Supplementary information for the manuscript:

Environmental Damage of Different Waste Treatment Scenarios by Considering Avoided Emissions Based on System Dynamics Modeling

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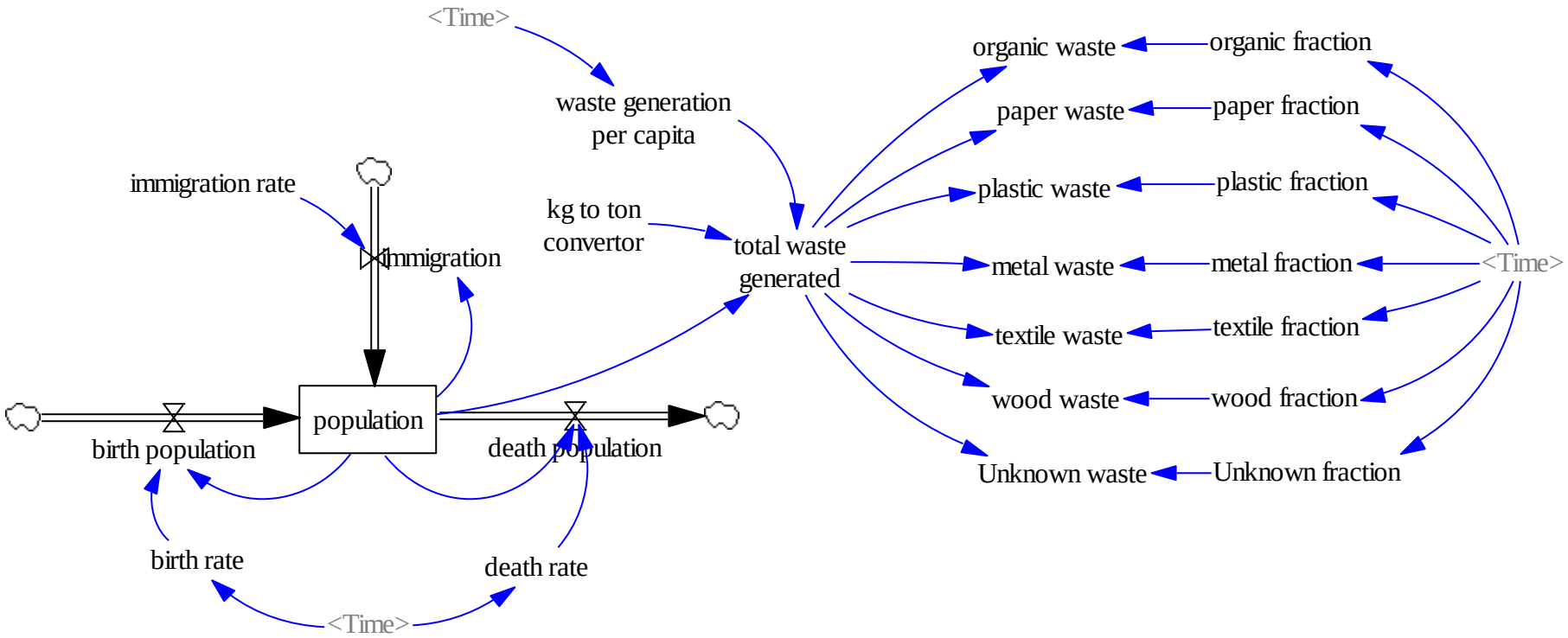


