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Projecting the Current & Future Impact of Storm Surges on Coastal Flood Extent at Pigeon Point, South-West Tobago, through Hydrodynamic Modeling Analyses



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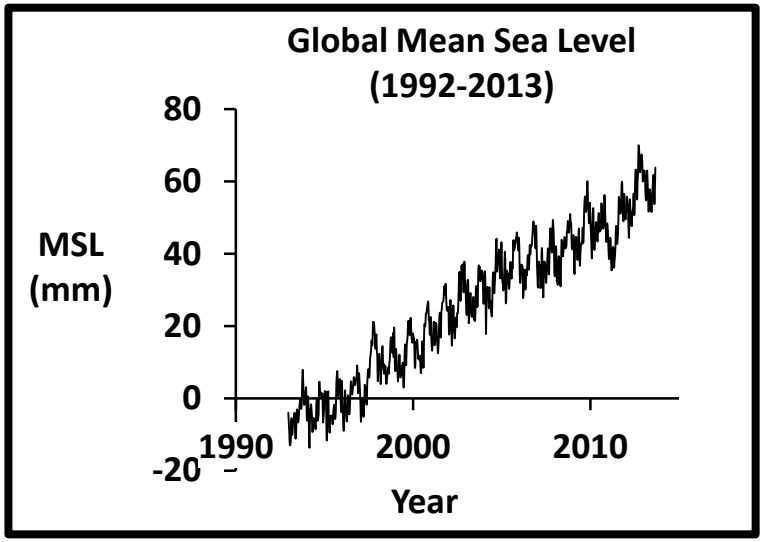
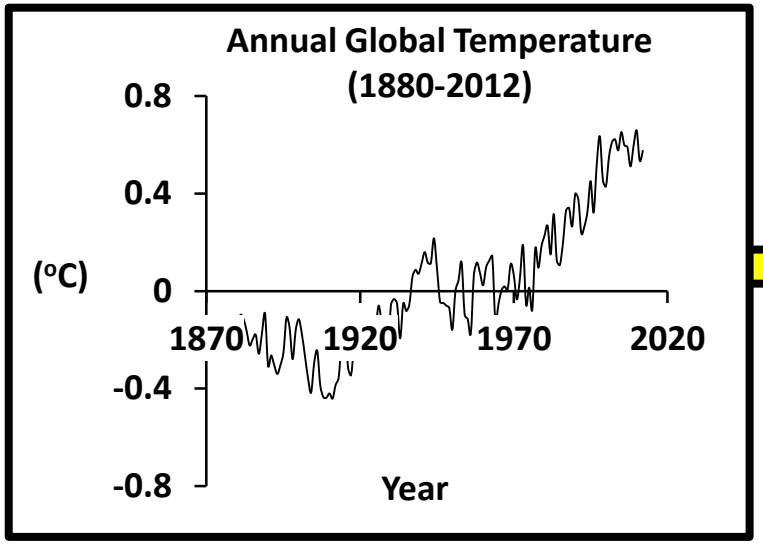
Introduction



Rising Sea Levels



Rising Global Temperatures

Increase proportion of Category 4 – 5 hurricanes (Holland & Bruyere, 2014)

Increase storm surge intensity (Grinsted et al 2012; 2013)

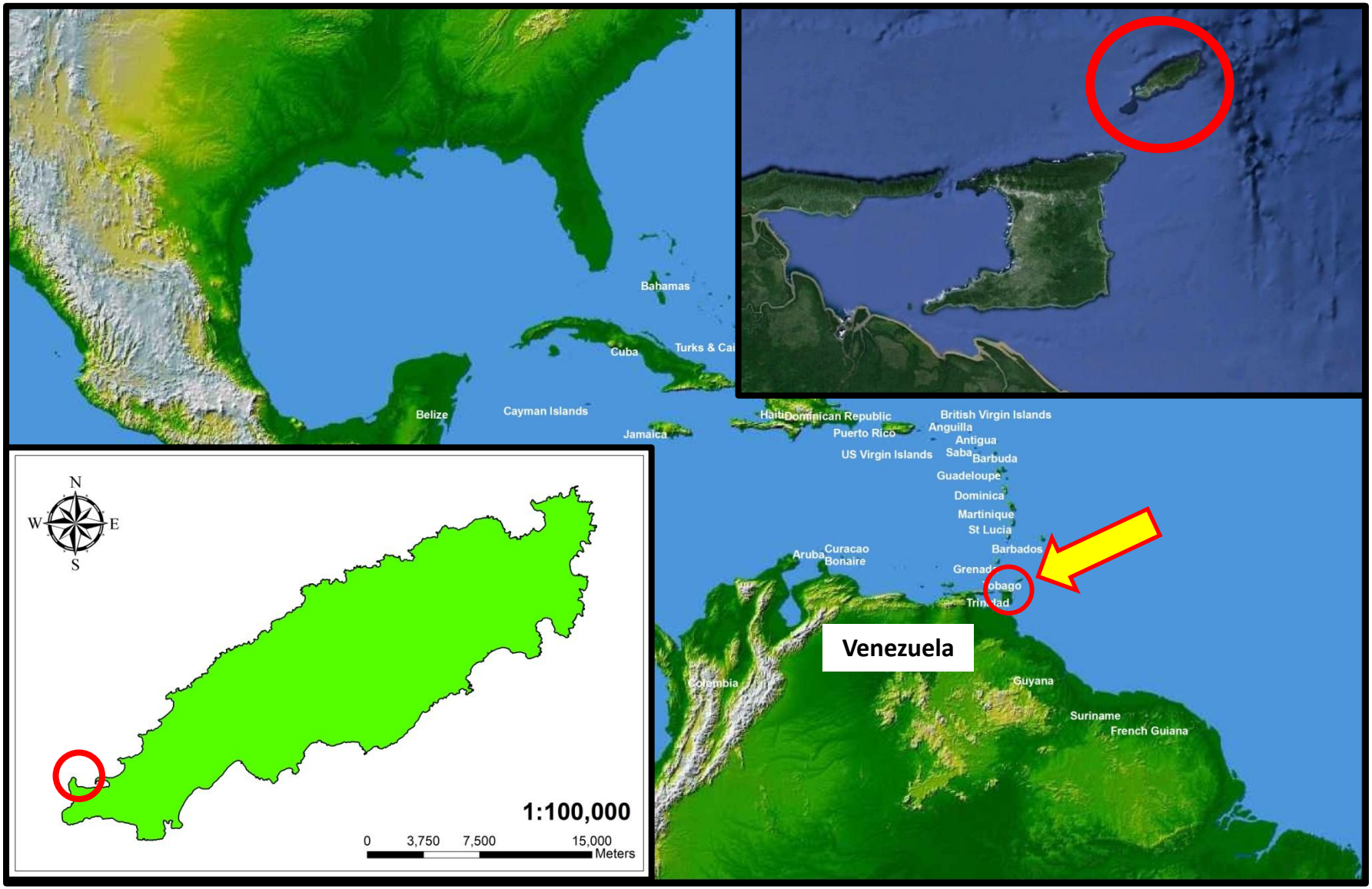
Increased probability of coastal floods for low lying coastal areas

