SPOTLIGHT

Analyzing disaster recovery after Hurricane Dorian in the Bahamas

Gain a geospatial perspective on real-world problems.

See how Maxar satellite imagery and advanced analytics can be applied to solve the world's most complex challenges.

MAXAR

MAXAR TOOLS

On September 1, 2019, Hurricane Dorian made landfall in the Bahamas. By the storm's end, more than 75% of homes on the Abaco Islands had been destroyed, according to Mercy Corps.[1] Although the island nation and its Ministry of Tourism are currently welcoming vaccinated tourists, COVID-19 has hampered recovery efforts,[2] and residents live with the effects. Two years after the devastating storm, Maxar has applied unique tools to assess recovery in the Bahamas by evaluating building repair, vegetation health and regrowth as well as public sentiment surrounding recovery efforts.

THE BAHAMAS | WESTERN ATLANTIC OCEAN MAXAR VIVID BASEMAP

THE BAHAMAS CONSISTS OF APPROXIMATELY 700 CORAL ISLANDS; ABOUT 30 ARE INHABITED.[3,4]

SUMMARY OF UNIQUE TOOLS & APPLICATIONS

High-resolution electro-optical imagery from Maxar includes native 30 cm class, delivering clear, rich images that empower better decision-making through improved situational awareness. Maxar's 125+ petabyte imagery archive offers historical context and reveals change over time at global scale.

Geospatial Human Imagery Verification Effort (GeoHIVE) is Maxar's crowdsourcing platform that allows users to discover and verify features of interest in Maxar's high-resolution satellite imagery. Crowdsourced rapid response damage assessment offers a fast and scalable solution for characterizing damage across broad areas of interest (AOIs) after natural disasters.

Maxar on-the-ground surveying provides valuable insight from both direct engagement (face-to-face interviews) and nonintrusive collection (photographs and other media). Maxar maintains access to a global network of data collectors who can monitor local sentiment and significantly enrich or validate satellite-derived data.

Normalized Difference Vegetation Index (NDVI) is a method used to extract and model characteristics of vegetation in remotely sensed data, revealing vegetation health and recovery. NDVI is calculated using the visible and near-infrared light reflected by vegetation, available in Maxar multispectral imagery.

[1] Mercy Corps. The Facts: Hurricane Dorian's devastating effect on The Bahamas. August 2020.
[2] South Florida WPLG Local 10 News. After Dorian and COVID, Bahamas eager to welcome you back. May 2021.
[3] The Commonwealth.com. The Bahamas. August 2021.
[4] The Encyclopædia Britannica, Inc. The Bahamas. October 2021.

RECOVERY EFFORTS UNDERWAY TWO YEARS AFTER HURRICANE DORIAN

Hurricane Dorian caused an estimated $3.4 billion in damage, approximately 25% of the Bahamas' 2018 gross domestic product (GDP), according to the World Bank.[5] International organizations, nongovernmental organizations (NGOs), governments and private donors came together in January 2020 for the Hurricane Dorian Private Sector Pledging Conference, where donors pledged $1.5 billion in recovery funding and in-kind services.[6] The U.S. Agency for International Development donated $25 million, bringing the total contribution of the U.S. government to $34 million and making it the largest humanitarian donor for this relief effort, according to the Agency.[7] The Center for Disaster Philanthropy 2019 Atlantic Hurricane Season Recovery Fund awarded six grants totaling more than $2 million to recovery projects related to health, housing, environment, livelihoods and education, according to the Center.[8,9,10]

Two years after the natural disaster, recovery efforts remain underway and have far to go, according to Maxar analysis. The COVID-19 pandemic hampered recovery and reconstruction efforts early on, forcing aid groups like All Hands and Hearts, an NGO that rebuilds schools and homes, to temporarily suspend full operations because of volunteer-based models and supply chain delays, according to the organization's Operations Manager, Aileen Boyle.[11] The pandemic continues to be a major obstacle to Bahamian recovery, as the Central Bank of the Bahamas projected "only marginal growth" for 2021: "Developments continue to be dominated by the COVID-19 pandemic."[12]

