutting issues or categories that would greatly increase resilience:

I. Encourage inspections and control during construction process

II. Revise and upgrade building code's safety and resilience standards for essential infrastructure. Essential infrastructure refers to facilities housing large amounts of users, including vulnerable populations (schools, healthcare facilities) and facilities that provide basic services (electricity, telecommunications, water and sanitation)

III. Establish special safety standards for tourism, fisheries and commerce infrastructure, including setbacks from seashore. Consider special mitigation measures for infrastructure that must remain close to the shoreline, such as docks, vessels and fish processing facilities

IV. Request private providers and operators of public services to elaborate DRM plans that include preparedness, response and recovery actions, and that guarantee continuity, quality and redundancy

V. Elaborate guidelines for infrastructure inspection and repair prior to the start of the hurricane season

VI. Elaborate guidelines for the relocation and protection of specialized equipment and documents, including structural standards

VII. Incorporate maintenance programs in infrastructure development projects and DRM plans as routine activities, especially before the start of the hurricane season, after major disaster events, and periodically to assess the effects of low intensity / high frequency hazards

As discussed in the previous section and in previous assessments, the government of The Bahamas plays a key role in enforcing compliance with the building code and in defining spatial zoning strategies. In addition, maintenance persists as an unresolved issue that could be addressed in infrastructure development plans and DRM protocols. The country's high exposure to minor and major natural events affects infrastructure conditions and lack of maintenance and repair could lead to greater accumulated damage.

Table 87 summarizes subsector specific recommendations for risk reduction regarding compliance with the building code - a detailed analysis of these recommendations is presented in the Annex.

TABLE 87. SUBSECTOR RECOMMENDATIONS FOR RISK REDUCTION

Subsector	Recommendations
Education	Elaborate guidelines for mandatory and periodic infrastructure inspections prior to hurricane season Schedule and budget pre-hurricane season infrastructure repairs and retrofitting Annual management of potential threats (large trees, faulty fences, clogged drains and removal of over-burdened utility poles) Elaborate a manual of best practices for securing documents and equipment, identifying adequate spaces and containers for relocation and safe storage Establish strict government supervision on the design and construction of public and private education facilities Consider standards established by UNESCO "Safe Schools" initiative
Health	Identify facilities located at sea level or in flood-prone areas and introduce mitigation and protection measures Projects for new facilities must include topographic analyses and consider historical data of storm surge Elaborate design specifications for hurricane resistance, including location and protection of equipment (power generators, air conditioning units, water pumps and septic tanks) Establish strict government supervision on the design and construction of public and private health care facilities Consider standards established by WHO/PAHO "Safe Hospitals" initiative

Roads, airports, bridges, docks and seawalls	Implement a transport infrastructure risk management system that presents the hazard, exposure and vulnerability of infrastructure Define spatial limits based on hazard analysis or previous experiences Define a minimum level of foundation for the construction of critical infrastructure Review and update standards for transport infrastructure and monitor enforcement and condition
Power	Reinforce structure housing power plants, including generators and electronic equipment Elevate generators and other equipment to protect from flooding Retrofit storage rooms or relocate equipment before natural hazards, including vehicles Adjust design of new projects to wind, flooding and elevation analyses; consider relocation or retrofitting of existing facilities Avoid loose materials on site to prevent debris damage to structure, transformers and gas tanks, secure loose materials before natural hazards Improve drainage systems for rapid drainage of flood water, provide maintenance prior to hurricane season Establish quality, operation and maintenance guidelines for private operators, as well as continuity, redundancy and safety criteria Consider security measures to avoid vandalization, theft and interference Decentralize energy generation and transition to small localized grids Prefer renewable energy solutions in the reconstruction process
Telecommunications	Establish quality, operation and maintenance guidelines for private operators, as well as continuity, redundancy and safety criteria Promote joint investments from private operators and provide incentives for infrastructure upgrade Establish joint continuity plans with the energy sector Request disaster preparedness, response and recovery plans from operators, including access to energy through backup generators or batteries and protection and insulation of such equipment
Tourism	Reinforce the wind design code Analyze the pertinence of establishing special safety standards for tourism infrastructure Encourage inspections and control of construction processes Incorporate touristic infrastructure in zoning plans, including setbacks from seashore
Agriculture and fisheries	Incorporate proper seatbacks from seashore Enforce compliance with building code and identify additional protection measures for infrastructure that must remain close to the coast (docks, fishing gear storage, fish processing and storage)
Commerce	Analyze the pertinence of establishing special safety standards for commerce infrastructure, 'Allowable Strength Design' (ASD) or 'Load and Resistance Factor Design' (LRFD) Create a registry of authorized contractors Establish minimum distance to the coastline in zoning plans Expand registry of companies to MSME Promote participation of MSME in recovery and reconstruction processes

Source: Assessment team, 2019

VESSEL MANAGEMENT

It was observed that many vessels were displaced from the docks as the magnitude of the hurricane exceeded expectations. The movement of these vessels cause great environmental damage to marine ecosystems. It is recommended that strategies and protocols are developed, and best practices investigated to manage vessels during severe storm; all these recommendations must be transferred to vessel owners through public information and education materials. Practices should also include emptying vessels of fuel to avoid fire related damage and leakage.

AVOIDING FUTURE ENVIRONMENTAL IMPACT

A mapping of companies, which perform activities with high potential environmental impact, like petrochemicals, should be produced. These companies should develop contingency plans reviewed and inspected by the responsible government agency. Priority is to be given for companies with longer operating times, as their initial agreement with the government, might not reflect current more strict environmental regulations. The agreements should include hazard analyses; identify prospective, corrective and reactive measures to manage risks; delineate clear responsibilities and timelines for damage control actions, clean-up activities and further recuperation; and monitoring of affected ecosystems.

Before permitting the construction of an oil storage terminal, it is highly recommended to conduct a formal oil spill risk analysis (OSRA) and an environmental impact study (EIA). The objective is to estimate the risk of contact of oil spills with sensitive environmental and socio-economic resources both on land and at sea.

Hydrocarbons storage tanks are usually designed and built under rigorous codes and standards, for example, the American Petroleum Institute has an industry standard for tank design to be able to drain a minimum of 10 inches (25 centimeters) of rain over a 24-hour period. Above average rain fall may be one of the factors causing the failure of tanks' structural components leading to spills. Therefore, the regulations and standard should also consider and integrate local extreme risk factors the structure is expected to operate under.

Other important factor is the life span of a storage tank. Continuous inspection and maintenance programs are critical to prevent the storage facilities to be vulnerable to extreme weather events.

PILLAR 3: PREPAREDNESS

Even if risks can be identified and addressed, it is not possible to completely eliminate them. Therefore, preparedness refers to the knowledge and capacities developed by governments, businesses and communities to anticipate, respond to, and recover from the effects of a natural hazard or disaster. This pillar should contribute to an organized transition from response to recovery. The degree and quality of preparedness are closely correlated with the prior conduction of community-based risk analysis and the deployment of efficient early warning mechanisms. All this requires the establishment of institutional channels of communication between public bodies and the community.

Production and distribution of reliable data is only one component of improving preparedness. Public servants and other staff also need the necessary tools, knowledge and capacities to transform this information into applicable policies and plans. Training and retaining professionals and technical staff is an important measure for capacity development in the use of disaster risk and environmental information, as well as allocating equipment and materials to undertake the necessary activities.

AFFECTED POPULATION

EVACUATION PROCEDURES

The Government of Bahamas instituted an emergency evacuation for residents who would have been in the most vulnerable areas based on the projected trajectory of the hurricane. Flights from Abaco and Grand Bahama to New Providence were increased to assist those persons who chose to leave the island, while others left via private boats. There was also the evacuation of persons to shelters further inland on Abaco and Grand Bahama, however a good number of persons chose to stay back and “ride out” the storm even after numerous public appeals from the Prime Minster to evacuate.

Based on the official death toll and the number of persons unaccounted for after the passage of Hurricane Dorian, it is due time for a mandatory evacuation protocol to be established. It is worthy to note that the Prime Minster of Bahamas has recently proposed amendments in the form of a new bill to the Disaster Preparedness and Response Act. The bill seeks to empower the Prime Minister to make evacuation orders, curfews and restrictions of movement in certain areas for a specific period, for the protection of people. Additionally, under the proposed changes, where an evacuation order is in effect and residents within the specified area or island have not evacuated, without a justifiable reason, could be liable to a US$500 fine or one month in prison, or both. Before making evacuation mandatory, it is also necessary to have provisions in place that guarantee shelter for all those in need, as well as the conditions that trigger the mandatory evacuation. Even though these proposals are still in the consultative stage, it is recommended to approve the changes proposed by the bill.

SHELTERS ASSESSMENT

Given the frequency and magnitude of hurricanes affecting The Bahamas, it is recommended to elaborate a revision and maintenance plan that considers an annual comprehensive review and evaluation of all buildings used as shelters, preferably before the start of the hurricane season. This should be done to monitor the integrity and suitability of the infrastructure and identify any damage that can be repaired before the hurricane season. The Assessment team was informed that there were several shelters on Abaco and Grand Bahama that were deemed unsuitable to house persons in the event of a hurricane, however no repairs were made in time for the arrival of Hurricane Dorian. This resulted in several shelters being compromised and people having to move for their safety during the hurricane, which could potentially put people at risk and increase the number of affected or deceased persons. It is necessary to assess the pertinence and feasibility of building new shelters. This analysis should consider the number of shelters needed to house each island's population, determine mandatory safety and accessibility considerations, and be aligned with shelter and building codes. However, given the financial constraints faced by the country and the vast amount of reconstruction needs, it is also recommended to identify other structures that could function as shelters, such as community centers, and determine mandatory safety conditions and conduct periodical infrastructure checks.

There is also an increased need for more awareness raising and sensitization for the population of Bahamas to negate the cultural mindset that there are limited risks associated with these types of events. A common sentiment that was heard throughout the assessment, was that people did not anticipate such a devasting impact from the hurricane which was associated with storm surge and high intensity winds that pounded the islands for two days. Even though NEMA was very proactive with their warnings and updates via newspaper, radio, television and social media there is the need for strong public information campaigns to sensitize the population to the danger of these events. These campaigns should also be in different languages, for example in creole, since a larger number of Haitians were affected. Education and public awareness must always be a crosscutting component of any DRM plan.

SHELTER MANAGEMENT

The widespread damage and destruction of homes caused by Hurricane Dorian immediately generated a massive need for shelter, both for the more than 5000 people who evacuated to Nassau and those who remained on Abaco and Grand Bahama. The assessment team was informed that most activated shelters on the islands were stocked with supplies to accommodate displaced persons for a period of up to two weeks. However, some shelters were in activation a month after the hurricane and in some cases over the recommended capacity. Furthermore, most of the buildings used for shelters are gymnasiums, community centers, church halls and auditoriums which usually have paid events such as dinners, concerts and weddings, and given that people still occupied these buildings a month after the hurricane, there was a loss of income as pre-booked events had to be cancelled and deposits had to be refunded. As such, the government should identify, whenever possible, alternative temporary accommodation for persons who lost their homes as a short to medium term solution until their housing situation can be sorted.

