

# Risk and Vulnerability Assessment Methodology Development Project (RiVAMP)

Presented by: Planning Institute of  
Jamaica

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# Content of Presentation

- Context and Purpose of RiVAMP
- Description and Application of the Methodology
  - Stage I: Scoping
  - Stage II: Desk Study
  - Stage III: Field Work
  - Stage IV: Analysis
  - Stage V: Outputs
  - Stage VI: Evaluation
- The Way Forward



# **CONTEXT AND PURPOSE OF RIVAMP**



# Context

- Small island developing states (SIDS) at risk:
  - Sea level rise (SLR)
  - Storm events and storm surges
  - High exposure of populations to storms
  - High dependence on natural ecosystems
  - Relatively small economies, prone to external shocks



# Context

- Given their high vulnerability:
  - SIDS must practice disaster risk reduction (DRR) to protect lives, livelihoods
  - Protect economies
  - Achieve sustainable development goals



# Case Study: Jamaica

- Vision 2030 Jamaica-National Development Plan promises an economy that is prosperous (satisfying social, economic, environmental, cultural needs)
- Recognises that vulnerability to natural & Man-made hazards is a major threat to achieving that prosperity
- “Natural hazards ...lead to natural disasters” ...which ..”have dire consequences for economic activities, infrastructure, human welfare and natural resources management”( Vision 2030 Jamaica -National Development Plan)



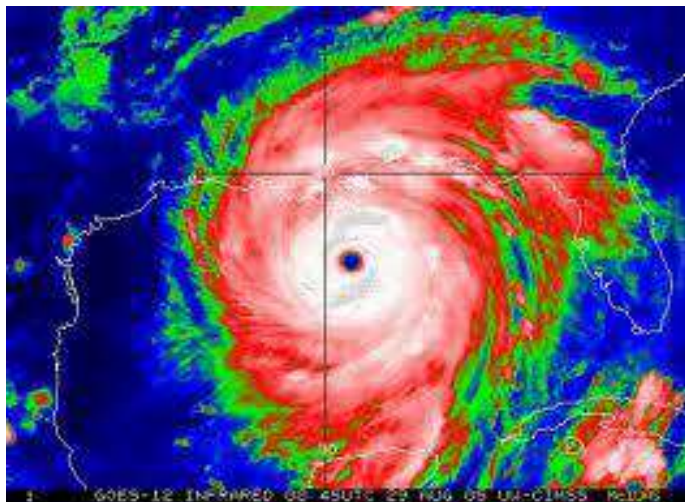
# Case Study: Jamaica



**Drought**



**Flood**



**Hurricanes**



**Storm Surge**





Banana and other crops destroyed by Hurricane Dean, 2007







Palisadoes after Hurricane Ivan, 2004

(Note: This is the only way to the Norman Manley International Airport)





The destroyed bridge at Harbour View, St Thomas following Tropical Storm Gustav, 2008



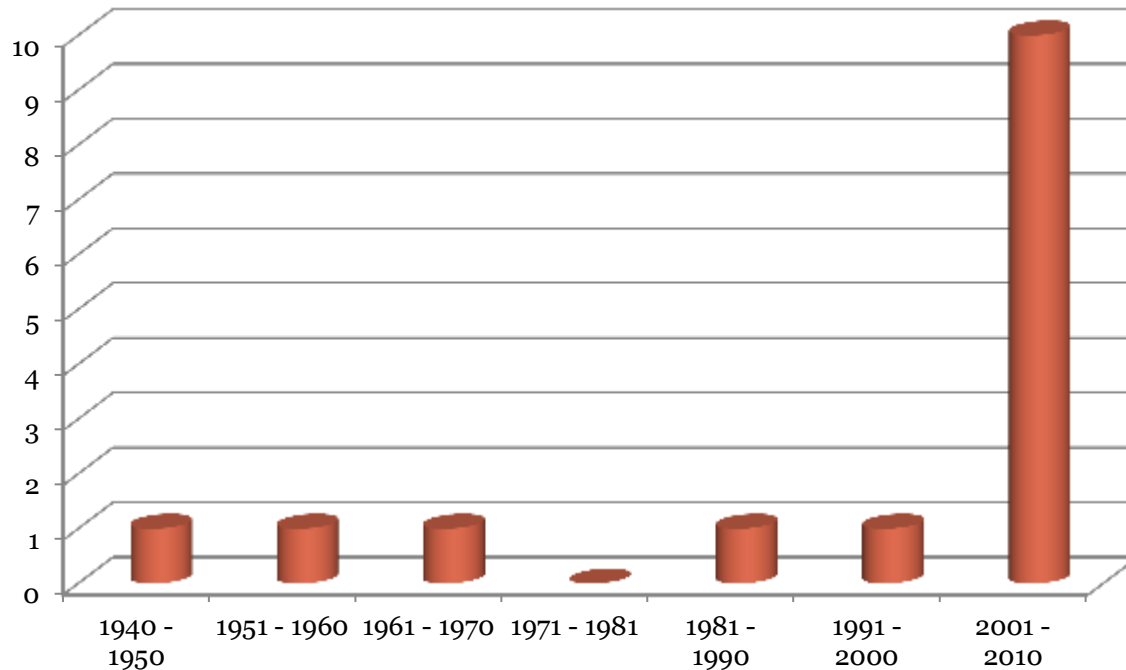


People “living on the edge” affected by major storm



# Case Study: Jamaica

- The frequency of disasters have been increasing

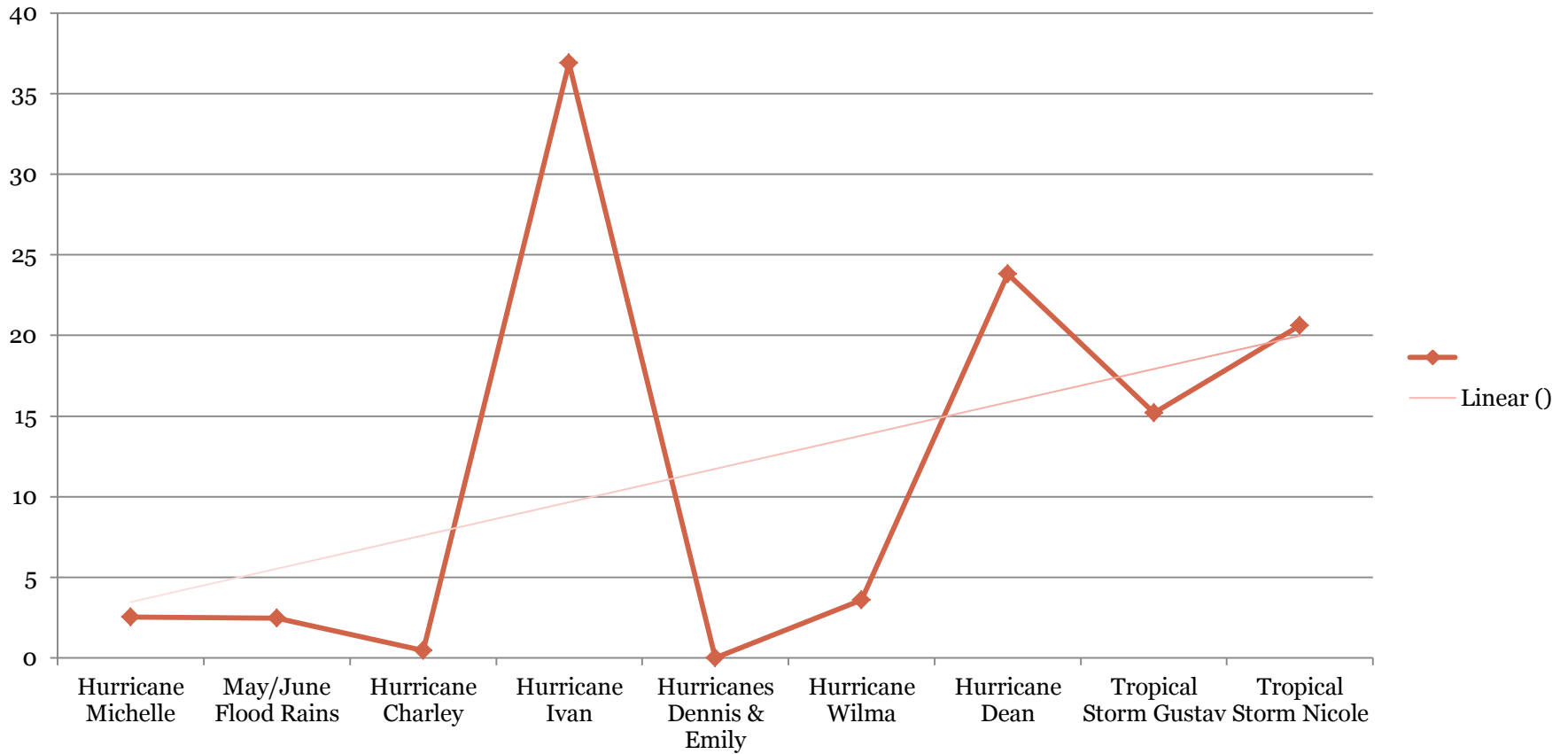


## Selected natural disasters in Jamaica and their costs

<b>EVENT</b>	<b>Year</b>	<b>Category</b>	<b>Cost (\$JB)</b>	<b>Impact (% GDP)</b>
Hurricane Gilbert	1988	5	~8.3	65.0
Hurricane Michelle	2001	4	2.52	0.8
May/June Flood Rains	2002	-	2.47	
Hurricane Charley	2004	4	0.44	0.02
Hurricane Ivan	2004	3	36.9	8.0
Hurricanes Dennis & Emily	2005	4	5.98	1.2
Hurricane Wilma	2005	5	3.6	0.7
Hurricane Dean	2007	4	23.8	3.4
Tropical Storm Gustav	2008		15.2	2.0
Tropical Storm Nicole	2010		20.58	1.9
<b>Total</b>	<b>2001-2010</b>		<b>111.48</b>	<b>~2.0/year</b>



# Case Study: Jamaica



Cost of Disasters (2001-2010)



# Affected Population

	<b>Year</b>	<b>Number of persons Affected</b>	<b>Some Severely Affected Communities</b>
Hurricane Ivan	2004	369 685	Portland Cottage, Rocky Point. Lionel Town, Mitchell Town Buff Bay, Fruitful Vale, Annotto Bay, Alexandria, Little London, Grange Hill
Hurricanes Dennis & Emily	2005	122 590	121 communities in St. Thomas, St Catherine, Clarendon, Kingston and St Andrew
Hurricane Dean	2007	179 552	Old Harbour Bay, Rocky Point, Portland Cottage, Cross Keys, Pratville, Alligator Pond
T.S. Gustav	2008	112 566	Hope tavern, Kintyre, Bull Bay, Gordon Town, Papine, August Town, Guava Ridge, Broad Gate