Great Abaco Island suffered 87% of the Bahamas' overall hurricane damages: Vulnerable communities were destroyed, thousands of people were displaced, and hundreds of people were reported missing or dead, according to Mercy Corps.[1] Hurricane Dorian's physical destruction on Great Abaco Island was extensive and remains visible. International Organization for Migration officers on Great Abaco Island reported removing 100 cubic meters of debris per day in October 2019.[13] In November 2019, the Bahamas' Ministry of Health said Hurricane Dorian created 1.3 billion pounds of debris and estimated it would cost approximately $74 million to clear.[14]

HURRICANE DORIAN BY THE NUMBERS

$3.4B
In damages —
roughly 25% of
Bahamas' 2018 GDP

13%
Hurricane damage not
on Great Abaco Island

$1.5B
Pledged by international
organizations, NGOs,
private donors and
other countries

87%
Hurricane damage
that occurred on
Great Abaco Island

$1.3B
Pounds of debris —
estimated $74M to clear

75%
Homes on Great Abaco
Island damaged
or destroyed

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[1] Mercy Corps. The Facts: Hurricane Dorian's devastating effect on The Bahamas. August 2020.

[5] The World Bank. The Bahamas GDP Growth (Annual %). August 2021.

[6] Bahamas Information Services. $1.5 billion in recovery funding and in-kind services pledged at Hurricane Dorian conference. January 2020.

[7] United States Agency for International Development (USAID). The Bahamas – Hurricane Dorian Fact Sheet #12. September 2019.

[8] Center for Disaster Philanthropy. $2 Million in Grants for Hurricane Dorian Recovery in the Bahamas. June 2020.

[9] American Red Cross. Hurricane Dorian Recovery. January 2021.

[10] United States Agency for International Development (USAID). Hurricane Dorian. November 2020.

[11] Malteser International. The Bahamas: Rebuilding Post-Dorian During a Pandemic. September 2020.

[12] Eyewitness News. Central Bank: Domestic economy could register only "marginal growth" this year. February 2021.

[13] International Organization for Migration (IOM). IOM Launches USD10 Million Appeal to Respond to Hurricane Dorian Damage. October 2019.

[14] NBC News. Two months after Hurricane Dorian, debris poses critical health risks for Bahamians. November 2019.

HIGH-RESOLUTION IMAGERY ENABLES ANALYSIS OF BUILDING RECOVERY

High-resolution imagery from Maxar's 125+ petabyte archive provides unrivaled historical visibility for disaster and recovery analysis anywhere on the globe. For this analysis, imagery was selected from pre-hurricane dates, post-hurricane dates and present day to assess the extent of destruction and recovery after Hurricane Dorian in Treasure Cay, Great Abaco Island, Bahamas.

Regular revisit of Maxar's satellite constellation provides high-resolution 30 cm class electro-optical imagery over significant areas, enabling precise analysis over time. Clear visual assessment supports more accurate allocation of recovery funding and evaluation.

Imagery-derived intelligence is actionable for disaster response and relief teams in addition to insurance evaluators and city planners.

TREASURE CAY BEACH VILLAS | NOVEMBER 13, 2015 | WORLDVIEW-2
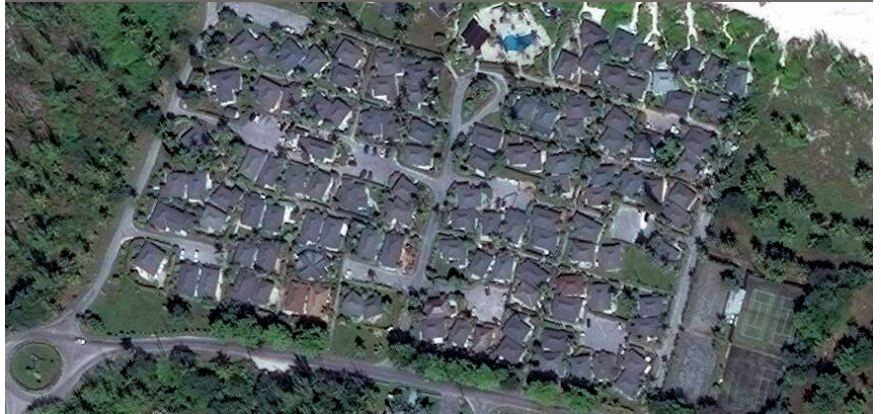
TREASURE CAY BEACH VILLAS | SEPTEMBER 11, 2019 | WORLDVIEW-2

