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Multicriteria decision evaluation of adaptation strategies for vulnerable coastal communities

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The issue

- ▶ Climate change Impacts
- ▶ Vulnerability of coastal communities
- ▶ Multi dimensionality (Economic, Environmental, Cultural and Social)
- ▶ Multiple Stakeholders (Government, Industry, NGO,...)

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Need to Know: Summary

1. Profiling the community along four pillars (Environment, Economic, Social and Cultural)
2. Understand storms and their impacts
3. Examine community vulnerability
4. Make better decisions by engaging the community and applying priorities

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Decision Hierarchy

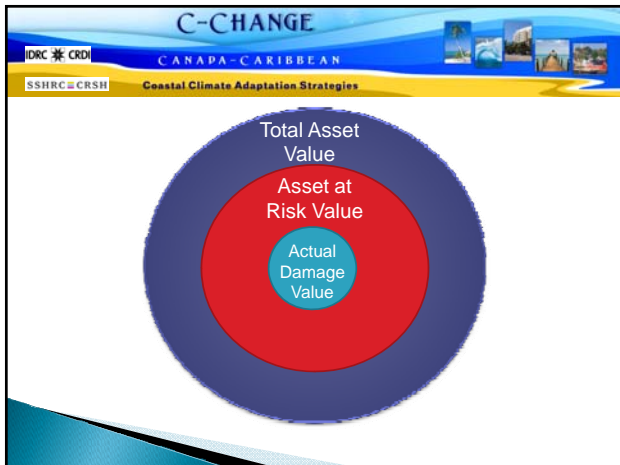
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Vulnerability: $V(u) = SQ^j(u) - SQ^0(u)$

Resilience: $R^j(A_i, u) = SQ^j(u) - SQ^j(A_i, u)$

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General utility function



Total Asset Valuation

Indicator	Number/Length/Area of assets	Total monetary value of assets
Houses	100	3,175,000

"At Risk and Damages Valuation"

	Scenario1	Scenario2	Scenario3	Scenario4	Scenario5	Scenario6
Houses	21	25	29	32	36	40
Asset at risk (AR)	666,750	793,750	920,750	1,016,000	1,143,000	1,270,000
Damage	84,000	112,500	174,000	224,000	288,000	360,000
New asset state (TA-D (p AR))	3,091,000	3,075,000	3,049,000	3,047,000	3,031,000	3,015,000

Impact of Adaptation Valuation

Adaptation cost	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Before	0	0	0	0	0	0
After	1,700,000	1,700,000	1,700,000	1,700,000	1,700,000	1,700,000
Houses	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Before	21	25	29	32	36	40
After	15	18	21	24	29	33
Asset at risk (AR)	476,250	371,300	666,750	762,000	920,750	1,047,750
Damages	60,000	90,000	126,000	168,000	232,000	297,000
New asset state (TA-D (p AR))	3,115,000	3,085,000	3,049,000	3,007,000	2,943,000	2,871,000

AHP Data Grid and Adaptation Alternatives

Alternative	Total	Economic Built Environment Houses (E. 649)	Economic Built Environment Buildings (E. 332)	Economic Public Works Parks (E. 446)	Economic Public Works Wharfs (E. 289)	Economic Public Works Weirs (E. 345)
No Storm	833	21,700	14,800	282,048	8,800	40,700
Scenario 1 impacts	706	20,910	5800	21,146	2,000	42,400
Scenario 2 impacts	640	20,790	5700	20,512	1,975	42,100
Scenario 3 impacts	615	20,900	4800	1,209,36	1,975	42,000
Scenario 4 impacts	567	20,400	4000	1,920,64	1,8125	41,900
Scenario 5 impacts	513	20,100	3000	1,844,76	1,7500	41,800
Scenario 6 impacts	476	20,100	3200	1,75,800	1,675	41,700
Path of BW (S1)	679	21,900	5700	21,146	2,150	42,300
Closing the gap (S1)	701	21,900	5700	229,100	2,000	42,300
New BW arm (S1)	707	21,900	5800	228,54	2,000	42,400
Path of BW (S2)	637	20,900	5300	20,512	2,025	42,300
Closing the gap (S2)	679	20,900	5000	21,146	2,175	42,400
New BW arm (S2)	695	20,900	5800	228,528	2,025	42,300