SOCIAL SECTORS

EDUCATION

Hurricane preparedness strategies should be mainstreamed in all schools across The Bahamas. A hurricane preparation checklist developed in collaboration with relevant stakeholders, should be enforced to ensure that activities such as premise inspections, tree trimming, drain cleaning, securing of documents, school supplies and equipment, and battening of windows and doors are completed prior to the arrival of the hurricane. It should also include recommendations for maintenance and post-disaster revisions.

It is also important that the academic calendar be adapted to include "recovery days" to compensate education days lost due to a disaster. An extension of the school year by a week will allow for pre- and post-disaster school closures even in the case of schools experiencing minimal to no damage.

HOUSING

The damage caused by a Hurricane Dorian effects has varied depending on location, building code compliance, condition of structures, zoning restrictions, type of effect (wind, surge, flooding, etc.) and several other factors. During the visits and meetings, it was evident that there is a strong coordination and response leadership from NEMA with other governmental institutions and stakeholders. The Bahamas has done important efforts in integrating members of multiple sectors and institutions to a provide coherent response to disasters. Lessons learned from previous hurricanes must be compared to the actual situation encountered in Dorian, which clearly represented a much larger challenge, so they can feed into existing plans.

Preparations to anticipate the impact of a hurricane are a complex task to be managed in a limited timeframe. An important point is to invest in pre-hurricane season information campaigns, emphasizing recommendations for preparedness. Based on the Team visits and inspection of the affected islands the following actions targeted at populations living in risk zones are recommended:

- Protect windows with permanent storm shutters or use marine plywood to cover doors and windows.
- Review information on location of the building in relation to sea level. The elevation is the major factor in determining and advising vulnerability to storm surge or flooding.
- Review the condition of buildings by conducting internal checkups and quick repairs of roofs, windows, outside pipes, and structure.
- Identify and store in a safe place all outside equipment and furnishings, which could be carried away by the storm and become a threat.
- Review and clean clogged rain gutters and downspouts to prevent flooding and unnecessary pressure on the awnings.
- Securely fasten rooftop equipment such as fans and air conditioning units.
- Turn off the electrical power, water, gas, and other utility services within the building at main switches.

INFRASTRUCTURE SECTORS

POWER

Disaster preparedness within the power sector depends on taking various preventative measures to ensure that the integrity of the power grid is maintained. Like the telecommunications sector, there should be yearly inspections of the integrity of all lines and poles before the start of the hurricane season. Repair and replacement of equipment and poles should follow inspection where necessary. Note that pole integrity should be kept at a high standard as downed poles can weigh down other poles causing further damage. Another important measure is the yearly trimming of trees that may pose a threat to power lines. Tree branches that are near to power lines and substation facilities pose a threat to the integrity of the distribution system whilst falling trees can cause even more serious damage. It is also advised to inspect and securely attach signage as they may be blown into the power grid by strong winds.

The previous section mentioned the need for standardization of the voltage used across the island of Abaco. This policy also has implications for disaster preparedness and management as a standard voltage will allow for the stockpiling of materials in a more efficient way.

Finally, a disaster response plan must be prepared and reviewed by the power company before the start of the hurricane season. The revision of this plan ensures that all persons involved are reminded of their roles and responsibilities and that the relevant equipment are in working condition. This activity must be done sufficiently in advance to address any potential issues that may be discovered.

ENVIRONMENT

CONNECTING ENVIRONMENT AND DISASTER WARNING

It is suggested to promote awareness raising campaigns about natural hazards, establishing a clear link between the protection of the ecosystem and the benefits for future risk avoidance. Considering the observed increased risk, there is also a need to work with the public to reduce the risk of fires. This would entail the implementation of a substantial education and outreach program to share the dangers of forest fires and how to prevent it.

Educational campaigns or administrative measures to promote the conservation and responsible use of water resources is also an urgent need, considering the possible effects on the water lenses, populations are under the risk of shortage or increased cost for water supplies.

MANAGEMENT OF OIL SPILL RISK

- All oil facilities must have disaster preparedness plans. A good reference for these plans may be the National Petroleum Council (NPC) as their reports suggests actions for identifying and reducing infrastructure vulnerabilities within the oil and natural gas industries.[27] Plans should include the following recommendations:

- Storage tanks are filled at least up to 20 per cent of their capacity, or 1 meter of their volume over the predicted storm surge line, as it improves its structural resistance.

- All mobile equipment and loose materials must be moved and placed in a safe place to prevent them from impacting the tanks, thus generating failures.

- Verify that all drainage systems are working both in the containment area and on the floating roofs of the tanks, as an obstruction can cause a roof to collapse.

27 2- See Securing Oil and Natural Gas Infrastructures In the New Economy-2001, Enhancing Emergency Preparedness for Natural Disasters 2014, Emergency Preparedness Implementation Addendum-2016.
3- See RRT6 Fact Sheet #103a Flood Preparedness Recommended Best Practices.

PILLAR 4: FINANCIAL PROTECTION

This pillar attempts to create strategies to protect governments, businesses and households from the economic impact of a disaster. Considering that risks cannot be eliminated, it is therefore important that countries protect their fiscal balance from shocks while they are still able to respond to the emergency. Financial protection refers to insurance at the sovereign and household levels, but also in terms of social protection for vulnerable populations. Resilient planning should provide for a financial strategy to protect public sector assets and create incentives for the private sector to protect its own. As a general measure, the promotion of an insurance culture would protect investments, contribute to better evidence-based decision-making and promote the development of exposure models and maps. It would also raise public awareness of the damage and losses that could occur in the absence of financial protections and would increase investors trust in the country, which should encourage private investment. Financial protection relies on ex ante instruments to finance disaster risk management. It is assumed that the other risk reduction mechanisms explained in other pillars have been applied, and this measure focuses only on residual risk.

A fiscal strategy for financial protection should be divided in funds for emergency response and funds for reconstruction. In addition to specific sectoral recommendations presented below, it is recommended to optimize the use and resilience of reconstruction funds and to promote insurance of public infrastructure.

The following efforts undertaken by the government of The Bahamas in the last two years are commendable:

A. Parametric insurance: a parametric insurance policy, unlike indemnity insurance, pays out on the occurrence of an event and impact of a predetermined intensity. The Bahamas has been part of the CCRIF insurance scheme since after Hurricane Matthew in 2016. This instrument was not designed to cover all the damage caused by a disaster but to give governments access to short-term liquidity mechanisms with a view to dealing with the emergency and reducing budgetary volatility.

B. Contingent credit lines. These are arranged before a disaster occurs and activated in the event of an emergency. They provide immediate liquidity and their interest rates are usually lower than traditional credit but increase a country's debt. After Hurricane Irma the government of The Bahamas acquired this product from The Inter-American Development Bank (IDB). The funds obtained through these loans are normally used during the emergency phase and the first stage of recovery.

FINANCING RECONSTRUCTION

As mentioned in the Macroeconomic Impacts chapter, the government of The Bahamas was approved by the IDB, CCRIF, and SPC to receive approximately $112 million to finance the emergency response. Given the magnitude of this disaster relative to the size of the economy, the reconstruction process will have to be financed in several budgetary years and with assistance of funds provided by multilateral agencies. It is recommended to elaborate a multi-year reconstruction plan with clear objectives, assignation of responsibilities and resources, communication and leadership channels, accountability measures, and revision periods to assess progress and adjust activities.

From the point of view of the public sector, the reconstruction financing should not be based on the total damage, but on the total damage of the public sector plus other areas that the government prioritizes., Considering the magnitude of the government efforts required for reconstruction, it is vital that public funds are not used to reproduce pre-disaster situations, such as rebuilding communities in the shoreline or in flood-prone areas. Moreover, special administrative procedures to facilitate procurement process of necessary goods and materials for emergency support should be considered. Allowing temporary and exceptional flexibility in the rules and procedures for emergency assistance would facilitate, for example, the usage of contingent lines of credit that usually have a limited time for execution.

In addition, funds acquired from international institutions must consider a disaster risk management component so that these investments and public debt are properly protected.

INSURANCE OF PUBLIC ASSETS

The purchase of insurance for public sector infrastructure should be further considered and the culture of insurance should be promoted. Financial protection should be established starting with new public works. For this, it is important to conduct negotiations with private insurance companies to include costs that the government would incur when buying this service. This policy is followed in other countries, such as Ecuador, where the purchase of insurance for public infrastructure is mandatory.

SOCIAL SECTORS

EDUCATION

If not already established, it is recommended that The Ministry of Education either allocate post-disaster recovery funding to the yearly budget for each school or allow for a small fund to be made available to district offices or the island administration for immediate access. These funds will allow for schools incurring minor damage to access funding for repairs and replacement of lost materials in a timely manner and ensure that lost days of schooling are minimized. The minor repairs linked to this budget should be conducted by a list of pre-approved contractors. Finally, disbursement of funds guidelines should be outlined to ensure proper management of funds and accountability given the chaotic atmosphere following a disaster.

INFRASTRUCTURE SECTORS

TELECOMMUNICATIONS

The government of The Bahamas through the PUC can ensure that financial protection is maintained by telecommunications service providers using insurance facilities that cover potential damage and losses related to disasters. Alternatively, a disaster fund or credit line may suffice for ensuring that telecommunications companies have access to resources for reconstruction and recovery efforts. As providers of a public service, telecommunications operators must also be required to ensure service continuity during and after a disaster.

POWER

One area not covered by insurance—because risk is so high—are overhead networks for power distribution and wire-based telecommunications. Repairs to these represent significant costs to telecommunications companies, and particularly to the power companies that own the infrastructure. Lack of insurance on this infrastructure also means a lack of pressure from insurance inspectors that would help assure high standards of maintenance, particularly in tree trimming and in replacing old or obsolete poles.

During Hurricane Matthew, less-than-optimal maintenance standards contributed to much of the service failure of this infrastructure. Broader cost sharing between pole owners (electricity utilities) and pole tenants (telecommunications companies) would help to fund better utility pole and right-of-way maintenance, thus reducing overall risk not only to these parties but also to those who rely on them. The utilities regulator should consider whether it would be appropriate for telecommunications operators to be charged for their tenancy on a per-attachment per-pole basis, rather than on a per-operator per pole basis. There is also a need to review charges paid by the government for public-sector uses of this infrastructure.

Another policy for financial protection of the power sector is the establishment of a "Hurricane Fund," which has been created in other countries such as Belize. Such a fund would be established under supervision of the regulator and paid for through a surcharge on electricity bills. Payments into this fund would continue until such time as the fund reaches a certain threshold at which time the funds would be set aside to gain interest through managed investments. In the event of disaster that will require a costly expenditure for recovery, power utilities could petition the regulator for release of these funds to defray their expenses. In effect, this would provide power companies with an insurance policy against damage to the distribution infrastructure, with coverage financed by the utility's customers.

