NISMOD

Hands-On 1 – Evaluating Current Infrastructure Performance

This hands-on exercise introduces the National Infrastructure Systems MODel – International (NISMOD-Int) excel tool. The exercise provides an overview of NISMOD's evidence-based infrastructure development process and expounds on the process' first step of evaluating current infrastructure performance. Examples are provided through application to the Small Island Developing State of Saint Lucia.

Learning objectives

- Navigate the NISMOD excel tool
- Evaluate infrastructure supply and demand using NISMOD
- Input and update infrastructure data and associated confidence levels.

Activity 1- Introduction to the NISMOD excel tool

NISMOD was developed by the University of Oxford-led Infrastructure Transitions Research Consortium (ITRC) in partnership with the United Nations Office for Project Services (UNOPS). It is an evidence-based infrastructure development modelling tool capable of analysing and planning national infrastructure systems. It allows decision-makers to evaluate current infrastructure performance, risks, and interdependencies, test different infrastructure development strategies, analyse their outcomes, and chart the best way forward (Adshead et al. 2018).

NISMOD can be applied to all the networked infrastructure systems: energy, transportation, water, waste, and digital communications. Thus far, the model has been successfully applied to varied developing country contexts, including Palestine, Curaçao, and Saint Lucia (Ives et al. 2019; Fuldauer et al. 2018; Adshead et al. 2021). The tool is available on Github here or on Zenodo here, which will need to be downloaded to undertake this hands-on session.

The evidence-based infrastructure development process used involves steps A-F shown in Figure 1.1 below.

- Steps A-B: Evidence-based infrastructure development involves first evaluating current infrastructure systems, then modelling future infrastructure needs via Steps A and B. Steps A and B require users to input key data such as a country's population, economy, available technology, and climate.

- Steps C-D: Steps C-D establish infrastructure performance targets and development visions and identify alternative strategies. The strategies developed are informed by policy documents, development plans, and stakeholder engagement.

- Steps E-F: Steps E-F conduct and illustrate strategy analyses based on target performance and make recommendations for implementation.