# Purpose of RiVAMP

- Analyses disaster risk taking natural environment into account
  - Other assessment tools do not adequately include role of ecosystems
- Approaches used for analyses:
  - Evidence based
  - Scientific
  - Qualitative





# Purpose of RiVAMP

- Targets SIDS, coastal areas
- Focuses on climate-related hazards and secondary effects (eg, flooding, storm surge, wind, sea level rise)



# Purpose of RiVAMP

- Highlights ecosystems protection as “no regrets” option
  - Cost effective
  - Relatively easy and fast installation (can be done with local population)
  - Low to moderate maintenance
  - Aesthetical and cultural value
  - Support biodiversity in providing food, livelihoods
  - Carbon storage
  - Pollution control
  - Emphasizes ecosystems goods and services



# Specific Objectives of RiVAMP

- Provide further evidence for historic and current changes in Negril
- Develop projections of future risks and vulnerability relative to climate change
- Propose solutions for minimizing or mitigating risks
- A methodology for replication in developing countries highly dependent on ecosystems



# THE METHODOLOGY



# Pre-Implementation

- Jamaica selected as pilot country by the United Nations Environment Programme (UNEP) in consultation with other international partners, 2009 due to:
  - Diverse ecosystems, rich biodiversity
  - Tourism “hotspot”
  - High economic dependence on ecosystems
  - Development pressures on natural environment
  - Exposed to SLR, storms and storm surges
  - Host of UNEP’s Caribbean Environment Programme



# Stage I: Scoping Exercises

- Scoping Mission by UNEP Team (Feb 2009)
  - Introduce methodology to national level partners and get buy-in
  - PIOJ selected as implementing partners
  - Multi-sectoral Advisory and Technical Committees established
  - Coastal resources identified as being in a critical state
  - Selection of Negril as main study area in consultation with national partners



# Selection Criteria

Selection criteria by order of importance	Negril		Treasure Beach		Trelawny to Discovery Bay		Montego Bay		Portland and St. Thomas		Portland Cottage to Portland Bight	
	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
8. physical vulnerability to natural hazards	2	16	3	24	1	8	1	8	3	24	3	24
7. coastal tourism	3	21	2	14	2	14	3	21	1	7	0	0
6. data availability	3	18	3	18	3	18	3	18	3	18	3	18
5. development pressure	3	15	1	5	3	15	3	15	2	10	0	0
4. ecosystem diversity (based number of different types of ecosystems)	2	8	1	4	3	12	2	8	3	12	3	12
3. socio-economic vulnerability	2	6	2	6	2	6	2	6	3	9	3	9
2. level of degradation	2	4	1	2	3	6	2	4	3	6	3	6
1. willingness of local communities to participate in pilot	3	3	3	3	2	2	3	3	2	2	2	2
<b>Total score</b>	<b>91</b>		<b>76</b>		<b>81</b>		<b>83</b>		<b>88</b>		<b>71</b>	
<b>Ranking</b>	<b>1</b>		<b>5</b>		<b>4</b>		<b>3</b>		<b>2</b>		<b>6</b>	

\* Rating: 0 = none; 1 = least; 2 = mid; 3 = most



# Stage I: Scoping Exercises

- Scoping Mission by UNEP Team (cont'd)
  - List of communities in Negril identified and two selected for project: Little Bay (rural fishing village), Whitehall (urban community)





# Study Area: Negril Environment Protection Area



# Stage II: Desk Study

- Identified existing data, research conducted on the study area, gaps in existing data
- Types of Data collected:
  - Spatial (e.g., satellite imagery)
  - Quantitative (e.g., distance of beach retreat in km)
  - Qualitative (e.g., governance systems and issues)
- PIOJ coordinated data collection, working with ministries, agencies, departments and UNEP



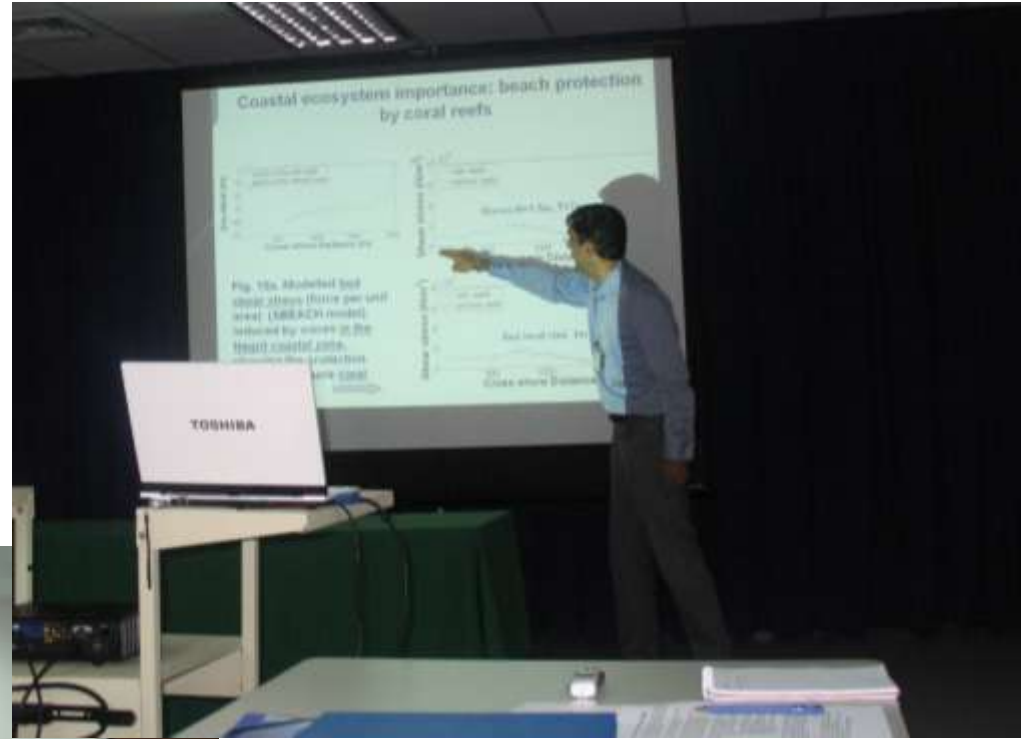
# Stage III: Field Work

- Consultations national, parish and community levels
- Types of information collected from stakeholders:
  - Knowledge on the types, roles, threats to, rate of change and state of ecosystems
  - Level of degradation observed
  - How livelihoods are linked to ecosystems
  - Local coping and adaptation strategies
  - Knowledge of/Perceptions of governance systems
  - Key issues and potential/proposed solutions



# National Level Consultations

Participants discussing options in breakout groups



Prof. Adonis Velegrakis, a beach erosion expert, demonstrates value of coastal ecosystems to beach protection



# Parish Level Consultations



Negril stakeholders participating in break-out groups

Charts showing outputs from stakeholder discussions  
(Photograph shows outputs from one group that focused on forest services, threats and solutions)



# Community Mapping

Residents of Little Bay sketch the layout of their community



Residents of White Hall using Google Earth to map present layout of the community



# Stage III: Field Work

- Additional data acquisition
  - Satellite imagery
  - GPS points
  - Photographs
  - Bathymetry (collected in previous project)



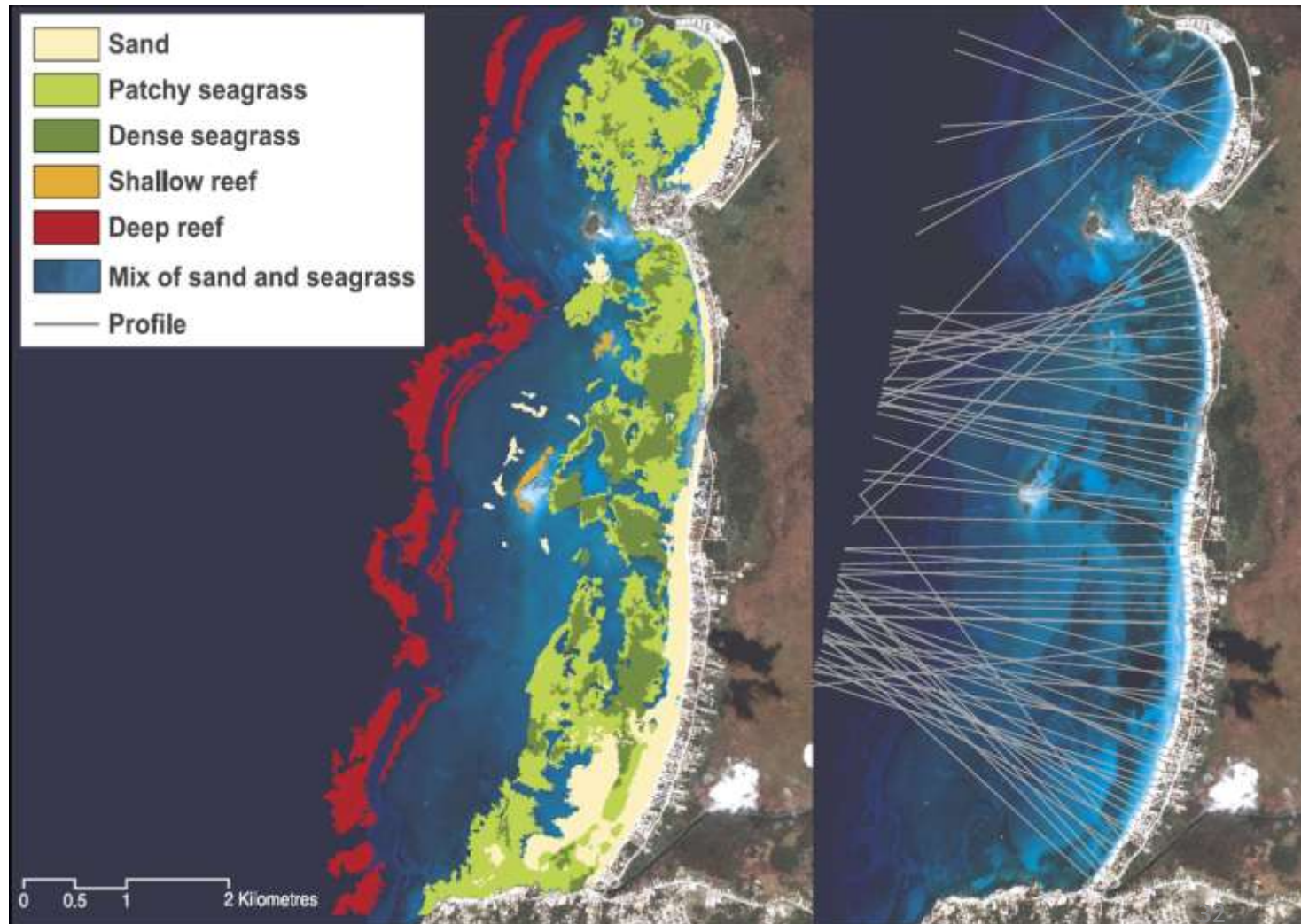
A member of the team takes GPS readings where community members indicated storm surges had reached