PRODUCTIVE SECTORS

TOURISM

Lack of insurance in small businesses is particularly acute, as recognized by The Bahamas Insurance Association (BIA). There is also extensive underinsurance as one moves away from New Providence. It is in the best interest for the tourism sector for insurance coverage to increase. Having insurance raises the possibility that the business affected by the storm will recover and undergo a resilient reconstruction process.

Insurance coverage should go beyond insuring tourism facilities and cover income. These policies are offered but only a small group of business takes them. Here there is also space for public action, generating information of the relevance of this type of coverage and giving incentives for the business to take them.

Tourism is very vulnerable to bad news. Bad publicity and intensive coverage of the storm sometimes generate adverse effects leading to cancelations or reducing future flows of tourists. The Bahamas Ministry of Tourism and Aviation has dedicated some resources to make clear that The Bahamas, as a destiny is still open[28]. This has been done in the past successfully. A proper fund to pay for these expenses should be created; this fund should accumulate resources in good times, to spend them in times of need.

28 "14 Islands Welcome You With Open Arms"

AGRICULTURE AND FISHERIES

Many of the fishing vessels, particularly those smaller, are not insured or are underinsured. It is important to encourage insurance not just for the vessels but also for all connected infrastructure. Having a complete registry for all the vessels, no matter their size, devoted to the fishing activity might help to device a public policy targeted at increasing insurance in the sector. There also public infrastructure supporting the fishing activity, these facilities should be required to be insured by law. CCRIf already offers insurance for fisheries.

A larger fraction of agricultural producers is not insured or underinsured. This is true for their infrastructure and even more for their crops. Insurance should be encouraged, and this insurance should be comprehensive, possibly including crops. Both the fisheries and the agriculture sectors would benefit from the promotion and creation of associations to seek better group rates, expand coverage and identify sectoral needs.

COMMERCE

While most large business were well insured, many small and microenterprises were not insured or were underinsured. As insurance is a key factor in the financial protection pillar, efforts should be made to increase insurance penetration, both for property and loss of business. In 2018 the government removed the VAT requirement from homeowners' insurance; something similar can be done for small and micro enterprises. While discussion with The Bahamas Insurance Association revealed that this measure has not yet significantly increased insurance penetration among homeowners, witnessing the level of devastation left by Hurricane Dorian may influence both homeowners and small business owners to increase their coverage. Another suggestion that arose in discussions was the possibility of government subsidizing insurance for homeowners and small businesses. While this would increase the government's annual expenditure, it may reduce the total relief expenditure in the event of another disaster. Besides direct subsidies, the government could also promote business associations and support their requests for group insurance and rates.

ENVIRONMENT

It is a good practice to request insurance coverage to remedy ecological disasters to companies that provide fuel storage. This type of insurance coverage should be accompanied by risk reduction and prevention activities outlined in disaster risk management plans.

Financial mechanisms offered by traditional bilateral and multilateral agencies will be critical for a resilient rebuilding of affected areas. Climate adaptation investments can, whenever possible, be channeled to the reconstruction projects. For example, the upcoming GEF-7 investment cycle will prioritize initiatives aimed at restoring water supply resources in post-disaster areas, flood and drought early warning systems, development of DRM plans, nature-based conservation efforts and data availability for science-based policies and decisions. Applying for these types of resources also requires staff training in project design and management. It is also recommended to design multisectoral proposals that consider multisectoral resilience building by linking the agendas of climate change and disaster risk management.

PILLAR 5: RESILIENT RECOVERY

The reconstruction process must avoid the reproduction of risk conditions and to improve resilience in the affected areas. Even if disasters have harmful effects on societies and economies, they are also an opportunity to change policies and practices. In this regard, it is important to plan a multi-risk reconstruction process that can respond not only to the hazard that caused the disaster, but to any hazard to which the country or community is exposed.

The recovery process takes place in two stages. The first involves attending to the affected population and seeking to restore the functionality of existing infrastructure and normalize production activities. The second involves upgrading strategic infrastructure in accordance with a vision of local development that considers the other recommended actions.

The most important recommendations in this section are persistent challenges highlighted in previous assessments: (i) enforce the application of the building code and establish sectoral standards for essential infrastructure and businesses; (ii) establish zoning strategies, including the development or update of coastal and marine management plans and construction restrictions in coastal and marine areas to ensure protection of ecosystems and promotion of tourism. Likewise, it is important to analyze the possibility of relocating some of the most affected communities, especially those located in risk-prone areas, and avoid similar situations in the future. And (iii) outline protocols to organize DRM efforts, these guidelines are particularly important during the preparedness and response stages to avoid confusion, manage support, coordinate mandates and empower sector leaders.

Previous assessments highlight the importance of avoiding the reproduction of pre-disaster risks. However, given the level of devastation of Hurricane Dorian, these recommendations become even more pertinent. The need to rebuild entire communities demands rethinking the location of settlements, redesigning its infrastructure, especially public infrastructure, and strengthening environmental restoration as a first protection barrier. Although communities need immediate solutions, especially in housing and employment, reconstruction efforts and plans should not be rushed and the opportunity to build resilience should be fully appreciated. The effects of Hurricane Dorian provide the government of The Bahamas and the communities on Abaco and Grand Bahama to be reconstructed as disaster and climate change resilient communities. The expertise of offices like UN-Habitat and UNOPS could be highly beneficial in the design of these communities and the proper and risk-sensitive execution of scarce reconstruction resources. Additionally, leveraging the on-going work with the IDBG under the Climate-Resilient Coastal Management and Infrastructure Program (BH-L1041) will be critical, particularly as a Coastal Zone Management Unit will be created to support the efficient use of reconstruction resources; and in support the Government in the design of building codes as well as appropriate enforcement mechanisms. Scaling these efforts quickly will be important to enhancing the resilience of the archipelago.

It is also important to remember the inextricable link between climate change, ecosystem protection and disaster risk management. The severity of the last hurricane seasons has not been an isolated or random event, but part of a comprehensive process of global changes. The main recommendation on preparing for future events, therefore, is to increase the resilience of natural, environmental, and social systems, especially those that provide protection against natural hazards (shorelines, mangroves and coral reefs). Both conservation and disaster risk reduction measures will benefit biodiversity and can thus form a cornerstone of efficient policies for integrated use of land, natural resources and sustainable tourism.

The challenges posed by disasters and climate change severely threaten development gains and further limit investment capacity. However, they also offer an opportunity for improved investments and financial management through multi-purpose projects that foster development and resilience and make efficient use of scarce resources. The goals and activities supporting climate change adaptation and disaster risk management are complementary and tend to overlap, climate change adaptation is also a fundamental component of disaster risk reduction. In addition, the nature of both challenges calls for strong collaboration with other sectors (water, energy, transportation, public infrastructure, agriculture, and planning, among others) to achieve widespread benefits and efficiently use resources. Prominent examples are healthy coral reefs, wetlands and other ecosystems that reduce vulnerability to climate change and increase resilience to disasters by acting as a first line of defense but are severely threatened by urbanization and the effects of climate change.

AFFECTED POPULATION

Government officials informed the Assessment team that they were only able to get to the affected people on Abaco three days after the hurricane because of the destruction and inaccessibility on the island. At times like these, society demands timely and efficient emergency response. The government should therefore focus on empowering its people by improving the preparedness of local communities, institutions and services for a more efficient local response. The promotion of community-based disaster management is an essential component of all emergency and development programming, by putting greater emphasis on what communities can do for themselves and how to strengthen their capacities in an emergency so they are not reliant solely on government help. It is recommended to establish a network of public and private entities, community-based organizations, women's organizations, youth and older persons' associations, and international and regional organizations that meet periodically and define roles and responsibilities in times of disasters to strengthen coordination among the different entities in disaster management and response. This sort of network can also enable the exchange of lessons learnt and best practice models, both between the protection and rescue institutions and services and between rescuers who often face the same tasks and challenges in their work. It is important to take full advantage of social media and other digital applications to facilitate communication, the use of chat groups and expert networks are highly recommended. In addition, most of these platforms are free of charge and are already ubiquitously and routinely used.

SOCIAL SECTORS

EDUCATION

A significant number of school days are lost following a weather event of the magnitude of Hurricane Dorian. In The Bahamas, national exam dates are fixed, therefore, lost school days must be made up in preparation for such exams. One way to minimize the number of lost school days following such events is to consider the creation of temporary virtual learning environment post-disaster scenarios with focus on students scheduled to take national exams within the school year. These virtual classes will allow for continuity of education and limit the number of makeup days to complete the school curriculum. To avoid connectivity issues these classes could be pre-recorded, following the normal curricular guidelines. Consideration should also be given to staggered school openings to minimize lost school days. On Grand Bahama, although some schools were severely damaged, others experienced minor damage and could have been opened to accommodate students, however, all schools remained closed for a significantly long period of time.

Although this alternative could greatly reduce lost school days, it requires important planning and setting up of adequate conditions. Given the widespread interruptions in the electricity sector and its effects in telecommunications, it would be important to consider offline schemes or to acquire mobile ICT infrastructure to support the initiative. It is also necessary to determine the location of these virtual lessons, whether in school or in students' homes. However, the latter could expose issues of access to equipment, electricity and telecommunications.

As a temporary measure, provision of transportation to displaced children to go to school should be considered, as the parents might not be able to bear these extra costs immediately after the event.

HOUSING

Building code revision

As it was informed to the Assessment team, the revision and upgrade of the existing building code is already underway. Timing is crucial in this process, so that the reconstruction process can be done in compliance with new requirements. It is also recommended to establish revision periods every five years and after major events, such as Hurricane Dorian.

The updated building code should incorporate measures considering stronger wind speeds and more severe conditions related to water surge. A key further aspect is to monitor and to establish an evaluation method using KPI's of the code's performance on future events. This will provide the institution involved with the required information to correct any deviation from the envisioned goal and provide space for future improvements. Training of professionals and consultants in charge of the construction process and the people associated with the sector must also be considered.

The successful application and enforcement of building codes is an important aspect in the process of having a resilient reconstruction process. Due to the spatial distribution of The Bahamas, other stakeholders besides the Ministry of Works should be empowered such BCA, Universities and local communities. This would facilitate the achievement of a successful program of Quality Assurance/ Quality Control (QA/QC) inspections, the enforcement of codes application and verification on the construction materials used. The success of this effort requires a gap analysis on the competency of local inspectors, designers, engineers, builders, and construction workers to prepare and receive adequate training to comply with the new requirements.

To strengthen these building regulations, governments must work with insurance and financial companies in the private sector. Financial incentives such as policy rate reductions, incentives or loans with lower interest rates could stimulate compliance with codes and standards.