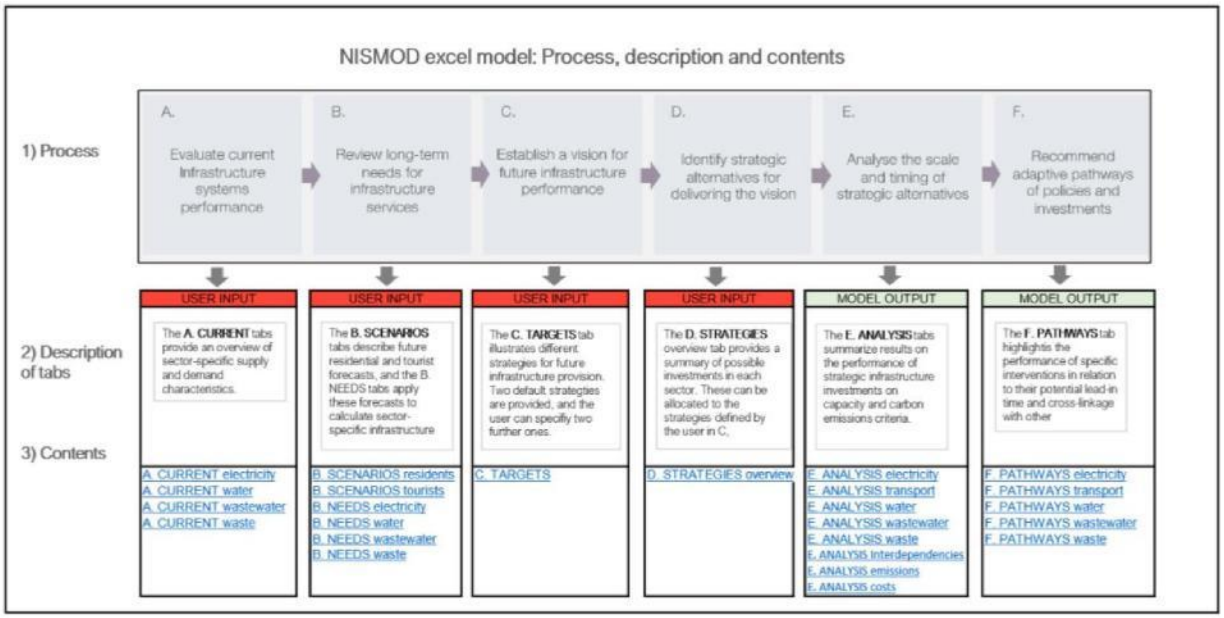

Figure 1.1: Overview of the NISMOD evidence-based infrastructure development process (Adshead et al. 2018)

The NISMOD tool is housed in excel. The layout of the tool is displayed in Figure 1.2. As seen in Figure 1.2, NISMOD consists of several sheet tabs. The first three tabs, license, background, and content, introduce the tool. The content tab contains the process, description, and contents table illustrated in Figure 1.1. The contents row lists the balance of the sheet tabs allocated to each step. These tabs contain the calculations, analysis, and graphs needed at each step. The steps' tabs are labelled with their letter. For example, Step A of the model depicted in Figures 1.1 and 1.2 involves four tabs labelled:

1. A. CURRENT electricity
2. A. CURRENT water
3. A. CURRENT wastewater
4. A. CURRENT waste

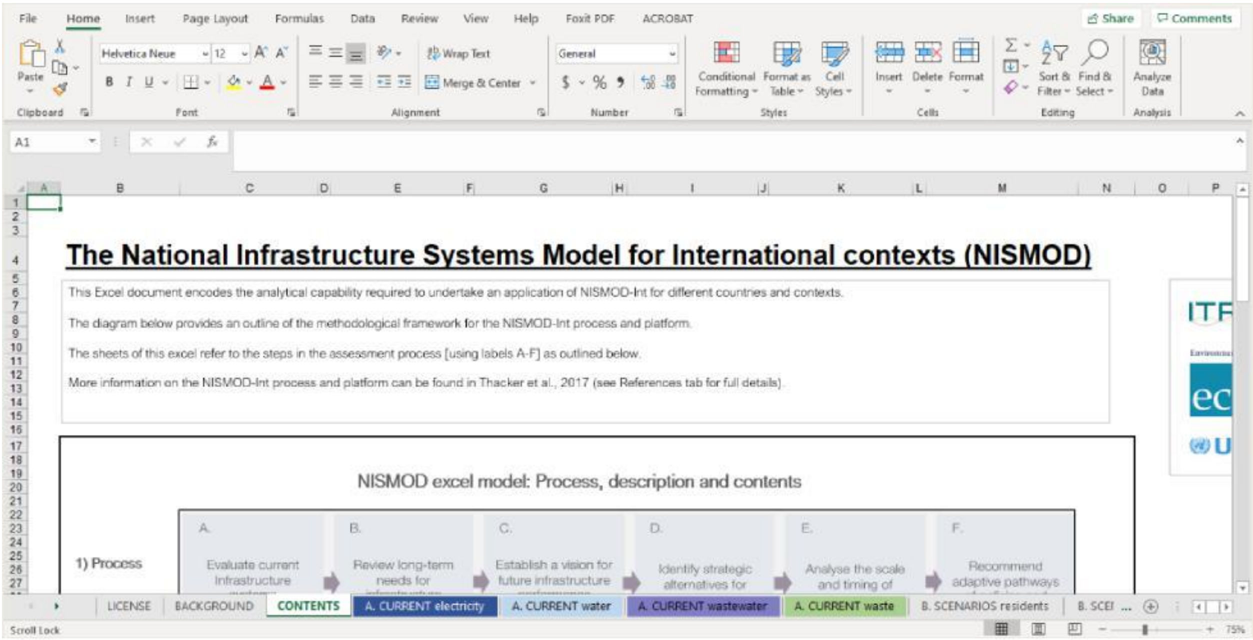

Figure 1.2: NISMOD excel tool layout (Adshead et al. 2018)

Users are to input data required in Steps A-D in order to generate the results displayed in Steps E-F. The data inputted is used to develop scenarios, project infrastructure needs, and devise strategies to reflect countries' policies and investment plans.