Aim & Objective

AIM: To determine the ***potential*** current and future extent of area that will flood from storm surges, of different levels, in the low lying Pigeon Point area of South-West Tobago.

OBJECTIVE: To develop an understanding of the degree of flooding and possible damage that these events can cause on low lying coastal areas which are widespread throughout the Caribbean under current and future sea level conditions through LISFLOOD-FP.

Study Site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St Lucia
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Meters

Study Site

Overview of Pigeon Point

Sandpit formed by waves and wave current.

Flat and low lying.

Characterised by white, sandy beaches.

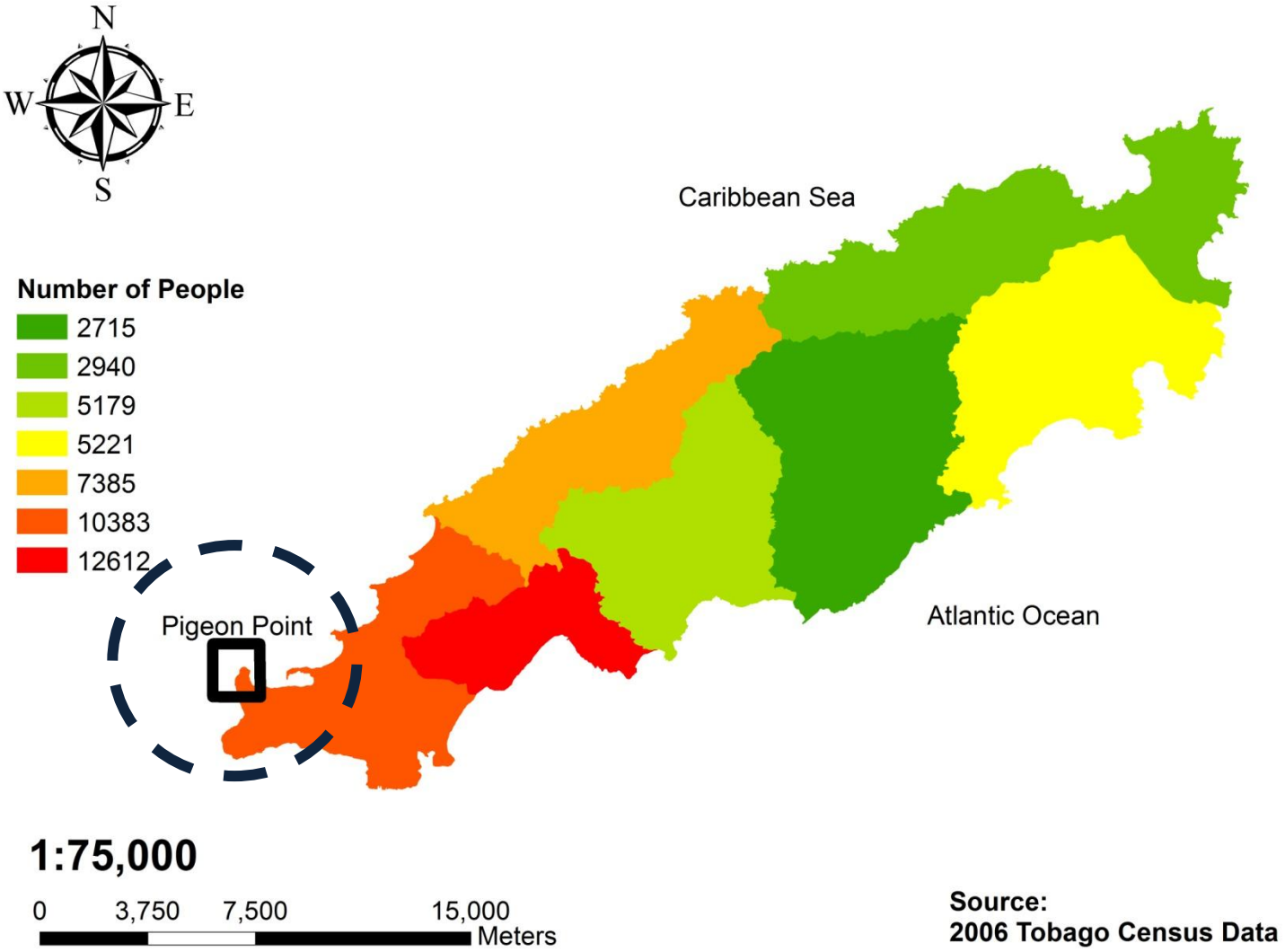
Composed of coralline limestone. Susceptible to wave erosion.