Finally, cooperation with other countries and international institutions should be considered to gather information on proven technical improvements and upgrades implemented in the building codes and constructions methods.

Construction methods / materials

As it has been discussed with the authorities and recommended in previous assessments[29], one important aspect of a resilient reconstruction for the housing sector is the use of approved and quality-controlled construction materials that are included in and regulated by the building code. Due to the natural condition of islands' territories and the complicated management of logistics, plus the limited production and availability of construction materials, there is a risk of using non-approved and non-recommended materials. Therefore, besides aspects related to correct location,

29 See IDB, ECLAC, PAHO (2015), (2017) and IDB, ECLAC, FAO, PAHO (2016).

planning should reinforce material selection, construction supervision and inspection to ensure optimum results to withstand hazards and mitigate risks.

A comprehensive analysis of materials and methods is particularly important given the role the government plays in providing support for reconstruction, especially in the housing sector. It is highly recommended that public disbursements consider these recommendations to avoid reproducing risks and to ensure optimal and resilient use of public reconstruction funds.

The resilience of structures can be improved using masonry walls and stronger roof solutions. While wooden reinforced roofs can be split and torn off by strong whirlwinds, concrete or steel roof stays put and prevents leakage.

During the sites visits to Abaco and East Grand Bahamas, it was observed that wooden structures and especially wooden roofs are extremely vulnerable, so it is imperative to evaluate technical and sustainable application of different construction methods and techniques. As wooden structures are and will continue to be part of the materials used in The Bahamas, it is important to reinforce the code regarding materials and construction methods, such as requirements for stronger / robust connections between the different wooden pieces. The connection between roof structures and walls is the most critical structural connection in a house to resist the effects of tropical storms. Observations on field visits revealed that roof damage were largely a result of poor anchoring to the crown beams of the houses. Rigorous specifications should be enforced for connection elements used to join columns and wooden beams.

Concrete has excellent structural performance and durability but is affected by early deterioration when subjected to a marine environment. Research indicates that seawater is not suitable for the mixing and curing of both plain and reinforced concrete in marine conditions. It is very common in the Caribbean Islands to use beach sand and in some cases, seawater, when mixing concrete. The problem with using aggregates with salty components is not with the concrete, but with the steel reinforcing. In cases where locally sourced materials are to be used, it is recommended that the approval of a civil engineer be required for a project to be able to proceed. Corrosion is the leading cause of damage to concrete structures, and a possible solution is the use of basalt rebar to reinforce the concrete. This corrosion-chemical-resistant composite material is made from basalt rock and is two times stronger and four times lighter than steel. The use of this material should be specifically authorized and recommended in the next revision of the building code.

Maintenance

A key aspect of vulnerability of infrastructure during hurricanes is the lack of proper maintenance. Buildings and houses properly maintained have proven more resilient. Unfortunately, perhaps due to cost and economic conditions, lack of maintenance appears to be a chronic problem with many public and residential buildings.

The building code should incorporate or improve an effective preventive maintenance program, especially for public infrastructure. Preventive maintenance plans will allow the sector to help proactively perform maintenance, repairs, and replacements. These procedures can prevent failures, mitigate damage and extend the lifetime of the assets, while reducing the personal and financial risk of households.

INFRASTRUCTURE SECTOR

ROADS, AIRPORTS, BRIDGES, DOCKS AND SEAWALLS

Similarly, to the housing sector, vital infrastructure assets should be designed and built according to the codes and standards. The codes and standards of design and construction should be reviewed considering the magnitude and frequency of events, and the type of damage generated by previous events to protect the assets and guarantee the continuation of service and fast recovery. Construction materials are very important in the application of construction codes in The Bahamas, as they can affect the ability of constructions to withstand hurricanes. Therefore, the use of resistant materials and their standardization are highly encouraged.

ZONING AND PROTECTION ELEMENTS

A resilient design must incorporate the strengthening of the infrastructure so that the performance of the system does not show significant deterioration during a hazard. The recovery process requires prioritization of the critical infrastructure, which allows the other systems to continue to operate. In this sense, transport networks are essential to ensure recovery and connectivity during and after disasters and should remain operational.

As seen in the field visits to the affected areas especially those close to the shoreline, these elements demonstrated an excessive exposure and vulnerability to Hurricane Dorian. Roads near to shorelines suffered severe damage as seen in Figure 46. The port infrastructure for small vessels also suffered major damage as seen in Figure 47. As suggested in previous assessment, it is recommended to reduce road exposure by defining a minimum distance to shorelines and by strengthening the infrastructure using, for example, elevation, greater thicknesses in the asphalt layers or better granular solution.

FIGURE 46. DAMAGED ROAD ON GRAND BAHAMAS ISLAND

Source: Assessment team, 2019

FIGURE 47. DAMAGED DOCK ON GRAND BAHAMA

Source: Assessment team, 2019

A collapsed bridge (as seen in Figure 48) in the route that connects the city of Cooper's Town with Crown Haven in the northern part of the Abaco Island shows the underestimation of the hydraulic flows under the bridge and the length of the spans. The reconstruction of this and other new bridges must incorporate a hydraulic analysis that allows estimating the necessary length of the bridge span even for extreme events such as hurricanes.

FIGURE 48. COLLAPSED BRIDGE IN NORTH ABACO

Source: Assessment team, 2019

In the case of airports, three types of effects were observed: (1) impact on structural elements due to severe winds; (2) impact on non-structural elements produced by wind and (3) operational effects resulting from the water level in the facilities. Structural damage includes buckling on metal beams, cracks in walls, and roof collapses. A resilient infrastructure recovery should incorporate a review of wind standards for design of critical infrastructures. An improvement in the design and building codes for wind can improve the performance of structural elements. Figure 49 shows some of the structural failures caused by wind.

FIGURE 49. STRUCTURAL DAMAGE IN THE AIRPORT ON ABACO

Source: Assessment team, 2019

In terms of non-structural damage caused by wind, it is observed that the fencings and the hangars were very affected (Figure 50). It is recommended to improve the materials of the fencing, and the distance between pillars to reduce the effect of the wind. Finally, flooding of the airport offices generated operational damage to the communication system, electricity generation, storage system, among others. The definition of a minimum construction level for the critical elements, which allow the operation of airports, is essential to incorporate in future designs. From the field visit it was observed that certain units of the Abaco airport were not affected by water intrusion because they were at a higher level.

FIGURE 50. DAMAGE TO NON-STRUCTURAL ELEMENTS IN FREEPORT INTERNATIONAL AIRPORT

Source: Assessment team, 2019

An important part of the electrical equipment for air control and security of airports was destroyed. International standards, good practices and protocol defined by the International Civil Aviation Organization (ICAO) require the optimal condition of the equipment. It is important to analyze the risks to which the equipment is exposed in the case of Category 5 hurricanes. For example, these types of equipment should be installed considering a lower elevation limit, which allows them to stay dry in the event of flooding or surge. Figure 51 shows the effect of the waterlogging on the runway and the facilities, and the potential operational consequences of the situation.

FIGURE 51. THE LEONARD M. THOMPSON INTERNATIONAL AIRPORT

Source: Google Earth and Terran Knowles/Our News Bahamas

WATER AND SANITATION

The vulnerability of the existing water provision infrastructure creates a significant exposure in the case of hurricanes, as well as maintenance issues, inefficiencies and an inconsistent supply of potable water and the collection of water sewage, directly affecting the population, the environment and the quality of service required for a vigorous tourism industry. Severe damage was observed in storage tanks (Figure 52), pumping stations (Figure 53), and in the sewage and distribution systems

FIGURE 52. MAIN STORAGE TANK DAMAGE IN MARSH HARBOUR PUMP STATION

Source: Assessment team, 2019

FIGURE 53. DAMAGE TO PUMP STATIONS IN MARSH HARBOUR AND TREASURE KEY

Source: Assessment team, 2019

Providing potable water and sanitation services are mandatory for successful recovery after a hurricane. Related infrastructure should be reinforced to ensure that it is resilient enough to natural hazards. This includes ensuring that water and sewerage services are reliable and as autonomous as possible. In field visits, the Assessment team identified two key issues: reliance on power for water generation and vulnerability of water storage tanks. Service providers should consider these issues and draft disaster risk management plans that address previous shortcomings and ensure access to potable water and adequate sanitation. In general, utilities regulators play a vital role in ensuring the private providers of public services improve their operation and guarantee continuity and quality.

DEPENDENCY ON ELECTRICITY FOR FRESHWATER PROVISION

As mentioned before, the geographical distribution of the water services is heavily dependent in an extremely vulnerable power distribution network (Figure 54) that suffered substantial damage on Grand Bahama and Abaco. A risk mitigation plan to enhance overall resilience of the water sector should start by assessing the reliability of the power sources, backup systems, emergency generators, and fuel logistics, along with providing adequate shelter to protect assets and backup generators from storms.

FIGURE 54. POWER DISTRIBUTION NETWORKS ON GRAND BAHAMA (VIA EAST END)

Source: Assessment team, 2019

It is recommended to execute a thoughtful evaluation process to install in remote areas a more reliable source of power, especially considering the use of different forms of renewable energy (Figure 55), such as wind, solar, and small-scale waste to energy, among others. This process can result from the budgeting swap from a costly, inefficient and vulnerable power distribution to stand alone power sources using renewable energy solutions.

FIGURE 55. SAMPLE OF SMALL SCALE / ENCLOSED RO SOLAR PLANTS


Source: https://www.solartronenergy.com/water-treatment/ (multiple suppliers)

REDUCE VULNERABILITY OF WATER STORAGE TANKS

As discussed with officers from WSC during the field visit, given the exposure of The Bahamas to major tropical storms, new water tanks shall be designed to withstand Category 5 hurricane-force winds. The roofs of tanks and the structure anchoring to the foundations were found to be particularly vulnerable, therefore, alternative designs are required. Efforts on this regard have been started by the initiative of the WSC like the new tank construction in Eleuthera (Figure 56) using different construction methods and materials (Glass-Lined-Steel) to increase the resilience of these assets. This is a perfect example of opportunities for local companies to offer solutions based on the islands' experiences and accumulated knowledge in the response to disasters.

FIGURE 56. SAMPLE OF SMALL SCALE / ENCLOSED RO SOLAR PLANTS

Source: https://ewnews.com/officials-view-water-storage-facility-on-eleuthera

Tanks should also be protected from the direct impact of wind, especially when they are empty. In this regard it is also recommended that an emergency management plan be prepared that clearly identifies all steps to follow in every stage of a tropical storm. This plan should contain two crucial elements:

I. A protocol on how to prepare each component of the system to improve its resilience to hazards.

II. A check-up protocol for system start-up after a storm to ensure that operations are safe and unnecessary losses are avoided.