Try It: Navigate the NISMOD excel tool.

1. Open the NISMOD excel file provided and read the information in the License, Background and Content tabs.
2. Browse the tabs for Steps A-F to get familiar with the layout and contents of the tool.

Activity 2- Introduction to Saint Lucia application

The NISMOD tool presented in this Hands-On is for the island of Saint Lucia. The tool was used as part of the joint work done by the University of Oxford UNOPS on Saint Lucia's National Infrastructure Assessment (Adshead et al. 2020). NISMOD was used to model long-term infrastructure strategies to meet national priorities in alignment with the Sustainable Development Goals (SDGs) and the Paris Agreement (Adshead et al. 2020).

The NISMOD analysis focused on St. Lucia's energy, water, wastewater, and solid waste systems. The transportation system could not be analysed to the same extent due to significant data gaps, but was indirectly considered (to be discussed in subsequent Hands-On sessions). Therefore, the relevant steps in the tool (Steps A, B, E, and F), as shown in Figure 1.1, contain tabs for electricity, water, wastewater, and waste.

The information used to populate NISMOD was obtained from a variety of sources including national policy documents, plans, strategies, and reports as well as in-country consultations. Where data was not available from these sources, information from regional and international studies were utilised. Given the importance of communicating data confidence levels, NISMOD uses the method illustrated in Figures 1.3 and 1.4 to indicate data confidence. Cells which contain data from primary national sources are of high confidence and coloured light pink. Cells with data originated from regional literature are coloured dark pink for medium confidence and cells with data based on global averages are coloured dark red for low 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 Anonymous primary source

Figure 1.3: Confidence levels depiction method (Adshead et al. 2018)

Annual demand										
	energy	electricty	demand	Losses	demand	GWh	2018		25.3	6%
	energy	electricty	demand	Domestic	demand	GWh	2018		126.9	32%
	energy	electricty	demand	Commercial	demand	GWh	2018		124.8	31%
	energy	electricty	demand	Hotels	demand	GWh	2018		81.5	20%
	energy	electricty	demand	Industry	demand	GWh	2018		17.5	4%
	energy	electricty	demand	Street lighting	demand	GWh	2018		10.9	3%
	energy	electricty	demand	Power Station and d	demand	GWh	2018		12.3	3%
				Total	demand		2018		399.2	

Figure 1.4: Table in the A. CURRENT Electricity Tab showing data of high confidence level (Adshead et al. 2018)

Users should enter the best and most recently available information into NISMOD. Where only medium or low confidence data can be found, effort should be made to source primary data. Each tab where data is inputted contains the data confidence table, notes on the source of data, as well as a list of references. Figures 1.5 and 1.6 illustrate an example of the notes and references included. Notes are accessed by hovering over a cell.

Capacity				
Unit	Year	Lifetime	Value	%
MW	2018		88.4	[illegible]
MW	2018		3.0	
MW	2015		0.19	0%
MW	**2018**		**91.6**	

3MW Solar Farm (LUCELEC news)

Figure 1.5: Table in the A. CURRENT Electricity tab showing data source notes accessed by hovering over a cell (Adshead et al. 2018)

References

LUCELEC Operating Statistics 2008-2017

Rocky Mountain Institute (RMI) by Torbert, R., Bunker, K., Doig, S., Locke, J., Mushegan, S., Teelucksingh, S., 2016. Developing the Saint Lucia Energy Roadmap.

http://www.lucelec.com/content/3-mw-solar-farm-now-feeding-lucelec-grid

World Bank (2017). Renewable Energy Sector Development Project (P161316).