# Stage IV: Analyses

- Spatial Overlays

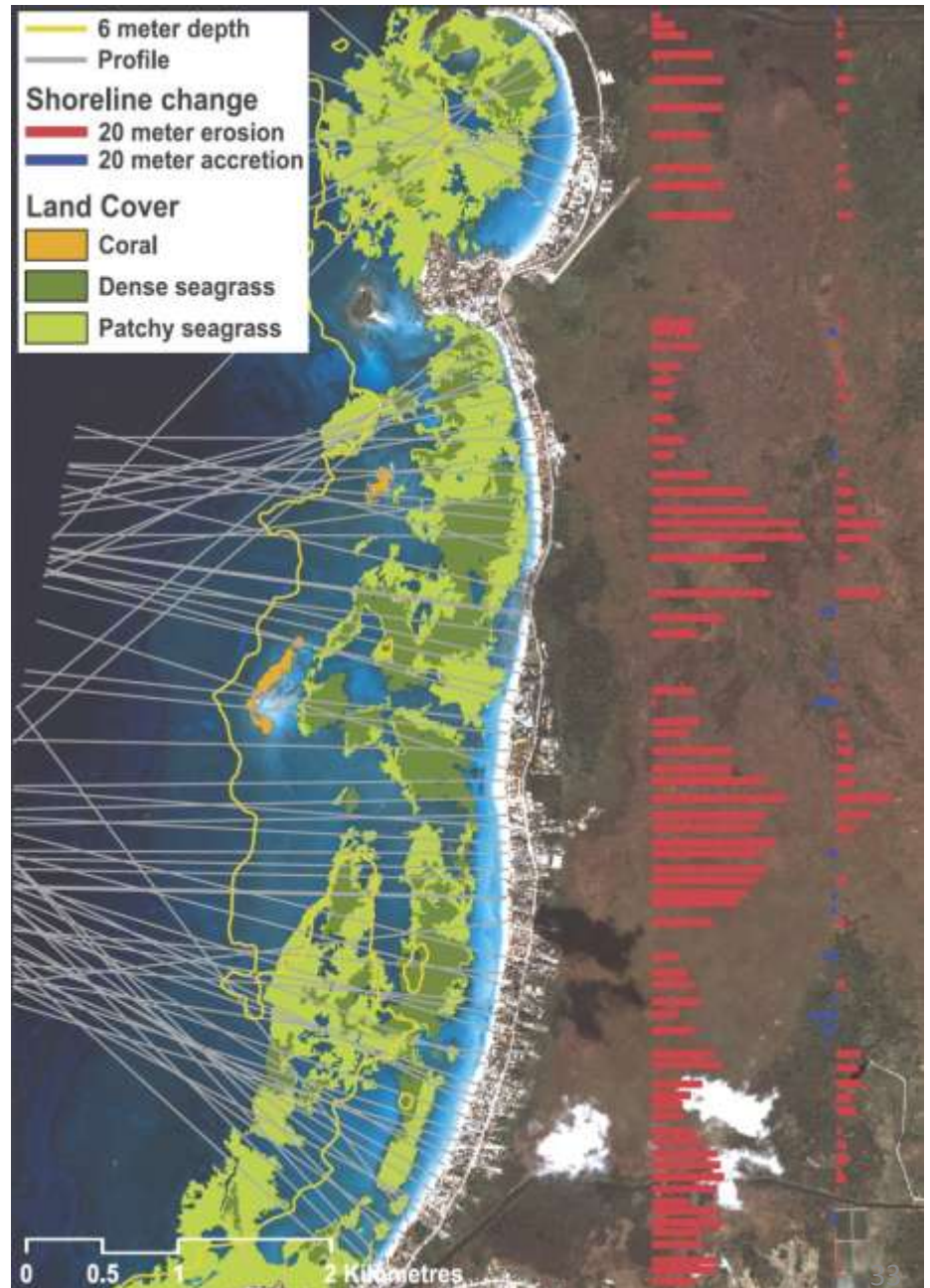
Distribution of the coastal ecosystems and locations of the profiles used for the multiple regression analysis, based on the QuickBird satellite image (16 January 2008)





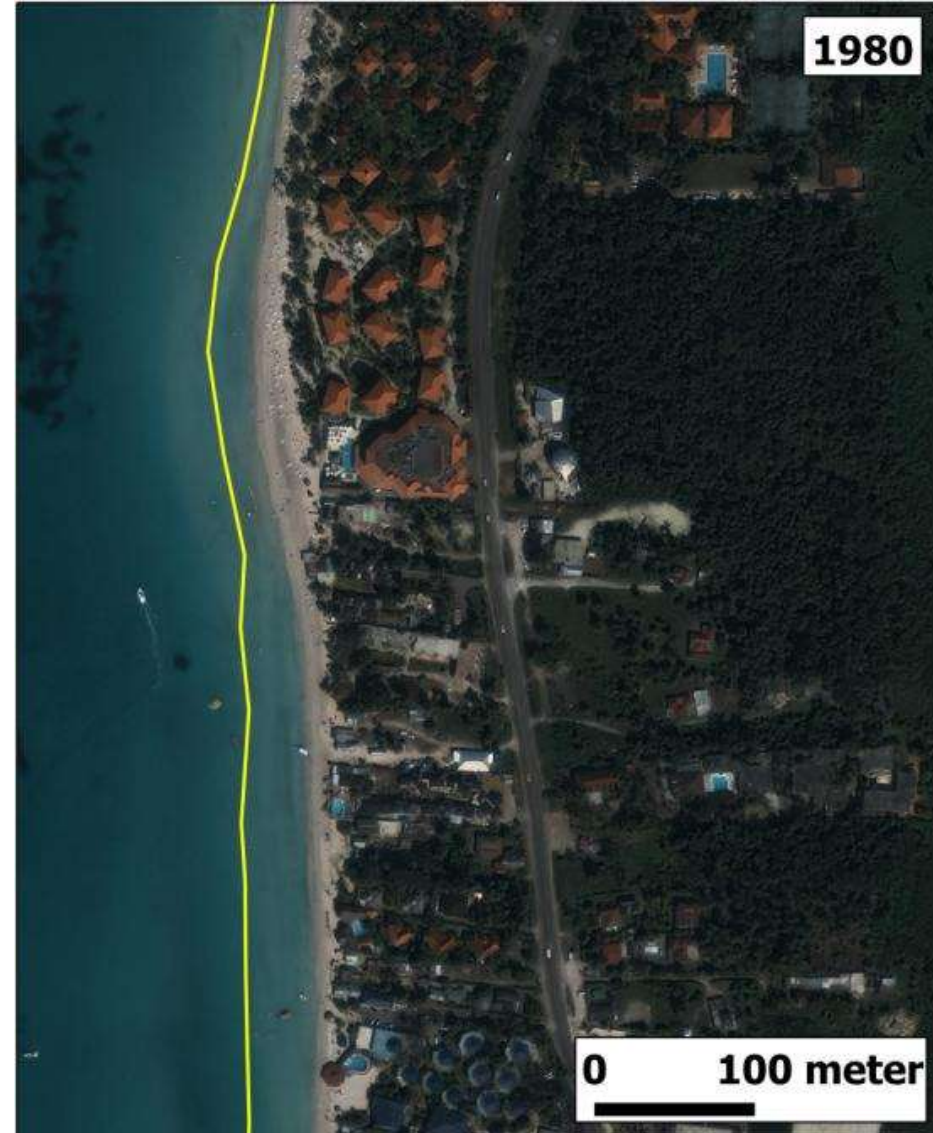
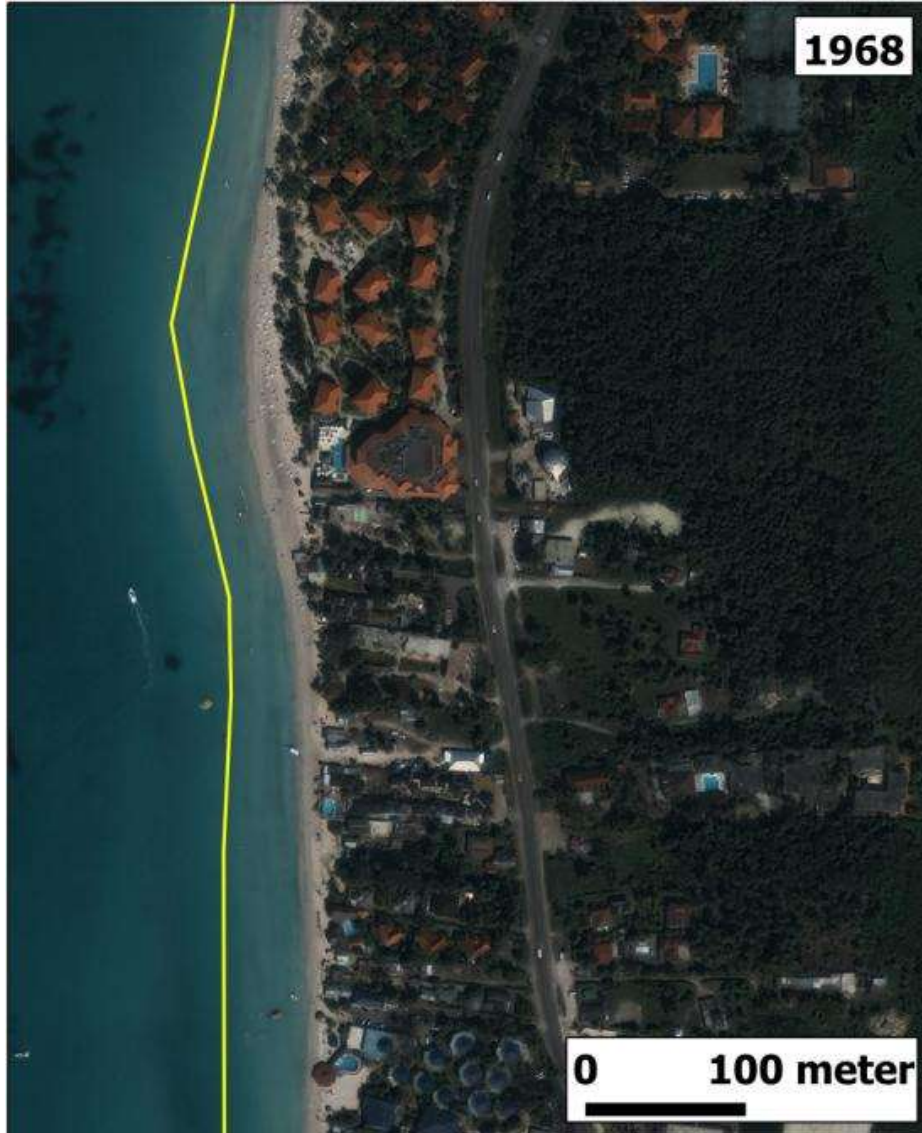
# Stage IV: Analyses