Figure S1. Stocks and flows of waste generation subsection

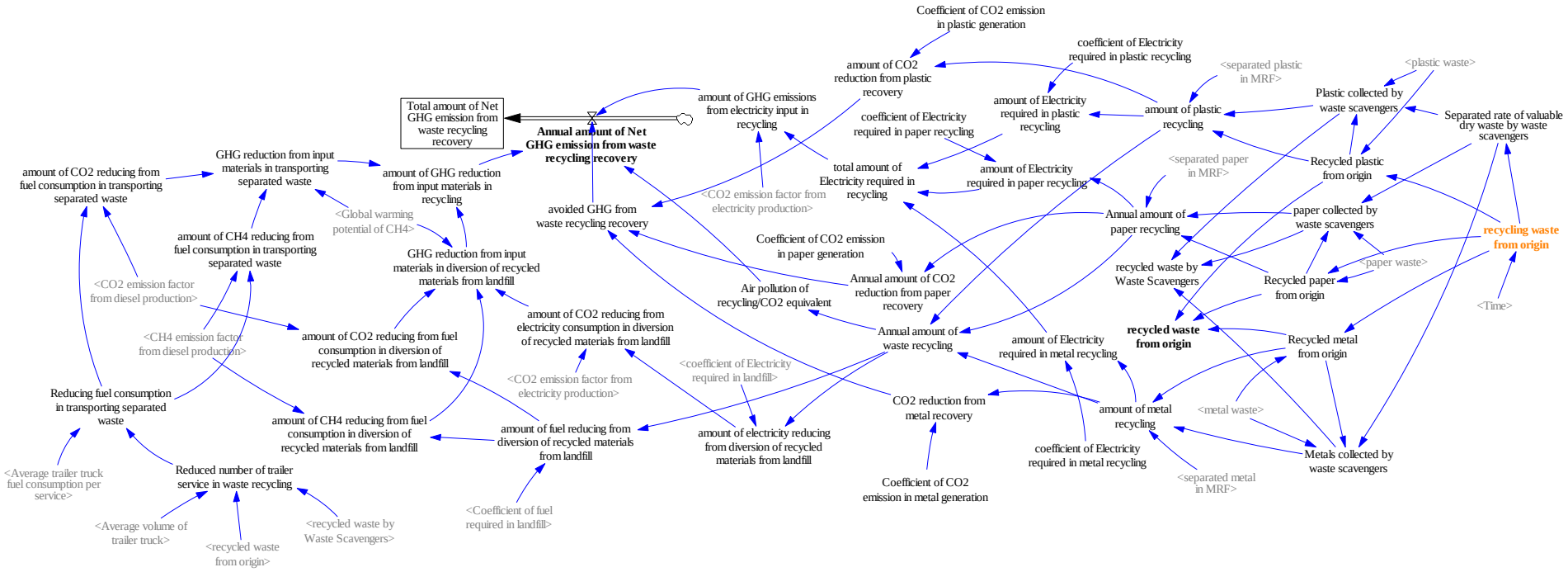


Figure S2. Stocks and flows of waste recycling subsection

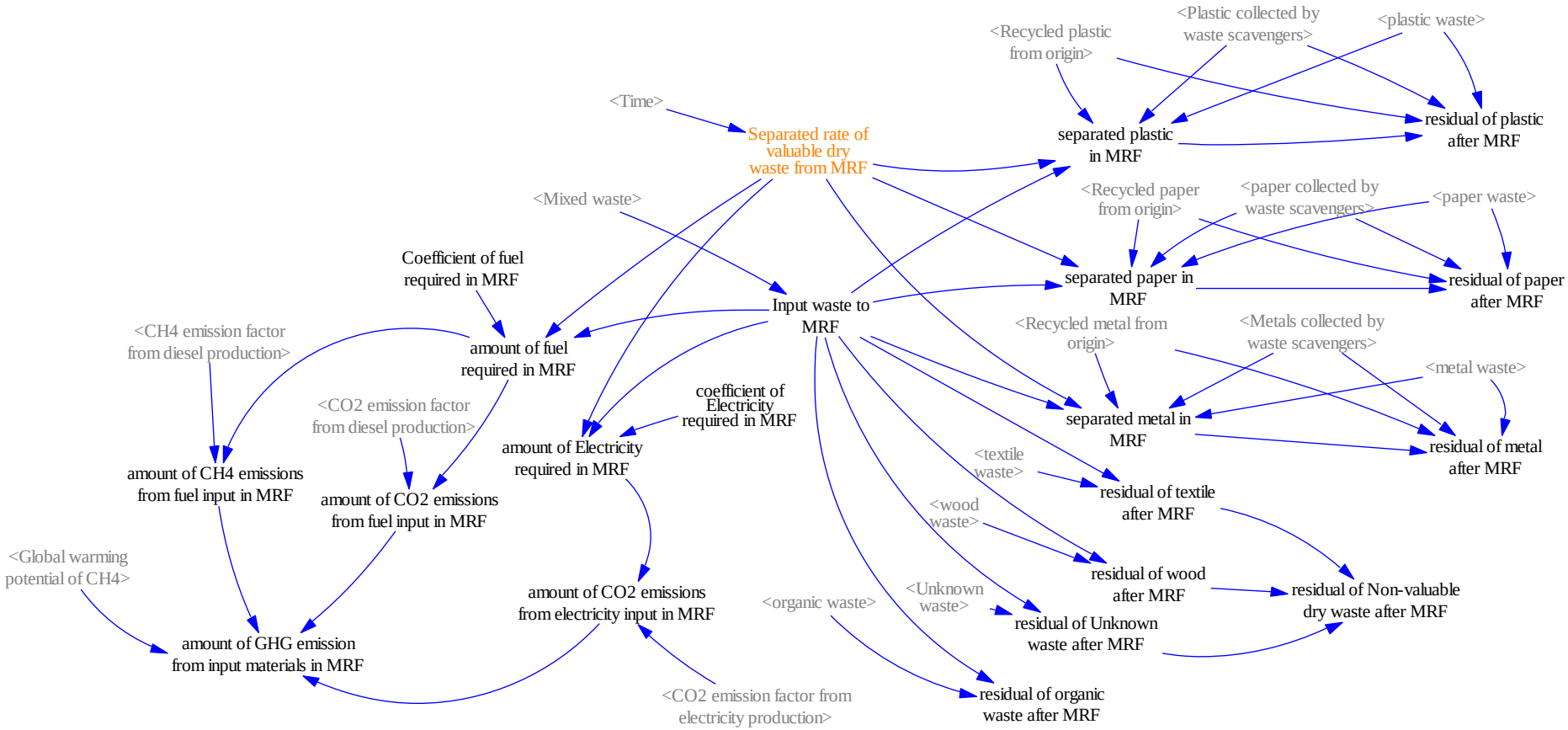


Figure S3. Stocks and flows of material recycling facility (MRF) subsection

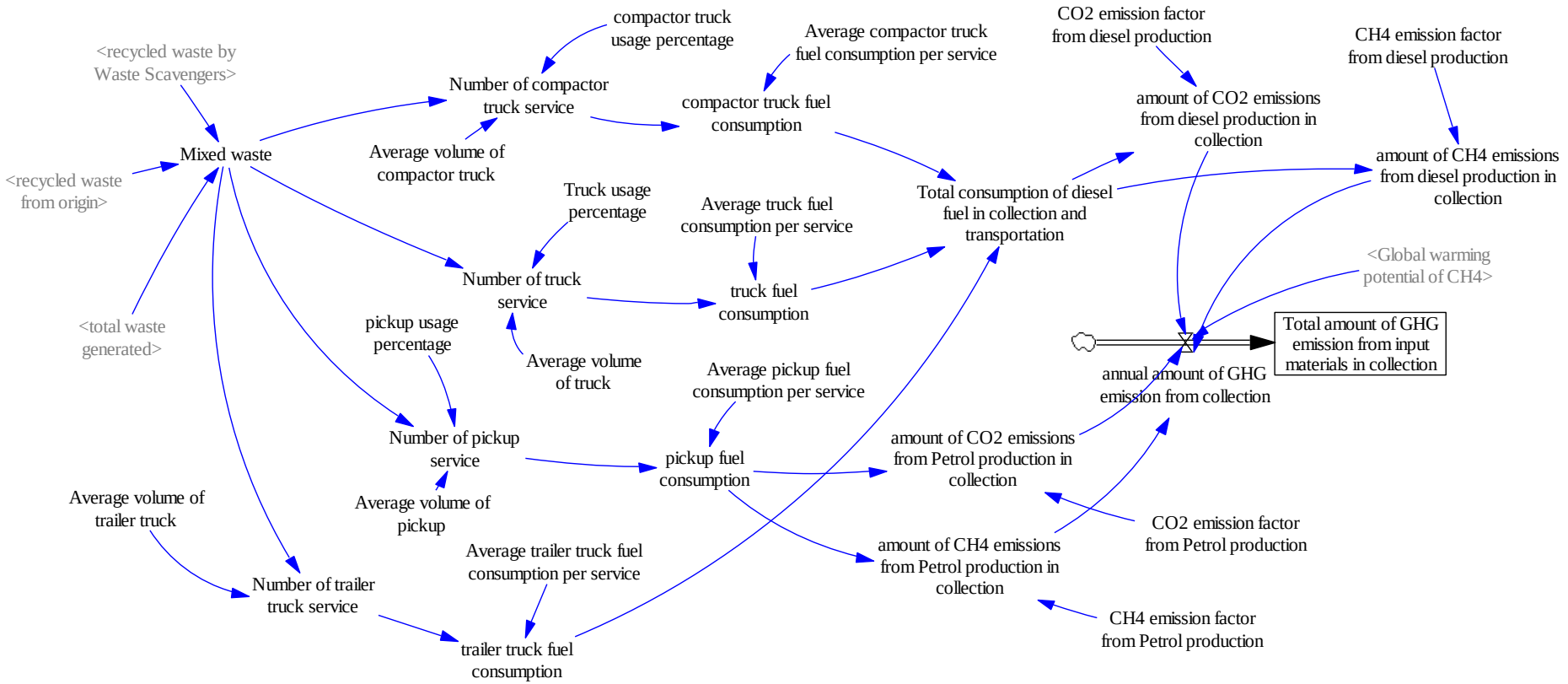


Figure S4. Stocks and flows of waste collection subsection

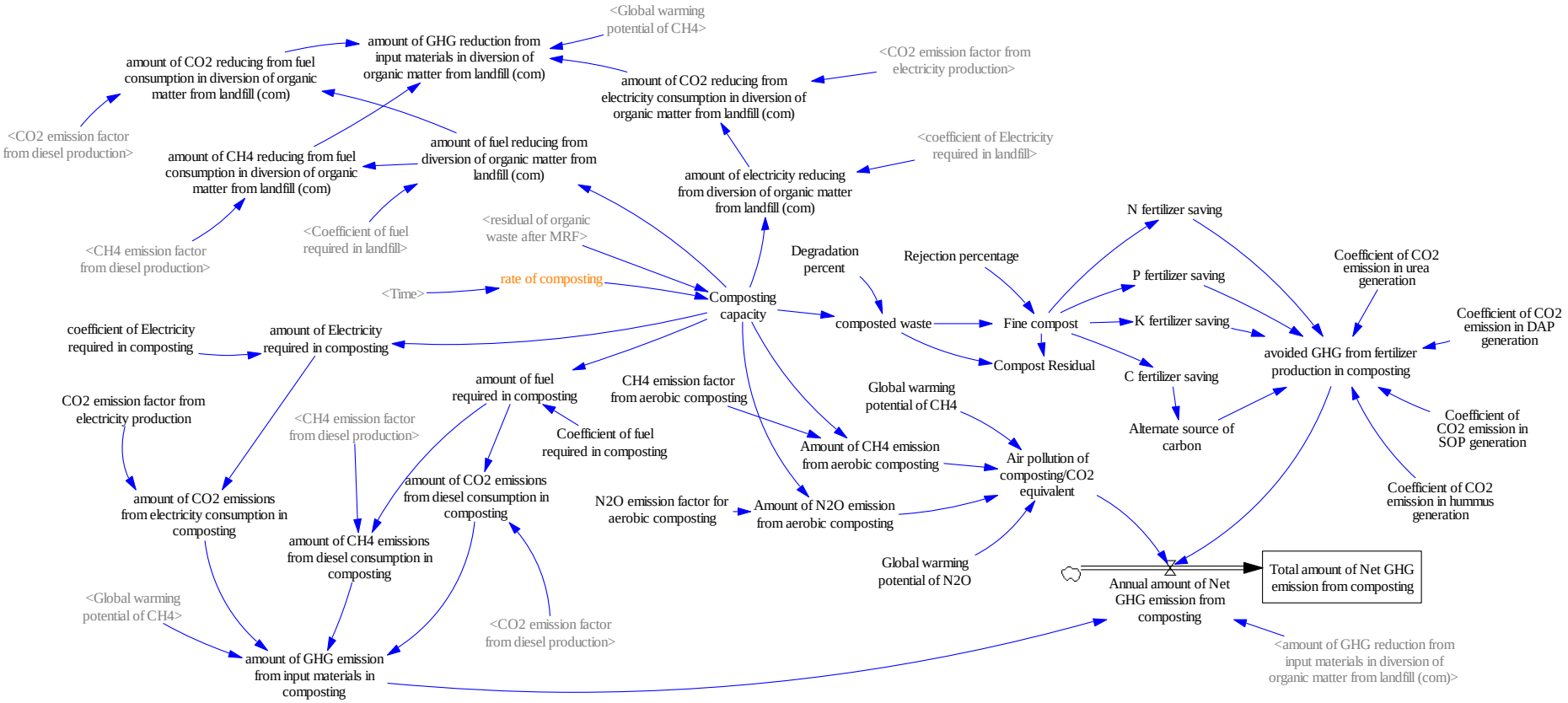


Figure S5. Stocks and flows of composting treatment subsection

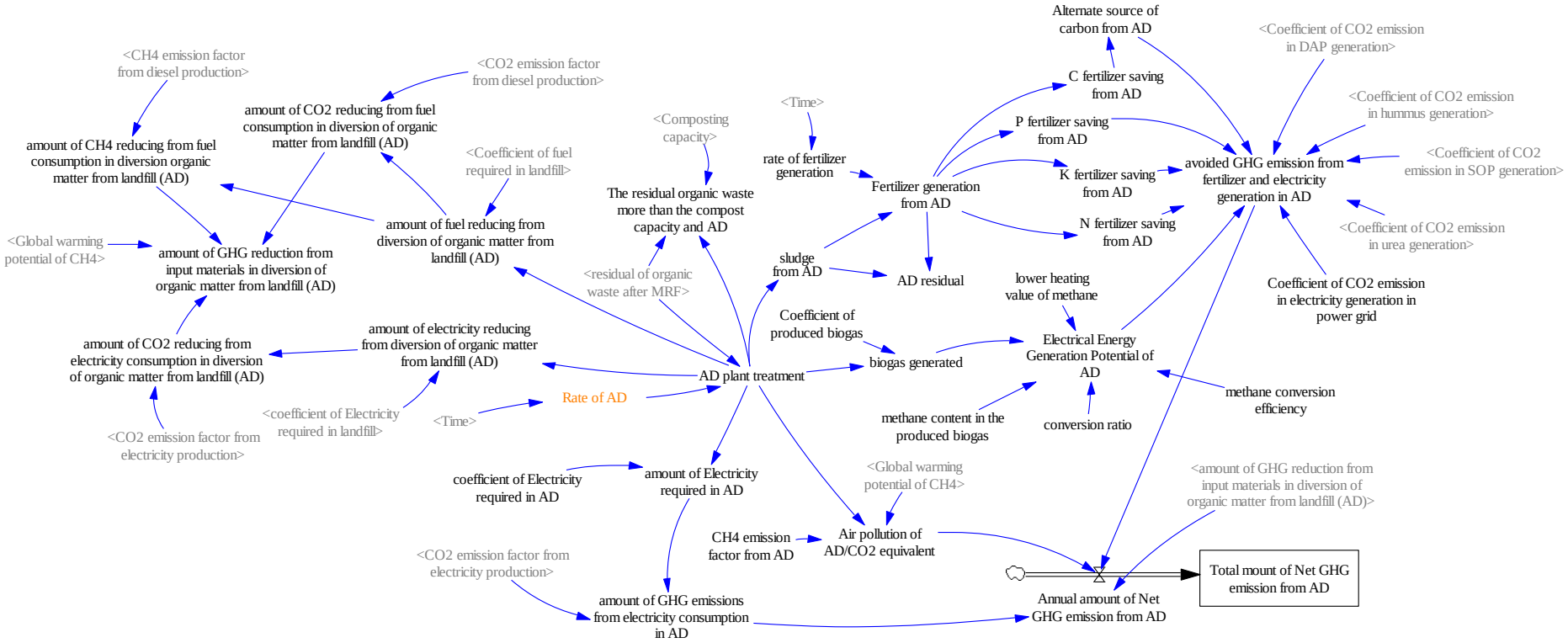


Figure S6. Stocks and flows of anaerobic digestion treatment subsection

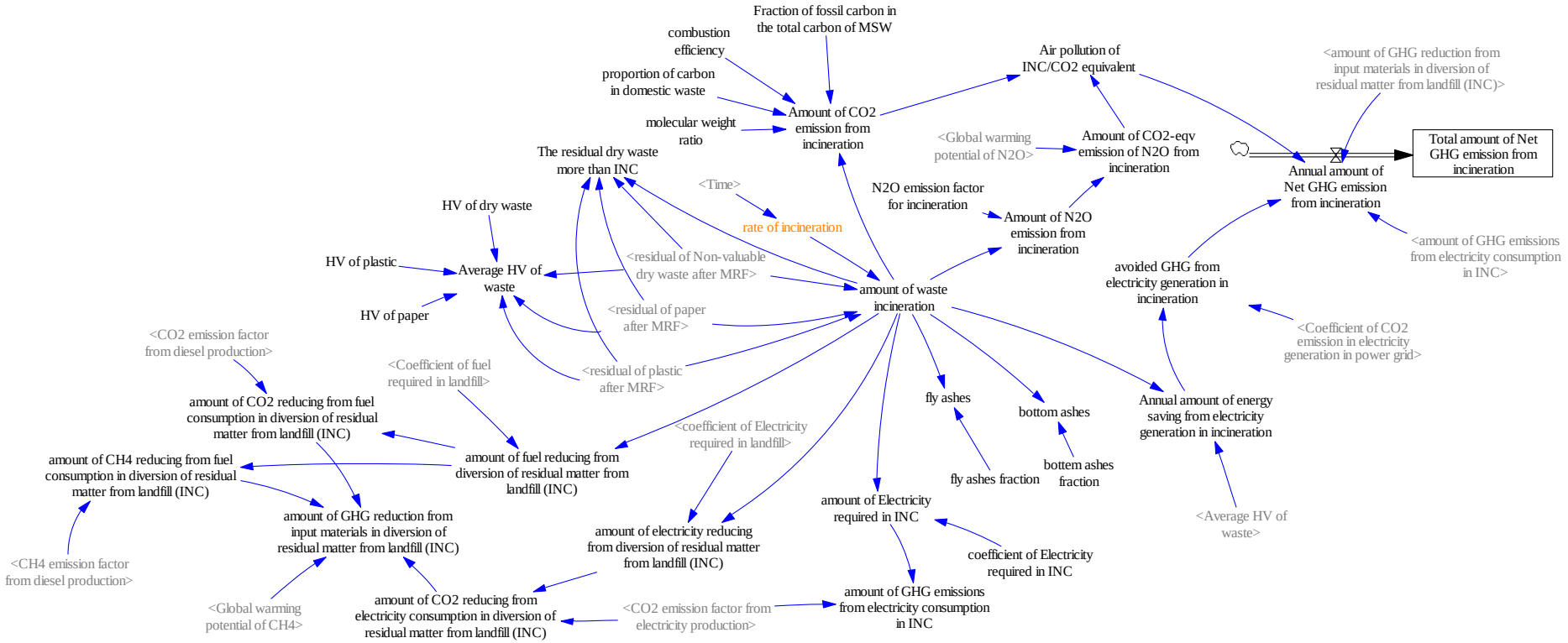


Figure S7. Stocks and flows of incineration treatment subsection

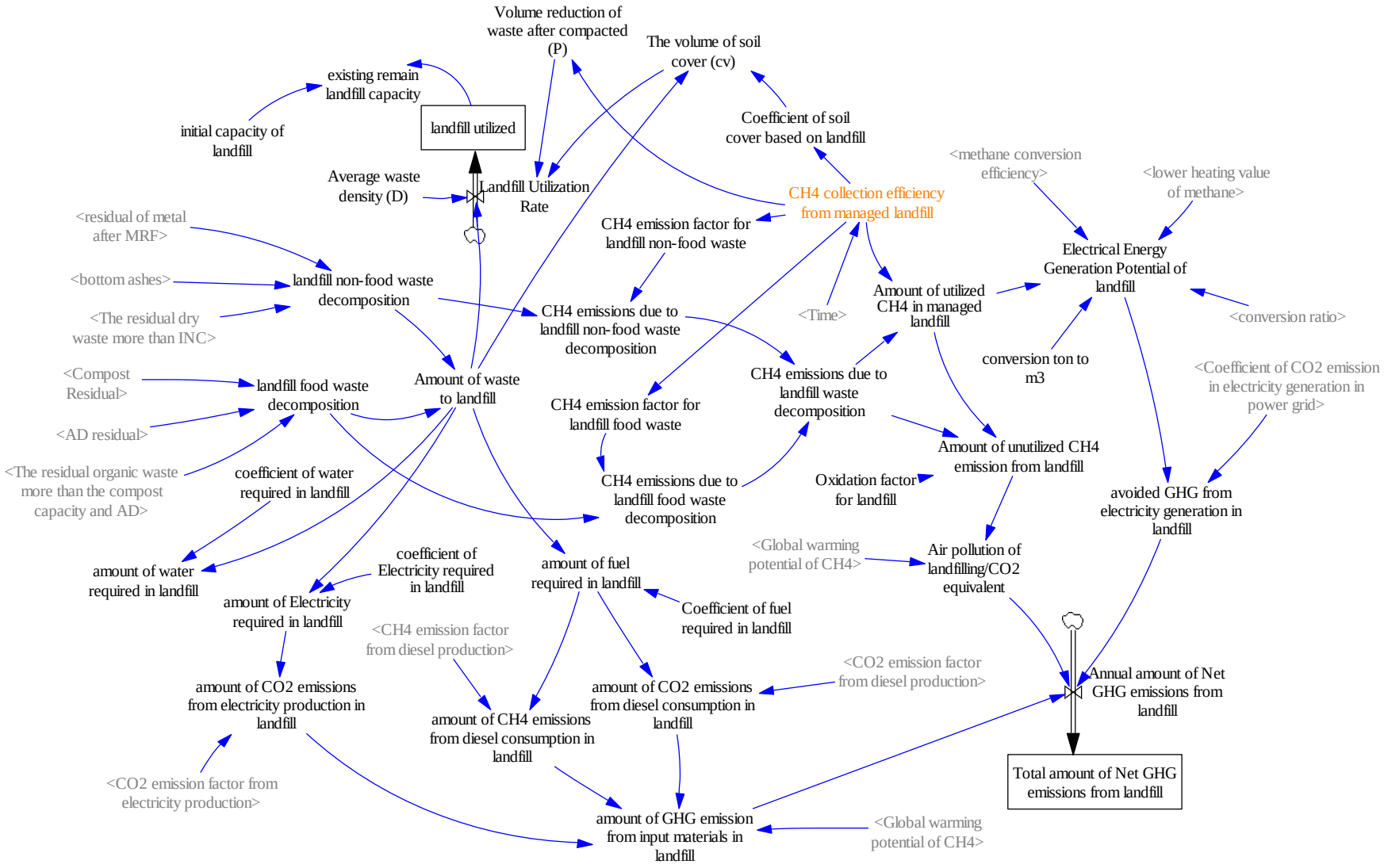


Figure S8. Stocks and flows of landfill subsection

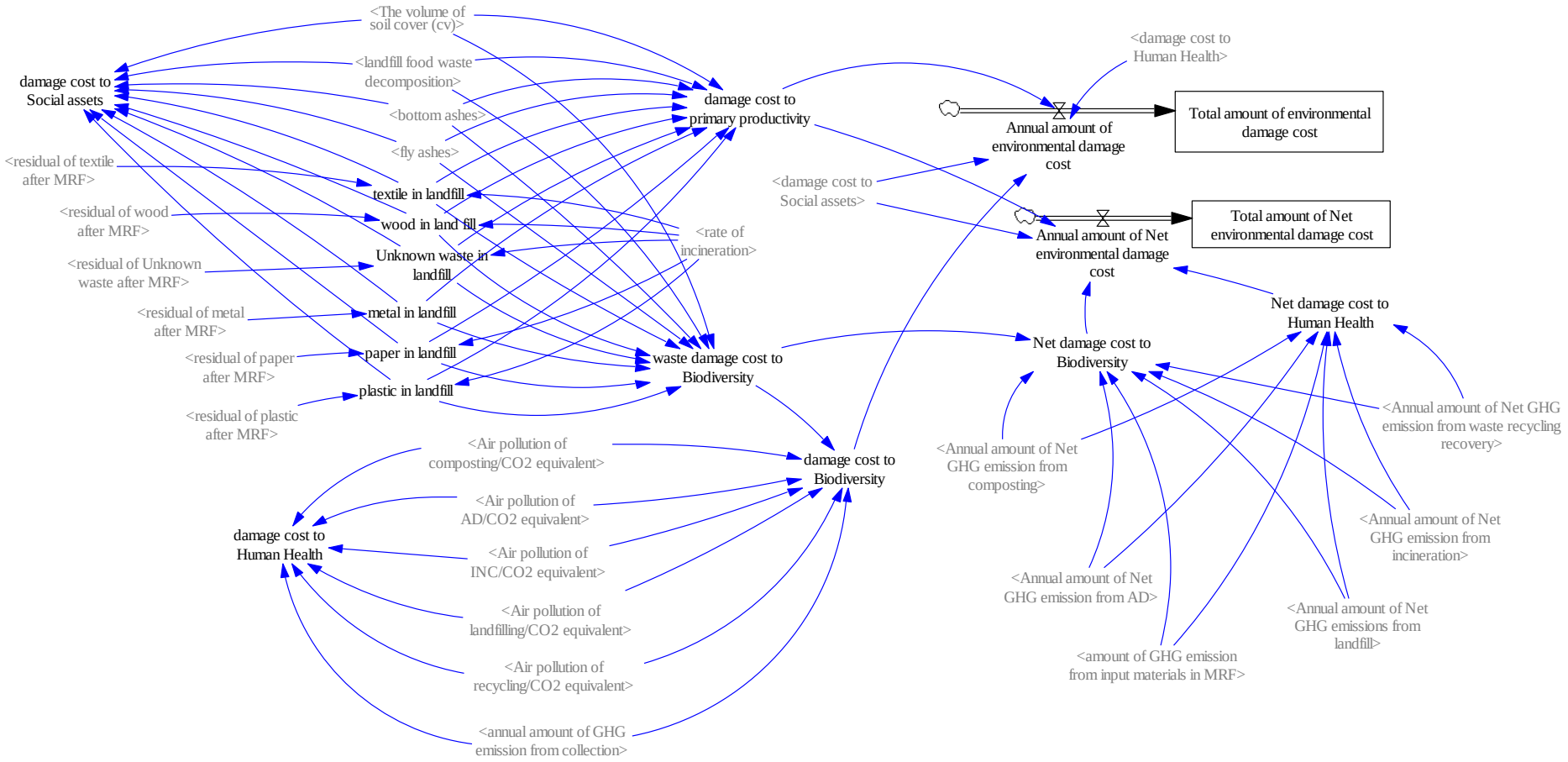


Figure S9. Stocks and flows of environmental damage cost subsection

Table S1. Integration and damage factor for environmental emissions in the MSW treatment

Category	Primary Productivity		Social asset		Biodiversity	
	IF (US$/kg)	DF (kg/kg)	IF (US$/kg)	DF (US$/kg)	IF (US$/kg)	DF (EINES/kg)
Food waste	3.83E-04	6.83E-03	1.30E-02	5.19E-03	5.17E-06	4.70E-16
Paper	5.26E-04	9.40E-03	1.78E-02	7.14E-03	7.10E-06	6.46E-16
Plastic & Rubber	4.21E-04	7.52E-03	1.43E-02	5.71E-03	5.68E-06	5.17E-16
Textile	1.05E-03	1.88E-02	3.57E-02	1.43E-02	1.42E-05	1.29E-15
Soil covering	2.34E-04	4.18E-03	7.93E-03	3.17E-03	3.16E-06	2.87E-16
Incineration ash	2.48E-04	4.42E-03	8.40E-03	3.36E-03	3.34E-06	3.04E-16
wood	2.10E-03	3.76E-02	7.14E-02	2.85E-02	2.84E-05	2.58E-15
Metals	3.01E-04	5.37E-03	1.02E-02	4.08E-03	4.06E-06	3.69E-16
Unknown	5.16E-04	9.21E-03	1.75E-02	6.99E-03	6.96E-06	6.33E-16
CO2					7.46E-03	6.78E-13

Category	Human health	
	IF (US$/kg)	DF (DALY/kg)
SO_2	2.52E+00	1.09E-04
NOx	9.48E-01	4.12E-05
CO_2	9.63E-03	4.19E-07

Table S2. Values of the variables and equations of the system dynamics model

Variable	Unit	Values and Equations	Type
AD plant treatment	ton/Year	residual of organic waste after MRF*Rate of AD	Proposed
AD residual	ton/Year	Sludge from AD –fertilizer from AD	-
Air pollution of AD/CO2 equivalent	ton/Year	AD plant treatment*CH4 emission factor from AD*Global warming potential of CH4	-
