ITRC mistral

multi-scale infrastructure systems analytics

AN INTERDEPENDENT **INFRASTRUCTURE SYSTEMS PLANNING TOOL** TO SUPPORT LONG-TERM, NATIONAL-SCALE DECISION-MAKING UNDER UNCERTAINTY

CASE STUDY: CARIBBEAN SMALL ISLAND DEVELOPING STATES

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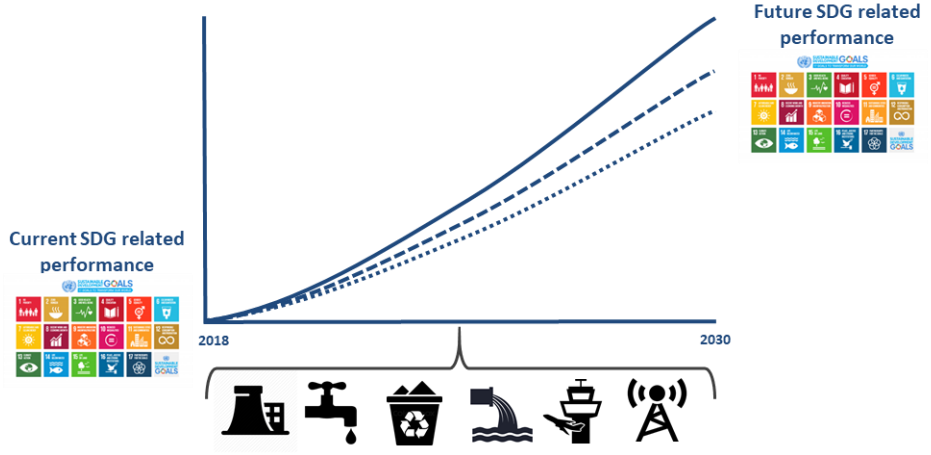
EPSRC Engineering and Physical Sciences Research Council · UNOPS · ITRC mistral · Ministerio de Tráfico, Transporte y Planificación Urbano

Rationale

Need for robust decisions to unlock sustainable development



National Infrastructure Systems MODelling

NISMOD

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NISMOD-Int

'Everything should be made as **simple** as possible, but not simpler.'

Albert Einstein

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NISMOD-Int: Value-added

- National-scale, system-of-systems infrastructure model
- Cross-sectoral interdependencies
- Complex portfolio of interventions
- Open-source
- Transparent
- User-guided: Iterative stakeholder engagement

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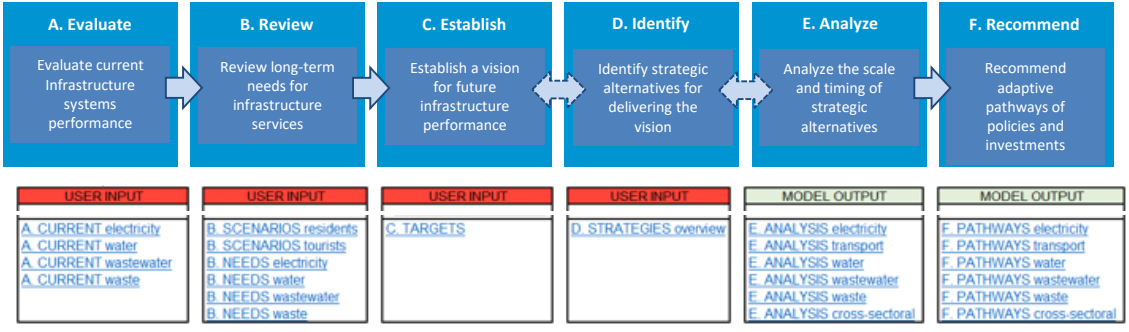
NISMOD-Int: Process

NISMOD-Int

Process

Set of steps for performing a National Infrastructure Assessment



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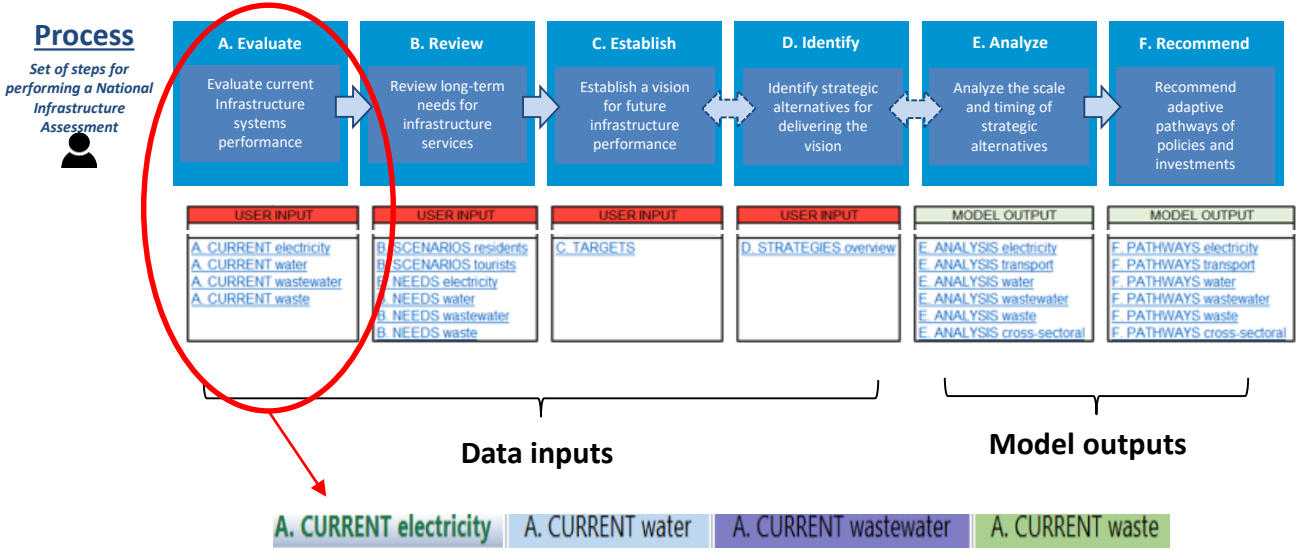
NISMOD-Int: Process