Composite map with  
chart of beach erosion  
and accretion, 1968-  
2006 and 2006-2008



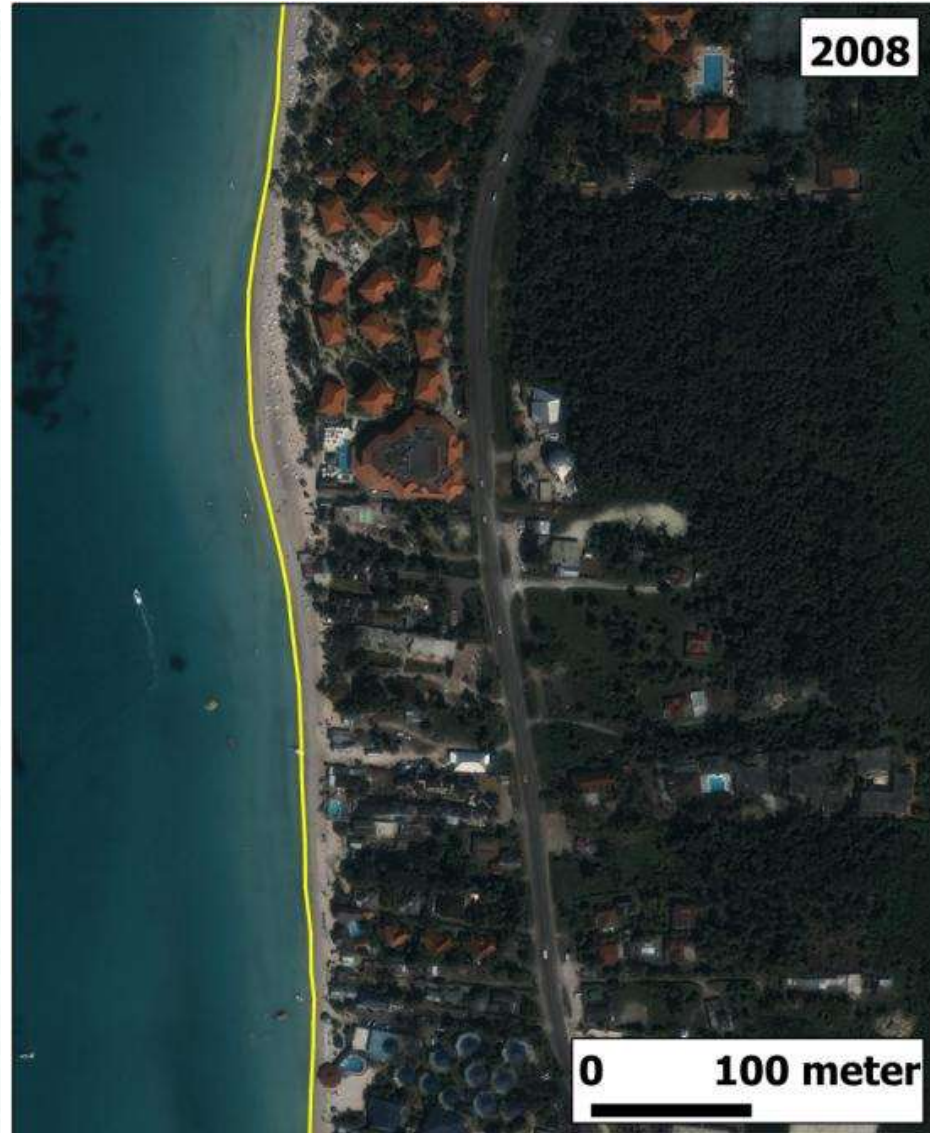
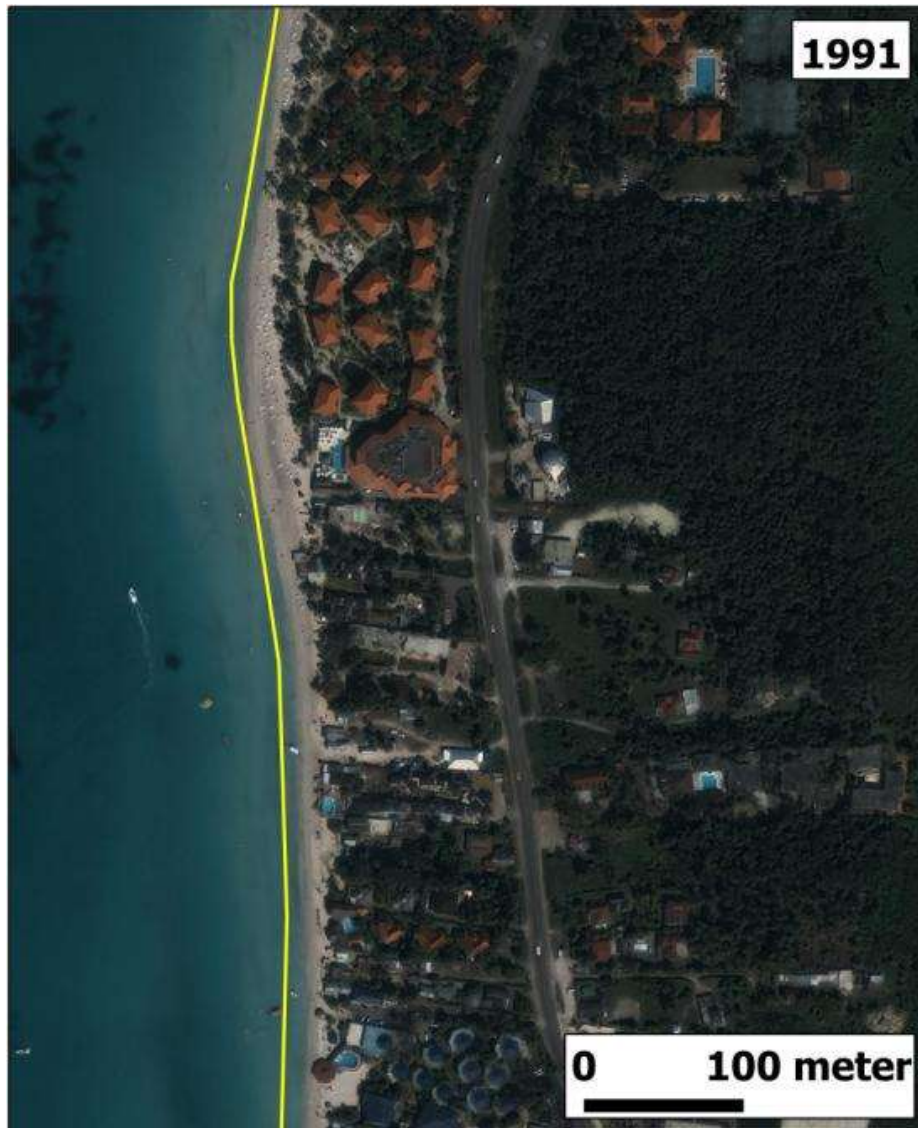
# Negril's Beach Retreat using satellite imagery

The yellow line represents the shoreline at the stated year



# Negril's Beach Retreat using satellite imagery

The yellow line represents the shoreline at the stated year



# Stage IV: Analyses

- Numerical Modelling

- Nearshore 2-D wave propagation model (WAVE-LS) and 1-D cross-shore model (SBEACH)
- Bathymetry data from SWI, 2006 survey with extension of onshore beach elevations of 1m above MSL using 74 beach profiles
- 10 and 50 year return periods

Return period (years)	Hs (m)	T (s)	Tidal level (m)	Coastal storm surge (m)	Min. ASLR (m)	Max. ASLR (m)	Min. combined sea level (m)	Max. combined sea level (m)
10	6.4	10.7	0.3	0.3	0.05	0.15	0.65	0.75
50	9.2	13.4	0.3	1.5	0.22	0.75	2.02	2.55

Source: Rahmstorf, 2007

Key:

Hs: Significant wave height (in metres)

T: wave period (in seconds)

ASLR: Accelerated sea level rise (in metres)



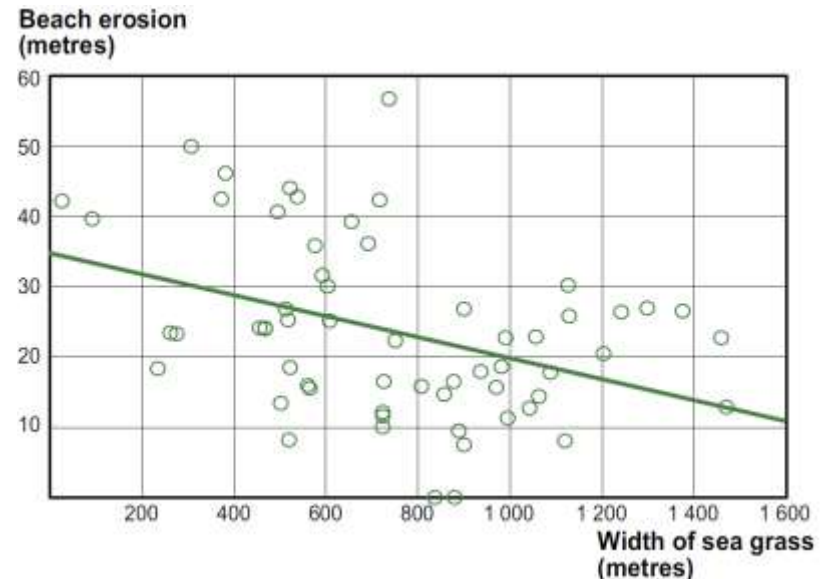
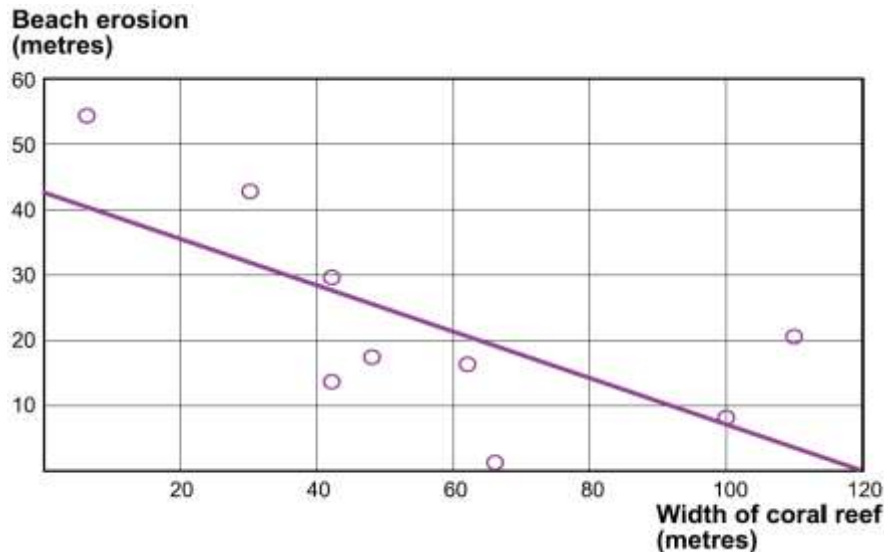
# Stage IV: Analyses