CODES AND STANDARDS

WSC shall continue working with the Ministry of Works in improving and upgrading the building code, as well as enforcing its application. The building code must include special conditions for water and sanitation assets and structures that must sustain the effect of hurricane wind forces and water surge, including the use of state-of-the-art technologies and methods. This effort shall include, but is not limited to:

- Review guidelines and standards for the whole system
- Strategic zoning / elevation of critical facilities
- Implement where applicable and if possible, robust solutions such as blast resistant / enclosed / waterproof for the pumping stations, electrical systems associated and storage tanks
- Implement stand-alone solutions leveraging on renewable energy resources

The cost associated with improving water and sewage systems to be more resilient to tropical storms is high. It is recommended to elaborate a detailed strategic plan prioritizing short term measures to recover services provisions while contemplating a long-term time horizon that can provide the system the robustness and reliance it requires.

It is also recommended to generate a fit for purpose guideline document for preparedness with a disaster actions check list for utilities (a link of a sample of an EPA check list can be found here: https://www.epa.gov/sites/production/files/2015-06/documents/hurricane.pdf).

Further, several key measures are recommended to improve reliability, resilience and quality of services:

- Improve the distribution network by implementing a more robust piping system, including industry standard leak detection systems, quality construction materials in accordance with urban development, as well as a comprehensive plan to mitigate the vulnerability of the system. Figure 57 presents a piping system visited in Marsh Harbour and Treasure Key as an example of above-mentioned aspects.

FIGURE 57. PIPING SYSTEMS / PUMPING SYSTEMS

Source: Assessment team, 2019

- Improve water treatment / desalinization capacity and resilience by developing a management plan identifying vulnerable and exposed areas and assets. It would be also recommended to have this type of equipment / facility under a strong wind resistance enclosure building.

- Develop a plan to increase reliability and reliance on the water source and collection system. During the field visit it was observed the vulnerability of this key component for the water sector (Figure 58). Reinforcing the design standards will increase the robustness of the system, especially in the piping recollection systems for ground water and power back up reliability to pump water to main pumping stations.

FIGURE 58. GROUND WATER COLLECTION SYSTEM / POWER BACK UP

Source: Assessment team, 2019

- Reinforce preventive and corrective maintenance standards and procedures to increase reliability of the system. Facilities visited on Abaco shown some level of deterioration due to a potential lack of maintenance.

- It is important to evaluate and plan an integrated waste management plan including water waste and solid waste, by reinforcing solutions and technologies that allow to mitigate the contamination risk on the sewage system, control of septic tanks construction, and implementing a public campaign of waste regulations and control, including recycling.

- Especial attention and focus should be given to marine water discharges and natural drainage from ponds / water reservoirs (subject to different sources of contamination) and its coexistence with the shoreline and beach area.

POWER

The vulnerability of The Bahamas energy systems to climate change and disasters demands a redesign of power grids and the incorporation of technological advancements for the improvement of the services. Decision makers and managers should overcome the current energy paradigm and promote the diversification and distribution of energy sources, the enhancement of energy efficiency and behavioral change among consumers.

The energy sector has an important role in every stage of the DRM cycle, it is important for stakeholders to incorporate DRM strategies in planning and early stages so that a more integral convergence between DRM and modernization of energy systems is achieved. A modern energy policy that incorporates widespread use of renewable energy (RE) and invests in energy efficiency (EE) would reduce risk in isolated communities, while reducing the country's expenditure on fossil fuels and production of greenhouse gas emissions.[30] At the same time, a more stable grid would increase the resilience in areas such as health, water, and production. Distributed generation would allow utilities and power users to diversify the energy sources from which the grid(s) is (are) nourishing. Although the installation of disperse power generators implies high investment costs, the capitalization of these systems could be balanced by the savings in transmission and distribution from high voltage/centralized power generation systems.

The first step is to assess the type of RE technologies to be incorporated into their energy mix. Moreover, it is important to strengthen the policy commitment to RE and to mobilize funding. Second, institutional, technical and human capacity to support RE deployment must be built across institutions and relevant actors. Individual assessments should be carried out to determine the path and pace to adopt the most suitable technologies and measures to mitigate and adapt to climate change and build resilience to disasters and climate change. Additionally, it is important that existing information and data is properly shared. Potential measures to enhance EE should be encouraged in the reconstruction of public and private properties, using both structural and technological measures through building energy codes and minimum energy performance standards (MEPS). Procedures for EE and RE technology upgrades in buildings should be streamlined to avoid the risk and expenses of bureaucratic processes and be focused on efficiency standards for technologies that are cheap and easy to deploy (e.g., cooling methods, natural ventilation systems, and lighting).

Although current grids could be, to some degree, compatible with available RE technologies adjustments in their design and technical features could be required. The integration of RE, into power grids requires a substantial transformation to:

I. Allow for a bi-directional flow of energy from top-down (i.e., from generators to users) to bottom-up (i.e., end-users contributing to the electricity supply) that could ensure stability when installing distributed generation;

II. Establish efficient electricity-demand and grid management mechanisms that allow reducing peak loads, and improve grid flexibility, responsiveness and security of supply in a context of increased systemic variability;

III. Improve the interconnection of grids at national and local level, this would increase grid balancing capabilities, reliability and stability;

IV. Introduce technologies and procedures to ensure proper grid operation, stability and control (e.g., frequency, voltage, power balance) in the presence of a significant share of variable renewable energies;

V. Introduce energy storage capacity to store electricity from variable renewable sources when power supply exceeds demand to increase system flexibility and security of supply.

30 This section is based on Flores and Peralta (2018)

TELECOMMUNICATIONS

Most of the communication between persons, between organizations (including government), and within organizations are based on three types of telecommunication activities: wired activity, wireless activity and satellite services. These three major activities, taken along with television, radio broadcasting and information services such as websites, are how information is shared to mobilize efforts both before and after a disaster.

A disaster, despite its negative effects, provides an opportunity for affected islands to update, renew and reorganize systems in place within the telecommunications sector. The destruction of old infrastructure provides difficult yet valuable experiential learning that should motivate more appropriate decision making.

In the case of Hurricane Dorian, the high winds and heavy rains brought with them floods, destruction and storm surge, and created great difficulty for rescue operations. Within this context, wireless telecommunications were found to play an exceptionally useful role in the response efforts. The prompt restoration of wireless telecommunication services meant that persons were able to communicate with each other, verify the safety of loved ones and seek help by sending their location to others. The ability to locate persons via the use of global positioning system (GPS) coordinates that were sent via the wireless network meant that first responders were able to coordinate their efforts to save the lives of those in the most dangerous predicaments after the storm.

Tropical cyclones (storms and hurricanes) are by far the most frequently occurring natural hazard in The Bahamas. As such, most wired telecommunications infrastructure (cables and microwave dishes) and some elements of wireless communications (cellular towers and antennae) are highly vulnerable to being damaged or destroyed by gale force winds. Extra care should therefore be put into making sure that these infrastructures meet higher standards of resilience.

Base transceiver stations, which are a major component of wireless networks, are highly susceptible to wind and water damage and should, therefore, be well insulated from the extreme weather, ensuring that materials used are of a high standard. The high level of flooding caused by Hurricane Dorian has brought attention to the need for elevation of equipment within base transceiver stations; the complete elevation of base transceiver stations; or where necessary the relocation of some stations to a more appropriate location on higher ground.

Periodic inspections of physical assets such as utility poles, cellular towers and antennae is an essential practice for encouraging maintenance of infrastructure as well as for assisting in identifying potential risks. One risk includes the falling of cellular towers due to powerful hurricane winds. These fallen towers can cause serious damage to other nearby structures if not situated in an area with enough clearance. The government office responsible for town and country planning has an opportunity to play a role in this regard by ensuring that newly erected towers are removed from built-up areas where damage can be done to other important surrounding buildings or infrastructure. Also, when authorizing the construction of new stations ensure that these are sufficiently elevated or in elevated locations.

FIGURE 59. FALLEN CELLULAR TOWER, WITH DESTROYED BASE TRANSCEIVER STATION

Source: Assessment team, 2019

PRODUCTIVE SECTORS

TOURISM

The recovery challenges for Grand Bahama and Abaco are different. For Grand Bahama most of the tourism infrastructure is located around Freeport and was not severely impacted. There were some small properties in the east end of Grand Bahama that were severely affected. For Abaco, particularly Central and North Abaco, the situation is different as part the touristic infrastructure was destroyed. The recovery will take longer and require more resources for Abaco and the east end of Grand Bahama.

Grand Bahama had not yet fully recovery from the adverse effects of Hurricane Matthew. The Grand Lucayan properties did not fully recover, and this has negatively affected the economic performance of the tourism sector. The importance of anchor properties is highlighted once again. It is important to generate the conditions for key properties to come back as soon as possible; they tend to pull the rest of the business with them.

On Abaco, where there is an important number of second homes and some luxury resort destinations, the recovery might be faster. A great number of these properties are insured, and some of them even have channels to assist loyal customers. In contrast, there are several smaller businesses, potentially non-insured, that will struggle to recover. It is important to assess these differences and provide assistance accordingly.

Regarding tourism infrastructure, it is recommended to generate a specialized auscultation manual to assess the specific damage for each facility. A resilient recovery must incorporate two key factors: (1) infrastructure strengthening through structural design and (2) efficient management of recovery times to reduce losses, for this, it is recommended to generate a master recovery plan based on the auscultations.

The recreational docks, which are key infrastructure for the tourism on Abaco, suffered severe damage. Figure 60 shows a destroyed recreational dock. The first cause of the failure is the connection between the piles and the deck board. It is observed that in general there was no failure in the piles of the dock but there was a failure in the board caused by the weak connection between both elements. For this, it is recommended to reinforce the pile - board connections and increase the control of the construction processes.

FIGURE 60. DAMAGED RECREATIONAL DOCK

Source: Assessment team, 2019

AGRICULTURE AND FISHERIES

It is necessary to establish a complete registry of all the vessels and fisherman devoted to the fishing activity. This will help in the design of a plan for the recovery of the sector, and to better target the allocation of reconstruction resources. It is important that the new infrastructure is build up to code, and there should be incentives for those managing key facilities to bring them back to operation as soon as possible. Fishing is an activity that supports many families, and in some areas of The Bahamas is the main activity, particularly in smaller communities.

The reconstruction of all agricultural infrastructure should be done meeting the code requirements. Regarding the greenhouses, information should be provided regarding better practices in materials, shapes and structures. There should be also information available on how to recover the affected soil. The current agricultural registry should be updated and expanded to include smaller producers. Information should also be provided to agricultural producers on the benefits of insurance and helping them design a plan to put in place in the event of a storm.

COMMERCE

Rebuilding efforts require the importation of construction materials. Typically, homeowners and businesses would import the necessary materials from large hardware stores in the United States. If local hardware stores are given the tax credits necessary to import rebuilding materials, this can keep a lot of the recovery expenditure within the economy. While local stores may not have the capacity for the full rebuilding effort, this measure will still be a boon to the local distribution sector.

