XLM-LIQUID WASTE TOOLKIT

User Manual

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Ministry of Social Security, National Solidarity, and Environment and Sustainable Development
(Environment and Sustainable Development Division)
Republic of Mauritius

XL-Mitigation Liquid WasteToolkit

About this manual

This manual, *XL-Mitigation Liquid Waste User Reference*, forms part of a family of toolkits to compute and plot a number of other variables including GHG emissions for Liquid Waste sector. The user reference has been written from an application developer's perspective. A fundamental conceptual and operational knowledge of Excel is assumed.

Disclaimer

Data used has been obtained from reliable sources. The Ministry of Social Security, National Solidarity, and Environment and Sustainable Development (Environment and Sustainable Development Division) assumes no responsibility for errors and omissions in the data provided. Users are, however, kindly asked to report any errors or deficiencies in this product to the Ministry. The choices of calculation made in this tool are derived from TNC Report (2016).

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XLM-Liquid Waste Toolkit

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XLM-Liquid Waste Toolkit

1. Introduction

This document refers to a user-friendly toolkit developed to mitigate the GHG emissions from the Liquid Waste sector of the Republic of Mauritius.

The mitigation for Liquid Waste sector was assessed in the Third National Communications (TNC) Report (2016) for a Business-as-Usual (BAU) and one other scenario, after a screening exercise to select the most feasible options. Thus, the other scenario, after the BAU, considered that there will be additional sewerage.

The XLM-Liquid Waste Toolkit performs basic calculations taking the population with different sanitation facilities. The trend in the different sanitation facilities until 2050 was worked out following assumptions taken from the TNC. Users of the XLM-Liquid Waste Toolkit can adjust the scenarios by choosing appropriate parameters/assumptions to suit their needs for the mitigation analysis.

2. Overview of the Liquid Waste sector

The amount of liquid wastes generated in Mauritius is increasing and in 2015 the treated wastewater reached 49.37 million m3 (Statistics Mauritius 2016) with an annual growth of ~5.6%. In 2014, the Government investment was around MUR 15 billion in the wastewater sector for the construction of wastewater treatment plants, pumping stations, trunk and street sewers and reticulation networks. For the coming years, investment in respect of wastewater infrastructure is expected to be around MUR 5.4 billion (WMA 2017).

Regions	Household connectivity
Plaines Wilhems Lot 1A Project (covering regions of Stanley, Palma, Hugnin, Bassin, Trèfles, Seeneevassen and Victoria)	Expected to cover around 6800 households to be connected to the public sewer.
Plaines Wilhems Sewerage Project Lot 1B (covering regions of West Rose Hill, Mont Roches, Roches Brunes, Plaisance); Plaines Wilhems Sewerage Project Lot 2 (covering regions of Central Quatre Bornes, Sodnac and Belle Rose).	Around 13,500 households have been connected to the public sewer.
Pailles Guibies Phase I with a pumping station and about 4 km of trunk sewers.	Objective of connecting 3,000 households.
The Grand Baie Sewerage Project Phase 1B, comprises of the construction of 80 km of street sewer, 12 km rising mains, 22 nos. pumping stations, refurbishment of the existing facilities at the Grand Baie wastewater treatment plant, and replacement of 6 km of CWA pipes	About 4,000 House Connections
CHA (6 sites) and low cost housing Estates	Plans to rehabilitate/provide wastewater disposal facilities for the period 2015 to 2020

Key facts about the wastewater system: (source: WMA)

Average daily volume of wastewater collected and treated including industrial wastewater	117,426.89 m^3
Number of Wastewater Treatment Plants	10
No of Wastewater Pumping Stations	72
Length of sewer main jetted as a part of preventive maintenance	99.5 km
No of sewer blockages cleared	11,200
No of Wastewater Carrier Operators	70
No of trips of wastewater disposal by WMA carriers	4,495
Number of trips of Wastewater disposal by private carriers	33,373
Total volume of seepage carted away by WMA & Private Cesspool Carriers	743,783 m^3