TREASURE CAY BEACH VILLAS | MARCH 13, 2021 | GEOEYE-1

GEOHIVE PROVIDES RAPID FEATURE CLASSIFICATION FOR DAMAGE ASSESSMENTS

Maxar's GeoHIVE crowdsourcing campaigns can run at established intervals to verify post-disaster recovery rates and extent over time, providing greater insight into the capacities of local and national government responses. GeoHIVE identified the extent of damage just days after Hurricane Dorian made landfall in the Bahamas. Analysts compared high-resolution Maxar imagery prior to Hurricane Dorian with imagery captured after the hurricane passed to classify the visible difference in building footprints and roof damage. Visible destruction (red), visible damage (gold) and no visible damage (green) were recorded.

In 2021, the GeoHIVE team analyzed the same neighborhood using the latest Maxar imagery. Between September 11, 2019, and March 13, 2021, most homes were rebuilt (yellow), while those with no visible damage after the hurricane remained visibly unchanged (green). Four destroyed homes were not rebuilt (orange).

Imagery showed 113 buildings in the Treasure Cay Beach Villas neighborhood prior to Hurricane Dorian. GeoHIVE analysts estimate 72 buildings were destroyed and 35 buildings were damaged but still standing, while six homes appear untouched. Imagery in 2021 showed 103 damaged or destroyed buildings were rebuilt back to their original footprints; four destroyed homes were not rebuilt. Original building footprints were derived from OpenStreetMap.

DESTRUCTION EXTENT | TREASURE CAY BEACH VILLAS
SEPTEMBER 11, 2019 | WORLDVIEW-2

RECOVERY EXTENT | TREASURE CAY BEACH VILLAS
MARCH 13, 2021 | GEOEYE-1
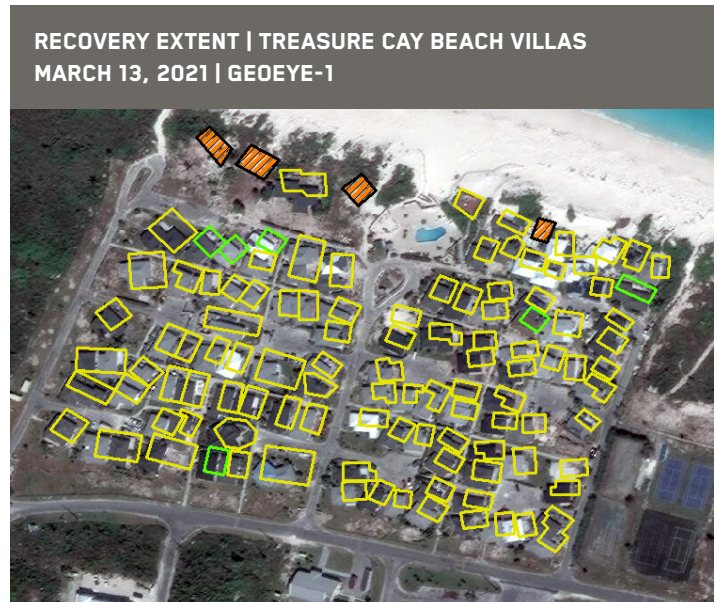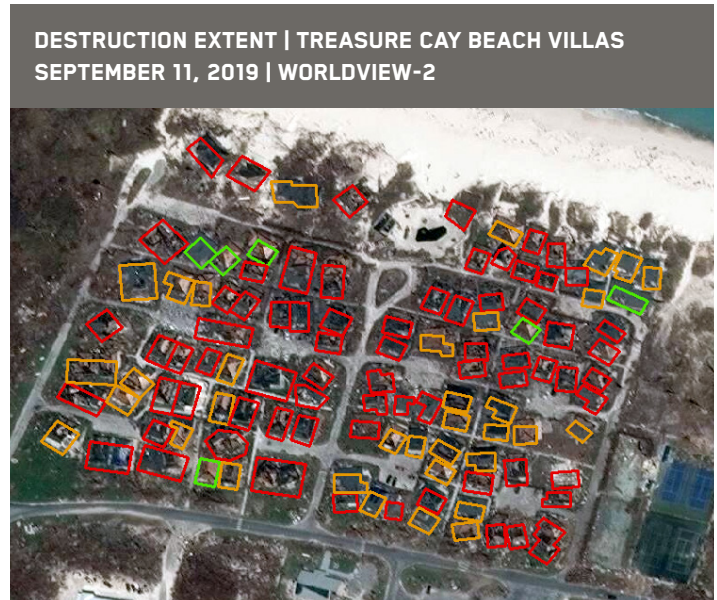
ON-THE-GROUND SURVEYS REVEAL PUBLIC SENTIMENT ABOUT RECOVERY