ENVIRONMENT

The protection and recovery of ecosystems is a fundamental component of protection against hazards and dissipation of disaster effects. When coastal and marine management plans and private projects are developed or updated, they should incorporate considerations such as dock construction requirements (height, distance between docks and materials) and the introduction of building restrictions in coastal and marine areas to protect ecosystems and promote tourism, including defining restrictions in land-maritime zones. Considering the plan to update the existing building code, it is advisable to include standards for improved design of septic tanks, especially for septic tanks close to coastlines and well fields.

FURTHER ASSESSMENT OF ENVIRONMENTAL DAMAGE

It is recommended that comprehensive seagrass and coral damage assessments are completed and made available in all the areas where significant stands of seagrasses exist, inside and outside of the protected areas, and specifically where known abundances of conch larvae are present. The same should apply to mangrove areas to determine the actual damage and assess their recovery or deterioration over time. For restoration of forests and coral ecosystems, an assessment of existing nurseries and a cost-benefit analysis of investing in full restoration of key affected areas should be included in future budgetary discussions.

Information collected from different sources and organizations that have been carried out in affected areas should be used to guide decision makers in any future reconstruction plans in this sector. Further surveys and monitoring activity are recommended to track the progress of ecosystem recovery in the short, medium and long-term.

FIRE CONTROL MEASURES

Pine forests on Abaco and Grand Bahama, within and outside protected areas, sustained substantial damage that will impact the region for years to come. In addition to the carbon offsets, the fuelwood that has been created is highly likely to cause widespread fires that surpass existing capacities to control. Wildfires tend to become widespread during the dry season, which runs from November through April. Downed trees should be removed or mulched as soon as possible, especially in areas that are near critical infrastructure or settlements or that have high biological value.

Volunteer firefighters on Abaco have been trained in wildfire control, however, an alternative plan for additional fire crews should be put in place, considering that many of the local personal have been affected by the disaster and might not be able to return home in the near future. Additional measures such as firebreaks and wide fire lines are to be considered in identified areas close to roads, national reserves and around the zone of the oil spill. To facilitate the examination and control of wildfire, foresters can also make use of NASA's Fire Information for Resource Management System (FIRMS), as well as consider the acquisition of drones and access to satellite images. Areas that will not be revegetated should be monitored to prevent intrusion of invasive species. Further, it is recommended to research, evaluate and apply potential market uses of fallen trees.

DEBRIS MANAGEMENT

Similarly, it is recommended to analyze the possibility of reusing debris or waste materials from demolitions for new projects, as they can be used as fillers or for land rising. The establishment of the landfills on Abaco and Grand Bahama should consider environmental standards and avoid creating risk of contamination. The high number of damaged vehicles and boats might require a special arrangement. Clearance salvage of sunken vehicles in communities in East Grand Bahamas will have to be conducted.

MANAGEMENT OF OIL SPILL

According to the latest information made available by Equinor, around 30% of the 119,000 oil barrels spilled have already been recovered and the clean-up continues. It is important that these efforts endure and are closely monitored by the government to avoid and confirm that the contamination of underground water and nearby shore has not occurred. Observations of the site indicated that the clean-up procedure chosen is the removal of affected soil. This implies the removal of the ecosystem foundation, which will have to be remediated by future measures.

Storage facilities design codes and standards should be reviewed to incorporate stronger conditions due to the increase in frequency and strength of this type of events in the region during the last years and lessons learned in what caused the failure of the existing structures.

As a safety measure, the roof and tank walls joint is designed so that the wall and bottom joint fails first. Therefore, the volume of rainwater and roof parts that can be submerged in the tank during the storm need to be considered in the calculation. Retaining walls design should also considers these elements plus the potential risk of storm surge.

FIGURE 61. SPILL AT SOUTH RIDING POINT OIL STORAGE FACILITY GRAND BAHAMA

Source: AP Photo / Ramon Espinosa

ECO-INFRASTRUCTURE

Finally, in the reconstruction plans of affected areas, eco-infrastructures must be considered as an ecological way of reducing the vulnerability to natural hazards. In this sense, it would be relevant to explore public-private partnerships and take advantage of the extensive experience that some countries have with this type of construction techniques and available technology.

RECOVERY OF PROTECTED AREAS

Clearance and rehabilitation of infrastructure will be required in national parks managed by The Bahamas National trust, specially Lucayan National Park on Grand Bahama. Although the damage has not yet been fully assessed, it is expected that national funds allocated to this organization will have to be sufficient to meet parks' needs and rebuild ecosystems and more resistant infrastructure. National parks are integral to the economic well-being and quality of life for both islands, and their repair is critical to support the economy and livelihoods.

Annex

SECTORAL RISK REDUCTION RECOMMENDATIONS

SOCIAL SECTORS

EDUCATION

Given the continuous damage to the infrastructure of educational facilities because of the increasing frequency of intense storms such as Hurricane Dorian, it is critical that inspection of school compounds be mandatory, periodical and undertaken during the pre-hurricane season. During this period, efforts should be made to have infrastructural issues repaired (especially damaged roofs, gutters, and windows) and potential threats such as large trees, faulty fences, clogged drains and over-burdened utility poles near school premises removed. Such guidelines should be adhered to as outlined in school maintenance plans.

Both Grand Bahama and Abaco Islands experienced high storm surges resulting in severe water damage at the ground level. In the case of the University of The Bahamas, there was significant loss of school equipment housed on the ground floor of offices and classrooms. During past hurricanes, they were housed on higher levels but incurred water damage from impacted roofs. It is, therefore, important to secure important documents and equipment, such as, computers, photocopiers, and audio-visual equipment in waterproof containers stored in a safe and protected location. Staff should identify a room within the interior of the school building that will offer the most protection from water damage for important documents and equipment. A manual outlining the best practices for securing documents and equipment should be shared with school staff and reshared prior to the arrival of a storm.

Regarding education facilities, the risk is evident when using constructions sheetrock materials on the main structure. Also, wooden beams for supporting the final roofing finish (galvanized iron sheet) is not recommended due to the lack of resistance of this material to humidity. Roofing works should have proper bracing and fixing into a metal structure, not only to withstand the hurricane but to have a faster recovery through metal components on the supporting structure and the roofing finish. For example, on Grand Bahama most of the schools suffered from shingles being blown off during the hurricane due to lack of proper bracing on this cover and because of this asphaltic material that has as many joints as many tiles are placed. If one tile allows water intrusion a cascade effect is generated, causing more damage as time goes on and shingles continue to fall off the roof. In addition to rain resilience, winds up to 150 mph will cause severe damage to roofs if shingles fail to maintain adherence to the supporting structure below.

A similar scenario was observed on Abaco, where roofs were blown off causing major flooding damage. Windows were also blown off, so a protection here and on doors becomes critical to withstand these types events.

All windows and doors on buildings are exposed directly to debris and heavy rainfall during a hurricane, so it is imperative to include aluminum shutters to avoid further damage due to water intrusion. These shutters will also prevent having to replace these structures after the event and economize on a near future on the rebuilding process.

Finally, all main structure components should be constructed using masonry with proper steel reinforcement as specified in the building code, to avoid any humidity and later mold effects on sheetrock or similar materials in wall divisions. This setback is no longer recoverable for walls built with wooden structure and following sheetrock covering.

For this matter, it is considered of high priority and importance for The Bahamas to establish strict government supervision on the design and building of public and private educational facilities to incorporate disaster risk reduction measures. Vital operation equipment should be protected by debris barriers made from forged steel that can prevent these assets to be blown off or damaged during a hurricane event.

HEALTH

Regarding health facilities, the risk in some medical care buildings is high considering their location at almost sea level and without design specifications for hurricane resistance. Crucial equipment for hospitals such as power generators, air conditioning units, water pumping equipment for potable wells and septic tanks are exposed to hurricanes. Equipment should be protected by debris barriers made of forged steel that can prevent these assets to be blown off or damaged during a hurricane.

The projects of new health care facilities must include both a topographic analysis and the historical data of storm surge and incorporate disaster risk management considerations in the feasibility, design, construction and maintenance phases. This would guarantee less damage, allow them to function during the emergency and recover faster. Some of the healthcare facilities are dangerously near to the coastline, so they are very vulnerable to any tidal variation. High Rock, Pelican Point and McClean Clinics for example, were severely affected by the surge generated by Dorian due to their closeness to the coastline and low elevation compared to sea level.

Finally, all main structural components should be masonry with proper steel reinforcement as specified on the building code to avoid any humidity and later mold effects on sheetrock or similar materials in wall divisions. For example, Grand Memorial Hospital located at Grand Bahama is unable to initiate operations because of the mold generated from rainwater intrusion. Walls built with wooden structure and following sheetrock covering are non-recoverable. Therefore, wood and sheetrock are not suitable for locations with high humidity or prone to flooding and severe rain fall.

For this matter, it is considered of high priority and importance for The Bahamas to establish strict government supervision on the design and building of medical care facilities, both public and private. The Marsh Harbour Healthcare Center is a good example of a structure that withstood the hurricane with great resilience, and most of its success came from proper design, construction methods and an ideal location on the island. The World Health Organization has already determined guidelines for safe hospitals, which should inform all construction, repair and maintenance activities.

INFRASTRUCTURE SECTORS

ROADS, AIRPORTS, BRIDGES, DOCKS AND SEAWALLS

Transportation infrastructure, which includes roads, airports, ports, docks, among others, is essential for The Bahamas since its spatial distribution requires high mobility and connection between and within the islands. In the context of disasters, it has been showed that more than a third of the losses are caused by the lack of connectivity to the affected areas that suffered damage to the transport infrastructure (Duwadi, 2013).

The first recommendation corresponds to the implementation of a transport infrastructure risk management system that allows to study the hazard, exposure and especially the vulnerability of the infrastructure. To reduce the exposure of the infrastructure, it is necessary to define spatial limits based on the hazard analysis or through the experience of past hurricanes. It is recommended to define a minimum level of the foundation for the construction of critical infrastructure. To reduce infrastructure vulnerability, it is recommended to review the building standards of the transport infrastructure and monitor the state of each asset.

POWER

The damage to facilities at Marsh Harbour were extensive and, due to the great effort directed toward restoring power, there was no official assessment as to whether the generation plant would be repaired or replaced. Despite this, some recommendations will be made based on the observations done at the time of this assessment.

The structure that housed the power plant at Marsh Harbour requires some reinforcement to maintain its integrity against a Category 5 hurricane. The main building sustained damage to its outer walls which was caused by heavy winds (see Figure 62). This opened the structure to further damage from rains and flooding. One of the most reliable methods of ensuring resilience against strong hurricane winds is to use steel reinforced concrete walls instead of sheet metal. The introduction of a concrete structure would require an overall larger facility and would incur significant costs, however the protection to the power generator and monitoring equipment within is well worth the expense. A reasonable compromise would be to ensure that the section of the power plant that houses equipment for monitoring the generators is made of concrete. As for the generators, they are likely to be very robust to winds however elevation is needed to protect against flooding. All equipment at this site requires some elevation considering the potential for flooding observed.