Alternative	Total	Economic Built Environment Houses (E. 649)	Economic Built Environment Buildings (E. 332)	Economic Public Works Parks (E. 446)	Economic Public Works Wharfs (E. 289)	Economic Public Works Weirs (E. 345)
No Storm	833	600	813	894	89	367
Scenario 1 impacts	706	568	846	412	382	390
Scenario 2 impacts	640	540	827	387	306	376
Scenario 3 impacts	615	621	595	331	268	362
Scenario 4 impacts	567	584	393	261	229	340
Scenario 5 impacts	513	491	293	173	187	332
Scenario 6 impacts	476	456	137	866	144	316
Path of BW (S1)	679	596	729	422	408	413
Closing the gap (S1)	701	598	744	264	384	411
New BW arm (S1)	707	603	768	585	324	418
Path of BW (S2)	637	559	655	387	376	404
Closing the gap (S2)	679	569	645	420	345	404
New BW arm (S2)	695	582	737	479	387	411

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Case Study: Little Anse Breakwater



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Little Anse Strategy Evaluation

- Define Community Profile and Status Quo assets
- Define Storm Scenario and estimate "at risk", and damages
- Feedback from all participants - priorities for criteria
- Combine all participants
- Rank alternatives

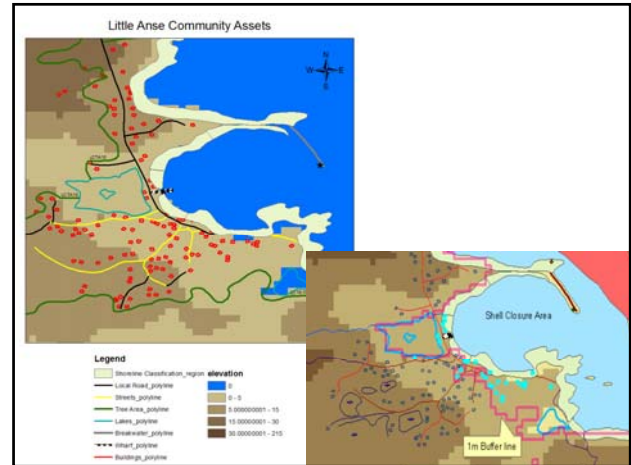
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Little Anse Hierarchy and water level scenarios

Goal: Adaptation of Little Anse community to storm surge events

- Economic**
 - Built Environment
 - Houses
 - Private buildings
 - Public Works
 - Roads
 - Wharf
 - Wells
 - Cost of adaptation
- Environmental**
 - Land Use
 - Residential land
 - Lake
 - Trees
- Cultural**
 - Community center
 - Church grounds
- Social**
 - Labour earnings
 - Safety (people over 60 years of age)
 - Safety (people under 14 years of age)

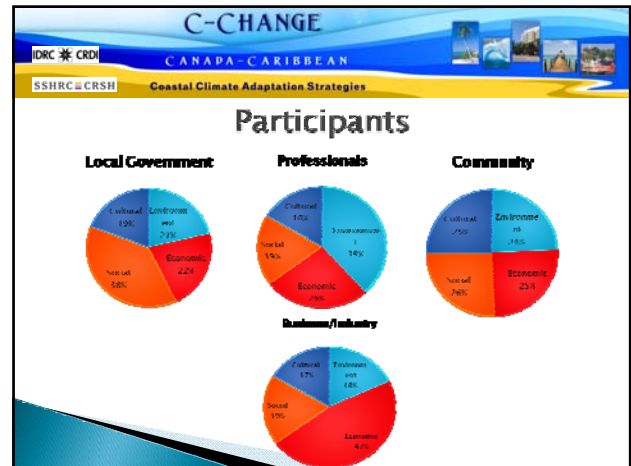
Scenario	Water level
I	1-1.25
II	1.26-1.5
III	1.51-1.75
IV	1.76-2.00
V	2.01-2.25
VI	More than 2.25



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MCDM + Multiple Participants

- Community:** representatives of the community at large
- Local Government:** representatives of local (municipal) government
- Business/Industry:** community industries
- Professional:** professionals providing service to the community, e.g., lawyers, doctors, nurses, engineers, etc.



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Goal: Adaptation of Little Anse community to storm surge events