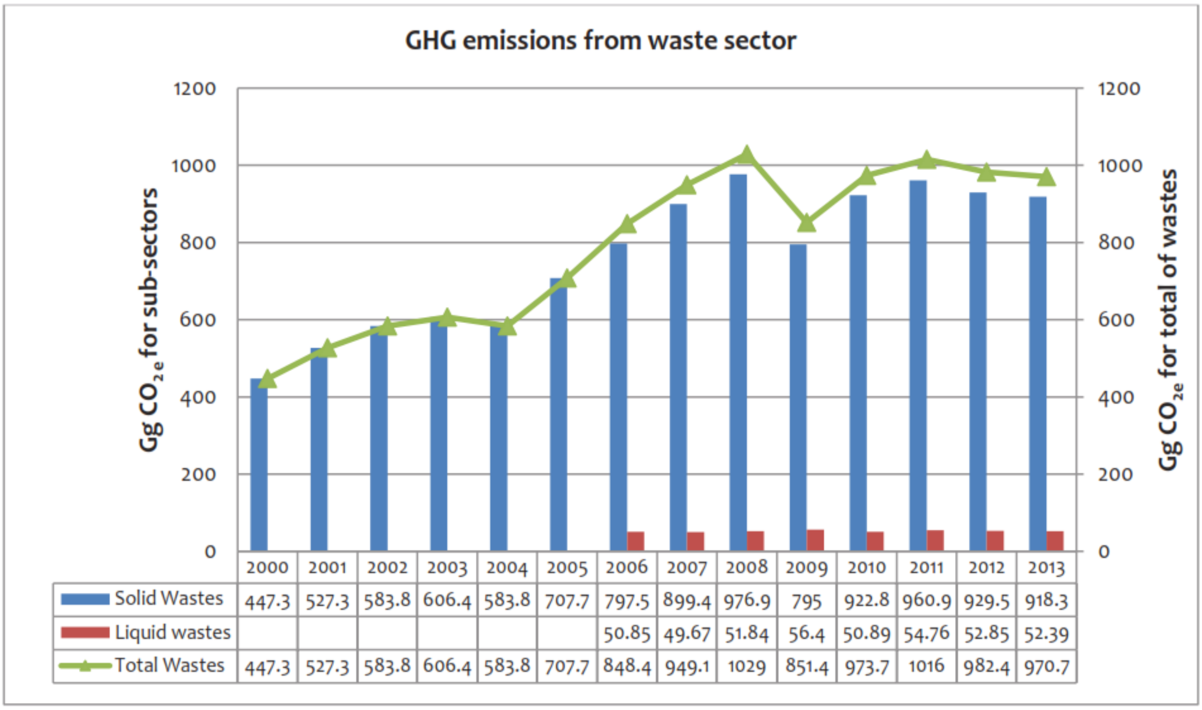
Key Facts about wastewater disposals: (source: SM, 2011 Census)

Sanitation facility	**% population having access**
Sewerage (Plaines Wilhems, Port Louis and Pte aux Sables, CHA estates and Grand Baie)	28
Absorption or Cess pit	63
Septic tank	6
Pit latrine	3

3. GHG Emissions from the Liquid Waste sector

The Liquid Waste sector is an important sector having GHG emissions in terms of CH_4 and N_2O. The amount of liquid wastes generated in Mauritius is increasing. In 2015 the treated wastewater reached 49.37 million m^3 (Statistics Mauritius 2016).

