

Table S1 Detailed technology descriptions implemented in Plant A and Plant B product systems.	2
Table S2. Normalized wastewater flow rates and substance concentrations of both influent and effluent for Plant A and Plant B for scenarios 0: discharge without treatment, 1: conventional WWTPs and 2: biofactory WW-CE [1].	3
Table S3. Normalized biosolid flow rates and substance concentrations for Plant A and Plant B for scenarios 0: discharge without treatment, 1: conventional WWTPs and 2: biofactory WW-CE [1].	4
Table S4. <i>Capital investment and maintenance costs of Plant A and Plant B normalized to 1,000,000 p.e./ day for scenarios 0: discharge without treatment, 1: conventional wastewater treatment plants and 2: biofactory wastewater circular economies.</i>	5
Table S5. Integrated LCA and LCC inventories of Plant A and Plant B normalized to 1,000,000 p.e./ day for scenarios 0: discharge without treatment, 1: conventional wastewater treatment plants and 2: biofactory wastewater circular economies.	6
Table S6. LCA inventory outputs of Plant A and Plant B normalized to 1,000,000 p.e./ day for scenarios 0: discharge without treatment, 1: conventional wastewater treatment plants and 2: biofactory wastewater circular economies.	8
Table S7. Type II SLCA stakeholder quantities per product system of Plant A and Plant B normalized to 1,000,000 p.e./ day for scenarios 0: discharge without treatment, 1: conventional wastewater treatment plants and 2: biofactory wastewater circular economies.	9
Table S8. Social Life Cycle Assessment Type II midpoint characterization inventories of Plant A and Plant B normalized to 1,000,000 p.e./ day for scenarios 0: discharge without treatment, 1: conventional wastewater treatment plants and 2: biofactory wastewater circular economies.	10
Table S9. Summary of the relationships between social impact categories, inventory categories and subcategories to relevant stakeholders [7].	11
Supplementary Data S1	12
Figure S1. Comparison of equal, entropy and ranked reciprocal weighted sum methods for overall sustainability impact.....	13

Table S1 Detailed technology descriptions implemented in Plant A and Plant B product systems.

Product System	Unit Process	Plant A	Plant B
Water Treatment	Primary treatment	16 x 4,000 m ³ rectangular sedimentation tanks	12 x 5,000 m ³ circular sedimentation tanks
	Waste Activated Sludge (WAS)	16 x 11,300 m ³ aerobic reactors	16 x 11,500 m ³ aerobic reactors
		16 x 6,000 m ³ circular clarification tanks	16 x 6,000 m ³ circular sedimentation tanks
	Disinfection contact chambers	2 x 15,000 m ³ rectangular raceways	2 x 15,000 m ³ rectangular raceways
Biosolids Production	Primary Sludge Thickening	4 x 7,000 m ³ circular gravitational thickeners	6 x 1,500 m ³ circular gravitational thickeners
	Secondary Sludge Thickening	6 x 1,000 m ³ flotation thickeners	8 x 2.5 m wide table thickeners
	Pre-thickening Thermal Hydrolysis		6 x 1,500 m ³ gravitational pre-thickeners
	Thermal Hydrolysis CAMBI		2 x hydrolysis tanks, 6-11 bars, 140 °C
	Anaerobic Digestors	8 x 15,000 m ³ reactors	7 x 14,000 m ³ reactors
	Centrifuge	5 x 2,300 kg TS/ h centrifuges	6 x 1,500 kg TS/ h centrifuges
	Gasometers	2 x 27.5 m diameter	2 x 27.5 m diameter
Biogas Production	Biogas Scrubbers	1 x 4,500 Nm ³ / h capacity	2 x 4,500 Nm ³ / h capacity
	Biogas Carbon Dioxide Removal	1 x 4,500 Nm ³ / h capacity	
Nutrient Removal	Coagulation-Flocculation	1 x 4,000 m ³ rectangular tank	
	Sequencing Batch Reactors	1 x 4,000 m ³ rectangular tank	1 x 4,000 m ³ rectangular tank
	Anammox DEMON Reactors	1 x 4,000 m ³ rectangular tank	1 x 4,000 m ³ rectangular tank

Table S2. Normalized wastewater flow rates and substance concentrations of both influent and effluent for Plant A and Plant B for scenarios 0: discharge without treatment, 1: conventional WWTPs and 2: biofactory WW-CE [1].