NISMOD-Int



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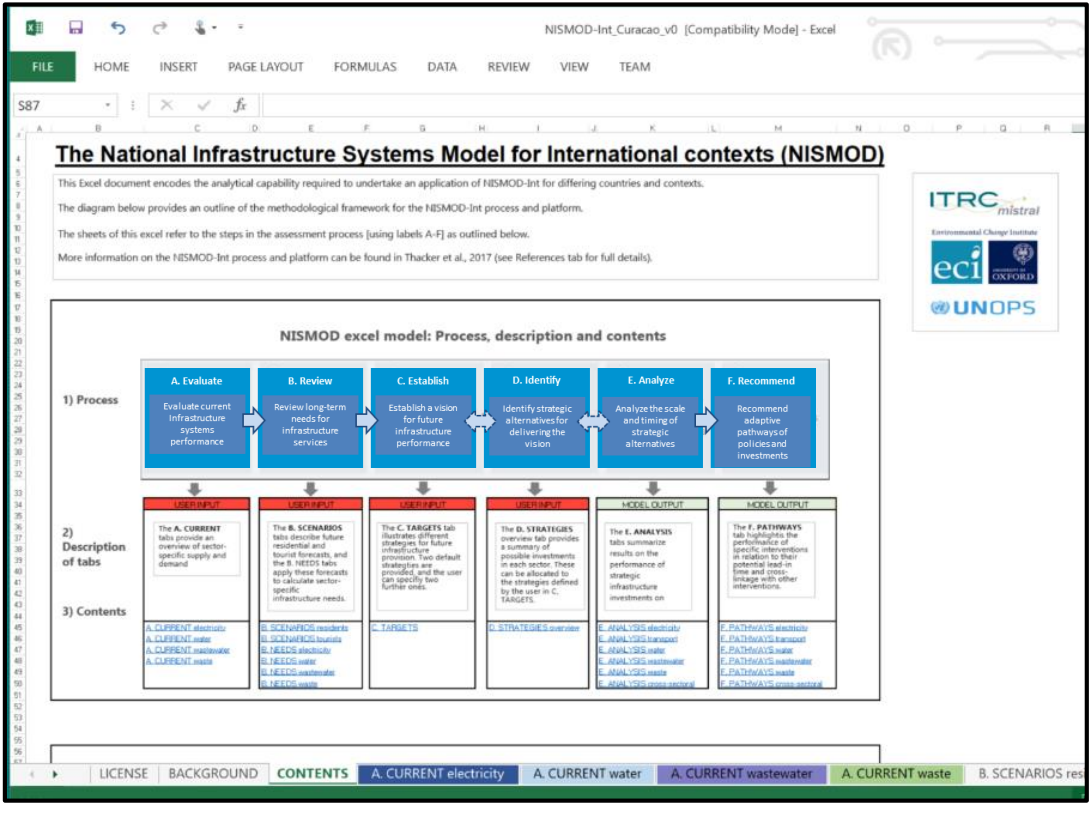
NISMOD-Int: Value-added



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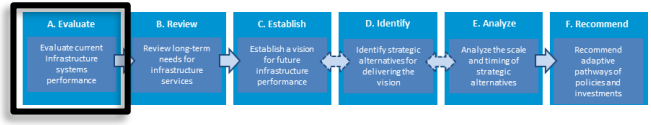
A. CURRENT tab: Assessment of current infrastructure



	ID	sector_1	type_1	type_2	type_3	other_1	Unit	Year	value	%
Supply		waste	landfill			supply	tonnes/year	2016	125,373	49%
		waste	incineration			supply	tonnes/year	2016	25,100	10%
		waste	unmanaged			supply	tonnes/year	2016	10,000	4%
		waste	recycling			supply	tonnes/year	2016	89,273	35%
		waste	repurposing			supply	tonnes/year	2016	7,250	3%
				Total		**supply**	**tonnes/year**	**2016**	**256,996**	
Annual demand		waste	demand	municipal waste		population	tonnes/year	2015	63,717	25%
		waste	demand	commercial waste		population	tonnes/year	2015	136,232	53%
		waste	demand	total cruise ship-induced waste		tourist cruise	tonnes/year	2015	6,573	3%
		waste	demand	total stay-over tourists-induced		tourist stay-o	tonnes/year	2015	50,475	20%
		waste	demand							
		waste	demand							
		waste	demand							

Users may **update inputs or sources** where more recent/ reliable data becomes available

Confidence level of source		Source example
	high	Primary source from in-country stakeholder
	med	Literature based on regional context
	low	Literature based on world average Anonymous primary source

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Data confidence

Confidence level of source		Source example
	high	Primary source from in-country stakeholder
	med	Literature based on regional context
	low	Literature based on world average