Sea around Tobago governed by trade winds.

Waves associated with tropical low pressure systems can approach the coastline from any direction (Deane 1993).

Study Site

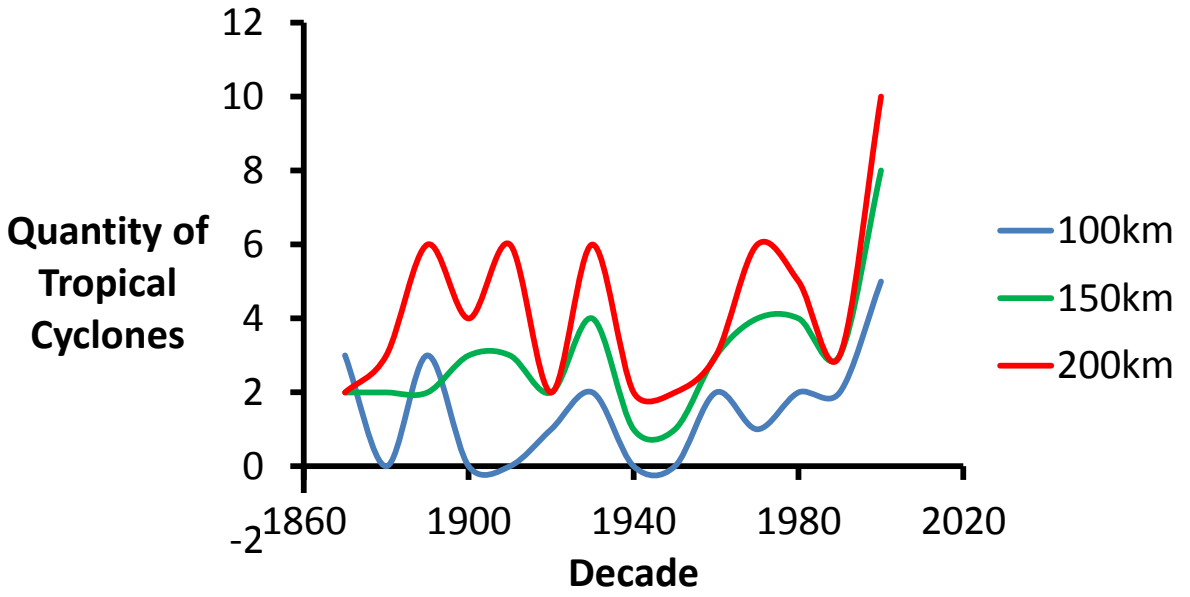
Tobago's Population Estimate per Parish



Pigeon Point Exposure to Storms/hurricanes:

No. of Tropical Cyclones within 100-200km Radius of Pigeon Point per Decade (1870-2009)

Radius (km)	# of Tropical Cyclones
100	23
150	43
200	64



Direct Landfalls (1870-2009):

1. Tropical Storm Arthur (1990)
2. Tropical Storm Joyce (2000)
3. Category 3 Hurricane Flora (1963)

Source:
National Hurricane Center, NOAA.