- Numerical Modelling (cont'd)
  - Model runs used different wave and sea level conditions: tidal effects, storm surges and long-term sea level rise
  - For tidal effect: mean high water on springs (SMHW) of 0.3m; and 0.3m and 1.5m for 10- and 50- year return storm respectively from SWI estimations



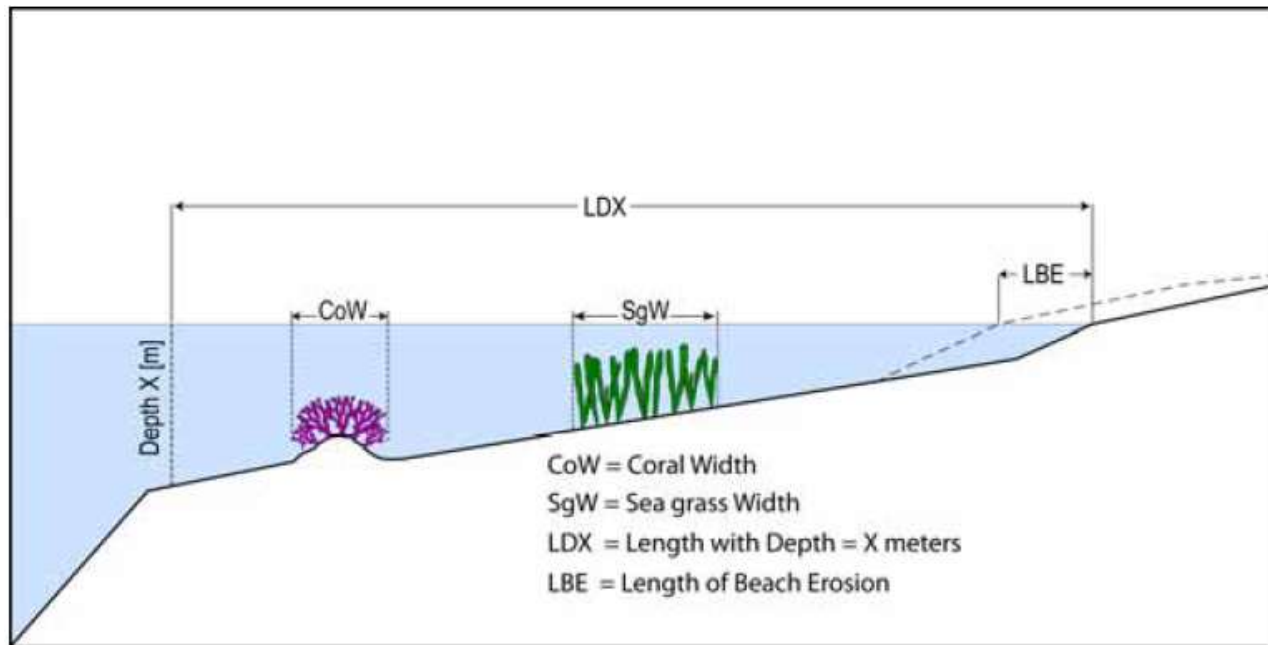
# Stage IV: Analyses

- Multiple Regression Analyses
  - Hypothesis: Beach erosion (dependent variable) is due to change in coral reef and seagrass bed cover (independent variables)



# Stage IV: Analyses

- Multiple Regression Analyses (cont'd)
  - Other important variables: depth at fixed distances, distance at specific depth (both affect slope of beach)



# Stage IV: Analyses

- Coastal Morphodynamic Models:
  - Assesses rate of erosion for sea level rise, storm surges
  - 6 Models used: Leont'yev; Larson and Kraus (SBEACH); Edelman; Brunn; Dean; Kriebel and Dean
  - Wave heights used (m): 1, 2, 3, 4, 5, 6
  - Wave periods (s): 3, 5, 6, 7, 8, 10, 12
  - Sediment grain size (mm): 0.2, 0.33, 0.50, 0.80, 1.0
  - SLR (m): 0.038, 0.05, 0.10, 0.15, 0.22, 0.30, 0.40, 0.50, 0.75, 1.0, 1.25, 1.50, 2.0, 3.0
  - Slopes(linear profiles): 1/10, 1/15, 1/20, 1/25, 1/30





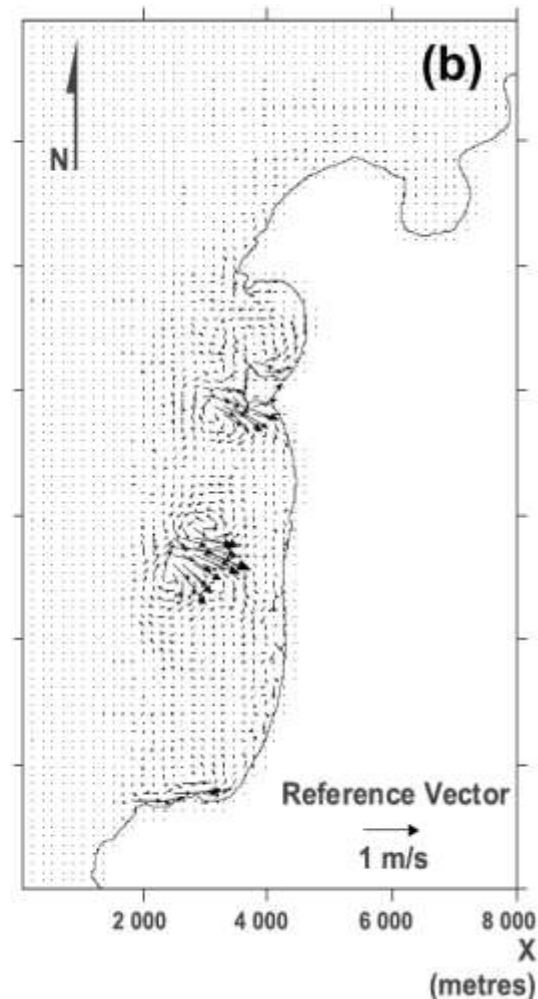
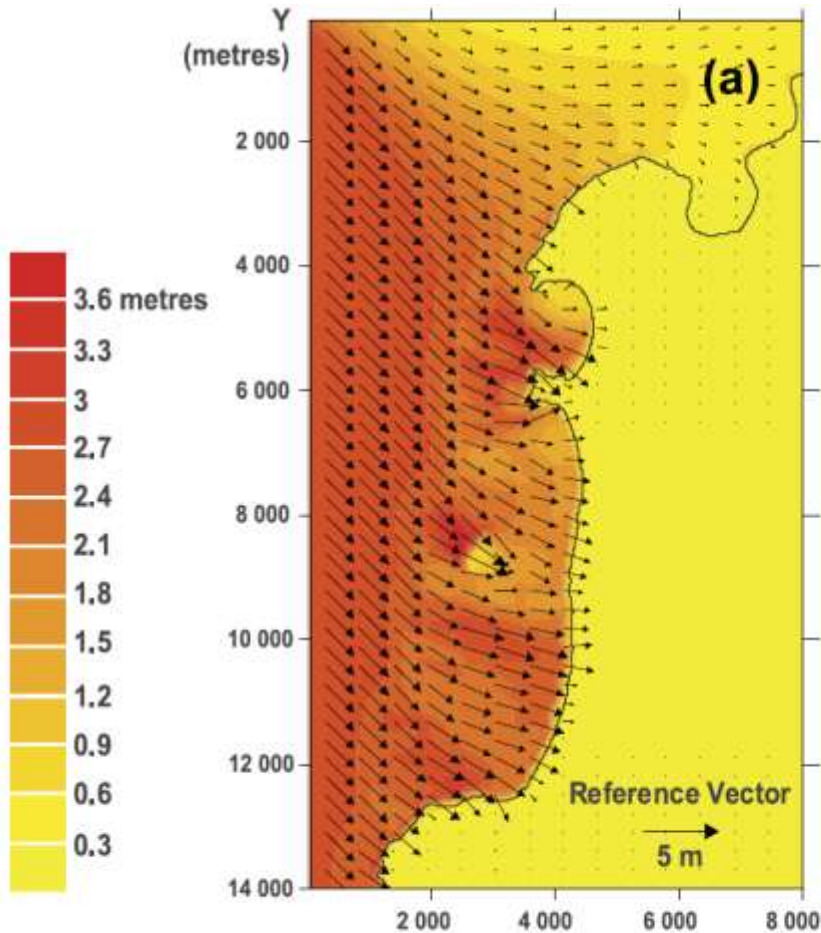
# Stage IV: Analyses

- Tropical Cyclone Exposure Models
  - Derives wind speed, storm surges (Note: landslide data was not available for inclusion in analysis)
  - Based on 6m elevation model
  - Exposure of population, assets assessed for 10- and 50-year return period storm events