Imagery analysis of natural disaster recovery can be supplemented with ground validation through Maxar's on-the-ground surveying capability. A global network of data collectors and polling professionals ensures surveys are administered in local languages, helping enrich and validate Maxar imagery analysis. Data is delivered via geospatial information, photos, videos, audio and written observations according to customer-driven survey queries.

Disaster recovery agencies can conduct ground surveys mere days after critical events to acquire the most accurate assessment of damage. Through Maxar's extensive crowd network, surveys can be submitted and commissioned within days of request, yielding results in as little as a few days to weeks, depending on ground conditions and accessibility.

ON-THE-GROUND SURVEYS | MARSH HARBOUR, BAHAMAS

MAXAR ON-THE-GROUND SURVEYING WAS CONDUCTED IN MARSH HARBOUR, GREAT ABACO ISLAND, BAHAMAS. GOLD SQUARES INDICATE GEOTAGGED LOCATIONS OF SURVEY RESPONSES. IMAGERY FROM MAXAR VIVID BASEMAP.

SURVEY PHOTOS PROVIDE VALUABLE GROUND TRUTH

For this Spotlight, Maxar commissioned a local data collection team across the Bahamas in April 2021 to obtain public insights on reconstruction efforts following Hurricane Dorian. Local Bahamians were surveyed in two categories: observation and perception. The observation survey consisted of objective questions about the level of recovery and the collection of photos of key infrastructure, including businesses, schools, churches and residential areas. The perception survey consisted of subjective questions to gauge the sentiments of interviewees about the state and rate of recovery in their areas.

Maxar's surveys found that, although billions of dollars have been invested in the Bahamas' reconstruction, 46% of the 265 locals surveyed said their cities had not yet returned to pre-Dorian conditions. The majority of interviewees reported some degree of rubble or debris remaining visible. Significantly, 61% of interviewees reported that NGOs and international agencies were the most active in providing aid immediately after the hurricane. Information like this can indicate the capacities of local and national governments to respond to natural disasters. On-demand photographic documentation in the observation survey provided key insights into the extent of street-level recovery beyond building footprint and roof damage assessments. This photo by the Maxar survey team shows rubble behind a destroyed building.

DESTROYED BUILDING | MARSH HARBOUR, BAHAMAS MARCH 6, 2021 | MAXAR GROUND SURVEY
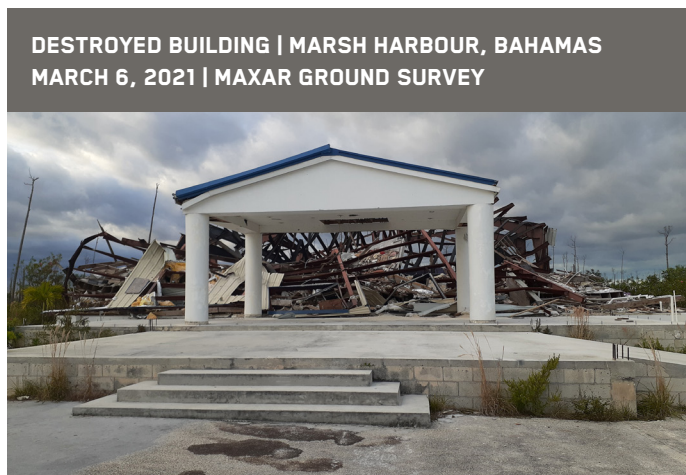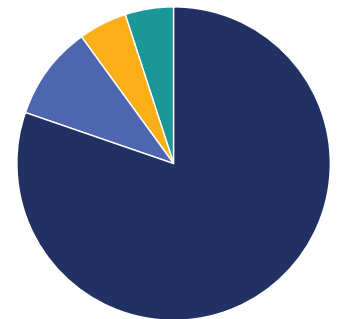

MAXAR SURVEYS PROVIDE UNPARALLELED ACCESS

Maxar survey partners maintain access to 100 countries around the world, including 16 unstable or inaccessible areas such as Syria, Iran, Yemen and Afghanistan. Polling is currently available in 27 languages.