Damage from Past Storms/Hurricanes

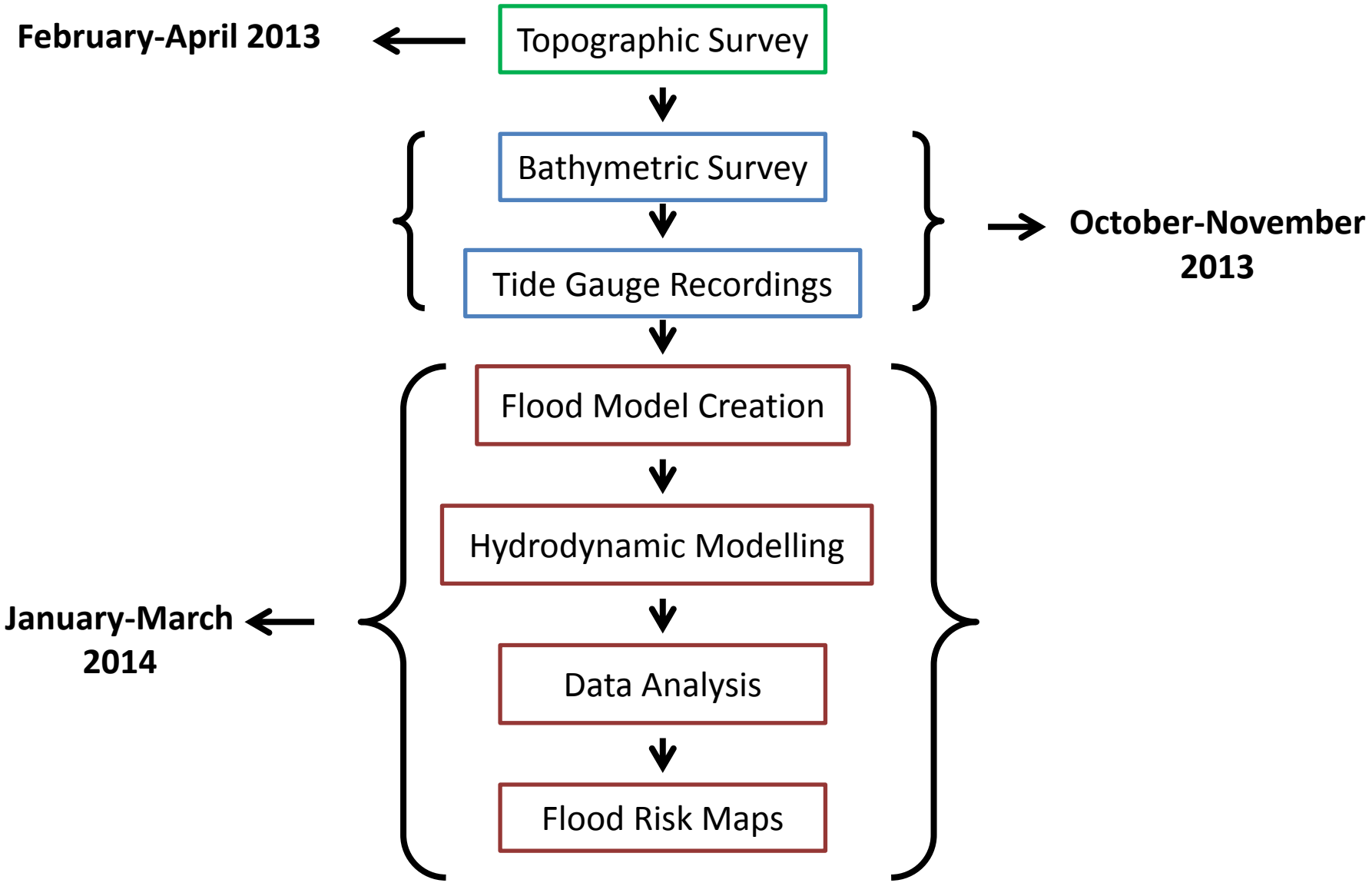
Hurricane Flora 1963 (Category 3 – Direct Landfall)

- Caused an estimated damage of US $60,000.00 in agricultural loss,
- Destroyed >35% of houses and damaged an additional 46.7%
- Killed 18 people
- Induced coastal erosion in south-west Tobago (inclusive of Pigeon Point)
- Destroyed a significant section of the mangroves near Pigeon Point.
- Changed the face of the economy

Hurricane Tomas 2010 (Category 2 – Within Close Proximity)

- A *feeder band* generated from Hurricane Tomas (2010) caused landslides and flooding in 13 and 9 communities, respectively.

Methodologies



-Seenath et al.-

Methodologies

Topography, Bathymetry & Tide Gauge Survey

Topography

- Surveyed using a Total Station.
- Two control points established due to absence of real ground coordinates.
- GPS data acquired at each control point to geo-reference all surveyed topographic points.

Bathymetry

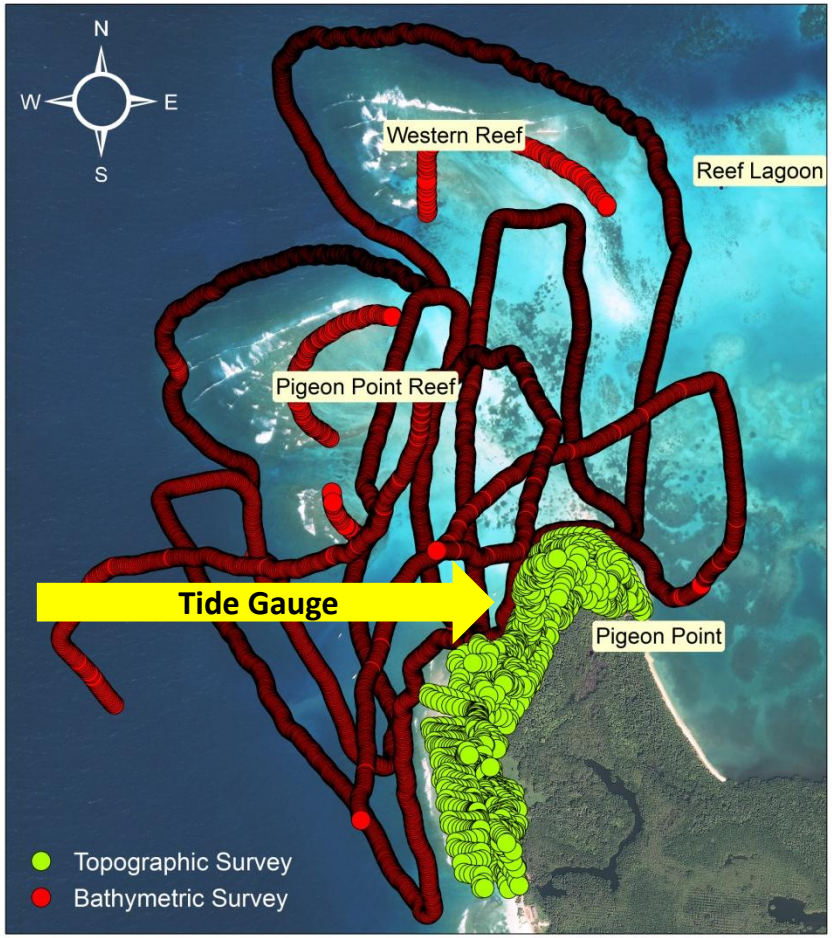
- Surveyed using an Innerspace 455 Echo-sounder