Figure 3.1 shows the trend of emissions for the overall waste sector. Emissions from liquid wastes are lower than those for solid wastes.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Solid Wastes	447.3	527.3	583.8	606.4	583.8	707.7	797.5	899.4	976.9	795	922.8	960.9	929.5	918.3
Liquid wastes							50.85	49.67	51.84	56.4	50.89	54.76	52.85	52.39
Total Wastes	447.3	527.3	583.8	606.4	583.8	707.7	848.4	949.1	1029	851.4	973.7	1016	982.4	970.7

Figure 3.1: Trend of emissions for Waste Sector (Source: TNC, 2016)

4. Liquid Waste Mitigation Actions proposed under 2016 TNC

4.1. Mitigation Scenarios and Assumptions

Relative to the BAU scenario, the other scenario was developed in TNC (2016). Scenario 1 (SC1) involves enhancing of the sewer network.

The assumptions adopted by TNC for mitigation actions for the Liquid Waste sector are summarized in Table 4.1. These assumptions in this table are taken into the calculations. This means that worksheets for assumptions already contain the percentages for the different options (that can be updated by the User).

Table 4.1: Mitigation actions proposed by TNC (2016) and assumptions used

Scenario		Assumptions
BAU	Business-As-Usual	BAU scenario assumes that connection to the sewer system up to 2017 proceeds at the same rate as in 2013, thereafter decreasing by a factor of 4.
SC1	Enhancing the capture of LFG for either flaring or electricity generation	Implementation of the Wastewater Master Plan II to increase household connectivity to the sewer system up to 80% by 2033. An additional 5% of households are assumed to be connected to the sewer system between 2035 and 2050. In this scenario, the utilization of centralized aerobic wastewater treatment system increases from 0.25 in 2015 to 0.75 in 2030, and to 0.85 in 2050 with corresponding decreases in the use of septic systems. The protein intake has been kept constant at 27.32 kg/cap/yr (which is the highest value reached in 2013).

The parameters used for the different scenarios appear in section 5.2.

4.2. TNC Targets under different scenarios

For this sector, the change in GHG emissions relative to BAU scenario is summarized in both Table 4.1 and Figure 4.1.

Table 4: TNC (2016) GHG Emissions for the Liquid Waste sector (Gg CO2e)

Scenario		**TNC TARGETS** *Expected GHG emissions*	**TNC Remarks**
BAU	Business-As-Usual	~166 Gg CO2e in 2020; ~172 Gg CO2e in 2050;	GHG emissions comprising both emissions of CH_4 and indirect N_2O (from protein intake) increase gradually over time.
SC1	Enhanced sewer connectivity	Relative to BAU, GHG Emissions reductions of: 53.95 GgCO2e in 2020; 108.53 GgCO2e in 2030; 121.78 GgCO2e in 2040; 130.56 GgCO2e in 2050;	The SC1 reduces the GHG emissions, though the utilization of centralized aerobic wastewater treatment system increases as well as the protein intake to some extent.

The overall projected emissions from BAU and SC1 are shown in Figure 4.1. It can be seen that enhanced sewer connectivity reduces considerably the GHG emissions.