Air pollution of composting/CO2 equivalent	ton/Year	(Amount of CH4 emission from aerobic composting*Global warming potential of CH4) + (Amount of N2O emission from aerobic composting*Global warming potential of N2O)	-
Air pollution of INC/CO2 equivalent	ton/Year	Amount of CO2 emission from incineration +Amount of CO2-eqv emission of N2O from incineration	-
Air pollution of landfilling/CO2 equivalent	ton/Year	Amount of unutilized CH4 emission from landfill*Global warming potential of CH4	-
Air pollution of recycling/CO2 equivalent	ton/Year	(recycled waste from origin+ recycled waste by Waste Scavengers)*1.03	[1]
Alternate source of carbon	ton/Year	C fertilizer saving*0.2418	[2]
Alternate source of carbon from AD	ton/Year	C fertilizer saving from AD*0.2418	[2]
Amount of CH4 emission from aerobic composting	ton/Year	CH4 emission factor from aerobic composting*Composting capacity	-
amount of CH4 emissions from diesel consumption in composting	ton/Year	amount of fuel required in composting *CH4 emission factor from diesel production	-
amount of CH4 emissions from diesel consumption in landfill	ton/Year	amount of fuel required in landfill*CH4 emission factor from diesel production	-
amount of CH4 emissions from diesel production in collection	ton/Year	Total consumption of diesel fuel in collection and transportation*CH4 emission factor from diesel production	-
amount of CH4 emissions from fuel input in MRF	ton/Year	amount of fuel required in MRF*CH4 emission factor from diesel production	-
amount of CH4 emissions from Petrol production in collection	ton/Year	pickup fuel consumption*CH4 emission factor from Petrol production	-
amount of CH4 reducing from fuel consumption in diversion of organic matter from landfill	ton/Year	amount of fuel reducing from diversion of organic matter from landfill *CH4 emission factor from diesel production	-
amount of CH4 reducing from fuel consumption in diversion of recycled materials from landfill	ton/Year	amount of fuel reducing from diversion of recycled materials from landfill *CH4 emission factor from diesel production	-
amount of CH4 reducing from fuel consumption in diversion of residual matter from landfill	ton/Year	amount of fuel reducing from diversion of residual matter from landfill *CH4 emission factor from diesel production	-