Supplemental Data

- Bathymetry and Topography data acquired from GEBCO to account for gaps of missing data.

Tide Gauge Recordings

- Tide Gauge deployed for one month.
- Tidally derived MSL used for vertical geo-referencing of all topographic surveys and bathymetry corrections.



Overview of Surveyed Area

Methodologies

Flood Model Creation,

Digital Elevation Model (Dem)

Topography + Bathymetry points combined into point shapefile, interpolated to 10 m grid spacing and exported in ASCII format using ArcGIS 10.1.

Storm Surge Levels

Minimum surge level on the Saffir Simpson Scale for Cat. 1-5 hurricanes combined with CMSL and IPCC minimum (0.28m) and maximum (0.98m) projection of sea level for 2100.

Creation of Storm Surge Levels

Saffir-Simpson	*Storm Surge Height*	*Storm Surge Levels*		
Category	*Metres (m)*	CMSL	IPCC-Min	IPCC-Max
		+0.0	+0.28m	+0.98m
1	**1.0** - 1.7	1.0 m	1.28 m	1.88 m
2	**1.8** - 2.6	1.8 m	2.08 m	1.98 m
3	**2.7** - 3.8	2.7 m	2.98 m	2.78 m
4	**3.9** - 5.6	3.9 m	4.28 m	3.68 m
5	>**5.7**	5.7 m	5.88 m	4.98 m

Modelling & Data Analysis

Modelling

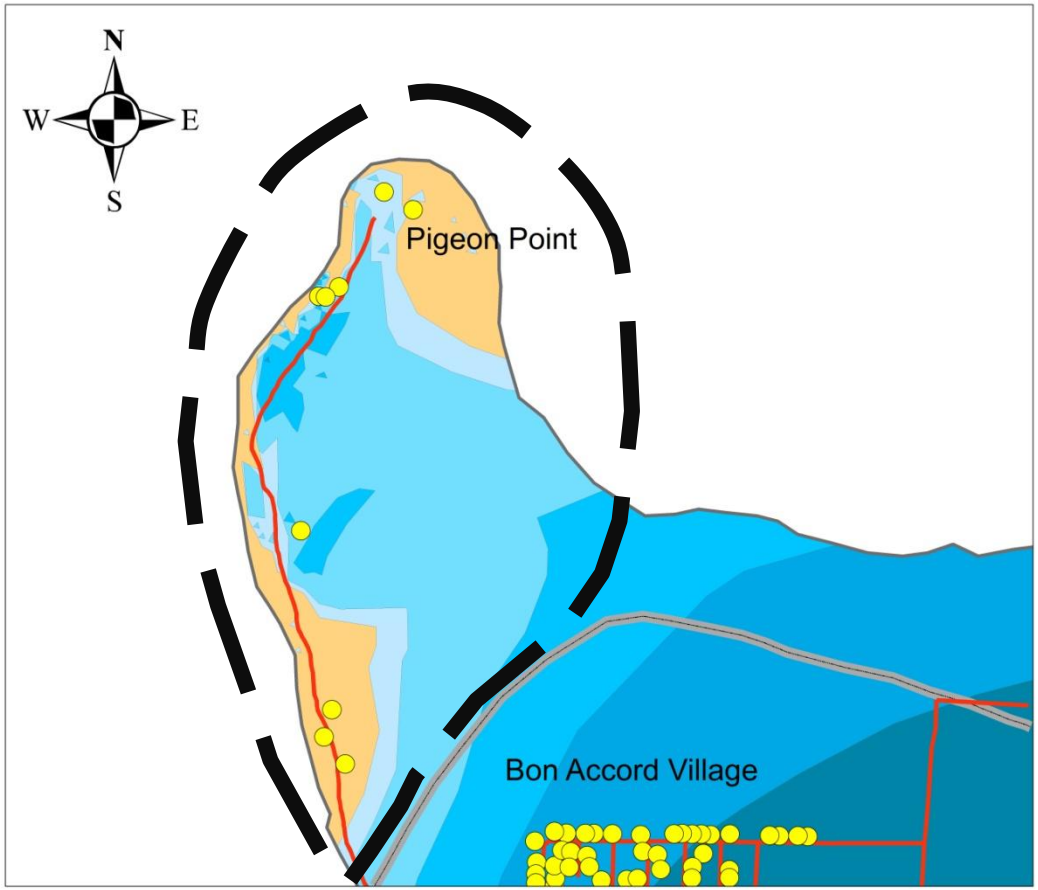
- Simulations were performed using the LISFLOOD-FP code.