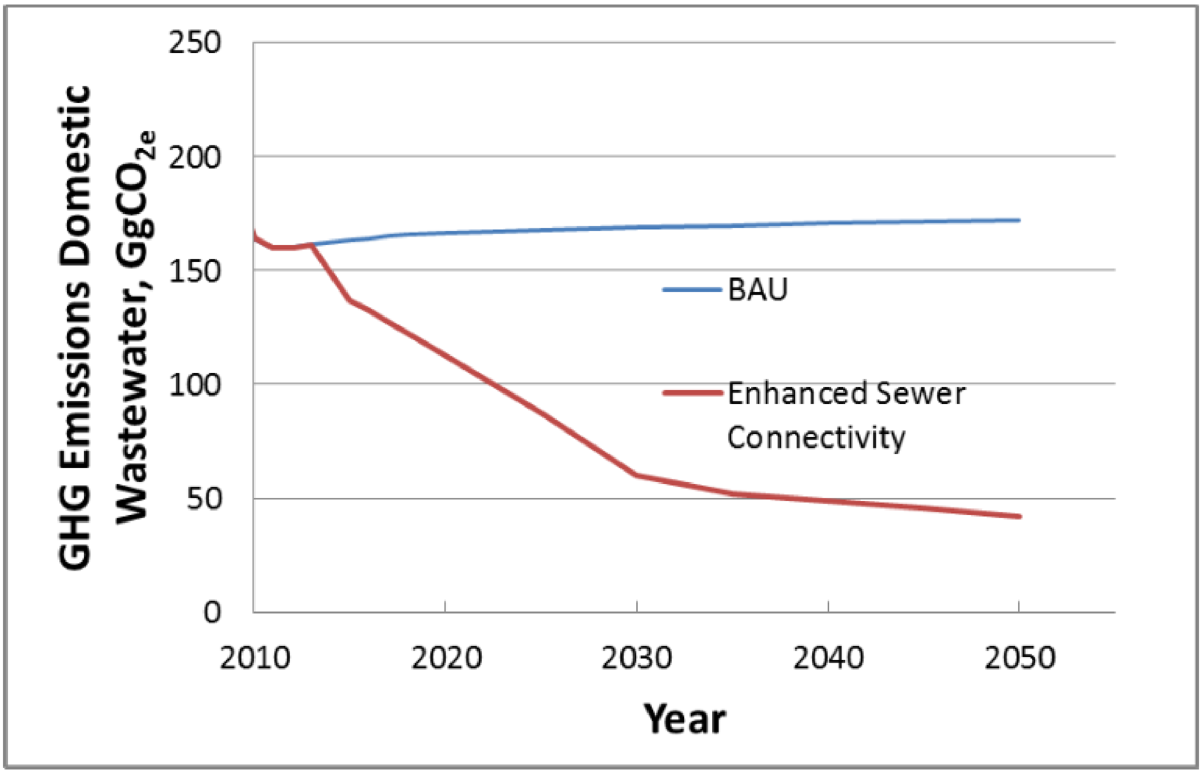


Figure 41: GHG Emissions scenarios in Liquid Waste sector (2010-2050) (source: TNC, 2016)

5. XLM–Liquid Waste Toolkit

The structure, methodology, components/modules and other details of XLM Toolkits has been described in the main User Manual.

5.1. Liquid Waste Data

The '*Data'* worksheet essentially contains the population, and sewerage or other sanitation facilities for each year. The actual data pertains to year 2006 to 2013 and beyond that, the projections have been made for the 2016 TNC study, but does not appear in the data sheet. These data are used in combination with the parameters in the '*Parameters'* worksheet (Global warming potentials, methane correction fractions, CH_4 emission factors, etc.) and the assumptions in the '*Assumptions'* worksheet, to make the calculations of the GHG emissions. The projected data are also used in the calculations for future emissions. The data sources for this sector are typically from the Waste Water Management Authority (WMA) and Statistics Mauritius for sanitation facilities available.

5.2. Liquid Waste Parameters

Table 5.1 presents the major parameters used for the liquid waste sector used in the XLM-Liquid Waste Toolkit; all parameters used appear in the '*Parameters'* worksheet.