SURVEY QUESTIONS ADMINISTERED IN APRIL 2021 IN THE BAHAMAS

Are small businesses back to normal operations?

Do you still see a lot of rubble and debris left over from Hurricane Dorian?
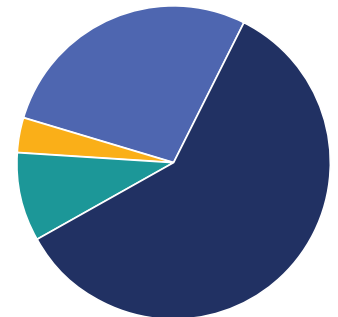
No | Yes, some | Yes, all | I don't know

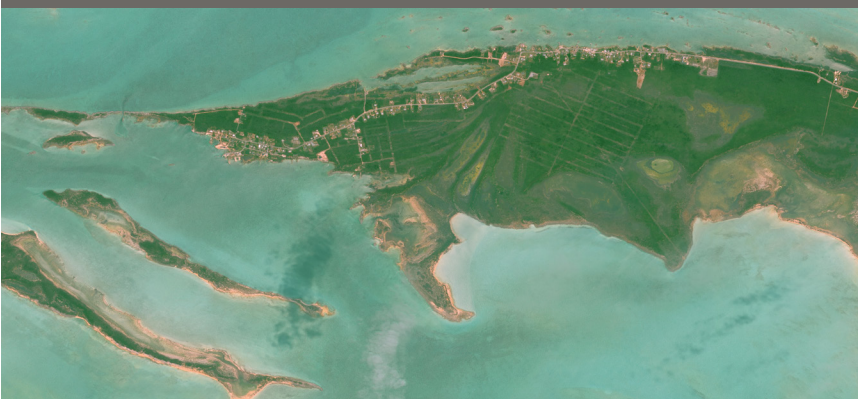# NDVI BOLSTERS ANALYSIS OF VEGETATION RECOVERY

BEFORE HURRICANE DORIAN | FOX TOWN, LITTLE ABACO ISLAND, BAHAMAS AUGUST 17, 2019 | WORLDVIEW-2

AFTER HURRICANE DORIAN | FOX TOWN, LITTLE ABACO ISLAND, BAHAMAS SEPTEMBER 11, 2019 | WORLDVIEW-2

PRESENT DAY | FOX TOWN, LITTLE ABACO ISLAND, BAHAMAS MAY 8, 2021 | WORLDVIEW-2

Visual analysis alone may not suffice in all areas of recovery quantification. The Normalized Difference Vegetation Index (NDVI) uses the visible and near-infrared light reflected by vegetation to extract and model characteristics of vegetation in remotely sensed data; Maxar's 125+ petabyte archive includes imagery with eight spectral bands. This method is based on healthy vegetation generally absorbing more visible light and reflecting more near-infrared light than unhealthy vegetation. For this study, an NDVI analysis over the area of Fox Town on Little Abaco Island was conducted, demonstrating the ability to analyze vegetation health and the extent of revegetation after Hurricane Dorian. Data derived from NDVI analysis can support recovery assessments for environmental monitoring groups and local governments. The image series shown here depicts the NDVI for Fox Town.