Figure 1.6: References listed in the A. CURRENT Electricity Tab at the bottom on the sheet (Adshead et al. 2018)

Try It: Go to the tabs for Steps A-F and carry out the following activities:

1. Read the introduction at the beginning of each tab and browse the summary charts and data/analysis displayed.

2. Note the data confidence, data source comments, and references on each tab.

Activity 3- Step A: Evaluating current infrastructure performance

As previously mentioned, the first step of the evidence-based infrastructure development process for NISMOD involves assessing the current performance of infrastructure systems. Step A's four tabs evaluate Saint Lucia's current electricity, water, wastewater, and waste systems by detailing the characteristics of the supply and demand components in each system. The characteristics gathered for each system vary slightly. The following sections explain the information to be gathered for each infrastructure system tab.

A. CURRENT electricity

Critical information is collected for electricity supply, annual supply, peak demand, and annual demand. As an example, Figure 1.7 depicts the supply table in the tool.

							Capacity					
	ID	sector_1	sector_2	type_1	type_2	other_1	Unit	Year	Lifetime	Value	%	
Supply		energy	electricity	generation	Diesel	supply	MW	2018		88.4	97%	
		energy	electricity	generation	Solar PV (Utility)	supply	MW	2018		3.0	3%	p. 139
		energy	electricity	generation	Solar PV (small)	supply	MW	2015		0.19	0%	
					Total	supply	MW	2018		91.6		

Figure 1.7: Supply table in the A. CURRENT Electricity tab (Adshead et al. 2018)

As seen in Figure 1.7, the following characteristics for each system component needs to be defined:

- **Sector_1:** Overarching infrastructure system.
- **Sector_2:** Sub-sector within the infrastructure system. For example, in the energy sector this may be electricity or transportation.
- **Type_1:** Broad type of component in the sub-sector, such as generation.
- **Type_2:** Specific type of component in the sub-sector. For instance, electricity generation may be via diesel generators, nuclear reactors, natural gas, or renewable energy sources such as solar, wind, hydropower, geothermal, or biomass.
- **Other_1:** Any further details on the system's components.
- **Unit:** Unit of the capacity recorded. For example, this may be MW for peak electricity or GWh for annual supply or demand.
- **Year:** Baseline year for the data. The Saint Lucia NISMOD used a baseline of 2018 (or the latest available data).
- **Lifetime:** Design life of the component if known.
- **Value:** Power or energy of electricity component based on the unit specified.

The "%" field is calculated by the tool in each tab for Step A. It illustrates the percentage of total supply or demand capacity. NISMOD also sums the total capacity value for each supply and demand group in each Step A tab.

A. CURRENT water

Information for similar fields is collected for the disaggregated supply, aggregated supply, peak demand, and annual demand of the water sector. Disaggregated supply is broken down into each supply infrastructure component including water treatment plants, raw intakes, and desalination plants. Aggregated supply groups the individual components into broader groups. As an example, Figure 1.8 illustrates the table for annual demand.

	ID	sector_1	type_1	type_2	other_1	Unit	Year	Lifetime	Capacity	Dry season (%)	Cap (m3/day)	Storage (m3)	Population	%
Annual demand		water	demand	Domestic		m^3/year	2018		4,968,304		13,612			24.3%
		water	demand	Commercial		m^3/year	2018		1,282,518		3,514			6.3%
		water	demand	Government		m^3/year	2018		1,140,667		3,125			5.6%
		water	demand	Hotel		m^3/year	2018		1,518,517		4,160			7.4%
		water	demand	Boats		m^3/year	2018		92,867		254			0.5%
		water	demand	NRW (real)	Non-revenue	m^3/year	2017		6,072,846		16,638			29.7%
		water	demand	NRW (apparent)	Non-revenue	m^3/year	2017		5,385,354		14,754			26.3%
		water	demand											
				Total	demand	m^3/year	2017		20,461,073		56,058			
				Population			2018		181,890					