Data Analysis

- Maximum flood output file (*.max*) loaded onto ArcMap 10.1 to determine inundation extent and quantity of area likely to flood.
- Maximum flooded area was found using a depth threshold of 0.01m.
- Results acquired converted into flood inundation maps.

Results

Potential Flood Extent under Current Mean Sea Level



Legend

- Buildings
- Roads
- Boundary
- Spring High Tide (CMSL)
- Category 1 - Min. Surge Height (CMSL)
- Category 2 - Min. Surge Height (CMSL)
- Category 3 - Min. Surge Height (CMSL)
- Category 4 - Min. Surge Height (CMSL)
- Category 5 - Min. Surge Height (CMSL)

Source:

1. Pleiades 2014 Satellite Image of Tobago

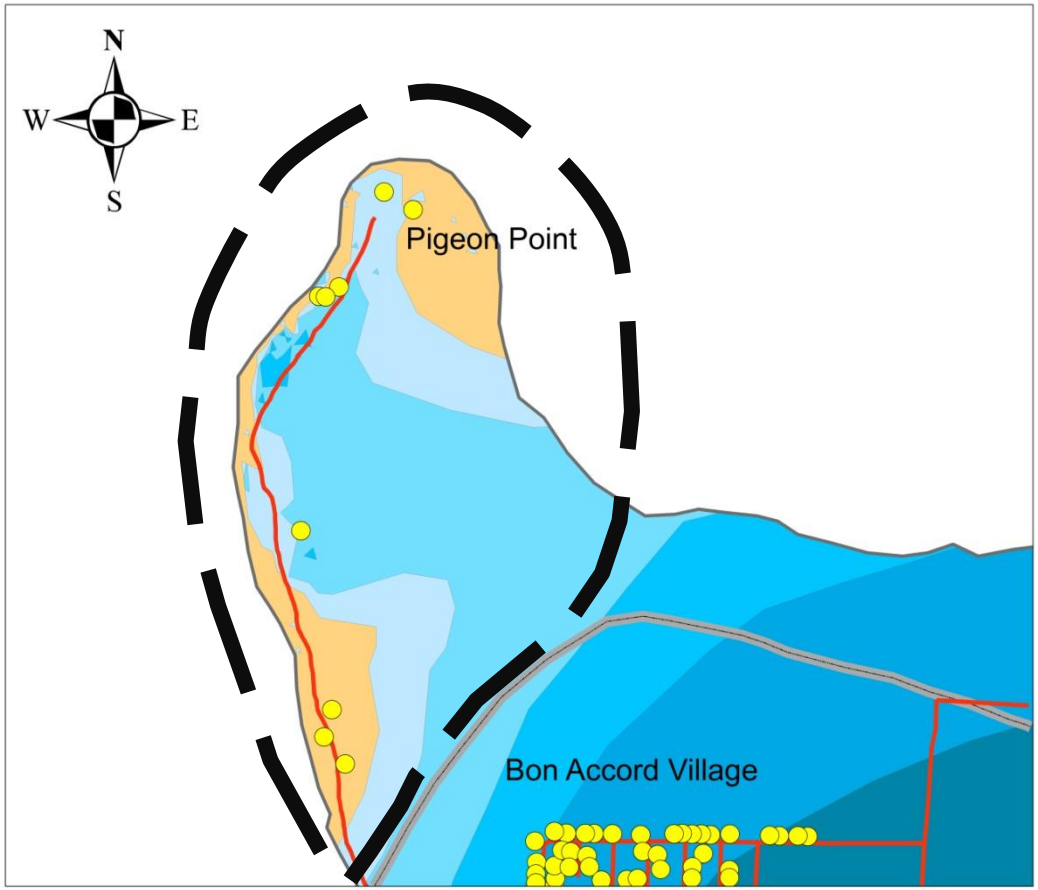
Author: Avidesh Seenath

1:3,000

0 250 500 1,000 Meters

Results

Potential Flood Extent under IPCC Minimum Projection of Sea Level for 2100



Legend

- Buildings
- Roads
- Boundary
- Spring High Tide (CMSL)
- Category 1 - Min. Surge Height (IPCC-Min)
- Category 2 - Min. Surge Height (IPCC-Min)
- Category 3 - Min. Surge Height (IPCC-Min)
- Category 4 - Min. Surge Height (IPCC-Min)
- Category 5 - Min. Surge Height (IPCC-Min)