amount of CH4 reducing from fuel consumption in diversion organic matter from landfill	ton/Year	amount of fuel reducing from diversion of organic matter from landfill *CH4 emission factor from diesel production	-
amount of CH4 reducing from fuel consumption in transporting separated waste	ton/Year	Reducing fuel consumption in transporting separated waste*CH4 emission factor from diesel production	-
Amount of CO2 emission from incineration	ton/Year	amount of waste incineration*molecular weight ratio*proportion of carbon in domestic waste *Fraction of fossil carbon in the total carbon of MSW*combustion efficiency	[3]
amount of CO2 emissions from diesel consumption in composting	ton/Year	amount of fuel required in composting*CO2 emission factor from diesel production	-
amount of CO2 emissions from diesel consumption in landfill	ton/Year	amount of fuel required in landfill*CO2 emission factor from diesel production	-
amount of CO2 emissions from diesel production in collection	ton/Year	Total consumption of diesel fuel in collection and transportation*CO2 emission factor from diesel production	-
amount of CO2 emissions from electricity consumption in composting	ton/Year	amount of Electricity required in composting*CO2 emission factor from electricity production	-
amount of CO2 emissions from electricity input in MRF	ton/Year	amount of Electricity required in MRF*CO2 emission factor from electricity production	-
amount of CO2 emissions from electricity production in landfill	ton/Year	amount of Electricity required in landfill*CO2 emission factor from electricity production	-
amount of CO2 emissions from fuel input in MRF	ton/Year	amount of fuel required in MRF*CO2 emission factor from diesel production	-
amount of CO2 emissions from Petrol production in collection	ton/Year	pickup fuel consumption*CO2 emission factor from Petrol production	-
amount of CO2 reducing from electricity consumption in diversion of organic matter from landfill (AD)	ton/Year	amount of electricity reducing from diversion of organic matter from landfill (AD)*CO2 emission factor from electricity production	Proposed
amount of CO2 reducing from electricity consumption in diversion of organic matter from landfill (com)	ton/Year	amount of electricity reducing from diversion of organic matter from landfill (com)* CO2 emission factor from electricity production	Proposed
amount of CO2 reducing from electricity consumption in diversion of recycled materials from landfill	ton/Year	amount of electricity reducing from diversion of recycled materials from landfill *CO2 emission factor from electricity production	Proposed
amount of CO2 reducing from electricity consumption in diversion of residual matter from landfill (INC)	ton/Year	amount of electricity reducing from diversion of residual matter from landfill (INC)" *CO2 emission factor from electricity production	Proposed

amount of CO2 reducing from fuel consumption in diversion of organic matter from landfill (AD)	ton/Year	amount of fuel reducing from diversion of organic matter from landfill (AD)" *CO2 emission factor from diesel production	Proposed
amount of CO2 reducing from fuel consumption in diversion of organic matter from landfill (com)	ton/Year	amount of fuel reducing from diversion of organic matter from landfill (com)" *CO2 emission factor from diesel production	Proposed
amount of CO2 reducing from fuel consumption in diversion of recycled materials from landfill	ton/Year	amount of fuel reducing from diversion of recycled materials from landfill *CO2 emission factor from diesel production	Proposed
amount of CO2 reducing from fuel consumption in diversion of residual matter from landfill (INC)	ton/Year	amount of fuel reducing from diversion of residual matter from landfill (INC)" *CO2 emission factor from diesel production	Proposed
amount of CO2 reducing from fuel consumption in transporting separated waste	ton/Year	Reducing fuel consumption in transporting separated waste*CO2 emission factor from diesel production	-
amount of CO2 reduction from plastic recovery	ton/Year	amount of plastic recycling*Coefficient of CO2 emission in plastic generation	-
Amount of CO2-eqv emission of N2O from incineration	ton/Year	Amount of N2O emission from incineration*Global warming potential of N2O	-
amount of electricity reducing from diversion of organic matter from landfill (AD)	Kwh/Year	AD plant treatment*coefficient of Electricity required in landfill	-
amount of electricity reducing from diversion of organic matter from landfill (com)	Kwh/Year	Composting capacity*coefficient of Electricity required in landfill	-
amount of electricity reducing from diversion of recycled materials from landfill	Kwh/Year	Annual amount of waste recycling*coefficient of Electricity required in landfill	-
amount of electricity reducing from diversion of residual matter from landfill (INC)	Kwh/Year	amount of waste incineration*coefficient of Electricity required in landfill	-
amount of Electricity required in AD	Kwh/Year	AD plant treatment*coefficient of Electricity required in AD	-
amount of Electricity required in composting	Kwh/Year	Composting capacity*coefficient of Electricity required in composting	-
amount of Electricity required in INC	Kwh/Year	amount of waste incineration*coefficient of Electricity required in INC	-
amount of Electricity required in landfill	Kwh/Year	Amount of waste to landfill*coefficient of Electricity required in landfill	-
amount of Electricity required in metal recycling	Kwh/Year	amount of metal recycling*coefficient of Electricity required in metal recycling	-
amount of Electricity required in MRF	Kwh/Year	IF THEN ELSE(Separated rate of valuable dry waste from MRF<=0, 0 , Input waste to	Proposed

		MRF*coefficient of Electricity required in MRF)	
amount of Electricity required in paper recycling	Kwh/Year	Annual amount of paper recycling*coefficient of Electricity required in paper recycling	-
amount of Electricity required in plastic recycling	Kwh/Year	amount of plastic recycling*coefficient of Electricity required in plastic recycling	-
amount of fuel reducing from diversion of organic matter from landfill (AD)	lit Gasoline/Year	AD plant treatment*Coefficient of fuel required in landfill	-
amount of fuel reducing from diversion of organic matter from landfill (com)	lit Gasoline/Year	Composting capacity*Coefficient of fuel required in landfill	-
amount of fuel reducing from diversion of recycled materials from landfill	lit Gasoline/Year	Annual amount of waste recycling*Coefficient of fuel required in landfill	-
amount of fuel reducing from diversion of residual matter from landfill (INC)	lit Gasoline/Year	amount of waste incineration*Coefficient of fuel required in landfill	-
amount of fuel required in composting	lit Gasoline/Year	Composting capacity*Coefficient of fuel required in composting	-
amount of fuel required in landfill	lit Gasoline/Year	Amount of waste to landfill*Coefficient of fuel required in landfill	-
amount of fuel required in MRF	lit Gasoline/Year	IF THEN ELSE(Separated rate of valuable dry waste from MRF<=0, 0 , Input waste to MRF*Coefficient of fuel required in MRF)	Proposed
amount of GHG emission from input materials in composting	ton/Year	(amount of CH4 emissions from diesel consumption in composting*Global warming potential of CH4)+amount of CO2 emissions from diesel consumption in composting +amount of CO2 emissions from electricity consumption in composting	Proposed
amount of GHG emission from input materials in landfill	ton/Year	(amount of CH4 emissions from diesel consumption in landfill*Global warming potential of CH4)+amount of CO2 emissions from diesel consumption in landfill +amount of CO2 emissions from electricity production in landfill	Proposed
amount of GHG emission from input materials in MRF	ton/Year	(amount of CH4 emissions from fuel input in MRF*Global warming potential of CH4)+amount of CO2 emissions from fuel input in MRF +amount of CO2 emissions from electricity input in MRF	Proposed
amount of GHG emissions from electricity consumption in AD	ton/Year	amount of Electricity required in AD*CO2 emission factor from electricity production	-
amount of GHG emissions from electricity consumption in INC	ton/Year	amount of Electricity required in INC*CO2 emission factor from electricity production	-
amount of GHG emissions from electricity input in recycling	ton/Year	total amount of Electricity required in recycling*CO2 emission factor from electricity production	-
amount of GHG reduction from input materials in diversion of organic matter from	ton/Year	("amount of CH4 reducing from fuel consumption in diversion organic matter from landfill (AD)"*Global warming potential of CH4)+"amount of CO2 reducing from	Proposed

landfill (AD)		fuel consumption in diversion of organic matter from landfill (AD)"+"amount of CO2 reducing from electricity consumption in diversion of organic matter from landfill (AD)"	
amount of GHG reduction from input materials in diversion of organic matter from landfill (com)	ton/Year	("amount of CH4 reducing from fuel consumption in diversion of organic matter from landfill (com)"*Global warming potential of CH4)+"amount of CO2 reducing from fuel consumption in diversion of organic matter from landfill (com)"+"amount of CO2 reducing from electricity consumption in diversion of organic matter from landfill (com)"	Proposed
amount of GHG reduction from input materials in diversion of residual matter from landfill (INC)	ton/Year	("amount of CH4 reducing from fuel consumption in diversion of residual matter from landfill (INC)"*Global warming potential of CH4)+"amount of CO2 reducing from fuel consumption in diversion of residual matter from landfill (INC)"+"amount of CO2 reducing from electricity consumption in diversion of residual matter from landfill (INC)"	Proposed
amount of GHG reduction from input materials in recycling	ton/Year	GHG reduction from input materials in diversion of recycled materials from landfill + GHG reduction from input materials in transporting separated waste	Proposed
amount of metal recycling	ton/Year	Recycled metal from origin+ Metals collected by waste scavengers+ separated metal in MRF	Proposed
Amount of N2O emission from aerobic composting	ton/Year	Composting capacity*N2O emission factor for aerobic composting	-
Amount of N2O emission from incineration	ton/Year	amount of waste incineration*N2O emission factor for incineration	-
amount of plastic recycling	ton/Year	Recycled plastic from origin+ Plastic collected by waste scavengers+ separated plastic in MRF	Proposed
Amount of unutilized CH4 emission from landfill	ton/Year	CH4 emissions due to landfill waste decomposition*(1-Oxidation factor for landfill)-Amount of utilized CH4 in managed landfill	[4]
Amount of utilized CH4 in managed landfill	ton/Year	CH4 emissions due to landfill waste decomposition*CH4 collection efficiency from managed landfill	-
amount of waste incineration	ton/Year	("residual of Non-valuable dry waste after MRF"+ residual of paper after MRF+ residual of plastic after MRF)*rate of incineration	Proposed
Amount of waste to landfill	ton/Year	landfill food waste decomposition+ "landfill non-food waste decomposition"	-
annual amount of avoided GHG from MSW	ton/Year	avoided GHG emission from fertilizer and electricity generation in AD+ avoided GHG from electricity generation in incineration +avoided GHG from electricity generation in landfill+ avoided GHG from fertilizer production in composting +avoided GHG from waste recycling recovery	Proposed
Annual amount of CO2 reduction from paper recovery	ton/Year	Annual amount of paper recycling*Coefficient of CO2 emission in paper generation	-
Annual amount of energy saving from	Kwh/Year	amount of waste incineration*(Average HV of waste*0.8939*0.28*0.29)	[5]

electricity generation in incineration			
Annual amount of environmental damage cost	USD/Year	damage cost to Biodiversity+ damage cost to Human Health+ damage cost to primary productivity+ damage cost to Social assets	[6]
annual amount of GHG emission from collection	ton/Year	(((amount of CH4 emissions from diesel production in collection+ amount of CH4 emissions from Petrol production in collection)*Global warming potential of CH4)+amount of CO2 emissions from diesel production in collection+ amount of CO2 emissions from Petrol production in collection)	Proposed
Annual amount of GHG emission from input materials from MSW	ton/Year	amount of GHG emission from input materials in composting+ amount of GHG emission from input materials in landfill+ amount of GHG emission from input materials in MRF+ amount of GHG emissions from electricity consumption in AD+ amount of GHG emissions from electricity consumption in INC+ amount of GHG emissions from electricity input in recycling	Proposed
Biodiversity damage	EINES/Year	(bottom ashes*3.03941e-16*1000)+(landfill food waste decomposition*4.69727e-16 *1000)+(metal in landfill*3.69072e-16*1000)+(Unknown waste in landfill* 6.32978e-16*1000)+(paper in landfill*6.45875e-16*1000)+(plastic in landfill *5.167e-16*1000)+("The volume of soil cover (cv)"*2.87056e-16*1000)+(textile in landfill*1.29175e-15*1000)+(wood in land fill * 2.5835e-15*1000)+(fly ashes* 4.10079e-16 *1000) +("Air pollution of landfilling/CO2 equivalent"*6.7787e-13*1000)+("Air pollution of AD/CO2 equivalent"*6.7787e-13 *1000) +("Air pollution of composting/CO2 equivalent" *6.7787e-13*1000)+ ("Air pollution of INC/CO2 equivalent"*6.7787e-13*1000) + ("Air pollution of recycling/CO2 equivalent" *6.7787e-13*1000)+(annual amount of GHG emission from collection * 6.7787e-13*1000)	[7]
annual amount of GHG emission from MSW	ton/Year	"Air pollution of AD/CO2 equivalent"+ "Air pollution of composting/CO2 equivalent"+ "Air pollution of INC/CO2 equivalent" +"Air pollution of landfilling/CO2 equivalent"+ "Air pollution of recycling/CO2 equivalent +annual amount of GHG emission from collection	Proposed
Annual amount of Net environmental damage cost	USD/Year	damage cost to primary productivity+ damage cost to Social assets+ Net damage cost to Biodiversity+ Net damage cost to Human Health	Proposed
Annual amount of Net GHG emission from AD	ton/Year	("Air pollution of AD/CO2 equivalent" +amount of GHG emissions from electricity consumption in AD)-(avoided GHG emission from fertilizer and electricity generation in AD+ "amount of GHG reduction from input materials in diversion of organic matter from landfill (AD)")	Proposed
Annual amount of Net GHG emission from composting	ton/Year	("Air pollution of composting/CO2 equivalent" +amount of GHG emission from input materials in composting)-(avoided GHG from fertilizer production in composting +"amount of GHG reduction from input materials in diversion of organic matter from landfill (com)")	Proposed