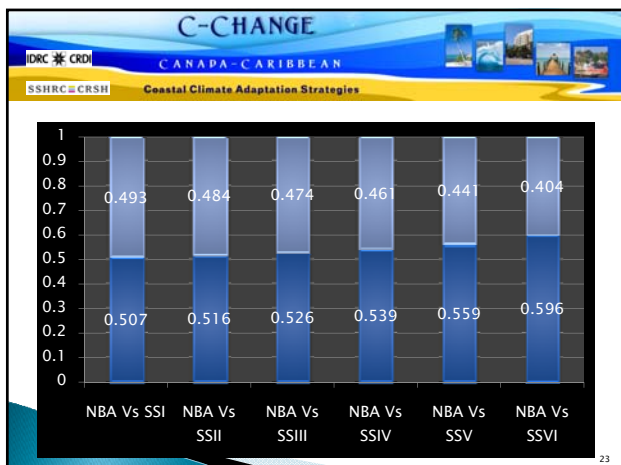
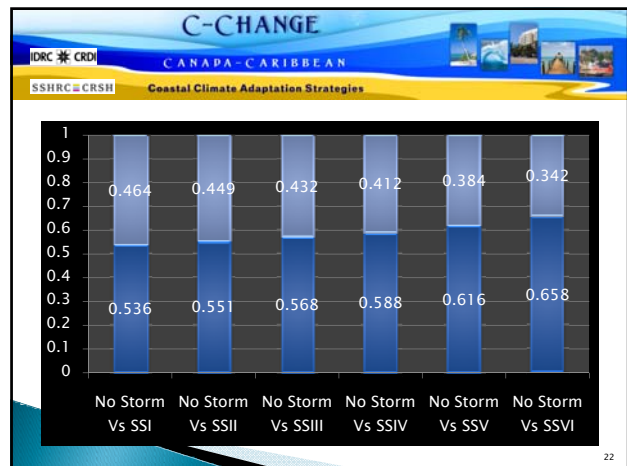
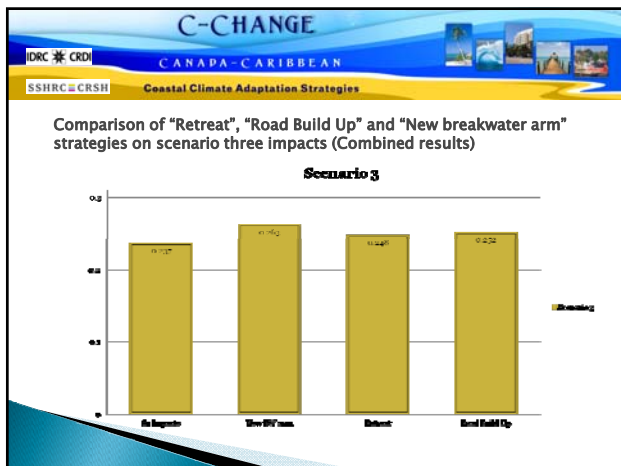
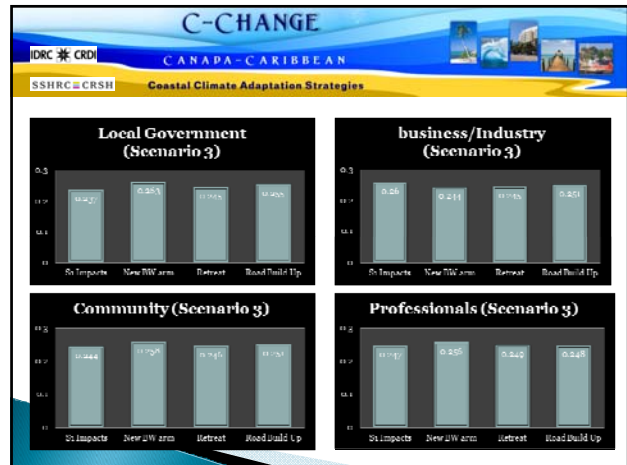
- Economic (L: .285)
 - Built Environment (L: .278)
 - Houses (L: .668)
 - Buildings (L: .332)
 - Public Works (L: .484)
 - Roads (L: .451)
 - Wharfs (L: .245)
 - Wells (L: .303)
 - Adaptation cost (L: .238)
- Environment (L: .224)
 - Land Use (L: 1.000)
 - Residential Land (L: .511)
 - Lake (L: .260)
 - Trees (L: .229)
- Cultural (L: .197)
 - Community Center (L: .507)
 - Church grounds (L: .493)
- Social (L: .294)
 - Income loss (L: .272)
 - Safety at risk (people over 60) (L: .412)
 - Safety at risk (people under 14) (L: .316)

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Adaptation Strategies

- Attack**
 - New breakwater arm (\$5.1M)
 - Close gap (\$4.6M)
- Defend**
 - Rehab the breakwater (\$1.7M)
 - New road (\$1.8M)
- Retreat**
 - Move people/houses (\$2.4M)

Status Quo - do nothing



Conclusion

- Multi criteria decision making does not push for a single strategy, it only shows the tradeoffs.
- The AHP framework for evaluating adaptation strategies is important for small communities decision support.
- Multi criteria decision making engages multiple participants and analysis of decision options.