Table 5.1: List of Parameters for the Liquid Waste sector

PARAMETERS FOR SCENARIO 1															
		A. PARAMETERS USED TO CALCULATE ORGANICALLY DEGRADABLE MATERIAL IN WASTEWATER (TOW)													
		Sewered Plaines		Absorption pit		Septic tank		Pit latrine		Sewered PL and Pte		5 CHA estates		Grand Baie	
		TNC	User Defined	TNC	User Defined	TNC	User Defined	TNC	User Defined	TNC	User Defined	TNC	User Defined	TNC	User Defined
	sewer	1.25	1.25	1	1	1	1	1	1	1.25	1.25	1.25	1.25	1	1
2006		8.2	8.2	13.505	13.505	13.505	13.505	13.505	13.51	14	14	13.7	13.7	8.1	8.1
2007		9.5	9.5	13.505	13.505	13.505	13.505	13.505	13.51	15.3	15.3	6.9	6.9	11.5	11.5
2008		13.3	13.3	13.505	13.505	13.505	13.505	13.505	13.51	22.55	22.55	4.85	4.85	12.7	12.7
2009		15.3	15.3	13.505	13.505	13.505	13.505	13.505	13.51	36.2	36.2	21.505	21.505	19.5	19.5
2010		15.7	15.7	13.505	13.505	13.505	13.505	13.505	13.51	16.5	16.5	16.5	16.5	17	17
2011		15.5	15.5	13.505	13.505	13.505	13.505	13.505	13.51	15.1	15.1	16.2	16.2	15.1	15.1
2012		15.9	15.9	13.505	13.505	13.505	13.505	13.505	13.51	13.9	13.9	21.505	21.505	13	13
2013		14.9	14.9	13.505	13.505	13.505	13.505	13.505	13.51	14.7	14.7	19.7	19.7	14.1	14.1
2015		14.9	14.9	13.505	13.505	13.505	13.505	13.505	13.51	14.7	14.7	19.7	19.7	14.1	14.1
2016	BOD, kgBOD/Cap/yr	14.9	14.9	13.505	13.505	13.505	13.505	13.505	13.51	14.7	14.7	19.7	19.7	14.1	14.1
2017		14.9	14.9	13.505	13.505	13.505	13.505	13.505	13.51	14.7	14.7	19.7	19.7	14.1	14.1
2018		14.9	14.9	13.505	13.505	13.505	13.505	13.505	13.51	14.7	14.7	19.7	19.7	14.1	14.1
2020		14.9	14.9	13.505	13.505	13.505	13.505	13.505	13.51	14.7	14.7	19.7	19.7	14.1	14.1
2025		14.9	14.9	13.505	13.505	13.505	13.505	13.505	13.51	14.7	14.7	19.7	19.7	14.1	14.1
2030		14.9	14.9	13.505	13.505	13.505	13.505	13.505	13.51	14.7	14.7	19.7	19.7	14.1	14.1
2035		14.9	14.9	13.505	13.505	13.505	13.505	13.505	13.51	14.7	14.7	19.7	19.7	14.1	14.1
2040		14.9	14.9	13.505	13.505	13.505	13.505	13.505	13.51	14.7	14.7	19.7	19.7	14.1	14.1
2045		14.9	14.9	13.505	13.505	13.505	13.505	13.505	13.51	14.7	14.7	19.7	19.7	14.1	14.1
2050		14.9	14.9	13.505	13.505	13.505	13.505	13.505	13.51	14.7	14.7	19.7	19.7	14.1	14.1

B. PARAMETERS USED TO CALCULATE EMISSION FACTORS	Maximum methane		Methan correction factor		Emission Factor, EF,	
	TNC	User Defined	TNC	User Defined	TNC	User Defined
Anaerobic digester for sludge	0.6	0.6	0.8	0.8	0.48	0.48
Septic system	0.6	0.6	0.5	0.5	0.3	0.3
Latrine	0.6	0.6	0.1	0.1	0.06	0.06
Centralised aerobic system	0.6	0.6	0	0	0	0

	GWP
CH4	25
N2O	298

Fnpr, kgN/kgprot	Fnon-con protein	Frac, industrial + commercial	Nremoved sludge, kg	EF, kgN2O-N/kgN	Emission Wwplant, KgN2O/yr	N2 to N2O conversion
0.16	1.4	1.25	0	0.005	0	1.571429

Protein intake per capita, kg/cap/yr	
average	26.481
median	26.685
highest	27.32
used	27.32

It is to be noted that most parameters are from the IPCC Guidelines (2006) for GHG inventories, but local factors can be used whenever available.