			Influent Characteristics						Effluent Characteristics					
			Plant A Scenarios			Plant B Scenarios			Plant A Scenarios			Plant B Scenarios		
Parameters			0	1	2	0	1	2	0	1	2*	0	1	2
Normalized Flows (m ³ / FU)	Description	Q	131,395.1	129,391.3	130,823.0	153,745.3	155,767.5	156,685.8	131,395.1	125,724.5	127,115.6	153,745.3	144,686.4	145,539.3
Substance Concentrations (mg/ L)	Total Solids	TS	351.99	506.76	516.46	321.18	364.18	359.65	351.99	26.46	30.40	321.18	12.87	14.22
	Volatile Solids	VS	268.86	384.81	394.21	266.60	296.99	294.27	268.86	22.13	25.88	266.60	11.48	12.67
	Total Kjeldahl Nitrogen	TKN	77.94	98.72	74.03	71.58	83.94	72.30	77.94	54.48	38.88	71.58	40.92	36.34
	Nitrate	NO ³	0.00	0.00	0.00	0.00	0.00	0.00	0	0.87	0.73	0	0.60	0.53
	Nitrite	NO ²	0.00	0.00	0.00	0.00	0.00	0.00	0	0.44	0.48	0	0.68	0.60
	Total Nitrogen	TN	77.94	98.72	77.00	71.58	83.94	72.30	77.94	55.79	39.81	71.58	41.20	36.59
	Total Phosphorous	TP	8.70	9.98	8.93	7.09	8.84	7.84	8.70	2.24	1.88	7.09	1.83	1.75
	Biological Oxygen Demand	BOD ₅	338.67	343.92	339.83	289.44	285.68	284.01	338.67	17.68	19.19	289.44	17.81	17.96
	Chemical Oxygen Demand	COD	616.19	627.94	618.56	645.27	640.49	631.73	616.19	52.83	58.99	645.27	55.27	56.99
	Chlorine	Cl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.26	0.00	0.33	0.33
	Arsenic	As	0.0027	0.0039	0.0039	0.0025	0.0028	0.0028	0.0027	0.0002	0.0002	0.0025	0.0001	0.0001
	Cadmium	Cd	0.0005	0.0007	0.0007	0.0004	0.0004	0.0004	0.0005	0.0000	0.0000	0.0004	0.0000	0.0000
	Chromium	Cr	0.0456	0.0656	0.0668	0.1058	0.1090	0.1077	0.0456	0.0034	0.0039	0.1058	0.0042	0.0047
	Copper	Cu	0.1747	0.2534	0.2578	0.3285	0.3386	0.3344	0.1747	0.0155	0.0178	0.3285	0.0156	0.0172
	Mercury	Hg	0.0004	0.0006	0.0006	0.0003	0.0004	0.0004	0.0004	0.0000	0.0000	0.0003	0.0000	0.0000
	Molybdenum	Mo	0.0038	0.0055	0.0056	0.0054	0.0061	0.0061	0.0038	0.0003	0.0003	0.0054	0.0002	0.0002
	Nickle	Ni	0.0156	0.0225	0.0229	0.0249	0.0157	0.0155	0.0156	0.0012	0.0014	0.0249	0.0010	0.0011
	Lead	Pb	0.0146	0.0211	0.0214	0.0152	0.0164	0.0162	0.0146	0.0011	0.0013	0.0152	0.0006	0.0007
	Selenium	Se	0.0010	0.0015	0.0015	0.0009	0.0011	0.0010	0.0010	0.0001	0.0001	0.0009	0.00004	0.00004
	Zinc	Zn	0.4038	0.5834	0.5936	0.3685	0.3798	0.3751	0.4038	0.0331	0.0381	0.3685	0.0161	0.0178
	Iron	Fe	0.0079	0.0114	0.0116	0.0072	0.0063	0.0062	0.0079	0.0006	0.0007	0.0072	0.0003	0.0003
	Calcium	Ca	20.3237	29.2445	29.7547	18.5451	19.1164	18.8785	20.3237	1.5280	1.7555	18.5451	0.7429	0.8211
	Magnesium	Mg	2.7475	3.9534	4.0224	2.4975	2.5744	2.5424	2.7475	0.2066	0.2373	2.4975	0.1000	0.1106
	Manganese	Mn	0.1672	0.2395	0.2438	0.1526	0.1018	0.1005	0.1672	0.0118	0.0136	0.1526	0.0058	0.0064

*Not including water recovery

Table S3. Normalized biosolid flow rates and substance concentrations for Plant A and Plant B for scenarios 0: discharge without treatment, 1: conventional WWTPs and 2: biofactory WW-CE [1].