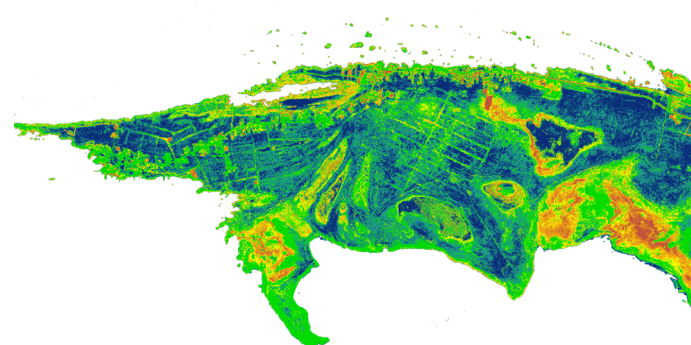# ANALYZING VEGETATION HEALTH GIVES INSIGHT INTO ENVIRONMENTAL RESILIENCE

Applying NDVI measurements to the same image over time can reveal changes in vegetative stress. Here, three pieces of imagery were analyzed independently of each other, with high vegetative health in green and low vegetative health in red. An NDVI change analysis was then conducted using post-hurricane and present-day imagery. This revealed areas of increasing NDVI (blue) which indicates improved vegetative health between the two time periods, and areas of decreasing NDVI (red) which could indicate poor revegetation after Hurricane Dorian. Identifying areas that show decreasing NDVI allows environmental groups to assess areas of long-term damage; conversely, seeing areas of quick recovery may indicate a more resilient response to natural disasters.
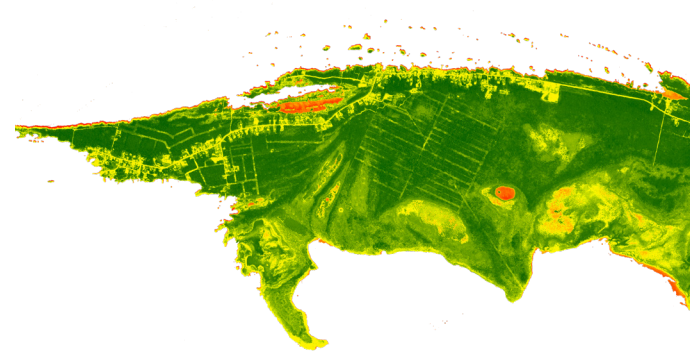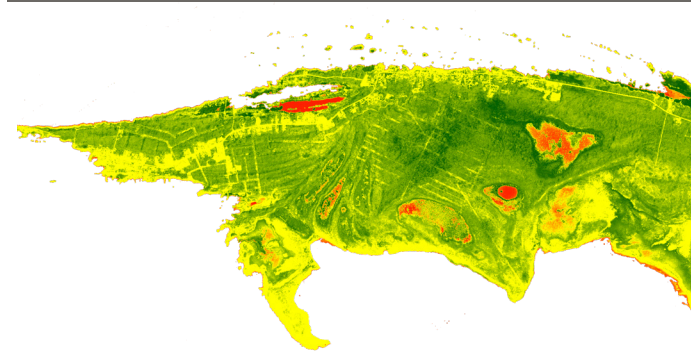
INCREASING NDVI

DECREASING NDVI

NDVI 1 MONTH BEFORE HURRICANE DORIAN

NDVI 1 WEEK AFTER HURRICANE DORIAN

NDVI CHANGE DETECTION SEPTEMBER 2019-MAY 2021


NDVI 20 MONTHS AFTER HURRICANE DORIAN
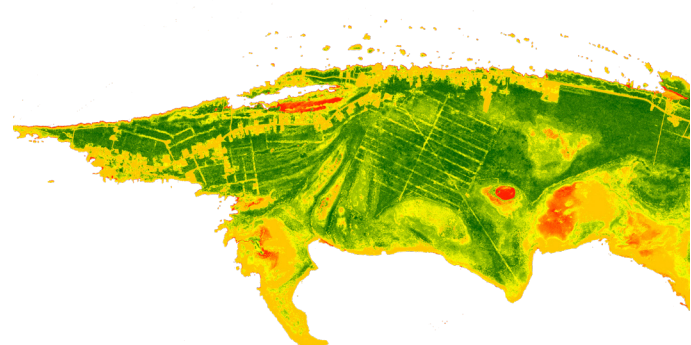
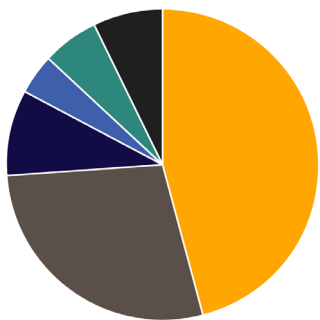LOW VEGETATIVE HEALTH   HIGH VEGETATIVE HEALTH
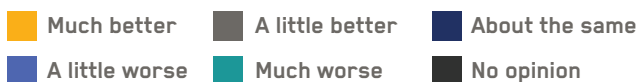
THE HUMAN COST OF SLOW RECOVERY IN THE BAHAMAS