The facility at Marsh Harbour also served as a storage site for various vehicles and equipment. The vehicles on site were all flooded along with other materials. This site should no longer be considered as secure for storing vehicles as there were significant losses.

The storage of various other materials on this site also brings the risk that some materials can be picked up by heavy winds and act as missiles which cause damage to the power generation structure, transformers and gas tanks. In this regard the relocation of storage is recommended. In the short-term equipment should at least be relocated to the side of the power plant that is not facing the oncoming winds.

To mitigate flooding in the long term, adequate drainage should be installed to allow for a rapid drainage of flood water. This combined with the elevation of equipment will go a long way in preventing future damage.

In the case of the flooded power plant on Grand Bahama, elevation of the generator may be enough, however, relocation should also be considered. No certain recommendation could be made as the privately-owned facility was not visited by the DaLA Assessment team. In this scenario, it is crucial to highlight the importance of regulating the quality of privately provided public services, such as electricity, and the need to establish continuity, redundancy and safety criteria for private operators.

With respect to the clients on Grand Bahama, the damage caused to the eastern end of the island has made it difficult for households and small businesses to receive a safe connection to the power grid. Reinforcement of the building code is, therefore, essential not only to the housing sector but for the power sector as power generation becomes costlier when there are less houses on the power distribution grid.

FIGURE 62. SEVERELY DAMAGED POWER PLANT AT MARSH HARBOUR

Source: Assessment team, 2019

Policies and investment programs are critical to reducing existing risks and preventing new ones from arising. In support of developing a more resilient power infrastructure on the island of Abaco, attention should be given to the two major 34.5kV transmission lines that run from the Wilson City power plant to Marsh Harbour power plant and storage facility (one power line on each side of the main road). The DaLA team observed that one of these lines went down during the hurricane while the other remained intact. This was due to the higher category of poles used for supporting the line that remained standing and operational. The consistent use of higher category poles is recommended for reconstruction, especially in the cases of essential power lines that connect the island's power stations. Also, of importance are the poles that support the power lines that go to the hospital and ports, as these are essential infrastructure that must remain connected to the power supply. This situation reaffirms the need to establish quality and operation guidelines for private operators of public services, especially as electricity availability affects a variety of essential services, such as telecommunications and health.

Further resilience can be added through the installation of storm guy wires to the transmission system. These additional points of support help to harden the more essential parts of the transmission and distribution grid and allow less damage during weather-related disasters.

Security after Hurricane Dorian was a major concern, as there were various breaches including; vandalization at various BPL facilities, vehicle theft, and interference with a fuel tank in an attempt to steal diesel. In the case of the breached fuel tank, a catastrophic fire could have followed the disaster, if not for the vigilance of the BPL staff. Security was an overall issue for the island of Abaco as there was a serious breakdown of social structure due to the widespread ruin. In such instances, patrols and military should be assigned to secure the power plants and other key infrastructure to avoid the creation of new risks and to support the rapid resumption of service. Also, social services should be quickly deployed to avoid feelings of abandonment or helplessness that could lead to acts of vandalism.

Five different voltage levels for transmission and distribution lines were observed, each of which required their own type of transformers and other supporting equipment. A helpful policy moving forward would be the standardization of the distribution network through the consistent use of equipment that supports one voltage level. This should allow for easier storage of the necessary materials for repairs and recovery and for more cost-efficient procurement practices. Further, there are implications for human resources as linesmen and other maintenance staff can be familiar with one standard throughout the island, saving the need for specialized labor depending on the type of system damaged.

On the island of Grand Bahama, damage to the main transmission line has disconnected the eastern end of the island from any source of power. The investment cost to replace the lost infrastructure to supply power to the eastern end of the island is likely to create a very high cost for service to consumers. A small localized grid with its own power generation source is therefore recommended for this section of the island. A small 1Megawatt diesel powered generator may be considered, though this option would also require substantial funding to set up and maintain. Renewable solar energy should be preferred if there is to be any major investment moving forward. Additionally, placing power generation sources closer to communities would make them less reliant on far-flung power lines that remain highly vulnerable to wind damage.

TELECOMMUNICATIONS

In support of the development of a more resilient telecommunications network the Public Utilities Commission (PUC), can encourage an above average - standard of infrastructure. Another incentive may be tax-based, where rates paid by telecommunications service providers to the government are marginally reduced as a type of reward for maintaining a resilient network. In the case of infrastructure that is already in place, the PUC may consider making continued use of the bandwidth spectrum, conditional upon submission and execution of a plan by the telecommunications carriers to ensure that a sufficient portion of their networks will be appropriately upgraded. For example, a coordinated upgrade of the cellular towers and base transceiver stations of both telecommunication service providers can take the form of one service provider spending extra to ensure a higher standard of infrastructure for one part of the island of Abaco (e.g. Central Abaco including Marsh Harbour and the various cays), while the other service provider spends extra to ensure a higher than average standard of infrastructure for another part of the island (e.g. North Abaco including Treasure Cay and the various cays). This scenario ensures that always there will exist some exceptional infrastructure throughout the island that is resilient to extreme weather events. Thus, service providers can benefit from each other's upgraded infrastructure through roaming agreements that allow for service throughout the entire island. This approach can allow the most rapid return of service to the end users – the people of the Bahamas.

As with previous assessments the resilience to hurricanes can be improved through the reinforcement of cellular antenna. Retrofitting antennas on cellular communications towers with additional bracing can prevent antennae from being blown out of alignment by high winds. It is recommended that this practice is adopted as a standard by all Bahamian cellular tower operators.

Various measures can be used to reduce the most frequent risks associated with wired and wireless telecommunications activity. As wired telecommunication components are typically above ground, the risk of damage can be reduced in two ways. The first and costlier option is burying most of the network cables underground to protect them completely from damage caused by strong winds.[31] The second option suggests using a type of 'fiber to the node' (FTTN) set up where cables (usually fiber) are run underground to the switch/cabinet/node that serves several clients, while the remainder of the network remains above ground. In both instances, care must be taken to ensure the soil in which cables are buried is not prone to landslide or flooding. In instances where burying cables is not advisable, a higher standard or class of utility pole is recommended.[32]

31 An activity that should be undertaken in collaboration with the Bahamas Power and Light Company on Abaco Island or the Grand Bahama Power Company on the island of Grand Bahama. This can ensure that all cable infrastructure can be carried out more efficiently and at shared expense.

32 Utility poles are often owned and managed by electric companies, in these instances an arrangement to split the cost of procurement or installation for the benefit off all parties involved is encouraged.

Loss of commercial power remains the greatest threat to the continued operation of telecommunications services, particularly mobile services, during and after a disaster. Backup generators or batteries located at cellular sites are a useful way to reduce the risk of failure. However, as Hurricane Dorian has highlighted the risk of flooding, upgraded insulation and elevated storage are advised to ensure the safety of batteries. In addition to this, it is important to consider security measures to ensure the safety of generators (a highly valuable resource after a disaster) as well as the potential logistical challenges to provide fuel for such generators. These types of measures could be included in mandatory disaster preparedness and response plans to be drafted by operators under the supervision and support of regulators and NEMA.

The elevated investment costs for ensuring a more resilient network with lower risk of failure can be balanced by the benefit of more rapid recuperation in the possible event of a hurricane. Previous Damage and Loss Assessments carried out in The Bahamas have noted that estimated losses from the non-provision of telecommunication services for one to three months after a disaster are significant, thus any efforts to mitigate similar losses should prove valuable.

PRODUCTIVE SECTORS

TOURISM

Unlike Hurricane Irma, Hurricane Dorian had a significant impact in the tourism infrastructure of Abaco, and to a lesser extent on Grand Bahama. Most of the tourism infrastructure is near the shoreline, this proximity increases the risk. In this case, it produced high consequences in terms of damage to structural and non-structural elements.

To effectively reduce the risk of the tourism infrastructure, it is recommended to reinforce the wind design code, and along with it, encourage inspections and control of construction processes with appropriate standards for this type of infrastructure. It is recommended to use concrete as a construction material because of its high structural performance and better response to wind solicitations. Water surge caused major damage in some areas. It is necessary that any new tourist development is done with proper setbacks from seashore, and in some cases stilts should be used to raise the level of the structure.

Hurricane Dorian caused important damage in the landscaping of the tourist facilities. This damage is the result of strong winds, salt-water intrusion and water surge. The replanting should be done with species resilient to tropical storms, avoiding species with superficial root systems prone to uprooting. The removal of compromised trees should be considered, even those known to be prone to uprooting like casuarinas. When considering planting new trees this should be done in groups, as it has been shown that trees planted in groups withstand strong winds better (Duryea and Kampf, 2007).

AGRICULTURE AND FISHERIES

The fishing activity and its infrastructure will remain near seashores, this makes this infrastructure vulnerable to water surge. Any reconstruction of the destroyed facility should take into consideration building according to code and establishing proper setbacks from the seashore wherever possible. Likewise, the docks and supporting infrastructure should be sturdy enough. In some occasions, the use of stilts for the infrastructure should be considered. Part of the lobster fishing is done using casitas, which are usually washed away during a storm. In some cases, it might be advisable to anchor them.

The buildings that support agricultural production should be code complying. Part of the agriculture in The Bahamas is done in greenhouses. It is important that any new greenhouse use structures, shapes and materials suitable for the country. It will be useful to move away from crystal greenhouses; these facilities are particularly vulnerable to wind damage.

COMMERCE

Structural failure patterns were identified in small and medium businesses located on both islands. The main causes observed suggest that the failures correspond to problems associated to the building materials and construction methods. During the field visit, lightweight material structures were observed with several damage to the roofs, walls, beams, non-structural elements and in some cases to the foundation. The importance of small and medium business in the supply of resources following disasters suggests that a design code with higher standards for those structures should be implemented. Depending of the structural design method, for example 'Allowable Strength Design' (ASD) or 'Load and Resistance Factor Design' (LRFD), some conservative factors could be added to the design of these structures, which play an essential role in the reconstruction process. In addition to improving and enforcing the building code when reconstructing Abaco and Grand Bahama, there is a need to create a registry of contractors. This registry will allow consumers to hire contractors that are adequately trained and abide by the appropriate building codes.

From the field visit it was observed that structures located closer to the shorelines suffered severe damage. In this sense, it is suggested to create a building regulation for the commerce sector that establishes a minimum distance to the coastline. This measure seeks to reduce the exposure of commerce infrastructure to potential new disasters.

In addition to structural protection, it is highly recommended to compile a comprehensive registry of micro, small and medium enterprises in the country. Information about the sector, location, size and other characteristics of these companies would allow for better public interventions, especially support for retrofitting and reconstruction, and access to credit. A comprehensive registry should also contribute to designing formalization strategies.