Annual amount of Net GHG emission from incineration	ton/Year	("Air pollution of INC/CO2 equivalent" +amount of GHG emissions from electricity consumption in INC)-(avoided GHG from electricity generation in incineration +"amount of GHG reduction from input materials in diversion of residual matter from landfill (INC)"	Proposed
annual amount of Net GHG emission from MSW	ton/Year	annual amount of GHG emission from collection +Annual amount of Net GHG emission from AD +Annual amount of Net GHG emission from composting +Annual amount of Net GHG emission from incineration +Annual amount of Net GHG emission from waste recycling recovery +Annual amount of Net GHG emissions from landfill+ amount of GHG emission from input materials in MRF	Proposed
Annual amount of Net GHG emission from waste recycling recovery	ton/Year	("Air pollution of recycling/CO2 equivalent" +amount of GHG emissions from electricity input in recycling)-(amount of GHG reduction from input materials in recycling +avoided GHG from waste recycling recovery)	Proposed
Annual amount of Net GHG emissions from landfill	ton/Year	("Air pollution of landfilling/CO2 equivalent" +amount of GHG emission from input materials in landfill)-avoided GHG from electricity generation in landfill	Proposed
Annual amount of paper recycling	ton/Year	Recycled paper from origin +paper collected by waste scavengers +separated paper in MRF	Proposed
Annual amount of waste recycling	ton/Year	amount of metal recycling +Annual amount of paper recycling +amount of plastic recycling	Proposed
annual of GHG reduction from input materials	ton/Year	"amount of GHG reduction from input materials in diversion of organic matter from landfill (AD)"+"amount of GHG reduction from input materials in diversion of organic matter from landfill (com)" +"amount of GHG reduction from input materials in diversion of residual matter from landfill (INC)" +amount of GHG reduction from input materials in recycling	Proposed
Average compactor truck fuel consumption per service	lit Gasoline/service	10.5	[8]
Average HV of waste	Kwh/ton	("residual of Non-valuable dry waste after MRF"*HV of dry waste +residual of paper after MRF*HV of paper +residual of plastic after MRF*HV of plastic)/("residual of Non-valuable dry waste after MRF" +residual of paper after MRF +residual of plastic after MRF)	[5]
Average pickup fuel consumption per service	lit Gasoline/service	8	[8]
Average trailer truck fuel consumption per service	lit Gasoline/service	65	[8]

Average truck fuel consumption per service	lit Gasoline/service	10	[8]
Average volume of compactor truck	ton/service	2.7	[8]
Average volume of pickup	ton/service	1.54	[8]
Average volume of trailer truck	ton/service	35	[8]
Average volume of truck	ton/service	2.38	[8]
Average waste density (D)	ton/m3	0.5	[9]
avoided GHG emission from fertilizer and electricity generation in AD	ton/Year	Alternate source of carbon from AD*Coefficient of CO2 emission in hummus generation +K fertilizer saving from AD*Coefficient of CO2 emission in SOP generation +N fertilizer saving from AD*Coefficient of CO2 emission in urea generation +P fertilizer saving from AD*Coefficient of CO2 emission in DAP generation +Electrical Energy Generation Potential of AD*Coefficient of CO2 emission in electricity generation in power grid	[5]
avoided GHG from electricity generation in incineration	ton/Year	Annual amount of energy saving from electricity generation in incineration *Coefficient of CO2 emission in electricity generation in power grid	Proposed
avoided GHG from electricity generation in landfill	ton/Year	Electrical Energy Generation Potential of landfill*Coefficient of CO2 emission in electricity generation in power grid	Proposed
avoided GHG from fertilizer production in composting	ton/Year	Alternate source of carbon*Coefficient of CO2 emission in hummus generation +K fertilizer saving*Coefficient of CO2 emission in SOP generation +N fertilizer saving *Coefficient of CO2 emission in urea generation +P fertilizer saving*Coefficient of CO2 emission in DAP generation	Proposed
avoided GHG from waste recycling recovery	ton/Year	CO2 reduction from metal recovery +Annual amount of CO2 reduction from paper recovery +amount of CO2 reduction from plastic recovery	Proposed
biogas generated	m3/Year	AD plant treatment*Coefficient of produced biogas	-
birth population	person/Year	birth rate*population	-
birth rate	1/Year	WITH LOOKUP (Time,([(2011,0.005)-(2020,0.02)], (2011,0.0140472), (2012,0.0145092), (2013,0.0147622), (2014,0.0155993),(2015,0.016005), (2016,.0155035), (2017,0.0144743), (2018,0.0124126), (2019,0.0101853), (2020,0.00849228)))	[10]
bottom ashes fraction	Dmnl	0.15	[11]
bottom ashes	ton/Year	amount of waste incineration* bottom ashes fraction	-
C fertilizer saving	ton/Year	Fine compost*0.21	[2]
C fertilizer saving from AD	ton/Year	Fertilizer generation from AD*0.21	[2]
CH4 emission factor for landfill food waste	Dmnl	IF THEN ELSE(CH4 collection efficiency from managed landfill<=0, 0.02027 , 0.05067)	[12]

CH4 emission factor for landfill non-food waste	Dmnl	IF THEN ELSE(CH4 collection efficiency from managed landfill<=0, 0.0177 , 0.04424)	[12]
CH4 emission factor from AD	ton/ton	0.002	[13]
CH4 emission factor from aerobic composting	ton/ton	0.004	[4]
CH4 emission factor from diesel production	ton/lit Gasoline	3.6e-08	[14]
CH4 emission factor from Petrol production	ton/lit Petrol	3.9375e-06	[15]
CH4 emissions due to landfill food waste decomposition	ton/Year	landfill food waste decomposition*CH4 emission factor for landfill food waste	-
CH4 emissions due to landfill non-food waste decomposition	ton/Year	"landfill non-food waste decomposition"*"CH4 emission factor for landfill non-food waste"	-
CH4 emissions due to landfill waste decomposition	ton/Year	CH4 emissions due to landfill food waste decomposition+"CH4 emissions due to landfill non-food waste decomposition"	-
CO2 emission factor from diesel production	ton/lit Gasoline	0.0026344	[14]
CO2 emission factor from electricity production	ton/Kwh	0.00064	[16]
CO2 emission factor from Petrol production	ton/lit Petrol	0.002985	[15]
CO2 reduction from metal recovery	ton/Year	amount of metal recycling*Coefficient of CO2 emission in metal generation	-
Coefficient of CO2 emission in DAP generation	Dmnl	0.602	[17]
Coefficient of CO2 emission in electricity generation in power grid	ton/Kwh	0.00082	[18]
Coefficient of CO2 emission in hummus generation	Dmnl	116	[4]
Coefficient of CO2 emission in metal generation	Dmnl	3.17	[4]
Coefficient of CO2 emission in paper generation	Dmnl	0.53	[4]
Coefficient of CO2 emission in plastic generation	Dmnl	1.82	[4]
Coefficient of CO2 emission in SOP generation	Dmnl	1.66	[17]
Coefficient of CO2 emission in urea	Dmnl	0.000574	[17]

generation			
coefficient of Electricity required in AD	Kwh/ton	8	[19]
coefficient of Electricity required in composting	Kwh/ton	65.5	[20]
coefficient of Electricity required in INC	Kwh/ton	45	[21]
coefficient of Electricity required in landfill	Kwh/ton	0.42	[22]
coefficient of Electricity required in metal recycling	Kwh/ton	420	[23]
coefficient of Electricity required in MRF	Kwh/ton	24	[15]
coefficient of Electricity required in paper recycling	Kwh/ton	24	[23]
coefficient of Electricity required in plastic recycling	Kwh/ton	342	[23]
Coefficient of fuel required in composting	lit Gasoline/ton	9	[20]
Coefficient of fuel required in landfill	lit Gasoline/ton	0.38	[22]
Coefficient of fuel required in MRF	lit Gasoline/ton	0.87	[15]
Coefficient of produced biogas	m3/ton	120	[24]
Coefficient of soil cover based on landfill	m3/ton	IF THEN ELSE(CH4 collection efficiency from managed landfill<=0, 0.33 , 0.17)	Proposed
combustion efficiency	Dmnl	0.95	[13]
compactor truck fuel consumption	lit Gasoline/Year	Number of compactor truck service*Average compactor truck fuel consumption per service	Proposed
compactor truck usage percentage	Dmnl	0.47	[8]
Compost Residual	ton/Year	composted waste-Fine compost	Proposed
composted waste	ton/Year	Degradation percent*Composting capacity	-
Composting capacity	ton/Year	residual of organic waste after MRF*rate of composting	-
conversion ratio	Kwh/MJ	0.28	[25]
conversion ton to m3	m3/ton	1524.4	-
damage cost to Biodiversity	USD/Year	waste damage cost to Biodiversity+("Air pollution of AD/CO2 equivalent" * 0.00745657 *1000)+ ("Air pollution of composting/CO2 equivalent" * 0.00745657 *1000)+("Air pollution of INC/CO2 equivalent" *0.00745657 *1000) + ("Air pollution of landfilling/CO2 equivalent" *0.00745657 *1000) + ("Air pollution of recycling/CO2 equivalent"*0.00745657*1000)+(annual amount of GHG emission from collection*0.00745657*1000)	[6]