# Stage V: Outputs

- Numerical Modelling

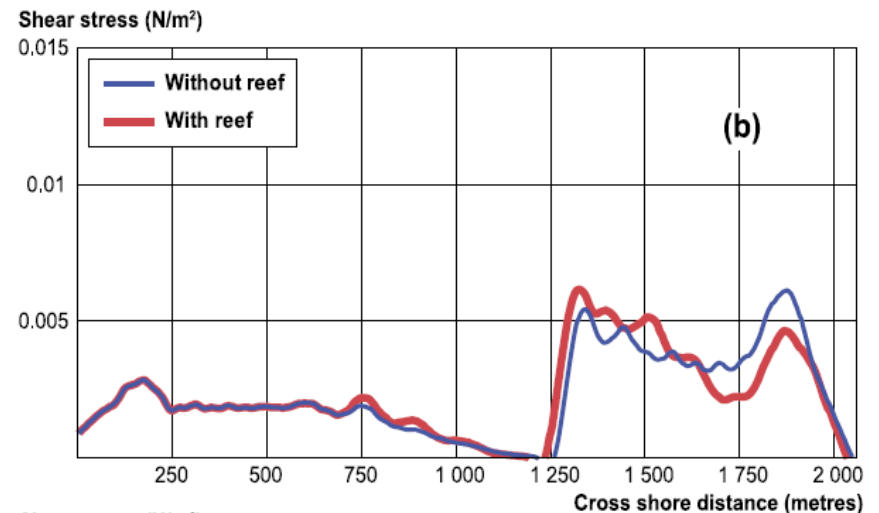
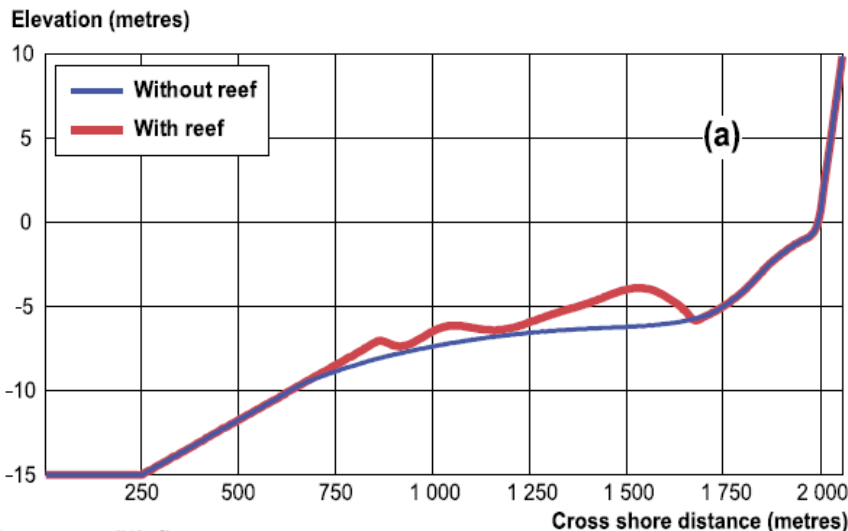


Numerical model results for wave heights (a) and wave-induced currents (b) at the Negril coast. Conditions: Offshore wave height ( $H_{rms}$ ) = 2.8 m,  $T_p=8.7$  s. Waves approach from the northwest. Note the diminishing wave heights and changed nearshore flow patterns at the lee of the shallow coral reefs



# Stage V: Outputs

- Numerical Modelling (cont'd)

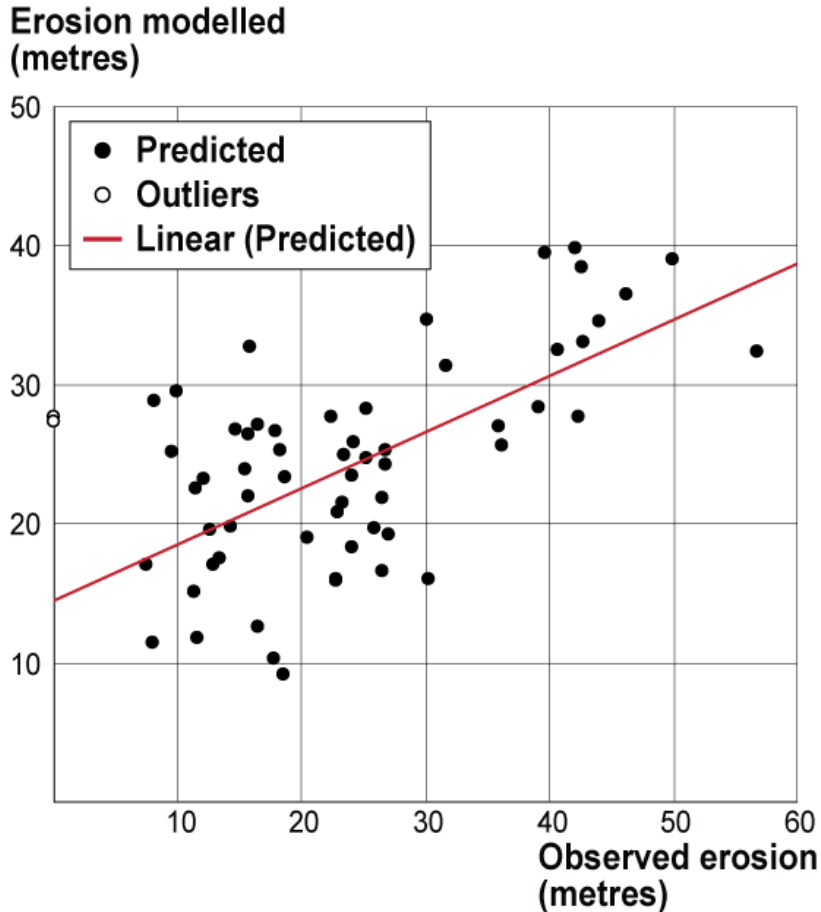


Modelled reef effects on the wave-induced shear stress by the SBEACH model (Larson and Kraus, 1989). (a) beach profile (b) cross-shore shear stress distribution for Mean Sea Level (MSL) and swell waves ( $H_s = 2.8$  m and  $T = 8.7$  s);

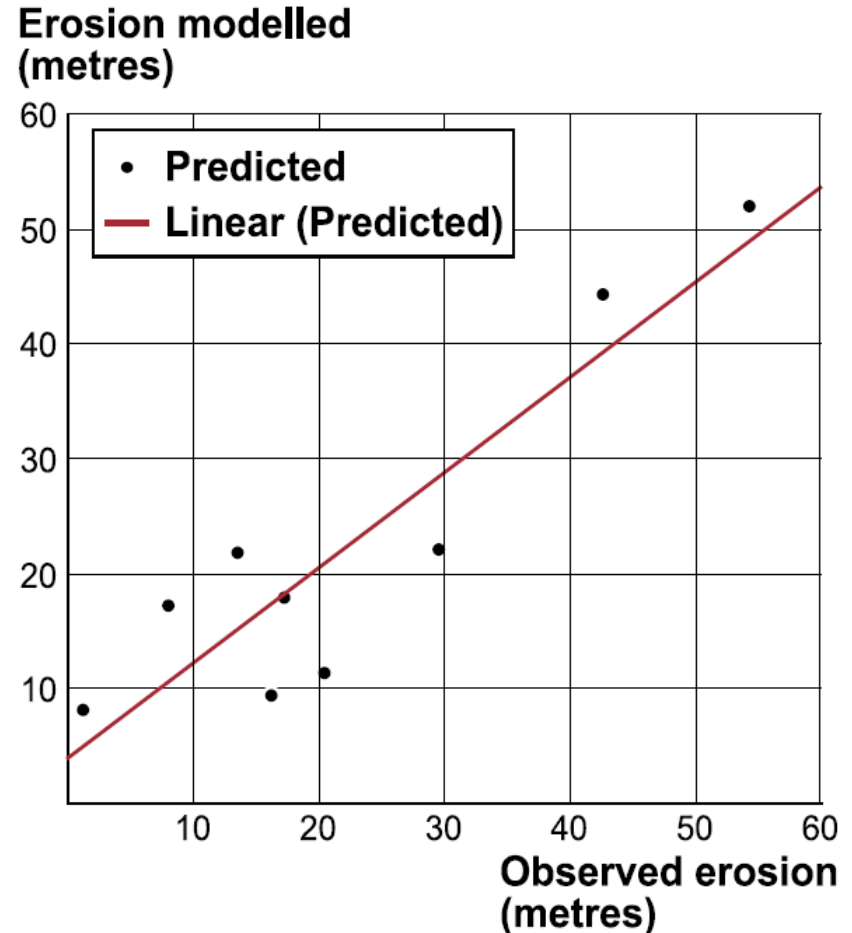


# Stage V: Outputs

- Multiple Regression Analysis



Erosion rate behind seagrass beds.