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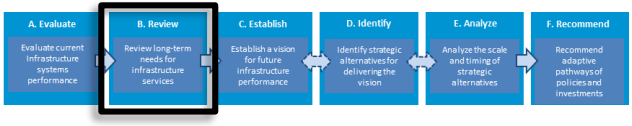
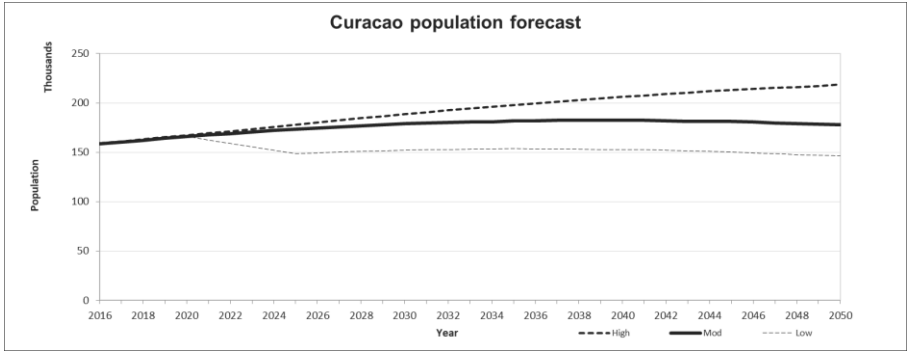
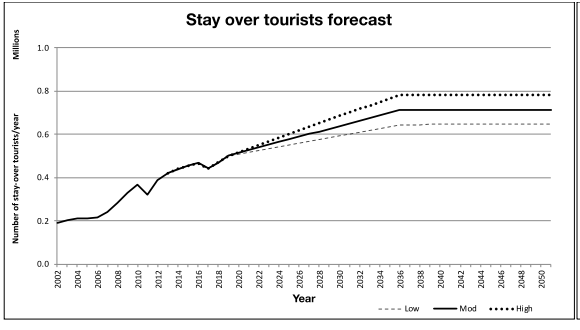
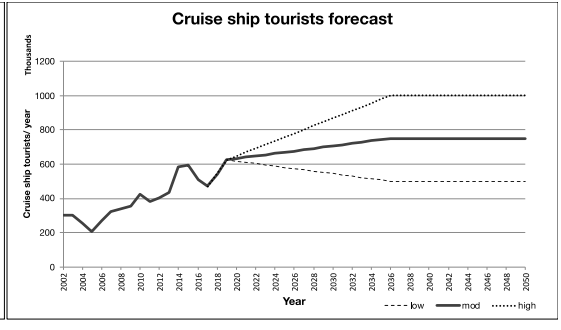
B. SCENARIOS tab: Future infrastructure needs calculations









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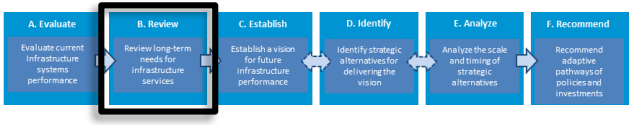
B. SCENARIOS tab: Future infrastructure needs calculations



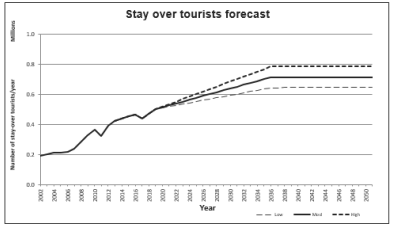
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW TEAM

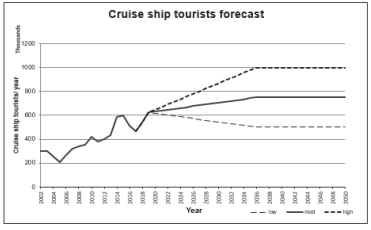
C5

Drivers of infrastructure needs: Tourism forecast

Alongside the residential population, tourists are also likely to continue placing demand on infrastructure and have historically demonstrated a disproportionately larger demand for infrastructure services compared to residents. **The main tourism-related drivers that affect infrastructure are projected increases in 1) stay-over tourists and 2) cruise ship tourists (see below).** Three scenarios have been developed for each category of tourist – high, moderate, and low – to encapsulate the range of tourism growth that could be seen on the island to the year 2050. The growth of tourists will be driven by two major transport infrastructure constructions, particularly port and airport capacity that increases visitor numbers to the island.

For further information on the methodology see the methodology and notes table (below).





Methodology

Parameters used	
Peak stay over tourist per day (Dec 2013)	12,024
Peak cruise tourists per day (Dec 2013)	2,786
Nights/ tourists/year (average)	8
Current capacity airport	1,600,000
Capacity airport expansion	2,500,000
Date airport expansion	2018
% tourists airport capacity annual	2352
Additional tourists from expansion full capacity	284,815
Total cruise tourists/ year (with mega pier 2)	1,000,000
Full capacity 2nd mega pier (in tourist/ day)	8,000
Additional cruise tourists from mega pier (assuming full capacity)	530,502

Confidence level of source	Source example
high	Primary source from in-country stakeholder
med	Literature based on regional context
low	Literature based on world average / Anonymous online source

Methodology:
The tourist numbers (total yearly tourists, tourists stay-over nights and cruise ship tourists) from the Curacao Tourism Board (2016 and 2016b) were used as baseline data (2001 -2016) for the tourist projections in this tab.

The future growth of tourists was assumed to be led by two main tourists constructions characterised further in the D.STATEGIES Overview tab under 'Transport': A) the expansion of the airport terminal (increasing stay-over tourists) and B) the construction of a new mega pier (increasing cruise ship tourists) (see parameter values used on the left of this tab).

For A) the expansion of the airport terminal, the following considerations have been made: the airport expansion to be finalised by the end of 2018 provides capacity for an additional 900,000 arrivals (Airport Tech, 2017). Each stay-over tourists is expected to stay for an average of 9 nights (see Curacao Tourism Board, 2018). Currently, 28% of the the yearly airport capacity can be attributed to tourists (see cell 'C12'). As such, the additional tourists from the terminal expansion (under full capacity) is given in cell C13. Three scenarios have been constructed, including 1) a low infrastructure-led growth rate, which assumes that 50% of the total tourist capacity of the airport terminal is used by 2035. 2) a medium infrastructure-led growth rate, assuming that 75% of the total tourist capacity of the airport terminal is used by 2035, and 3) a high infrastructure-led growth rate, assuming that the full capacity of the terminal for tourists is used by 2035. All three scenarios consists of a gradual increase of tourists to that capacity by 2035. After 2035, the growth rate is assumed to be 0%. For the peak calculations, the peak tourist month (December has been utilized).