damage cost to Human Health	USD/Year	("Air pollution of AD/CO2 equivalent"*0.0096346*1000)+ ("Air pollution of composting/CO2 equivalent" *0.0096346*1000)+ ("Air pollution of INC/CO2 equivalent"*0.0096346*1000)+ ("Air pollution of landfilling/CO2 equivalent" *0.0096346*1000)+("Air pollution of recycling/CO2 equivalent" *0.0096346 *1000)+(annual amount of GHG emission from collection*0.00745657*1000)	[6]
damage cost to primary productivity	USD/Year	(bottom ashes*0.000247622*1000)+(landfill food waste decomposition *0.000382689 *1000) +(metal in landfill*0.000300684*1000) + (Unknown waste in landfill*0.00051569*1000)+(paper in landfill *0.000526197*1000) + (plastic in landfill *0.000420958*1000) + ("The volume of soil cover (cv)"*0.000233866*1000)+(textile in landfill *0.00105239*1000)+(wood in land fill*0.00210479*1000) +(fly ashes*0.000334*1000)	[6]
damage cost to Social assets	USD/Year	(bottom ashes*0.00839637*1000)+(landfill food waste decomposition *0.0129762 *1000) + (metal in landfill *0.0101956*1000)+(Unknown waste in landfill*0.017486*1000)+(paper in landfill *0.0178423*1000)+ plastic in landfill *0.0142738*1000)+("The volume of soil cover (cv)"* 0.0079299 *1000) + (textile in landfill*0.0356846*1000)+(wood in land fill * 0.0713691*1000)+(fly ashes*0.00904*1000)	[6]
death population	person/Year	population*death rate	-
death rate	1/Year	WITH LOOKUP (Time,([(2011,0)-(2020,0.005)], (2011,0.00360786), (2012,0.00336101), (2013,0.00347682), (2014,0.00335204), (2015,0.0035451), (2016,0.00369931), (2017,0.00341142), (2018,0.0037919), (2019,0.00397731), (2020,0.00548129)))	[10]
Degradation percent	Dmnl	0.4	[9]
Electrical Energy Generation Potential of AD	Kwh/Year	biogas generated*conversion ratio*lower heating value of methane*methane content in the produced biogas *methane conversion efficiency	[25]
Electrical Energy Generation Potential of landfill	Kwh/Year	Amount of utilized CH4 in managed landfill*conversion ton to m3*conversion ratio*lower heating value of methane*methane conversion efficiency	[26]
existing remain landfill capacity	m3	initial capacity of landfill-landfill utilized	Proposed
Fertilizer generation from AD	ton/Year	sludge from AD*rate of fertilizer generation	-
FINAL TIME	Year	2050	-
Fine compost	ton/Year	composted waste*Rejection percentage	-
fly ashes	ton/Year	amount of waste incineration*fly ashes fraction	-
fly ashes fraction	Dmnl	0.05	[11]
Fraction of fossil carbon in the total carbon of MSW	Dmnl	0.39	[4]
GHG reduction from input materials in diversion of recycled materials from landfill	ton/Year	(amount of CH4 reducing from fuel consumption in diversion of recycled materials from landfill *Global warming potential of CH4)+amount of CO2 reducing from fuel consumption in diversion of recycled materials from landfill +amount of CO2	Proposed

		reducing from electricity consumption in diversion of recycled materials from landfill	
GHG reduction from input materials in transporting separated waste	ton/Year	(amount of CH4 reducing from fuel consumption in transporting separated waste *Global warming potential of CH4)+amount of CO2 reducing from fuel consumption in transporting separated waste	Proposed
Global warming potential of CH4	Dmnl	28	[27]
Global warming potential of N2O	Dmnl	265	[27]
Human Health damage	DALY/Year	("Air pollution of AD/CO2 equivalent"*4.18896e-07*1000)+("Air pollution of composting/CO2 equivalent"*4.18896e-07*1000)+("Air pollution of INC/CO2 equivalent"*4.18896e-07*1000)+("Air pollution of landfilling/CO2 equivalent" *4.18896e-07*1000)+("Air pollution of recycling/CO2 equivalent"*4.18896e-07*1000)+(annual amount of GHG emission from collection*6.7787e-13 *1000)	[7]
HV of dry waste	Kwh/ton	15000	[28]
HV of paper	Kwh/ton	12000	[28]
HV of plastic	Kwh/ton	25000	[28]
immigration	person/Year	immigration rate*population	-
immigration rate	1/Year	0.0115527	[10]
initial capacity of landfill	m3	1e+07	[9]
INITIAL TIME	Year	2020	-
Input waste to MRF	ton/Year	Mixed waste	-
K fertilizer saving	ton/Year	Fine compost*0.0032	[2]
K fertilizer saving from AD	ton/Year	Fertilizer generation from AD*0.0032	[2]
kg to ton convertor	kg/ton	1000	-
landfill food waste decomposition	ton/Year	Compost Residual +AD residual +The residual organic waste more than the compost capacity and AD	Proposed
landfill non-food waste decomposition	ton/Year	residual of metal after MRF +bottom ashes +The residual dry waste more than INC	Proposed
Landfill Utilization Rate	m3/Year	(Amount of waste to landfill/"Average waste density (D)")*(1-("Volume reduction of waste after compacted (P)" /100))+"The volume of soil cover (cv)"	[29]
landfill utilized	m3	INTEG (Landfill Utilization Rate, 0)	-
lower heating value of methane	MJ/m3	37.2	[30]
metal fraction	Dmnl	WITH LOOKUP (Time, ([(2008,0)-(2020,0.02)], (2011,0.008), (2017,0.0073), (2020,0.0105)))	[31]
metal in landfill	ton/Year	residual of metal after MRF	-
metal waste	ton/Year	metal fraction*total waste generated	-
Metals collected by waste scavengers	ton/Year	(metal waste-Recycled metal from origin)*Separated rate of valuable dry waste by waste scavengers	Proposed

methane content in the produced biogas	Dmnl	0.6	[25]
methane conversion efficiency	Dmnl	0.26	[2]
Mixed waste	ton/Year	total waste generated-recycled waste from origin-recycled waste by Waste Scavengers	Proposed
molecular weight ratio	Dmnl	11/3	[13]
N fertilizer saving	ton/Year	Fine compost*0.00935	[2]
N fertilizer saving from AD	ton/Year	Fertilizer generation from AD*0.00935	[2]
N2O emission factor for aerobic composting	ton/ton	0.0003	[4]
N2O emission factor for incineration	ton/ton	5e-05	[4]
net human health damage	DALY/Year	(Annual amount of Net GHG emissions from landfill*6.7787e-13*1000)+(Annual amount of Net GHG emission from AD*6.7787e-13 *1000) +(Annual amount of Net GHG emission from composting *6.7787e-13*1000)+ (Annual amount of Net GHG emission from incineration*6.7787e-13*1000)+ (Annual amount of Net GHG emission from waste recycling recovery *6.7787e-13*1000)+(amount of GHG emission from input materials in MRF*6.7787e-13*1000)	Proposed
Net damage cost to Biodiversity	USD/Year	waste damage cost to Biodiversity+(Annual amount of Net GHG emission from AD *0.00745657*1000)+(Annual amount of Net GHG emission from composting *0.00745657*1000)+(Annual amount of Net GHG emission from incineration*0.00745657*1000) + (Annual amount of Net GHG emissions from landfill*0.00745657*1000)+(Annual amount of Net GHG emission from waste recycling recovery*0.00745657*1000)+(amount of GHG emission from input materials in MRF*0.00745657*1000)	Proposed
Net damage cost to Human Health	USD/Year	(Annual amount of Net GHG emission from AD*0.00745657*1000)+(Annual amount of Net GHG emission from composting *0.00745657 *1000) +(Annual amount of Net GHG emission from incineration*0.00745657 *1000) + (Annual amount of Net GHG emissions from landfill *0.00745657*1000)+ (Annual amount of Net GHG emission from waste recycling recovery * 0.00745657 *1000) +(amount of GHG emission from input materials in MRF * 0.00745657 * 1000)	Proposed
net biodiversity damage	EINES/Year	(bottom ashes*3.03941e-16*1000)+(landfill food waste decomposition*4.69727e-16*1000)+(metal in landfill*3.69072e-16*1000)+(Unknown waste in landfill*6.32978e-16*1000)+(paper in landfill*6.45875e-16*1000)+(plastic in landfill*5.167e-16*1000)+("The volume of soil cover (cv)"*2.87056e-16*1000)+(textile in landfill*1.29175e-15*1000)+(wood in land fill* 2.5835e-15 *1000)+(fly ashes*4.10079e-16 *1000) +(Annual amount of Net GHG emissions from landfill*6.7787e-13*1000)+(Annual amount of Net GHG emission from AD*6.7787e-13 *1000) +(Annual amount of Net GHG emission from composting *6.7787e-13*1000)+	Proposed

		(Annual amount of Net GHG emission from incineration *6.7787e-13*1000)+ (Annual amount of Net GHG emission from waste recycling recovery *6.7787e-13*1000)+(amount of GHG emission from input materials in MRF*6.7787e-13*1000)	
Number of compactor truck service	service/Year	(Mixed waste*compactor truck usage percentage)/Average volume of compactor truck	Proposed
Number of pickup service	service/Year	(Mixed waste*pickup usage percentage)/Average volume of pickup	Proposed
Number of trailer truck service	service/Year	Mixed waste/Average volume of trailer truck	Proposed
Number of truck service	service/Year	(Mixed waste*Truck usage percentage)/Average volume of truck	Proposed
organic fraction	Dmnl	WITH LOOKUP (Time ([(2004,0.5)-(2020,0.8)], (2011,0.717), (2017,0.7173), (2020,0.7079)))	[31]
organic waste	ton/Year	organic fraction*total waste generated	-
Oxidation factor for landfill	Dmnl	0.1	[4]
P fertilizer saving	ton/Year	Fine compost*0.00235	[2]
P fertilizer saving from AD	ton/Year	Fertilizer generation from AD*0.00235	[2]
paper collected by waste scavengers	ton/Year	(paper waste-Recycled paper from origin)*Separated rate of valuable dry waste by waste scavengers	Proposed
paper fraction	Dmnl	WITH LOOKUP (Time,([(2008,0)-(2020,0.9)], (2011,0.081), (2017,0.0817), (2020,0.0668)))	[31]
paper in landfill	ton/Year	residual of paper after MRF*(1-rate of incineration)	-
paper waste	ton/Year	total waste generated*paper fraction	-
pickup fuel consumption	lit Petrol/Year	Number of pickup service*Average pickup fuel consumption per service	Proposed
pickup usage percentage	Dmnl	0.31	[8]
Plastic collected by waste scavengers	ton/Year	(plastic waste-Recycled plastic from origin)*Separated rate of valuable dry waste by waste scavengers	Proposed
plastic fraction	Dmnl	WITH LOOKUP (Time,([(2008,0)-(2020,0.2)], (2011,0.091), (2017,0.0894), (2020,0.1214)))	[31]
plastic in landfill	ton/Year	residual of plastic after MRF*(1-rate of incineration)	-
plastic waste	ton/Year	plastic fraction*total waste generated	-
population	person	INTEG (birth population +immigration- death population, 2.913e+06)	-
Primary Production damage	kg/Year	(bottom ashes*0.00442183*1000)+(landfill food waste decomposition *0.00683373 *1000) +(metal in landfill2*0.00536936 *1000) +(Unknown waste in landfill * 0.00920875 *1000) +(paper in landfill*0.00939638*1000) +(plastic in landfill* 0.00751711*1000)+("The volume of soil cover (cv)"*0.00417617*1000)+(textile in landfill*0.0187928*1000)+(wood in land fill*0.0375855*1000)+(fly ashes*0.00596596*1000)	[7]
proportion of carbon in domestic waste	Dmnl	0.2	[13]