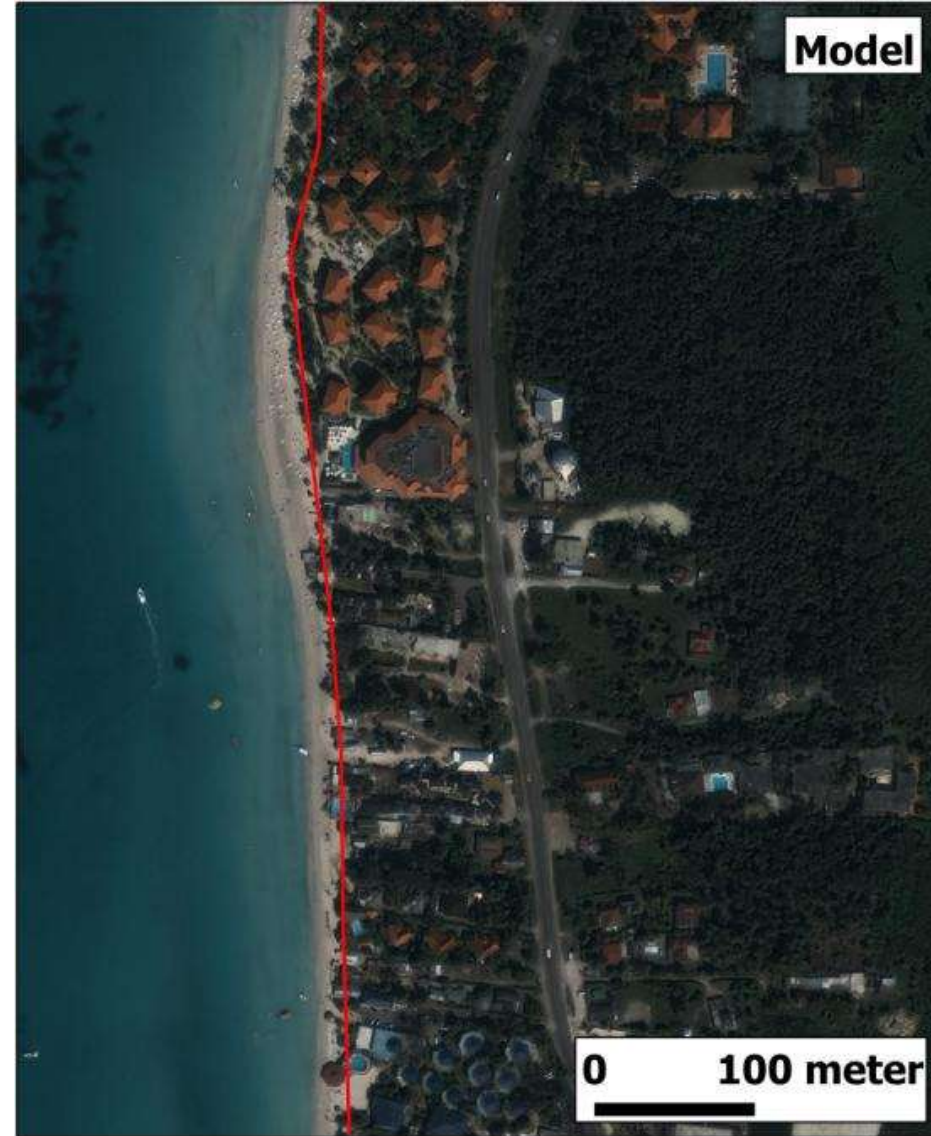
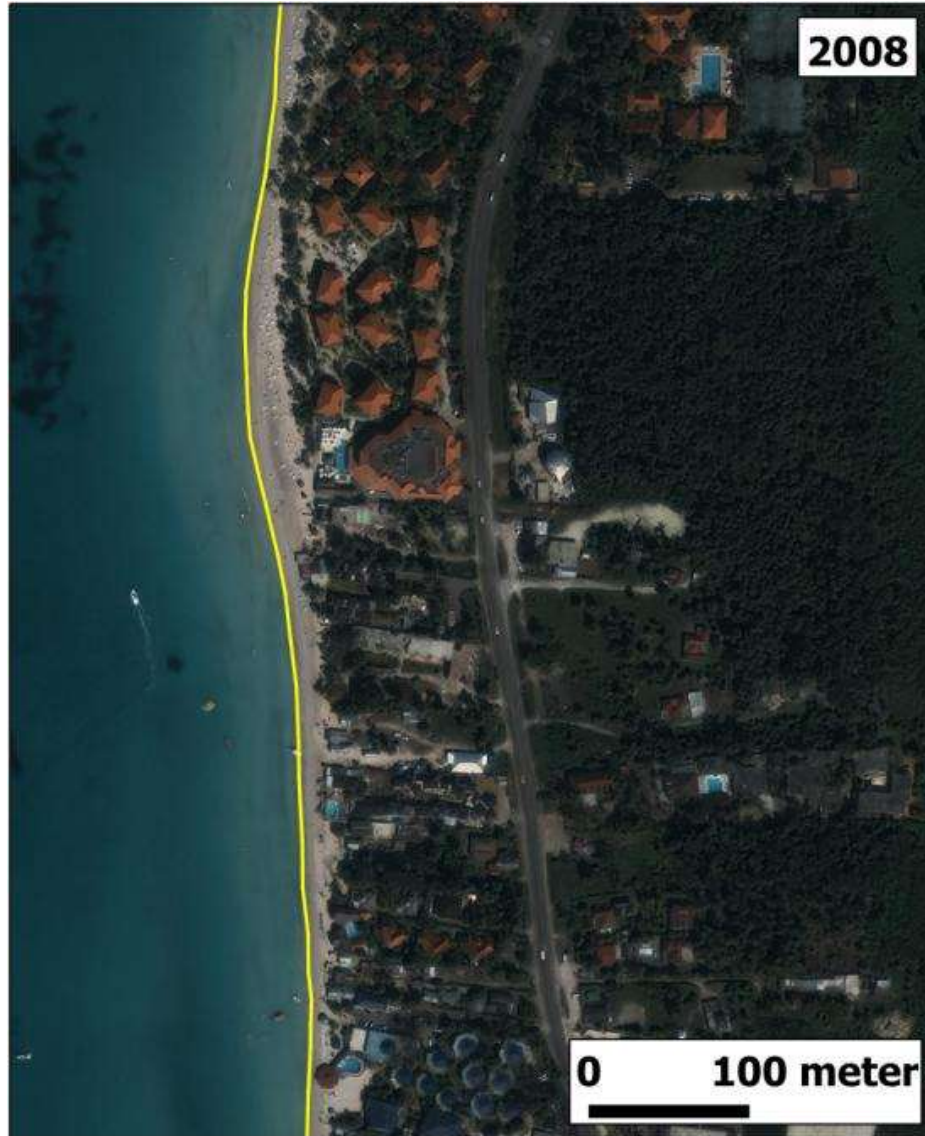


Erosion rate behind shallow coral reefs.



# Negril's Beach Retreat using satellite imagery

The yellow line represents current shoreline. The red line is a projection of shoreline change

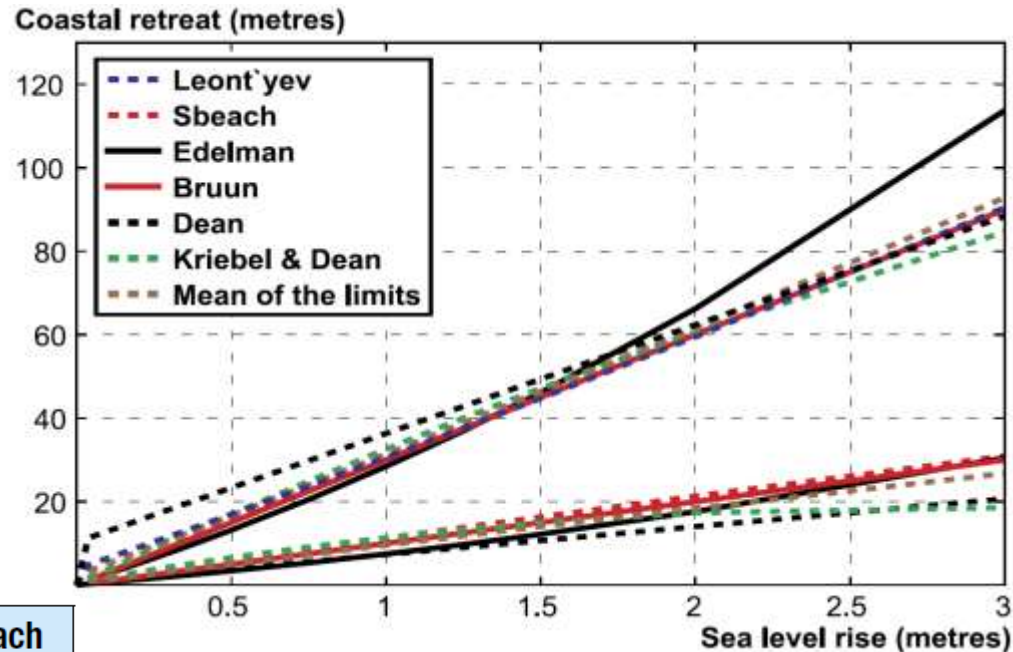


# Stage V: Outputs

- Coastal morphodynamic models

Beach erosion in Negril under different SLR scenarios

Sea level change (m)	Minimum beach retreat (m)	Maximum beach retreat (m)
0.35	3.6	12.3
0.52	5.3	17.3
0.65	6.3	20.9
0.75	7.5	24.0
1.05	10.0	32.9
2.02	20.6	61.9
2.55	25	78.7



Projections of beach erosion using different models



# Stage V: Outputs

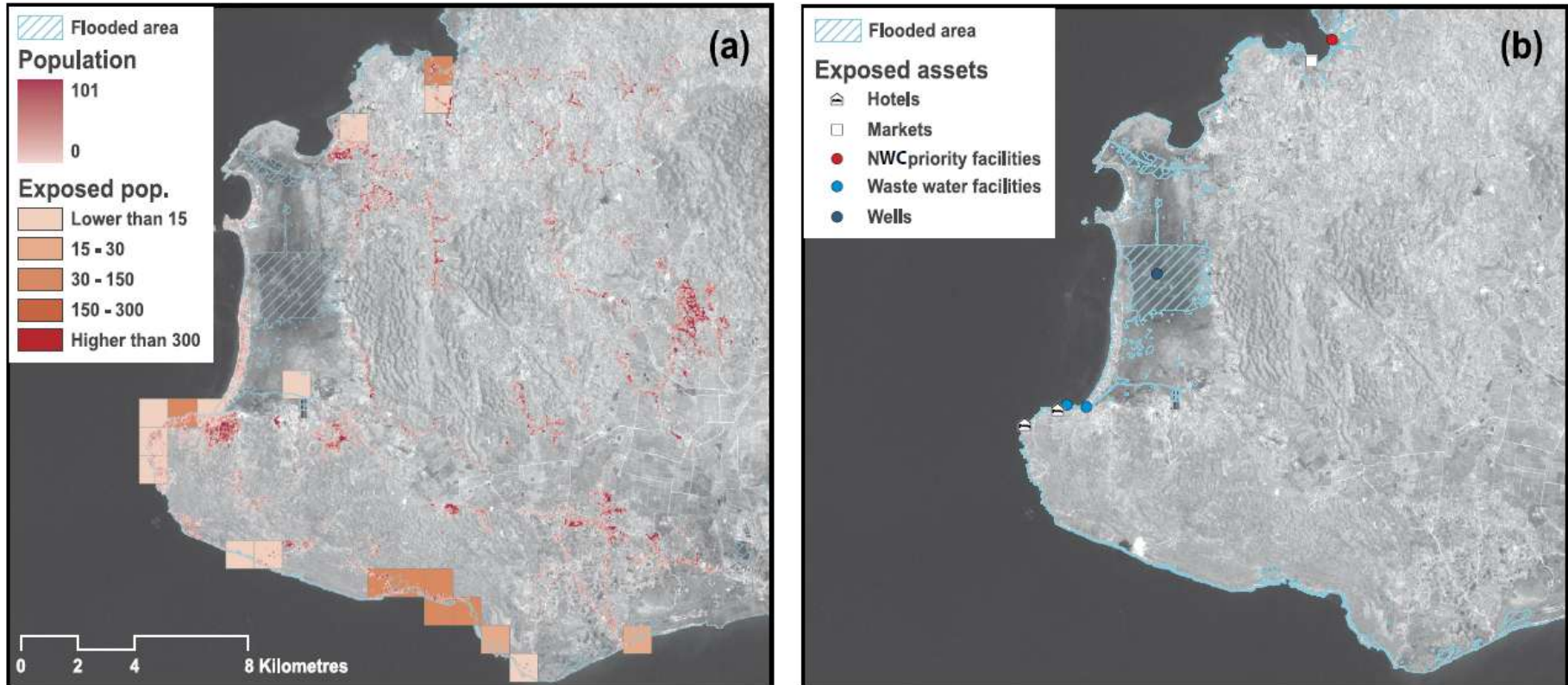
- Tropical Cyclone Exposure Models

Note the 10- and 50-year floods (see key)



# Stage V: Outputs

- Tropical Cyclone Exposure Models



10-year storm exposure of a) population, b) assets. Some 478 persons would be affected by flooding; at least 2 hotels, 2 wastewater facilities, 1 market, 1 well and 1 NWC facility will be flooded.