For B) the construction of a second cruise terminal, the expected total capacity (including both cruise terminals) is expected to be 1 million cruise tourists per year (Business Curacao (2015). Each cruise ship tourists is expected to stay for an average of 1 day. Three infrastructure-led cruise-ship scenarios have been developed: 1) a low growth rate, assuming 50% of the total cruise ship capacity built in 2018 is utilized by 2035, 2) a medium growth rate, assuming that 70% of the capacity is utilized by 2035; and 3) a high growth rate, assuming that the full capacity if utilized by 2035. For the peak calculations, the peak tourist month (December has been utilized). For the calculations of tourists until 2018, the historic average growth rate of the past 5 years was applied for stay-over tourists (7%) and cruise ship tourists (14%).

Assumptions:
The trend indicating a decrease in tourists staying in traditional hotels and an increase in tourists staying at privately owned apartments is considered to have a null effect on

... A. CURRENT waste | B. SCENARIOS residents | B. SCENARIOS tourists | B. SCENARIOS (aggregated) | B. NEEDS electricit

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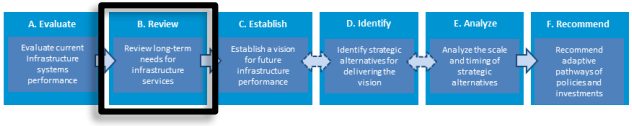
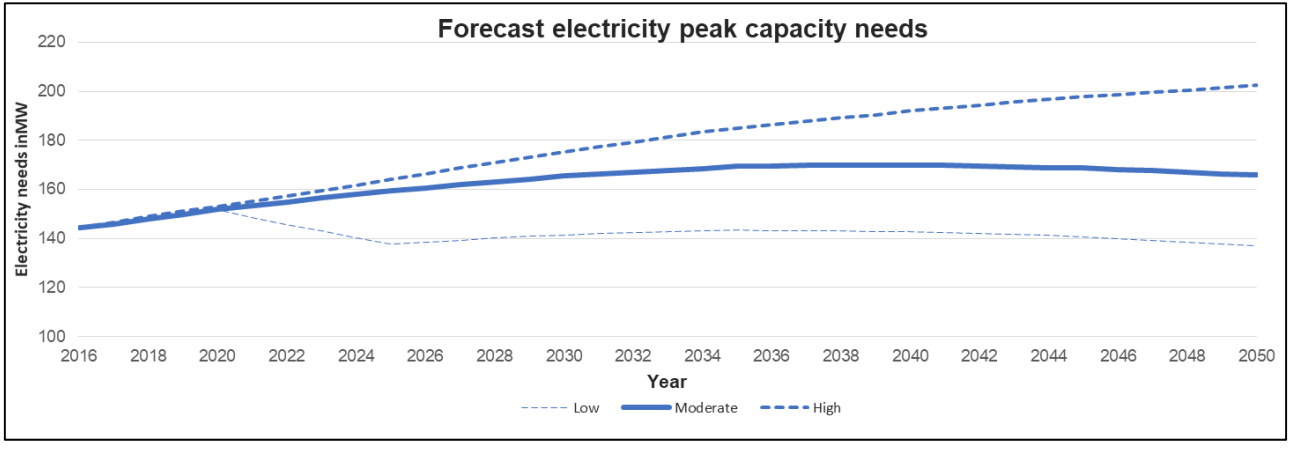
B. SCENARIOS tab: Future infrastructure needs





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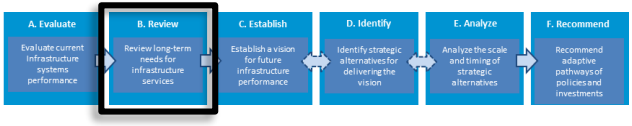
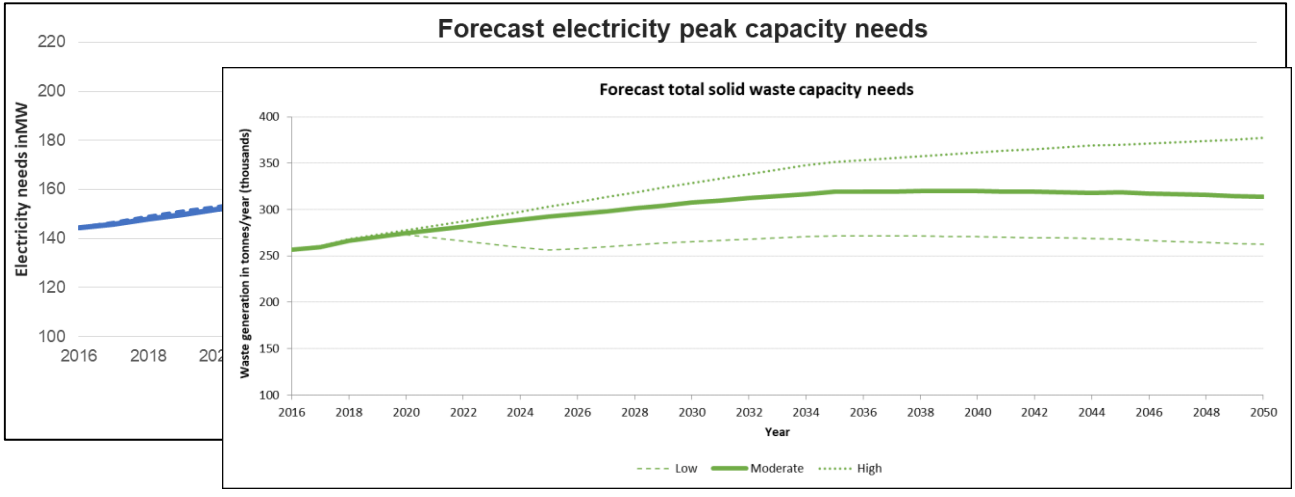
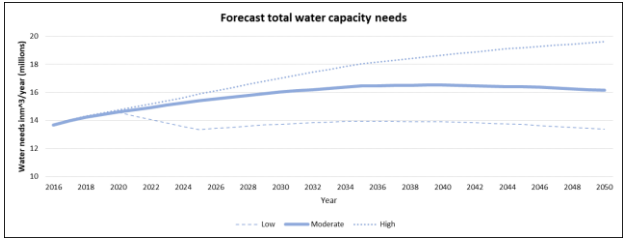
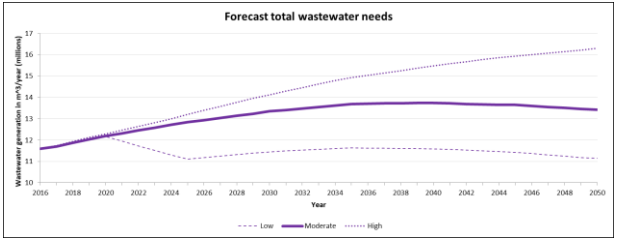
B. SCENARIOS tab: Future infrastructure needs