rate of fertilizer generation	Dmnl	WITH LOOKUP Time, ([(2020,0)-(2050,1)], (2020,0), (2022,0), (2023,0), (2024,0), (2025,0.5),(2030,0.5), (2040,0.5), (2050,0.5)))	Assumption-expert
Recycled metal from origin	ton/Year	metal waste*recycling waste from origin	-
Recycled paper from origin	ton/Year	paper waste*recycling waste from origin	-
Recycled plastic from origin	ton/Year	plastic waste*recycling waste from origin	-
recycled waste by Waste Scavengers	ton/Year	Plastic collected by waste scavengers +paper collected by waste scavengers +Metals collected by waste scavengers	-
recycled waste from origin	ton/Year	Recycled metal from origin +Recycled paper from origin +Recycled plastic from origin	-
Reduced number of trailer service in waste recycling	service/Year	(recycled waste from origin +recycled waste by Waste Scavengers)/Average volume of trailer truck	Proposed
Reducing fuel consumption in transporting separated waste	lit Gasoline/Year	Reduced number of trailer service in waste recycling*Average trailer truck fuel consumption per service	Proposed
Rejection percentage	Dmnl	0.25	[2]
residual of metal after MRF	ton/Year	metal waste-Recycled metal from origin-Metals collected by waste scavengers -separated metal in MRF	Proposed
residual of Non-valuable dry waste after MRF	ton/Year	residual of textile after MRF +residual of Unknown waste after MRF +residual of wood after MRF	Proposed
residual of organic waste after MRF	ton/Year	MIN(Input waste to MRF, organic waste)	Proposed
residual of paper after MRF	ton/Year	paper waste-Recycled paper from origin-paper collected by waste scavengers -separated paper in MRF	Proposed
residual of plastic after MRF	ton/Year	plastic waste-Recycled plastic from origin-Plastic collected by waste scavengers-separated plastic in MRF	Proposed
residual of textile after MRF	ton/Year	MIN(Input waste to MRF, textile waste)	Proposed
residual of Unknown waste after MRF	ton/Year	MIN(Input waste to MRF, Unknown waste)	Proposed
residual of wood after MRF	ton/Year	MIN(Input waste to MRF, wood waste)	Proposed
separated metal in MRF	ton/Year	MIN(Input waste to MRF , (metal waste-Recycled metal from origin-Metals collected by waste scavengers))*Separated rate of valuable dry waste from MRF	Proposed
separated paper in MRF	ton/Year	MIN(Input waste to MRF , (paper waste-Recycled paper from origin-paper collected by waste scavengers)) *Separated rate of valuable dry waste from MRF	Proposed
separated plastic in MRF	ton/Year	MIN(Input waste to MRF , (plastic waste-Recycled plastic from origin-Plastic collected by waste scavengers)) *Separated rate of valuable dry waste from MRF	Proposed
Separated rate of valuable dry waste by waste scavengers	Dmnl	WITH LOOKUP (recycling waste from origin, ([(0,0)-(0.7,0.5)], (0,0.3), (0.1,0.23), (0.2,0.17), (0.3,0.12), (0.4,0.07), (0.5,0.02), (0.6,0.01)))	Assumption-expert
sludge from AD	ton/Year	AD plant treatment*0.3	[3]

Social assets damage	USD/Year	(bottom ashes*0.00335855*1000)+(landfill food waste decomposition* 0.00519048 *1000) +(metal in landfill*0.00407824*1000)+(Unknown waste in landfill *0.0069944 *1000) +(paper in landfill*0.00713691*1000) +(plastic in landfill* 0.00570953* 1000)+("The volume of soil cover (cv)" *0.00317196*1000)+(textile in landfill*0.0036251*1000)+(wood in land fill* 0.0285476*1000)+(fly ashes *0.0036251*1000)	[7]
textile fraction	Dmnl	WITH LOOKUP (Time,([(2008,0.01) -(2020,0.03)], (2011,0.027), (2017,0.0272), (2020,0.0209)))	[31]
textile in landfill	ton/Year	residual of textile after MRF*(1-rate of incineration)	-
textile waste	ton/Year	textile fraction*total waste generated	-
The residual dry waste more than INC	ton/Year	("residual of Non-valuable dry waste after MRF"+ residual of paper after MRF +residual of plastic after MRF)-amount of waste incineration	Proposed
The residual organic waste more than the compost capacity and AD	ton/Year	residual of organic waste after MRF-(AD plant treatment +Composting capacity)	Proposed
The volume of soil cover (cv)	m3/Year	Amount of waste to landfill*Coefficient of soil cover based on landfill	-
Total amount of avoided GHG from MSW	ton	annual amount of avoided GHG from MSW, 0)	-
total amount of Electricity required in recycling	Kwh/Year	amount of Electricity required in metal recycling +amount of Electricity required in paper recycling +amount of Electricity required in plastic recycling	Proposed
Total amount of environmental damage cost	USD	INTEG (Annual amount of environmental damage cost, 0)	-
Total amount of GHG emission from input materials from MSW	ton	INTEG (Annual amount of GHG emission from input materials from MSW,0)	-
Total amount of GHG emission from input materials in collection	ton	INTEG (annual amount of GHG emission from collection, 0)	-
Total amount of GHG emission from MSW	ton	INTEG (annual amount of GHG emission from MSW, 0)	-
Total amount of GHG reduction from input materials	ton	INTEG (annual of GHG reduction from input materials, 0)	-
Total amount of Net environmental damage cost	USD	INTEG (Annual amount of Net environmental damage cost, 0)	-
Total amount of Net GHG emission from composting	ton	INTEG (Annual amount of Net GHG emission from composting,0)	-
Total amount of Net GHG emission from incineration	ton	INTEG (Annual amount of Net GHG emission from incineration,0)	-
Total amount of Net GHG emission from MSW	ton	INTEG (annual amount of Net GHG emission from MSW,0)	-
Total amount of Net GHG emission from waste recycling recovery	ton	INTEG (Annual amount of Net GHG emission from waste recycling recovery,0)	-

Total amount of Net GHG emissions from landfill	ton	INTEG (Annual amount of Net GHG emissions from landfill, 0)	-
Total consumption of diesel fuel in collection and transportation	lit Gasoline/Year	compactor truck fuel consumption +trailer truck fuel consumption +truck fuel consumption	Proposed
Total mount of Net GHG emission from AD	ton	INTEG (Annual amount of Net GHG emission from AD,0)	-
total waste generated	ton/Year	(population*waste generation per capita)/kg to ton convertor	-
trailer truck fuel consumption	lit Gasoline/Year	Number of trailer truck service*Average trailer truck fuel consumption per service	Proposed
truck fuel consumption	lit Gasoline/Year	Number of truck service*Average truck fuel consumption per service	-
Truck usage percentage	Dmnl	0.22	[8]
Unknown fraction	Dmnl	WITH LOOKUP (Time,([(2008,0.05) -(2020,0.09)], (2011,0.07), (2017,0.0714), (2020,0.0693)))	[31]
Unknown waste	ton/Year	total waste generated*Unknown fraction	-
Unknown waste in landfill	ton/Year	residual of Unknown waste after MRF*(1-rate of incineration)	-
Volume reduction of waste after compacted (P)	Dmnl	IF THEN ELSE(CH4 collection efficiency from managed landfill<=0, 0.4 , 0.9)	[9]
waste damage cost to Biodiversity	USD/Year	(bottom ashes*3.34335e-06*1000)+(landfill food waste decomposition *5.167e-06 *1000)+(metal in landfill *4.05979e-06*1000)+(Unknown waste in landfill *6.96276e-06*1000)+(paper in landfill *7.10463e-06*1000) +(plastic in landfill*5.6837e-06*1000)+("The volume of soil cover (cv)" * 3.15761e-06*1000) +(textile in landfill*1.42093e-05*1000)+(wood in land fill * 2.84185e-05*1000)+(fly ashes*4.51e-06*1000)	[6]
waste generation per capita	kg/person/Year	WITH LOOKUP (Time, ([(2011,200)-(2020,300)], (2011,229.95), (2016,255.5), (2017,255.135),(2020 , 247.105)))	[32]
wood fraction	Dmnl	WITH LOOKUP (Time, ([(2008,0.003)-(2020,0.007)], (2011,0.006), (2017,0.0057), (2020,0.0032)))	[31]
wood in land fill	ton/Year	residual of wood after MRF*(1-rate of incineration)	-
wood waste	ton/Year	total waste generated*wood fraction	-

Table S3. The variables and equations related to the implementation of the scenarios

Variable	Scenarios	Type	Values and Equations
S1	recycling	recycling waste from origin	WITH LOOKUP (Time, ([(2020,0)-(2050,0.7)], (2020.09,0.1), (2023,0.1), (2025.05,0.27), (2028.9,0.5), (2035,0.65), (2039.54,0.7), (2050,0.7))
S2	Sanitary landfill	CH4 collection efficiency from managed landfill	WITH LOOKUP (Time, ([(2020,0)-(2050,1)], (2020,0), (2022,0), (2023,0.75), (2024,0.75), (2025,0.75), (2030,0.75), (2040,0.75), (2050,0.75))
S3	composting	Separated rate of valuable dry waste from MRF	WITH LOOKUP (Time, ([(2020,0)-(2050,0.5)], (2020,0), (2022,0), (2023,0.5), (2030,0.5), (2040,0.5), (2050,0.5))
		rate of composting	WITH LOOKUP (Time, ([(2020,0)-(2050,0.5)], (2020,0), (2022,0), (2023,0.5), (2030,0.5), (2040,0.5), (2050,0.5))
S4	AD	Separated rate of valuable dry waste from MRF	WITH LOOKUP (Time, ([(2020,0)-(2050,0.5)], (2020,0), (2022,0), (2023,0.5), (2030,0.5), (2040,0.5), (2050,0.5))
		Rate of AD	WITH LOOKUP (Time, ([(2020,0)-(2050,1)], (2020,0), (2022,0), (2023,0), (2024,0), (2025,0.5), (2030,0.5), (2040,0.5), (2050,0.5))
S5	INC	rate of incineration	WITH LOOKUP (Time, ([(2020,0)-(2050,1)], (2020,0), (2022,0), (2023,0), (2024,0), (2025,1), (2030,1), (2040,1), (2050,1))
S6	ISWM	recycling waste from origin	WITH LOOKUP (Time, ([(2020,0)-(2050,0.7)], (2020.09,0.1), (2023,0.1), (2025.05,0.27), (2028.9,0.5), (2035,0.65), (2039.54,0.7), (2050,0.7))
		CH4 collection efficiency from managed landfill	WITH LOOKUP (Time, ([(2020,0)-(2050,1)], (2020,0), (2022,0), (2023,0.75), (2024,0.75), (2025,0.75), (2030,0.75), (2040,0.75), (2050,0.75))
		Separated rate of valuable dry waste from MRF	WITH LOOKUP (Time, ([(2020,0)-(2050,0.5)], (2020,0), (2022,0), (2023,0.5), (2030,0.5), (2040,0.5), (2050,0.5))
		rate of composting	WITH LOOKUP (Time, ([(2020,0)-(2050,0.5)], (2020,0), (2022,0), (2023,0.5), (2030,0.5), (2040,0.5), (2050,0.5))
		Rate of AD	WITH LOOKUP (Time, ([(2020,0)-(2050,1)], (2020,0), (2022,0), (2023,0), (2024,0), (2025,0.5), (2030,0.5), (2040,0.5), (2050,0.5))
		rate of incineration	WITH LOOKUP (Time, ([(2020,0)-(2050,1)], (2020,0), (2022,0), (2023,0), (2024,0), (2025,1), (2030,1), (2040,1), (2050,1))

Validation tests for the system dynamics model

We examined the model with structure assessment tests as presented by Rahmandad et al. [33]. The structure assessment tests involved both direct structure and structure-oriented behavior tests. The direct structure test involved relations and assumptions and relevant variables, and examined the static structure of the model. First, the dimensional consistency test was used to check the structural validity of the model. The dimension consistency test shows the correctness of the selection and entry of units in the mathematical model, Figure S10 shows the result of the dimensional consistency.

After confirming the compatibility test of the dimensions, the initial simulation was performed. In this section, the change diagram of each of the key and important variables of the flow diagram of the waste management system, whose behavior is important for determining the overall state of waste management, was examined. The structuralist behavior test considers the behavior of the model with some selected parameters and their extreme values, as well as in a sensitivity analysis with a constant step parameter change to investigate the behavior. In the initial simulation, the amount of total waste generated, which has the role of input to the system, was investigated. The behavior of total waste generated was influenced by the population, and with the increase of this variable, the amount of total waste generated also increases (Figure S11). In addition, the amount of waste in different treatment methods was checked and it was found that in the BAU scenario, there is no input waste to these methods and all the waste is transferred to the landfill (Figure S12).

Extreme conditions were examined to inspect the equations for extreme values and the plausible response when subjected to extreme values of the parameters. This test checked the model behavior no matter how extreme the policy would be to impose. To perform extreme condition experiment, extreme values were given to selected parameter: "recycling waste from origin". Four scenarios were done for validation: scenario A (recycling waste from origin = 0.2, which was the first extreme condition test), scenario B (recycling waste from origin = 0.4), scenario C (recycling waste from origin = 0.6), and scenario D (recycling waste from origin = 0.8, which was the fourth extreme condition test). Results from scenario A present that the accumulated amount of recycled waste at the end of 30 years will be 3,418,030 ton. For scenario B, there is an increase of 9% in the total recycled waste, reaching 3,723,760 ton. With scenario C, there is an increase of 23% in the total amount of recycled waste (4,191,010 ton), accumulated during the simulation horizon. For scenario D, accumulated amount of recycled waste at the end of 30 years will be 48,762,100 ton with 39% increase (Figure S13).