Local enterprises should also be part of the recovery and reconstruction efforts, as they can provide products and services necessary to prepare and respond to the emergency. The "Green Response" initiative of the Association of Caribbean States promotes the use of green materials to respond to the emergency, which could be developed and provided by local suppliers.

REFERENCE MATERIALS

Abaco CARES (2010). BEC continues with planned upgrades at power plant. Abaco Cares, Website. http://Abacocares.org/inthenews2.php

Anderson L., Dahlgren C, Knowles L et al. Marine Protection Plan for expanding The Bahamas Marine Protected Areas Network to meet The Bahamas 2020 declaration.

Arkema, K., D. Fisher, K. Wyatt (2017). Economic Valuation of Ecosystem Services in Bahamian Marine Protected Areas. Prepared for Breef By The Natural Capital Project, Stanford University.

Ariel E. Lugo, Caroline S. Rogers and Scott W. Nixon (2000). Hurricanes, Coral Reefs and Rainforests:

Resistance, Ruin and Recovery in The Caribbean. Royal Swedish Academy of Sciences.

Aven, T. (2010). On how to define, understand and describe risk. Reliability Engineering and System Safety, 95(6), 623–631. https://doi.org/10.1016/j.ress.2010.01.011

Balaguru, K; Foltz, G., Leung, R. (2018) Increasing Magnitude of Hurricane Rapid Intensification in the Central and Eastern Tropical Atlantic.

Bayraktarov E., M. I. Saunders, S. Abdullah et al (2016). The cost and feasibility of marine coastal restoration. Ecological Applications, 26(4), 2016, pp. 1055–1074

Bello, O.; Khamis, M.; Osorio, C.; Peralta, L (2017). Mainstreaming disaster risk management strategies in development instruments. Policy briefs for selected member countries of the Caribbean Development and Cooperation Committee. ECLAC.

Bil, M., Sedonik, J., Kubecek, J., Vodak, R., & Bilova, M. (2014). Road Network Segments at Risk – Vulnerability Analysis and Natural Hazards Assessment, 1–18. http://www.population-protection.eu/prilohy/casopis/eng/20/87.pdf

CEPAL (2019). Planificación para el Desarrollo Territorial Sostenible en América Latina y el Caribe. [LC/CRP.17/3], Santiago.

Clavelle T.; Jylkka Z. (2013) Ecosystem Service Valuation of Proposed Protected Areas on Abaco, The Bahamas. Sustainable Fisheries Group, University of California, Santa Barbara.

Cohen, Mark. (2010). A Taxonomy of Oil Spill Costs. Resources for the Future.

Duryea, M. and Kampf. E. (2007). Wind and Trees: Lesson Learned from Hurricanes. University of Florida IFAS Extension.

Duwadi, S., Pagán, J. (2013). Disaster Risk Reduction Through Resilient Highways: A Research and Development Program. Rev. Int. de Desastres Naturales, Accidentes E Infraestructura Vial, 13(1), 129–144.

Economic Commission for Latin America and the Caribbean (ECLAC) (2014). Handbook for disaster assessment.

Etkin, D. (2004). MODELING OIL SPILL RESPONSE AND DAMAGE COSTS. USA EPA Archive Document

Holland, G. & Bruyère, C.L. Clim Dyn (2014). Recent intense hurricane response to global climate change.

ICD Utilities Limited (2016). 2016 Annual Report. Grand Bahama Power Company, Website. https://gb-power.com/media/file/ICDU%202016%20Annual%20Report.pdf

ICF Consulting. The Bahamas National Report Integrating Management of Watersheds and Coastal Areas in Small Island Developing States (SIDS) Of the Caribbean.

IDB, ECLAC, PAHO (2017), Assessments of the Effects and Impacts of Hurricane Irma (The Bahamas).

IDB, ECLAC, PAHO (2015) Assessments of the Effects and Impacts of Hurricane Joaquin (The Bahamas).

IDB, ECLAC, FAO, PAHO (2016) Assessments of the Effects and Impacts of Hurricane Matthew (The Bahamas).

Javanbarg, M. B.; Takada, S. (2007). Redundancy model for water supply systems under earthquake environments, in Proceedings of 5th International Conference on Seismology and Earthquake Engineering, May 2007, Tehran, Iran, 1–8.

Knowles, Rachel (2019). BPL fuel charge drops for first time in months. The Nassau Guardian, Website. https://thenassauguardian.com/2019/05/16/bpl-fuel-charge-drops-for-first-time-in-months/

Lugo, A (2008) Visible and Invisible Effects of Hurricanes on Forest Ecosystems: An International Review Austral Ecology (2008) 33, 368–398.

Lugo A., Rogers, S. Nixon, S (2000). Hurricanes, Coral Reefs and Rainforests: Resistance, Ruin and Recovery in the Caribbean, Royal Swedish Academy of Sciences and Hurricanes: Science and society."

McGranahan, Gordon; Balk, Deborah; Anderson, Bridget. (2007). "The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones" Environment & Urbanization, Vol 19(1): 17–37. International Institute for Environment and Development.

National Hurricane Center (2019). "Tropical Weather Discussion". August 19, 2019. [Online] https://web.archive.org/web/20190902182712/https://www.nhc.noaa.gov/archive/text/TWDAT/2019/TWDAT.201908191805.txt

National Hurricane Center (2019). "Tropical Depression FIVE Discussion Number 1". August 24, 2019. [Online] https://web.archive.org/web/20190902182712/https://www.nhc.noaa.gov/archive/text/TWDAT/2019/TWDAT.201908191805.txt

National Hurricane Center (2019). "Tropical Storm Dorian Number 2". August 24, 2019. [Online] https://web.archive.org/web/20190825033128/https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.002.shtml

National Hurricane Center (2019). "Tropical Storm Dorian Number 6". August 25, 2019. [Online] https://web.archive.org/web/20190902193729/https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.006.shtml

National Hurricane Center (2019). "Tropical Storm Dorian Number 7". August 26, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.007.shtml

National Hurricane Center (2019). "Tropical Storm Dorian Advisory Number 11". August 26, 2019. [Online] https://web.archive.org/web/20190827093529/https://www.nhc.noaa.gov/archive/2019/al05/al052019.public.011.shtml

National Hurricane Center (2019). "Tropical Storm Dorian Discussion Number 13 ...Corrected". August 27, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.013.shtml?

National Hurricane Center (2019). "Hurricane Dorian Advisory Number 23". August 29, 2019. [Online] https://web.archive.org/web/20190831171829/https://www.nhc.noaa.gov/archive/2019/al05/al052019.public.023.shtml

National Hurricane Center (2019). "Hurricane Dorian Advisory Number 25A". August 30, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.public_a.025.shtml?

National Hurricane Center (2019). "Hurricane Dorian Tropical Cyclone Update". August 30, 2019. [Online] https://web.archive.org/web/20190831171835/https://www.nhc.noaa.gov/archive/2019/al05/al052019.update.08310027.shtml

National Hurricane Center (2019). "Hurricane Dorian Intermediate Advisory Number 33A". September 1, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.public_a.033.shtml?

National Hurricane Center (2019). "Hurricane Dorian Tropical Cyclone Update". September 1, 2019. [Online] https://web.archive.org/web/20190901212550/https://www.nhc.noaa.gov/archive/2019/al05/al052019.update.09011856.shtml

National Hurricane Center (2019). "Hurricane Dorian Discussion Number 34". September 1, 2019. [Online] https://web.archive.org/web/20190907042538/https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.034.shtml

National Hurricane Center (2019). "Hurricane Dorian Discussion Number 34". September 1, 2019. [Online] https://web.archive.org/web/20190907042538/https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.034.shtml

National Hurricane Center (2019). "Hurricane Dorian Tropical Cyclone Update". September 1, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.update.09020152.shtml?

National Hurricane Center (2019). "Hurricane Dorian Discussion Number 36". September 2, 2019. [Online] https://web.archive.org/web/20190902091351/https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.036.shtml

National Hurricane Center (2019). "Hurricane Dorian Discussion Number 37". September 2, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.037.shtml?

National Hurricane Center (2019). "Hurricane Dorian Discussion Number 40". September 3, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.040.shtml?

National Hurricane Center (2019). "Hurricane Dorian Discussion Number 41". September 3, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.041.shtml?

National Hurricane Center (2019). "Hurricane Dorian Discussion Number 47". September 4, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.047.shtml?

National Hurricane Center (2019). "Hurricane Dorian Discussion Number 47". September 4, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.047.shtml?

National Hurricane Center (2019). "Hurricane Dorian Tropical Cyclone Update...Corrected". September 5, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.update.09051612.shtml?

National Hurricane Center (2019). "Hurricane Dorian Discussion Number 52". September 6, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.052.shtml?

National Hurricane Center (2019). "Hurricane Dorian Tropical Cyclone Update". September 6, 2019. [Online] https://web.archive.org/web/20190906134748/https://www.nhc.noaa.gov/archive/2019/al05/al052019.update.09061254.shtml

National Hurricane Center (2019). "Hurricane Dorian Discussion Number 57". September 7, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.057.shtml?

National Hurricane Center (2019). "Hurricane Dorian Discussion Number 58". September 7, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.public.058.shtml?

National Hurricane Center (2019). "Post-Tropical Cyclone Dorian Tropical Cyclone Update". September 7, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.update.09072305.shtml?

National Hurricane Center (2019). "Bulletin Post-Tropical Cyclone Dorian Intermediate Advisory Number 63A". September 8, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.public_a.063.shtml?

National Hurricane Center (2019). "Post-Tropical Cyclone Dorian Discussion Number 64". September 8, 2019. [Online] https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.064.shtml?

SENES Consultants Limited (2005). The National Capacity Needs Self-Assessment (NCSA) Project.

Silver, J. Arkema, K. Griffin, R. Lashleu, B. LeMAY, M. et al (2019). Advancing Coastal Risk Reduction Science and Implementation by Accounting for Climate, Ecosystems, and People. Front. Mar. Sci., 24 September 2019

The College of Bahamas (2005). The Bahamas State of Environment Report.

The Nature Conservancy (2004) Fire Management Assessment of the Caribbean Pine (Pinus caribea) Forest Ecosystems on Andros and Abaco Islands , The Bahamas

Trenberth, K. E., Cheng, L., Jacobs, P., Zhang, Y., & Fasullo, J. (2018). Hurricane Harvey links to ocean heat content and climate change adaptation. Earth's Future, 6. https://doi.org/10.1029/2018EF000825

Un-Habitat (2015). Urbanization and Climate Change in Small Island Developing States

Us Army Corps Engineer (2004. Water Resources Assessment of The Bahamas.

Utilities Regulation and Competition Authority (2017). 2017 Annual Report and 2018 Annual Plan, URCA Website. https://www.urcabahamas.bs/wp-content/uploads/2018/05/2017-Annual-Report-and-2018-Annual-Plan.pdf

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