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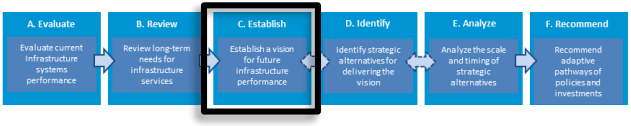
C. TARGETS tab: Setting portfolios and visions



Strategy = portfolio of investments

- Can represent a target, e.g. ‘Environmental Action’

Users can establish their own vision for their strategies by inputting a relevant name

USER INPUT REQUIRED	
strategies (default/user)	strategy name
EBI_1	inaction
EBI_2	EBI strategy
User_1	User strategy 1
User_2	Example Strategy

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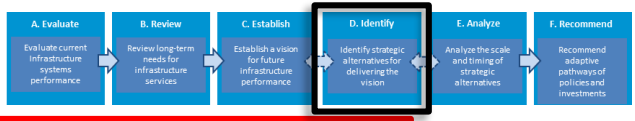
D. STRATEGIES tab: Creating new infrastructure strategies



Users can select which investments are included in a strategy. Here, 'Example Strategy' is focused on 'Environmental Action'.

					USER INPUT REQUIRED	
Sector	**Strategic alternatives**				**Strategy mapping**	
	ID	sector_1	type_1	type_2	USER STRATEGY 1	EXAMPLE STRATEGY
Energy	ene1	electricity	supply	Dual fuel diesel plant	0	1
	ene2	electricity	supply	SWAC	0	0
	ene3	electricity	supply	Solar microgeneration	0	1
	ene4	electricity	supply	Wind generation	0	0
	ene5	electricity	supply	Waste-to-energy plant	0	0
	ene6	electricity	supply	SWAC full-scale	0	0
	ene7	electricity	supply	Solar microgeneration	0	1
	ene8	electricity	supply	OTEC plant	0	0
	ene9	electricity	supply	Solar microgeneration	0	1
	ene10	electricity	efficiency	Technical grid improvements	0	0
	ene11	electricity	demand	Consumption reduction, domestic (15%)	0	1
	ene12	electricity	demand	Consumption reduction, service sector (10%)	0	1
	ene13	electricity	demand	Consumption reduction, domestic (25%)	0	1
	ene14	electricity	efficiency	Technical grid improvements	0	1

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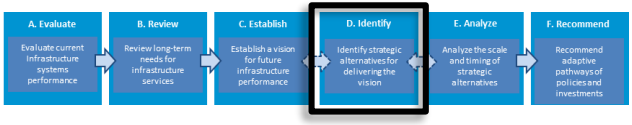
D. STRATEGIES tab: Adding new interventions



Users can add new investments, which should be allocated a 'Year' and 'Value'.

Sector	Strategic alternatives					Capacity/ demand			Cost		Carbon		
	ID	sector_1	type_1	type_2	type_2_size	Unit	Year	Value	CAPEX ($)	OPEX ($/t/year)	Id	CO_2eq	Unit
Energy	ene13	electricity	demand	Consumption reduction, domestic (25%)	large	GWh	2035	-177			28	-43,493	t CO_2eq/year
	ene14	electricity	efficiency	Technical grid improvements	large	GWh	2032	-40			28	-9,836	t CO_2eq/year
	ene15	electricity	supply	Solar expansion	large	GWh	2036	50			10	2,400	t CO_2eq/year