Figure 1.8: Annual demand table in the A. CURRENT water tab (Adshead et al. 2018)

The definitions of the fields, shown above, are as follows:

- **Sector_1**: Overarching infrastructure system.
- **Type_1:** Type of system component. For the water sector this may be supply infrastructure or demand.
- **Type_2:** Specific type of component. For supply, types of components include water treatment plants, raw intakes, and desalination. For demand, as seen in Figure 1.8, users are to specify the origin of the demand such as domestic, commercial, or hotel.
- **Other_1:** Any other details on the system component. For example, for supply this would include the treatment type or process.
- **Unit:** Unit of the capacity recorded.
- **Year:** Baseline year for the data. The Saint Lucia NISMOD used a baseline of 2018 (or the latest available data).
- **Lifetime:** Design life of the component if known.
- **Capacity:** Volume of water per year supplied or demanded per infrastructure component based on the unit specified.
- **Dry Season %:** For water supply infrastructure, this field details the percentage of full capacity available during the dry season.
- **Cap (m3/day):** Daily capacity calculated as annual capacity divided by 365.
- **Storage (m3):** Water supply infrastructure storage volume capacity.

A. CURRENT wastewater

Data is gathered for the supply, peak demand, and annual demand of the wastewater system. The definition of the fields specific to the wastewater system are as follows:

- **Sector_1:** Overarching infrastructure system.

- **Type_1:** Type of system component. For the wastewater sector this may be supply infrastructure or demand.
- **Type_2:** Specific type of component. Supply types of components include wastewater treatment plants, sewerage networks, septic tanks, and pit latrines. Additionally, for this field, users are to specify the origin of demand.
- **Other_1:** Any other details on the system component.
- **Unit:** Unit of the capacity recorded.
- **Year:** Baseline year for the data. The Saint Lucia NISMOD used a baseline of 2018 (or the latest available data).
- **Lifetime:** Design life of the component if known.
- **Treatment Value:** Volume of wastewater treated per year.
- **Access Value:** Maximum volume of wastewater per year that can be treated or handled by the infrastructure component.
- **Population:** Number of people served by the infrastructure

component. A. CURRENT waste

Similar information is collected for the solid waste system for disaggregated supply, aggregated supply, and annual demand. The types of information inputted are detailed below.

- **Sector_1:** Overarching infrastructure system.
- **Type_1:** Type of system component. For the waste sector this includes landfills, recycling, treatment, and unmanaged waste for supply as well as demand.
- **Type_2:** Provides more details on the waste component. For supply, this would be the specific facility while for demand this field would contain the origin of the demand such as residential, commercial, agricultural, and biomedical.
- **Type_3:** Further details of the component, such as mixed or separated waste for supply or for demand.
- **Other_1:** Supply or demand component.
- **Unit:** Unit of the capacity recorded. For Saint Lucia's waste sector, the units used were either tonnes or tonnes per year.
- **Year:** Baseline year for the data. The Saint Lucia NISMOD used a baseline of 2018 (or the latest available data).
- **Lifetime:** Design life of the component if known.

- **Value:** Weight of waste supplied for treatment or disposal or demanded per infrastructure component based on the unit specified.

Try It: Become familiar with Step A tabs.

1. Read all information in tabs A. CURRENT electricity, A. CURRENT water, A. CURRENT wastewater, and A. CURRENT waste.
2. Match the overview provided above to each tab and note the percentage and summation calculations done by the tool.

Activity 4 – Insert your own data

Try It: Research and update the demand characteristics of the electricity system with 2019 data as the tool currently has 2018 data.

1. Search the St. Lucia Electricity Services Limited (LUCELEC) 2019 Annual Report provided for the Operating Statistics 2010-2019.
2. Extract the MWh (1 MWh= 1 kWh x 1000) use for Domestic, Commercial (including hotels), Industrial, Street Lighting, Power Station and Office Use, and Losses as shown in Figure 1.9 below.