Maxar's on-the-ground survey capability can reveal vital insights regarding the psychological and economic recovery of communities after natural disasters. The perception survey, given to more than 200 interviewees, revealed that 64% of locals surveyed believed their quality of life was worse in April 2021 than before Hurricane Dorian. However, showing remarkable resiliency and positivity, 74% of interviewees expressed belief that their quality of life will be better in two years. Gauging public sentiment through custom-built surveys delivered by native-language speakers is a powerful tool for measuring the invisible impact of disasters.
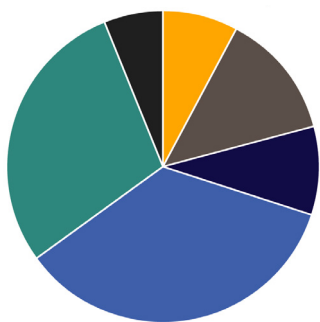
VULNERABLE HAITIANS LOSE HOMES, MANY DEPORTED

Haitians, the largest minority in the Bahamas, accounting for approximately 20% of the country's population, regularly face discrimination and deportation, according to the Internal Displacement Monitoring Centre (IDMC).[15,16,17] Prior to Hurricane Dorian, Haitians lived in informal settlements such as the Mudd and Pigeon Peas shantytowns on Great Abaco Island, where more than 75% of homes were either damaged or destroyed, Mercy Corps reports.[1] According to The New Yorker, homes in the informal settlements were mostly made of plywood and often lacked plumbing and electricity.[18] Because of unknown numbers of inhabitants in the informal settlements, the precise number of deaths due to Hurricane Dorian are debated, but the National Catholic Reporter interviewed locals who believe the number may be up to 1,000.[19]

Social and economic tensions have existed between Haitians and Bahamians for decades, per the IDMC.[16] Many Bahamians view poor Haitian migrants, who travel to the Bahamas in search of work, with resentment and contempt, citing undocumented migration from Haiti as the main national concern, reports The Sun Turks and Caicos.[17] In an effort to assuage the concerns of locals, current Prime Minister Hubert Minnis has vowed to eradicate shantytowns and promote "Bahamization," reports The Nation.[16,20] Tensions peaked in the aftermath of Hurricane Dorian, when anti-Haitian demonstrators gathered outside hurricane shelters hosting Haitians and called for their repatriation, according to The Nation.[20] The New York Times reports at least 340 Haitian migrant workers have been deported since September 2019.[21]

In your opinion, is the overall quality of life better or worse than it was two years ago?

In your opinion, do you expect the overall quality of life to be better or worse two years from now?

- 🟧 Much better
- ⬜ A little better
- 🟦 About the same
- 🟦 A little worse
- 🟩 Much worse
- ⬛ No opinion

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[1] Mercy Corps. The Facts: Hurricane Dorian's devastating effect on The Bahamas. August 2020.
[15] Worldometers. The Bahamas Population. August 2021.
[16] Internal Displacement Monitoring Centre. Displacement in Paradise: Hurricane Dorian slams the Bahamas. May 2020.
[17] The Sun Turks and Caicos. The Bahamas Prepares for Haitian Exodus. July 2021.
[18] The New Yorker. When Climate Change and Xenophobia Collide. February 2021.
[19] National Catholic Reporter. Bahamian church seeks to assist Haitian refugees facing loss of homes. April 2021.
[20] The Nation. First Came the Hurricane, Then Came the Campaign of Terror. October 2020.
[21] The New York Times. Bahamas says undocumented Haitians are safe, for now. September 2019.

NATURAL DISASTER ASSESSMENTS REQUIRE A MULTIFACETED APPROACH

FOR A BETTER WORLD— MAXAR'S OPEN DATA PROGRAM

In response to Hurricane Dorian, Maxar activated its Open Data Program, releasing pre-hurricane and post-hurricane satellite imagery of the Bahamas free of charge for disaster response teams. Team Rubicon utilized this data to determine where to deploy response teams, ultimately dispatching 555 volunteers to the Bahamas.[22]

When crises occur, Maxar is committed to supporting the humanitarian community by providing critical and actionable information to assist response efforts. Associated imagery and crowdsourcing layers are released into the public domain for rapid use so those working on the front lines can increase their impact and effectiveness.

For more on disaster response, visit explore.maxar.com/disaster-response.

CONCLUSION

Recovery in the Bahamas continues years after Hurricane Dorian pummeled the island nation and is continuously delayed by the global COVID-19 pandemic. As national leaders and international partners pursue restoration of infrastructure and the economy, post-disaster assessments remain of importance.