5.3. Liquid Waste Assumptions

The assumptions (in the '*Assumptions*' worksheet) used in the XLM-Liquid Waste Toolkit are essentially the changes over the years which fluctuates depending on national circumstances such as households and industrial activities, etc.; these assumptions are derived from TNC (2016). The main assumption considers the percentage population connected to the different sanitation systems which have been altered to make projections, based on the TNC. Thus, for instance, sewer connectivity can be seen to increase each year by a certain percentage, while pit latrines may decrease.

5.4. Graphic Analysis and Reporting

Graphic analysis in the '*Query*' worksheet provides the following choices for the type of plots:

Sector	Type of Plot	Plot numbers
Liquid Waste	ALL	1-25;
	Population and Connectivity	1-8; 14-20;
	GHG Emissions	9-13; 21-25;
	Total GHG Emissions (TNC)	13, 25;

The complete set of figures that the XLM-Liquid Waste Toolkit provides is listed in Table 5.3. In this table, the rightmost column denotes the general topic or item for which the plots can be generated for graphical analysis.

Table 5.3: List of graphics for the Liquid Waste sector

		Plot Numbers	
		BAU	SC1
Connectivity	Population	1	
	Sewered Plaines Wilhems Population	2	14
	Population with Absorption pit	3	15
	Population with Septic tanks	4	16
	Population with pit latrines	5	17
	Sewered PL and Pte aux Sables	6	18
	5 CHA Estates	7	19
	Grand Baie sewerage connections	8	20
GHG Emissions	CH4 Emissions Gg	9	21
	CH4 Emissions Gg CO2 e	10	22
	N2O Emissions Gg	11	23
	N2O Emissions Gg CO2 e	12	24
	Total GHG CO2 e	13	25

6. References

- Statistics Mauritius (2016): Statistics Mauritius, Digest of Environment Statistics 2015, Vol. 14, Ministry of Finance and Economic Development, November 2016
- Statistics Mauritius, Digest of Energy and Water, 2015
- **TNC (2016).** Third National Communication: Report to the United Nations Framework Convention on Climate Change. Republic of Mauritius, Port Louis
- **IPCC (2006).** Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

7. Appendices

A: List of Acronyms and Abbreviations

Toolkit		Others	
BAU	Business as Usual	IPCC	International Panel of Climate Change
GUI	Graphics User Interface	GHG	Greenhouse Gas
UD1	User-defined Scenario – Case 1	TNC	Third National Communications
UD2	User-defined Scenario – Case 2	WMA	Wastewater Management Authority
SC*i*	Scenario *i*	GWP	Global Warming Potential
XLMT	Excel Mitigation Toolkit		

B: Useful Links

IPCC

TNC

WMA

CENSUS (page 172 for sanitation) and general census

Digest environment and others

C: Governing Equations

Calculation of CH4 remissions

Terms	Description	Units	Data Sources	Remarks
(1) TOTAL ORGANICALLY DEGRADABLE MATERIAL IN DOMESTIC WASTEWATER (TOW) TOW = P x BOD x 0.001 x I x 365				
P	Country population in inventory year	Number (person)	Statistics Mauritius - Census	Some interpolations may be needed.
BOD	Country-specific per capita BOD in inventory year	g/person/day	WMA	Needs to be converted to Kg for one year.
0.001	Conversion from grams BOD to kg BOD		IPCC 2006 GL	
I	Correction factor for additional industrial BOD discharged into sewers		IPCC 2006 GL	For collected wastewater, the default is 1.25, for uncollected the default is 1.00.
365	No. of days in a year			Number of days in a year
(2) CH_4 EMISSION FACTOR FOR EACH DOMESTIC WASTEWATER TREATMENT/DISCHARGE PATHWAY OR SYSTEM (EF_j) $EF_j = B_o \times MCF_j$				
B_o	Maximum CH_4 producing capacity	kg CH_4/kg BOD	IPCC 2006 *Table 6.2*	j = Type of treatment/discharge pathway or system
MCF_j	Methane correction factor (fraction)	dimensionless	IPCC 2006 *Table 6.2*	These are available for each type of wastewater treatment
(3) TOTAL CH_4 EMISSIONS FROM DOMESTIC WASTEWATER $CH_4 \text{ Emissions} = \left[\sum_{i,j} U_i \times T_{i,j} \times EF_j\right](TOW - S) - R$				
∑	Summation			The calculations are done for each treatment type and regions/systems and in the end summed or added up
i	Income group		Expert judgement	income group: rural, urban high income, and urban low income
j	Treatment/discharge pathway or system		Expert judgement	
S	Organic component removed as sludge in inventory year	kg BOD/yr	WMA	Sludge removed
U_i	Fraction of population in income group i in inventory year	fraction	Assumed	
$T_{i,j}$	Degree of utilisation of treatment/discharge pathway or system, j, for each income group fraction i in inventory year	fraction	Assumed degree of utilisation kept more or less the same throughout the years	Anaerobic digester for sludge: 0.01; Septic system: 0.9; Latrine: 0.01; centralized aerobic treatment: 0.01
R	Amount of CH_4 recovered in inventory year	kg CH_4/y	WMA	Methane recovered –flared/used for electricity production