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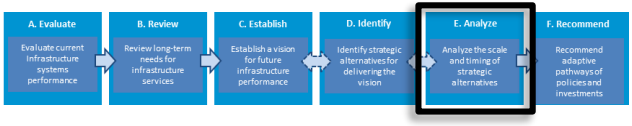
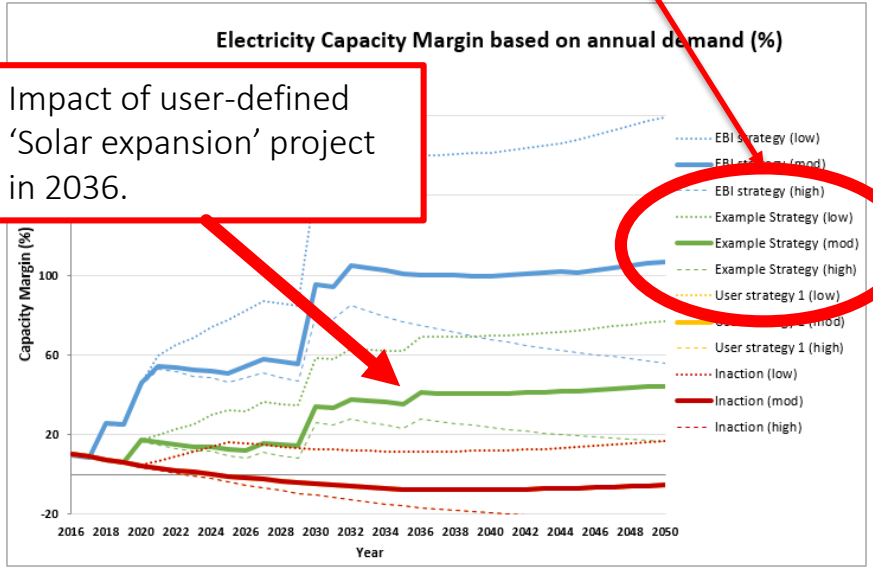
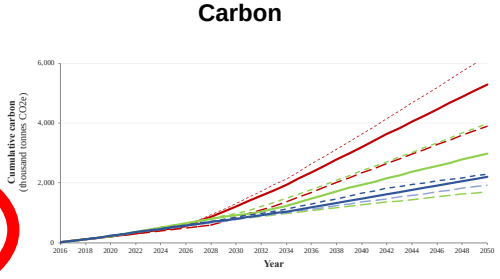
E. ANALYSIS tab: Holistic, national-scale results

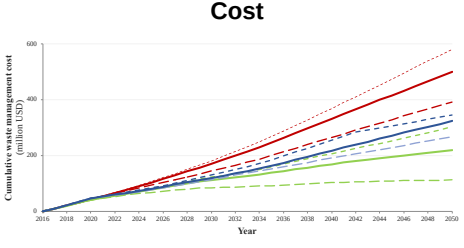
User strategies can be compared with other pre-defined strategies.



Impact of user-defined 'Solar expansion' project in 2036.







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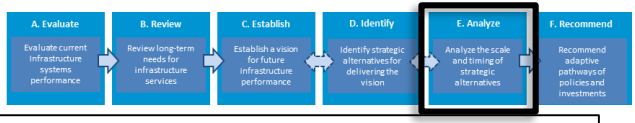
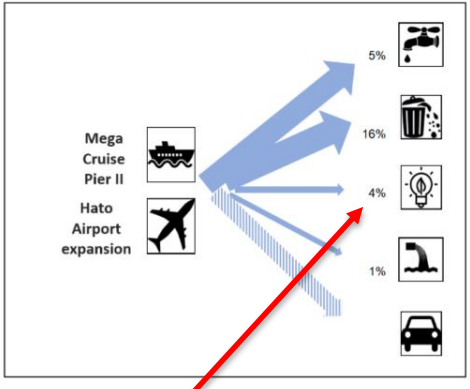
E. ANALYSIS tab: Cross-sectoral interdependencies



1) INFRASTRUCTURE SUPPLY INTERDEPENDENCY - ADDING CROSS-SECTOR DEMAND: Tourism - the impact of port and airport capacity expansion

These calculations assume that the full capacity of the two constructions are met (including 1) the second Mega Pier for cruise ship tourists and 2) the airport terminal expansion for tourists.



Methology calculations — USER UPDATE

Capacity installation tourism		Electricity demand (peak)			Water demand			Waste demand			Wastewater demand	
Additional tourists from expans	264,815	per stay over touris	0.000013	GWh/per/year	Per stay-over	0.35	m^3/day	Per stay over tourist	0.01	tonnes/day	Per stay-over tourist w	0.266
additional tourist nights	[illegible]	se tourist	0.000013	GWh/per/year	Per cruise tou	0.01	m^3/day	Per cruise-ship touris	0.01	tonnes/day	Per cruise tourist wast	0.008
additional cruise tourists	530,502											
Capacity used	100%											

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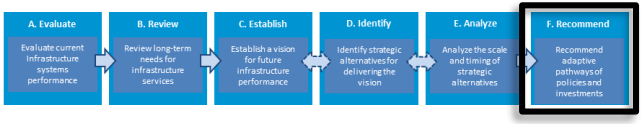
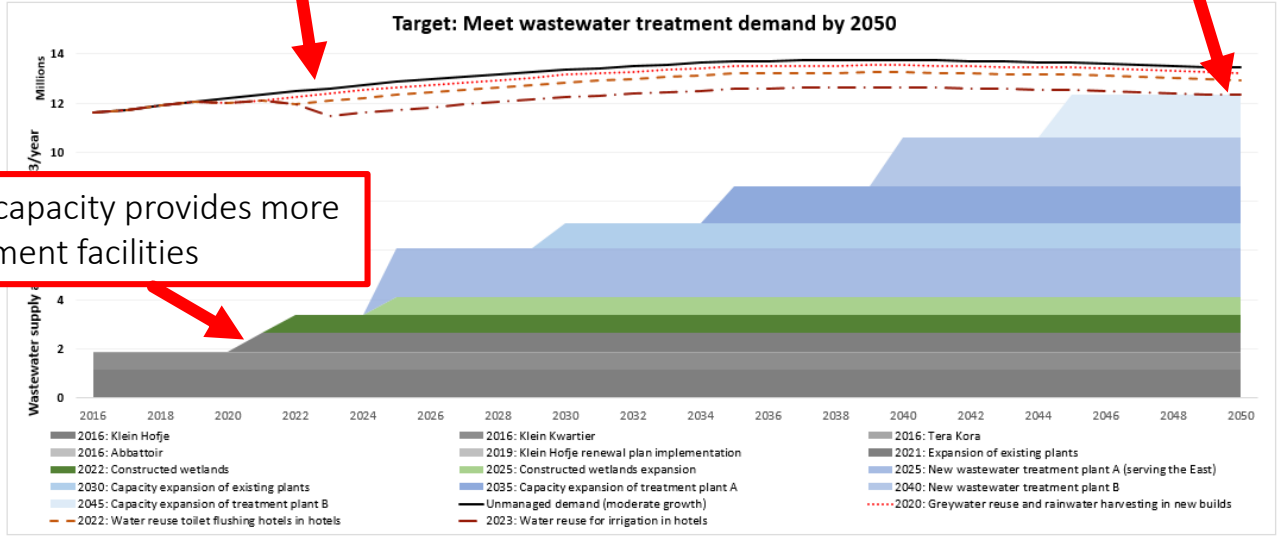
F. DECISIONS tab: Potential quick wins