A United Nations climate report released in August 2021 found that high-intensity hurricanes have increased because of warmer global temperatures and are more likely to stall in place, leading to devastating rainfall, reports CNN.[24] After any disaster, high-resolution Maxar imagery provides superb visibility and enables recovery analysis for the near and long term. NDVI analysis reveals the extent of revegetation, while crowdsourcing through GeoHIVE allows rapid assessment of infrastructure damage. Maxar on-the-ground surveys can capture the sentiments of those directly affected by natural disasters, as well as of disenfranchised populations in difficult-to-reach areas. Maxar's comprehensive suite of products and capabilities position government and civilian organizations to effectively plan, allocate resources, save time and deploy aid workers to the most vulnerable areas.

"Boats are still in yards and on land, and sunken boats and cars are still in the water. Destroyed houses and businesses remain abandoned, and no one knows what will be done with the ruins."[23]

- ANDREA DUNNE-SOSA, AMERICAS REGIONAL DIRECTOR AT PROJECT HOPE
  AUGUST 24, 2021

[22] Maxar Blog. Maxar and BAE Systems bring geospatial insights to Team Rubicon's Hurricane Dorian response in the Bahamas. December 2019.
[23] Project Hope. Rise of COVID-19 Cases Threatens Bahamas' Reconstruction Two Years After Hurricane Dorian. August 2021.
[24] CNN. How the climate crisis is changing hurricanes. August 2021.

FOR A BETTER WORLD

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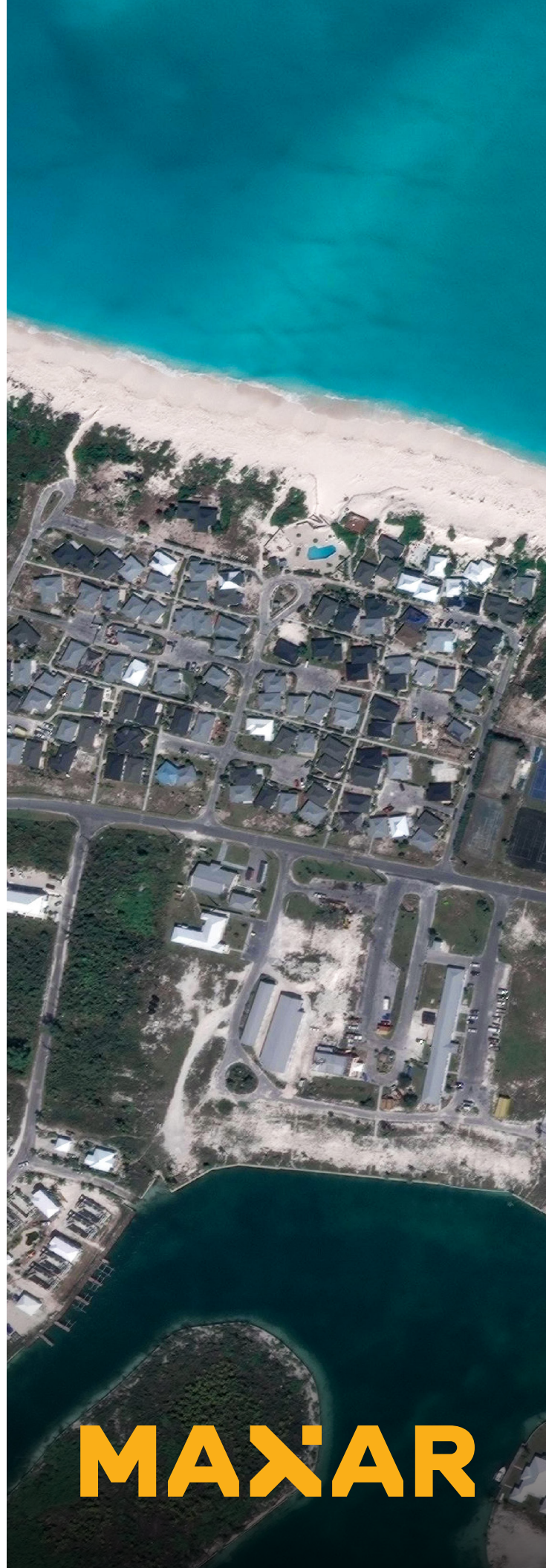
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