The graph of actual and estimated values for population and total waste variables is shown in Figure S14 and Figure S15. The reference mode presents real data about population and total waste generated in Figure S14 and Figure S15, respectively.

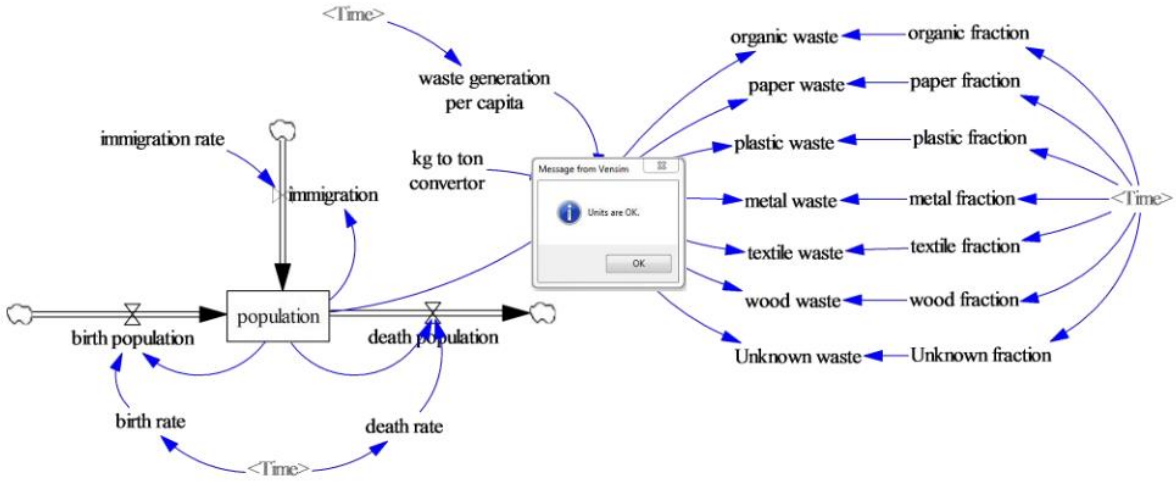


Figure S10. The result of the dimension consistency test

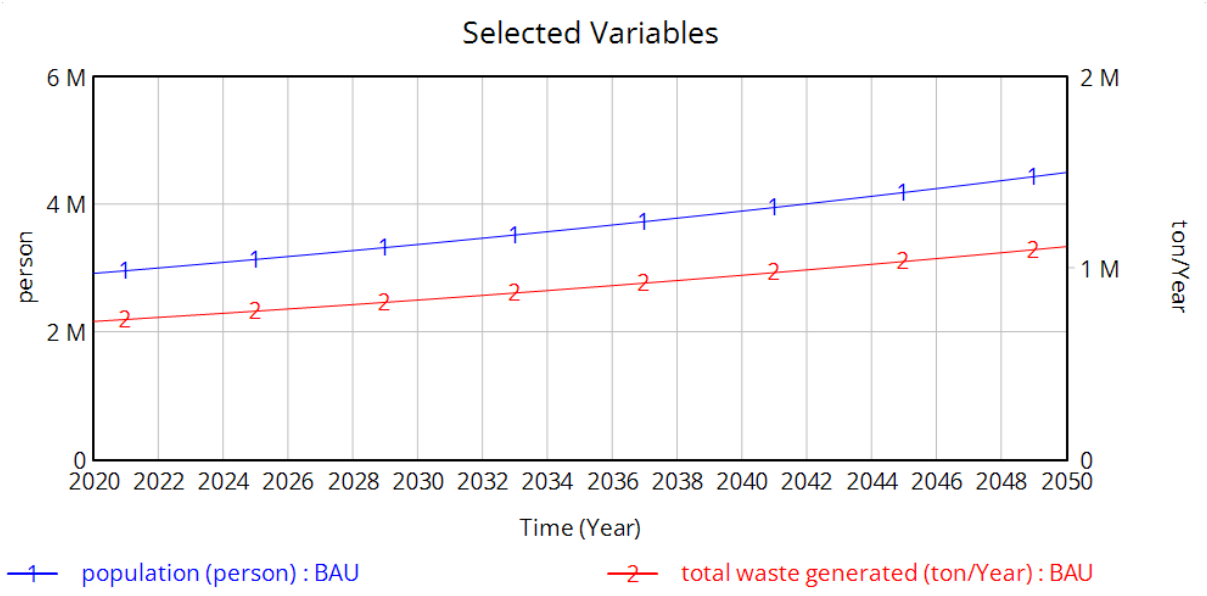


Figure S11. Behavior of population and total waste generated variables

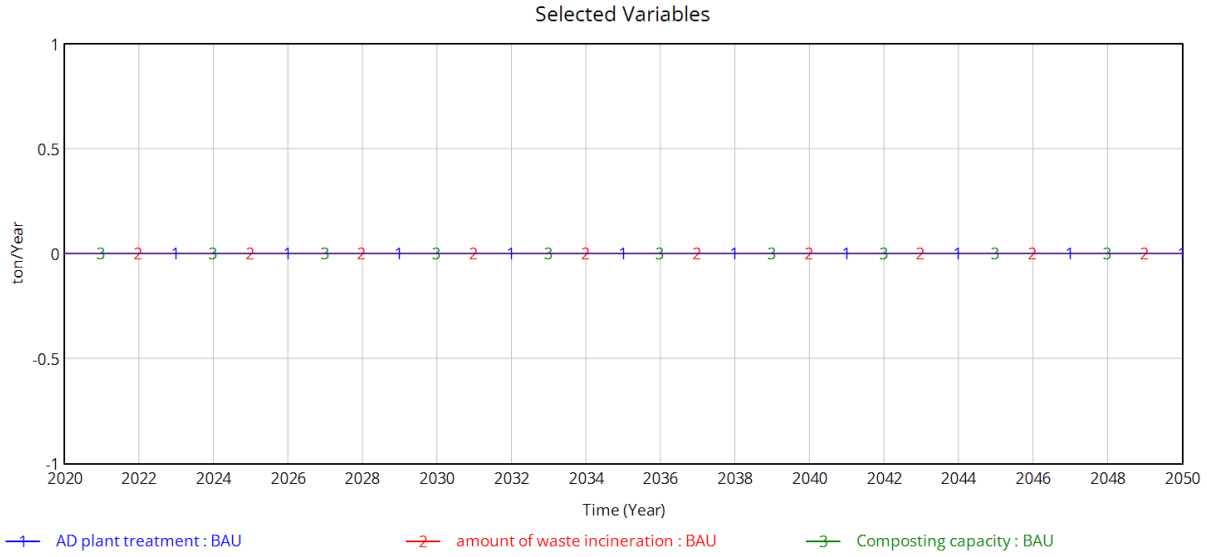


Figure S12. Amount of waste in anaerobic digestion, incineration and composting in the BAU Scenario

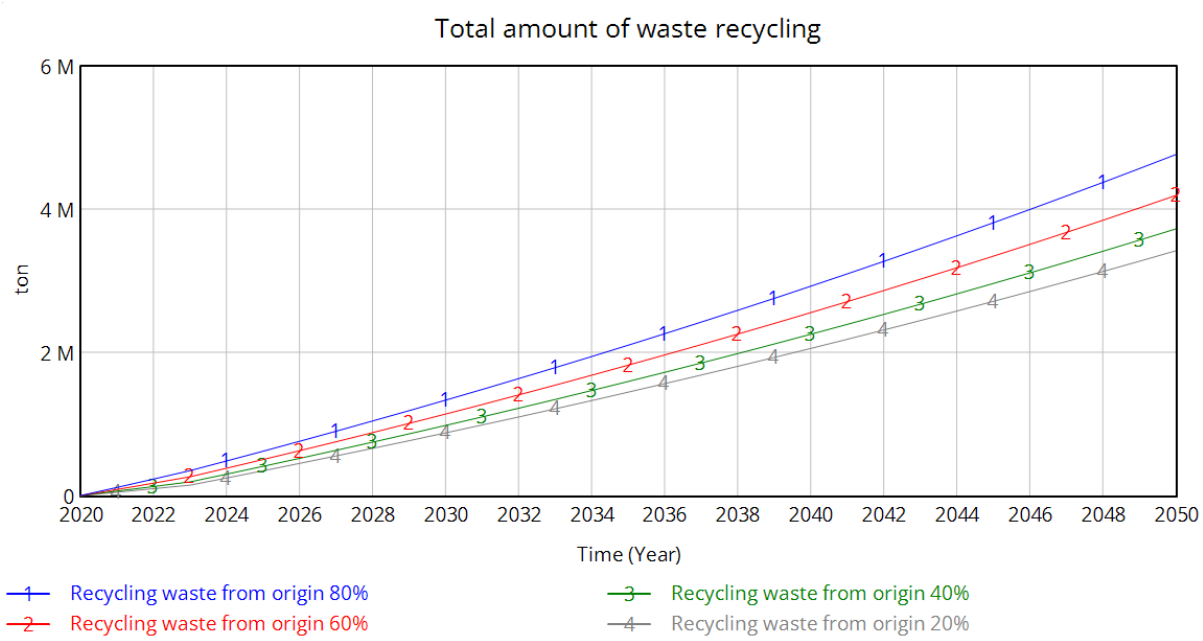


Figure S13. The result of the extreme condition test for recycling waste form the origin

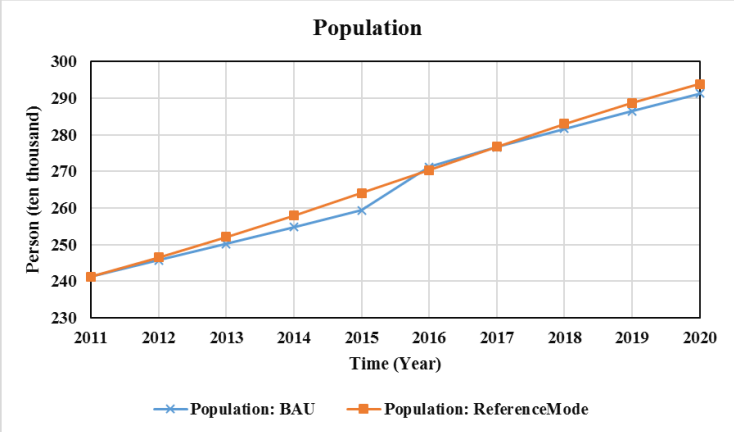


Figure S14. Behavior reproduction tests for the population

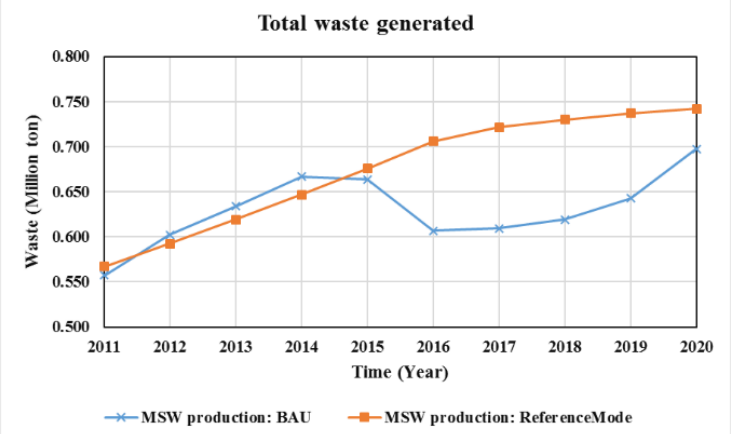


Figure S15. Behavior reproduction tests for the total waste

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