Operating Statistics
2010-2019

	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Generating Plant (kW)										
Available Capacity	88,400	88,400	88,400	88,400	88,400	88,400	88,400	88,400	76,000	76,000
Firm Capacity	68,000	68,000	68,000	68,000	68,000	68,000	68,000	68,000	55,600	55,600
Peak Demand	62,550	60,600	61,700	60,300	59,000	58,900	59,700	59,800	60,300	59,200
Percentage growth in peak demand	3.2%	-1.8%	2.3%	2.2%	0.2%	-1.3%	-0.2%	-0.8%	1.9%	5.9%
Sales (kWh x 1000)										
Domestic	130,156	126,916	127,732	123,839	116,133	111,922	112,743	112,272	113,505	113,757
Commercial (including Hotels)	210,114	206,320	202,770	194,966	192,442	191,294	193,199	192,847	190,846	188,640
Industrial	18,326	17,494	18,256	18,519	17,999	17,673	17,624	17,679	18,761	18,373
Street Lighting	10,342	10,893	10,896	10,905	10,966	11,050	10,913	10,526	10,263	9,959
Total Sales	368,938	361,623	359,654	348,229	337,540	331,939	334,479	333,324	333,375	330,729
Power Station and Office Use (kWh x 1000)	12,325	12,288	13,196	13,770	13,715	13,918	14,706	14,511	14,599	14,127
Losses (kWh x 1000)	26,658	25,317	27,450	29,432	30,013	33,574	33,791	36,948	37,234	36,033
Units Generated/Purchased (kWh x 1000)	407,921	399,228	400,300	391,431	381,268	379,431	382,976	384,783	385,208	380,889

Figure 1.9: Extract from the LUCELEC Operating Statistics 2010-2019 (St. Lucia Electricity Services Limited 2020)

3. Calculate the demand of hotels and the commercial electricity demand excluding hotels. Based on Torbert et al. (2016), 20% of total electricity demand from commercial activities in St. Lucia originate from hotels. Therefore, hotel demand is equal to20% of the total commercial demand reported. Commercial demand (excluding hotels) would therefore be equal to 80% of total commercial demand.

4. Convert all values obtained to GWh. 1 GWh = 1000 MWh

5. Update the annual demand table in NISMOD tab A. CURRENT electricity, as shown in Table 1.1 below. The cells coloured yellow are the values to be changed. The cells coloured grey are calculated by the NISMOD tool.

6. Ensure that the capacity value cells are coloured light pink in the tool as the information inputted is from a national document.

					Capacity				
Sector_1	**Sector_2**	**Type_1**	**Type_2**	**Other_1**	**Unit**	**Year**	**Lifetime**	**Value**	**%**
energy	electricity	demand	Losses	-	GWh	2019	-	26.7	7%
energy	electricity	demand	Domestic	-	GWh	2019	-	130.2	32%
energy	electricity	demand	Commercial	-	GWh	2019	-	168.1	41%
energy	electricity	demand	Hotels	-	GWh	2019	-	42.0	10%
energy	electricity	demand	Industry	-	GWh	2019	-	18.3	4%
energy	electricity	demand	Street Lighting	-	GWh	2019	-	10.3	3%
energy	electricity	demand	Power station and Office Use	-	GWh	2019	-	12.3	3%
			Total	**demand**	**GWh**	**2019**	-	407.9	-

Table 1.1: Table showing results of updated annual demand table for A. CURRENT electricity (Adshead et al. 2018)

Summary

This hands-on introduced the NISMOD tool, specifically applied to the Saint Lucia case study. The various activities walked you through the first step of the evidence-based infrastructure development process: Step A. Evaluate Current Infrastructure System Performance. Through the activities you should be familiar with the layout of Steps A-F of the NISMOD tool, understand the data needed for Step A, and be able to input or update Step A infrastructure data.

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