Calculation of N_2O remissions

Terms	Description	Units	Data Sources	Remarks
(1) N_2O EMISSIONS FROM WASTEWATER EFFLUENT N_2O Emissions = $N_{EFFLUENT} \times EF_{EFFLUENT} \times (44/28)$				
N_2O emissions	N2O emissions in inventory year	kg N_2O/yr		Calculated
$N_{EFFLUENT}$	Nitrogen in the effluent discharged to aquatic environments	kg N/yr	IPCC 2006 *Table 6.11*	
$EF_{EFFLUENT}$	Emission factor for N_2O emissions from discharged to wastewater	kg N_2O-N/kg N	IPCC 2006 *Table 6.11*	
44/28	Conversion factor for kg N_2O-N into kg N_2O			
(2) TOTAL NITROGEN IN THE EFFLUENT $N_{EFFLUENT}$ = (P x Protein x F_{NPR} x $F_{NON\text{-}CON}$ x $F_{IND\text{-}COM}$) − N_{SLUDGE}				
P	Human population	Number	Statistics Mauritius	
$N_{EFFLUENT}$	Total annual amount of nitrogen in the wastewater effluent	kg N/yr		Calculated
Protein	Annual per capita protein consumption	kg/person/yr	FAO database	Protein intake per capita, kg/cap/yr average 26.4812 median 26.685 highest 27.32 used 27.32
F_{NPR}	Fraction of nitrogen in protein (default = 0.16)	kg N/kg protein	IPCC 2006 *Table 6.11*	
$F_{NON\text{-}CON}$	Factor for non-consumed protein added to the wastewater	dimensionless	IPCC 2006 *Table 6.11*	
$F_{IND\text{-}COM}$ =	Factor for industrial and commercial co-discharged protein into the sewer system	dimensionless	IPCC 2006 *Table 6.11*	
N_{SLUDGE}	Nitrogen removed with sludge (default = zero)	kg N/yr	IPCC 2006 *Table 6.11*	
(3) N_2O EMISION FROM CENTRALIZED WASTEWATER TREATMENT PROCESSES $N2O_{PLANTS}$ = P x T_{PLANT} x $F_{IND\text{-}COM}$ x EF_{PLANT}				
N_2O_{PLANTS}	Total N_2O emissions from plants in inventory year	kg N_2O/yr		
P	Human population	number	Statistics Mauritius	
T_{PLANT}	Degree of utilization of modern, centralized WWT plants	%	IPCC 2006 *Table 6.11*	
$F_{IND\text{-}COM}$	Fraction of industrial and commercial co-discharged protein		IPCC 2006 *Table 6.11*	(default = 1.25) based on data in Metcalf & Eddy (2003) and expert judgment)
EF_{PLANT}	Emission factor	3.2 g N_2O/person/year	IPCC 2006 *Table 6.11*	