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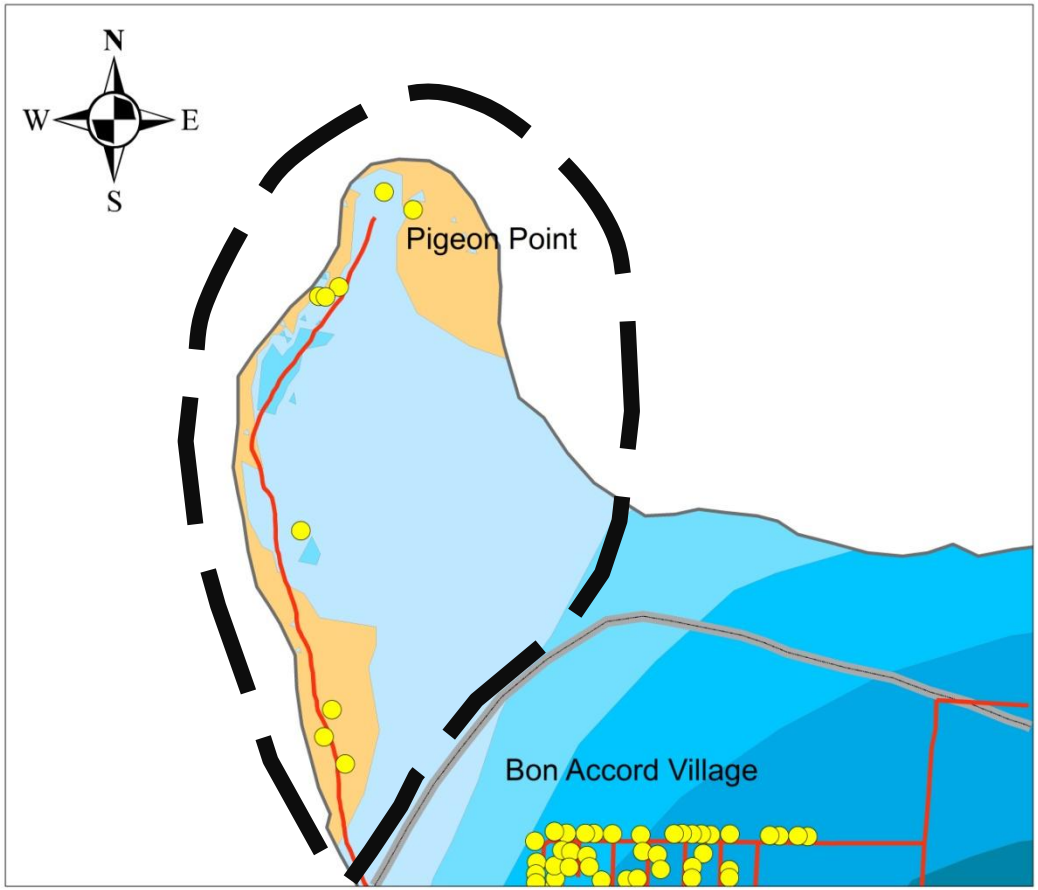

Legend

- Buildings
- Roads
- Boundary
- Spring High Tide (CMSL)
- Category 1 - Min. Surge Height (IPCC-Max)
- Category 2 - Min. Surge Height (IPCC-Max)
- Category 3 - Min. Surge Height (IPCC-Max)
- Category 4 - Min. Surge Height (IPCC-Max)
- Category 5 - Min. Surge Height (IPCC-Max)

Source:

1. Pleiades 2014 Satellite Image of Tobago

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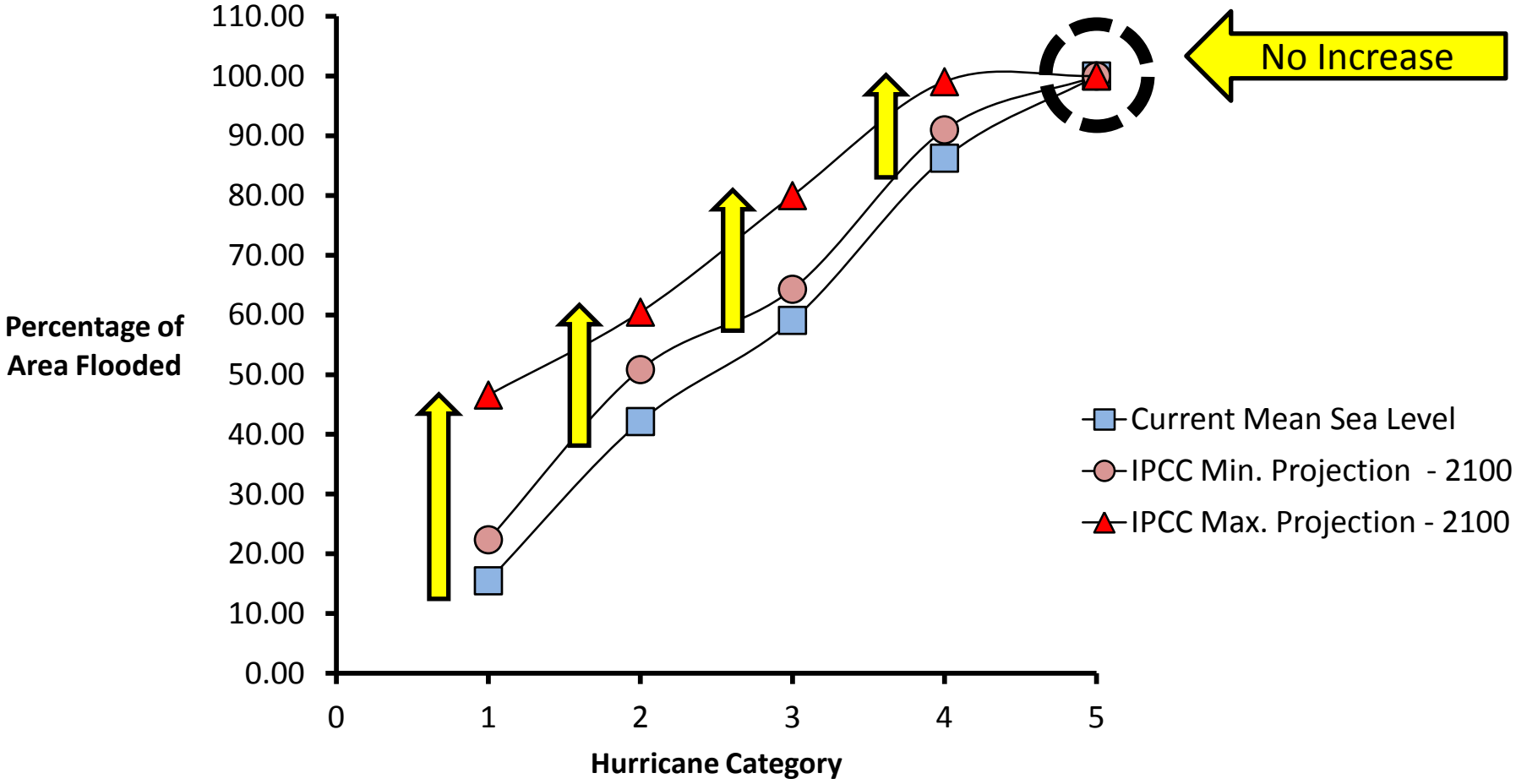
1:3,000