Demand management measures reduce demand

Target is met in 2050

New capacity provides more treatment facilities



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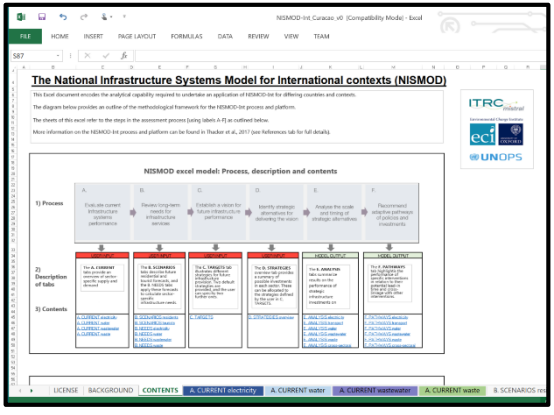
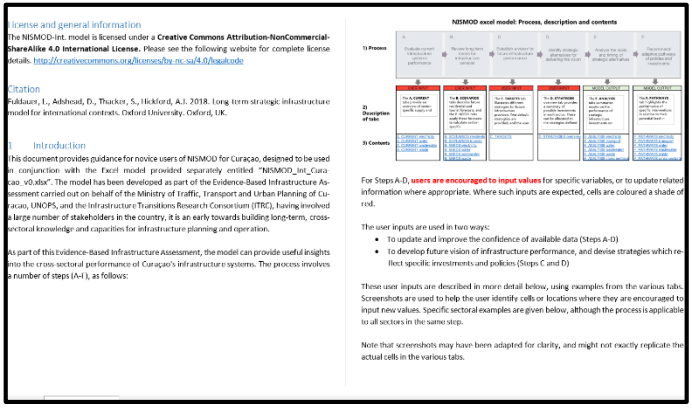
Outputs: Capacity-building

Model



User-guide



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Impacts

Impacts to date on two levels:

Specific decisions/ legislations

Policy process

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Conclusions and next steps

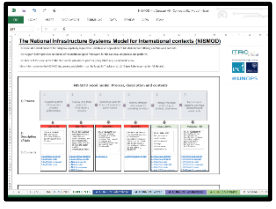
Conclusions

Advancing cross-sectoral, transparent, national-scale infrastructure planning under uncertainty

- De-politicize
- Underpinned by data
- Transparent
- Tool maintained by relevant stakeholders in-country
- Future: St. Lucia, Grenada, …

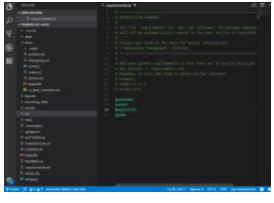
Next steps

Excel model



- Additional functionality
- Other sectors
- Social infrastructures
- Ongoing maintenance

Python model



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Thank you!

Questions?

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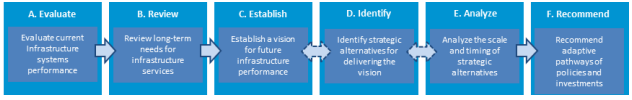
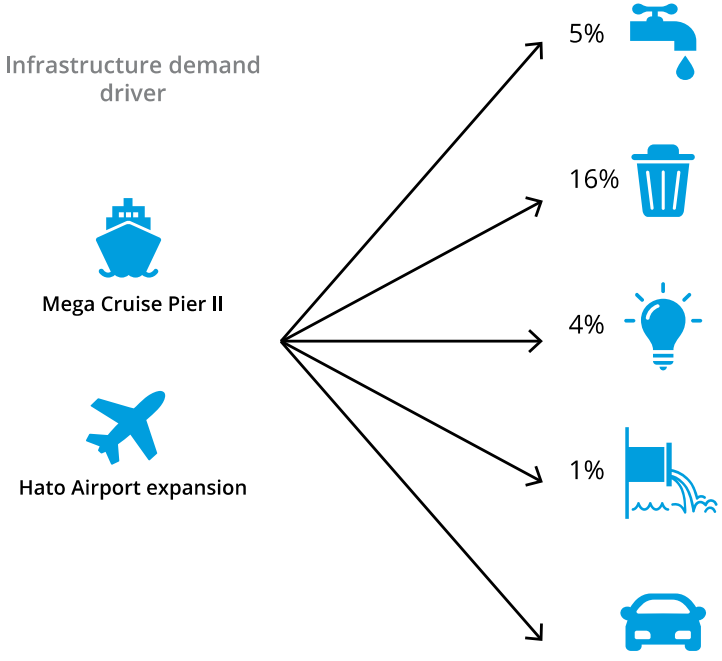
Environmental Change Institute
University of Oxford