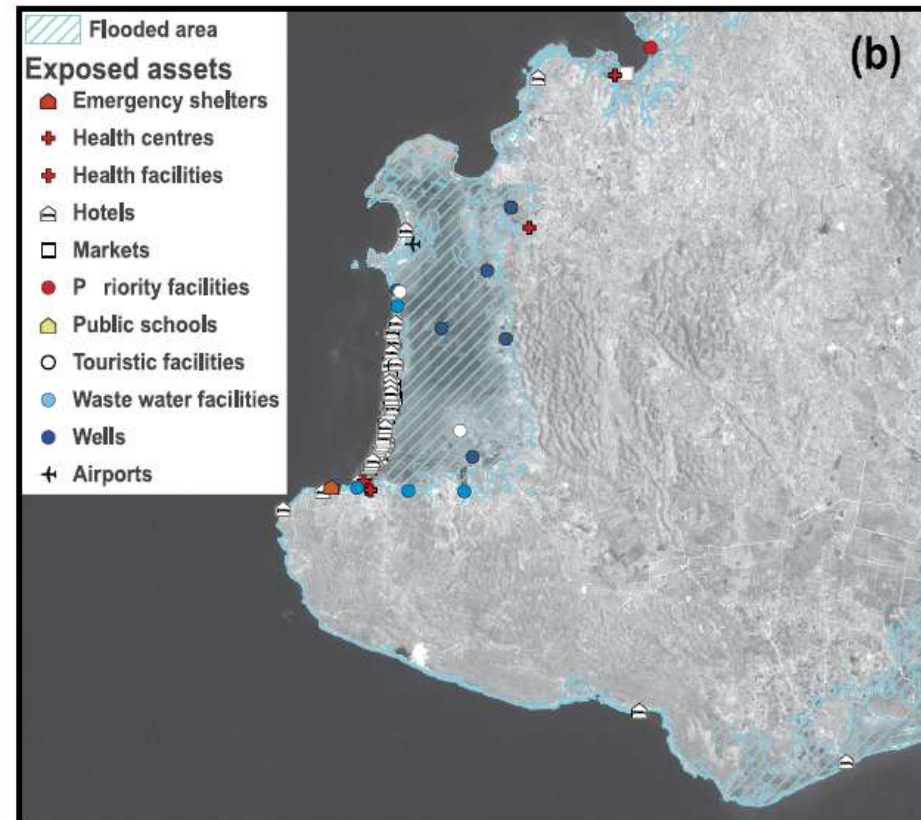
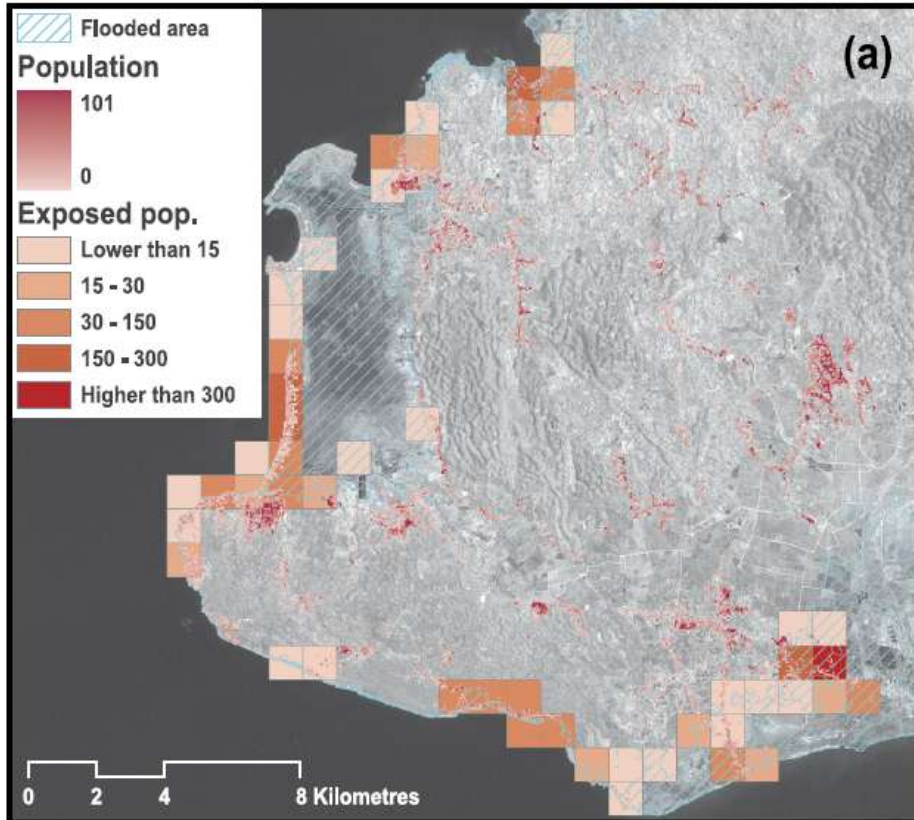
Note: Population does not include guests/occupancy in hotels





# Stage V: Outputs

- Tropical Cyclone Exposure Models



50-year storm exposure of a) population, b) assets. About 2,487 persons would be affected by flooding; at least 63 hotels, 3 health centres, 8 wastewater facilities, 1 market, 9 wells and 1 NWC facility will be flooded.

Note: Population does not include guests/occupancy in hotels



# Stage V: Outputs

- Results of consultation in Little Bay:
  - Have been affected by storm surges, flooding, strong winds due to storm events in last decade
  - Dependent on rainfall, trucks for potable water
  - Livelihood over previous decades was mainly fishing and farming, but currently supplemented due to change in ecosystems (eg, bike taxis, tourism industry)
  - Willing to learn more about ways to protect natural environment



# Stage V: Outputs

- Results of consultation in Whitehall:
  - Poor development due to squatting
  - Have been affected by flooding, strong winds due to storm events in last decade; smoke from peat fires in morass (due to drying)
  - Livelihoods largely in tourism industry



# Stage V: Outputs

- Summary:
  - Loss of coral reefs and seagrass beds have significantly contributed to the beach erosion.
  - Beach will retreat in response to SLR (more permanent) and storm surge (can be temporary) in “business as usual” scenario



# Stage V: Outputs

- Summary (cont'd):
  - Some level of adaptation and awareness of environmental issues local to national levels
  - 1 in 10 year and 1 in 50 year floods, storm events will affect hundreds or thousands of people, numerous hotels, and critical infrastructure needed to recover (water systems, health care facilities, road networks)



# Stage V: Outputs

- Recommendations:
  - Protect and enhance coastal ecosystems, specifically seagrass beds, coral reefs to protect beach and generate sediments
  - Construct off-shore structures including submerged breakwaters to protect beach from increased wave action



# Stage V: Outputs

- Recommendations (cont'd):
  - Beach nourishment (see table below)

d50 (mm)	Designed bed slope	Required material (m <sup>3</sup> /m)	Initial width (m)	Final width (m)
0.4	1/6.67	145.7	34.8	15
0.8	1/6.67	87.2	23.2	15
2.0	1/6.67	62.2	17.8	15
0.4	1/3	145.7	39.5	15
0.8	1/3	87.2	26	15
2.0	1/3	62.2	21.1	15

Note: Final width will occur once beach reaches equilibrium; assumption that nourishing material is 0.4mm



# Stage V: Outputs

- Recommendations (cont'd):
  - Protect upstream ecosystems (eg, forests)
  - Strengthen environmental governance: land-use planning and zoning; policies and legislation; reform local governance; establish more comprehensive mechanism for collaboration and coordination





# Stage V: Outputs

- Recommendations (cont'd):
  - Identify alternative livelihood options for communities
  - Build capacity of communities to adapt to potential threats
  - Improve environmental education and awareness among communities members, tourism interests



# Stage VI: Evaluation of RiVAMP

- Benefits:
  - Re-enforcement of existing knowledge that ecosystems are critical to DRR
  - Greater awareness of ecosystems goods and services in communities, through media



# Stage VI: Evaluation of RiVAMP

- Benefits:
  - Capacity building of national and local groups: exposure to technologies, new tools for consultations
  - Data: high resolution satellite imagery, community maps, outputs of study area, stakeholder perceptions on ecosystem services, threats, drivers of degradation



# Stage VI: Evaluation of RiVAMP

- Enabling factors:
  - Timeliness of RiVAMP (as ecosystems-based tool taking climate change into account)
  - Data availability (spatial, socio-economic, meteorological datasets; studies on erosion)



# Stage VI: Evaluation of RiVAMP

- Enabling factors:
  - Willingness of stakeholders to participate and good relationship amongst stakeholders
  - Presence of coordinating body (in the PIOJ)
  - Presence of strong local bodies in Negril



# Stage VI: Evaluation of RiVAMP

- Enabling factors (cont'd):
  - High level of knowledge at local and national levels
  - Flexibility of consultation approach, especially at community level
  - Presence of an Advisory Committee to give feedback
  - Professional and accommodating development and implementation (UNEP) team



# Stage VI: Evaluation of RiVAMP

- Disabling Factors:
  - Insufficient time for Technical Working Group to do analysis with UNEP team - UNEP team worked mainly out of the country
  - Short duration of desk study
  - Turn-around time for feedback from local stakeholders “tight”



# Stage VI: Evaluation of RiVAMP

- Recommendations for improvement:
  - Economic valuation of ecosystems
  - Relatively detailed stakeholder analysis (who, interests, participation required, influence)
  - Thorough pre-implementation research (data available, political landscape, informal dynamics, cultures, etc)
  - Clear indication of limitations





# Stage VI: Evaluation of RiVAMP

- Recommendations for improvement (cont'd):
  - Options for using methodology with less data
  - Different approaches detailed for rural vs urban communities
  - Inclusion of all drivers of ecosystem loss, stating where data is not available
  - Be more clear in collective effect of ecosystem and services



# THE WAY FORWARD



# RiVAMP II

- Targets Negril/Orange River watershed (Negril Great Morass)
- Early stages:
  - Preliminary desk study
  - Scoping mission to determine sites for data collection equipment
  - Collaborating with local partners
- Next Step: Continue data collection, collaboration



# Negril Activities

- Adaptation Fund:
  - “Enhancing the Resilience of the Agriculture Sector and Coastal Areas to Protect Livelihoods and Improve Food Security”
  - Will install off-shore submerged breakwaters in a vulnerable section of Long Bay beach coastline
  - Will begin 2012



# Negril Activities

- Climate Change Adaptation and Disaster Risk Reduction:
  - Aimed at reducing risks through protection and restoration of natural ecosystems
  - Will enhance state of seagrass beds in Long Bay, Negril
  - Has installed data collection equipment for better monitoring of coastal waters
  - Grant funded by European Union under Global Climate Change Alliance; Ending 2013



# References

- United Nations Environment Programme. 2010. “Linking Ecosystems to Risk and Vulnerability Reduction: The Case of Jamaica, Results of the Pilot Assessment”. UNEP in collaboration with the Planning Institute of Jamaica.  
[http://pioj.gov.jm/Portals/0/Sustainable\\_Development/RiVAMP-FINAL.pdf](http://pioj.gov.jm/Portals/0/Sustainable_Development/RiVAMP-FINAL.pdf)
- Data from the Planning Institute of Jamaica (various sources)
- Rahmstorf, S. 2007. “A Semi-empirical approach to projecting future sea-level rise”. *Science*. 315:pp368-370.
- Smith Warner International (SWI). 2006. “Preliminary Engineering Report: Beach Restoration Works at Negril”.





The End!