0 250 500 1,000 Meters

Data Analysis

Percentage of Area Likely to Flood under Current & Future Sea Level from Minimum Storm Surge Levels per Hurricane Category



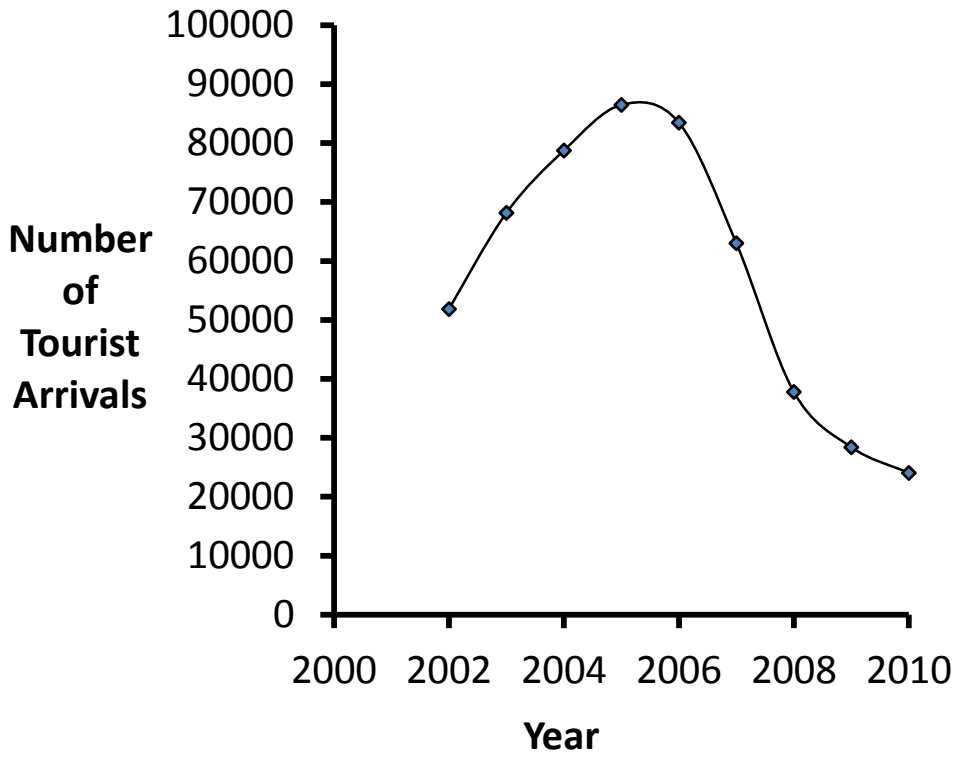
Discussion

Potential Implications on the People & Economy:

Tobago's economy thrives on coastal tourism with > 74% of Tourists visiting for Leisure/Beach Vacation. However, Tourism has been declining since 2006.

Despite decline, Pigeon Point maintained its level of visitors with >100,000 visitors per year (domestic + foreign) mostly from cruise ships and domestic tourism (Armstrong 2012).

Pigeon Point is perhaps the main tourism destination in Tobago.



Visitor Arrival to Tobago 2002-2010 (CSO Trinidad & Tobago)

Loosing Pigeon Point => Tourism Decline => Decline in GDP => Decline in economic growth

Conclusion(s)

1. Under current and future sea level, all of Pigeon Point will be affected by storm surges from Cat. 2-5 hurricanes. Those associated with a Cat. 1 will have minimal impact under CMSL, but, will affect majority of Pigeon Point under future sea level.

2. Rising sea levels will not significantly increase flood extent from storm surges, but instead, flood depth at Pigeon Point

3. Rising sea levels will increase the vulnerability of the locals and the island's economy to the impacts of storm surges.

Pigeon Point

Pigeon Point, SW Tobago, is susceptible to SLR and coastal flooding from storm surges.

Acknowledgements

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Thank you for your attention..... Any Questions?

FOR FURTHER ENQUIRIES
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