E. ANALYSIS tab: Cross-sectoral interdependencies





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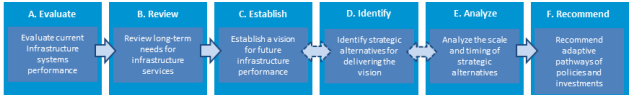
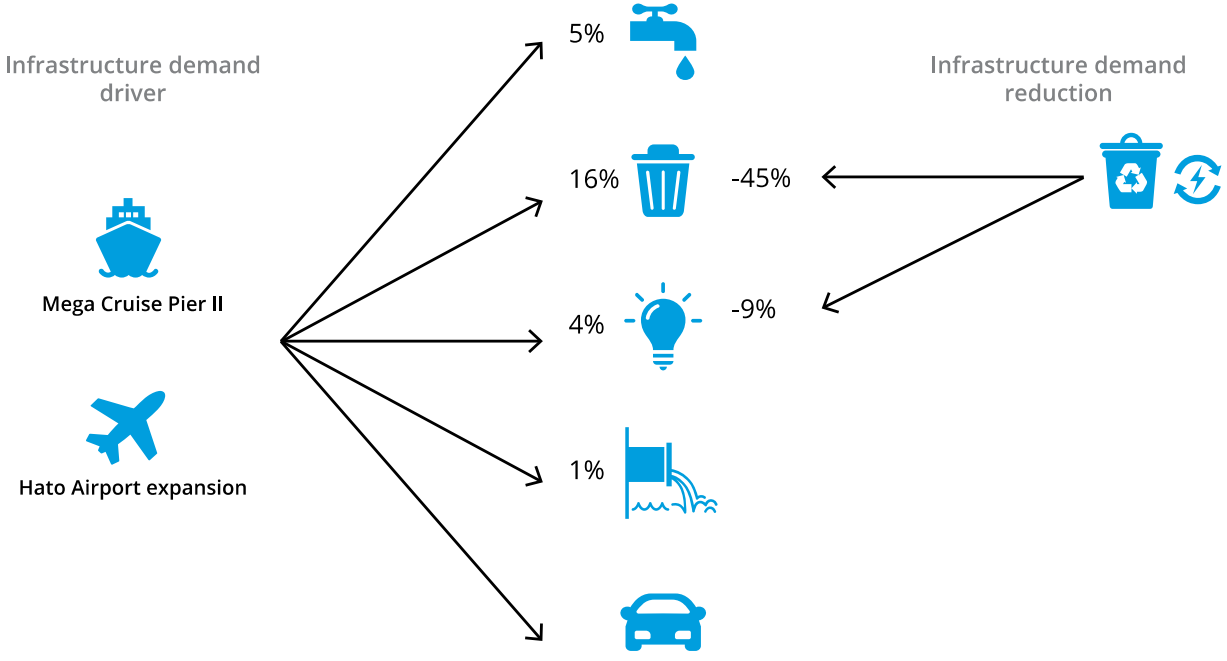
E. ANALYSIS tab: Cross-sectoral interdependencies





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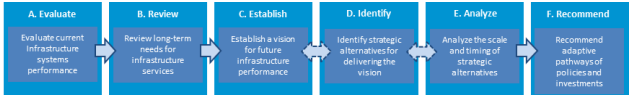
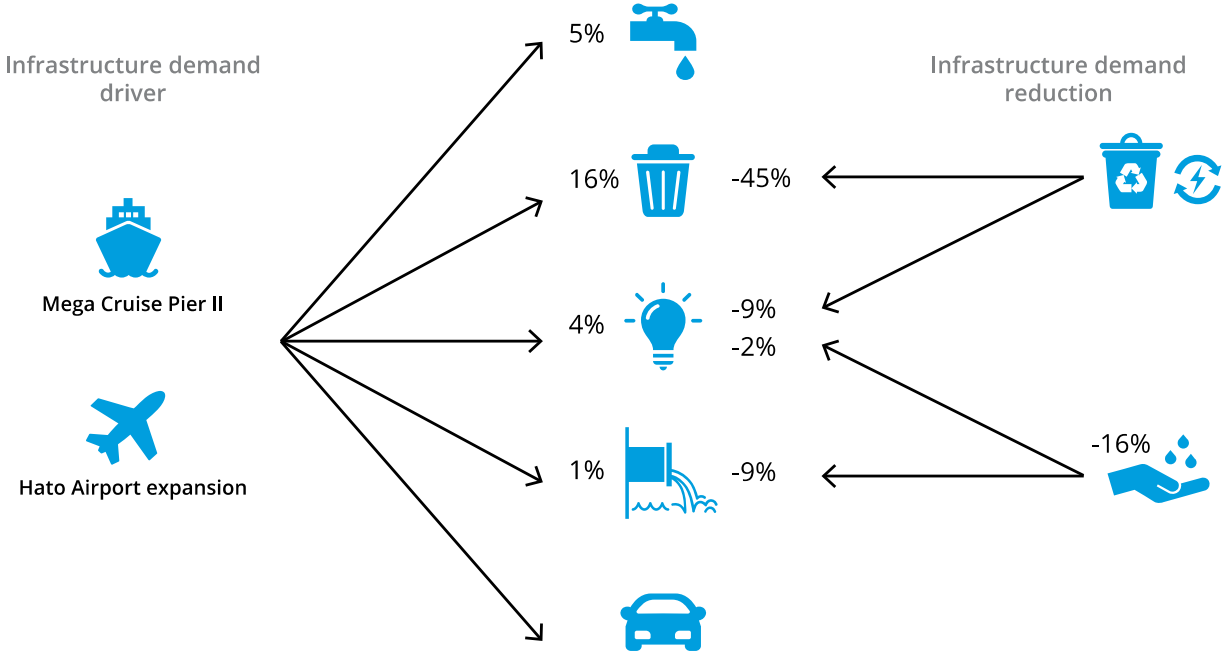
E. ANALYSIS tab: Cross-sectoral interdependencies





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