Parameters		Plant A Scenarios		Plant B Scenarios	
		1	2	1	2
Normalized Flows (m ³ / FU)	Q	100.16	100.16	131.15	132.39
Substance Concentrations (mg/L)	TS	202245.94	215142.51	196432.27	202245.94
	VS	123572.27	133123.13	117458.08	129293.38
	TN (TKN)	11366.22	8570.55	7250.86	7737.80
	TP	3076.95	2672.56	5617.12	2009.89
	BOD ₅	196026.00	171690.96	152376.80	128943.03
	COD	370948.98	371677.31	395834.80	325788.59
	Cl	0.00	0.00	0.00	0.00
	As	1.54	1.64	1.51	1.56
	Cd	0.24	0.26	0.22	0.23
	Cr	23.82	25.34	58.81	60.55
	Cu	91.25	97.07	182.64	188.05
	Hg	0.22	0.24	0.20	0.21
	Mo	2.18	2.32	3.32	3.41
	Ni	5.00	5.31	8.46	8.71
	Pb	8.01	8.52	8.84	9.10
	Se	0.59	0.62	0.57	0.59
	Zn	210.94	224.39	204.88	210.94
	Fe	3.50	3.73	3.40	3.50
	Ca	10616.09	11293.05	10310.93	10616.09
	Mg	1435.14	1526.65	1388.58	1429.68
	Mn	56.51	60.11	54.88	56.51

Table S4. Capital investment and maintenance costs of Plant A and Plant B normalized to 1,000,000 p.e./ day for scenarios 0: discharge without treatment, 1: conventional wastewater treatment plants and 2: biofactory wastewater circular economies.

Input	Product System	Unit/ FU	Plant A Scenarios		Plant B Scenarios		Sources
			1	2	1	2	
Capital Investment Civil Works and Equipment	Water Treatment	\$USD	74,522	76,038	158,312	159,246	[1], [2]
	Sludge Treatment		42,312	42,780	60,058	79,545	
	Biosolids Recovery		0	12,680	0.00	18,301	
	Biogas Recovery		0	5,692	0.00	18,368	
	Anammox		0	21,844	0.00	23,887	
Maintenance Costs Civil Works and Equipment	Water Treatment		775	791	1,200	1,106	
	Sludge Treatment		844	853	1,083	1,640	
	Biosolids Recovery		0	142	0	136	
	Biogas Recovery		0	234	0	844	
	Anammox		0	227	0	166	

Table S5. Integrated LCA and LCC inventories of Plant A and Plant B normalized to 1,000,000 p.e./ day for scenarios 0: discharge without treatment, 1: conventional wastewater treatment plants and 2: biofactory wastewater circular economies.

Inputs/ Outputs	Product System	Inventory Description	Unit/ FU	Plant A Scenarios		Plant B Scenarios		Source	LCC Prices	Plant A Scenarios		Plant B Scenarios		Source
				1	2	1	2		\$USD/ Unit	1	2	1	2	
Chemicals	Water	Influent	m³	129,936	131,694	155,767	156,686	[1]	0.854	110,970	112,470	133,030	133,810	[1]
		Chlorine	kg	579	636	890	890		0.68	394	433	605	605	
	Sludge	Polymers		1,064	1,039	395	790		4.62	4,916	4,800	1,826	3,648	
		Ferric Chloride		233	242	0	0		739.51	172,306	178,961	0	0	
	Energy Recovery	Caustic Soda		0	1,007	0	1,921		0.00344	0	3.5	0	6.6	
		Nutrients		0	5	0	2		3.3	0	16.5	0	5.9	
		Activated Carbon		0	16.5	0	0	[3]	0.28	0	46.2	0	0	
		Refrigerant		0	0	0	701	[1]	31.16	0	0	0	21,843	
		Motor Oil		0	0	0	124		12.15	0	0	0	1,507	
	Nitrogen Abatement	Sulfuric Acid		0	1,047	0	66	[4]	0.7	0	733	0	46	
		Caustic Soda		0	748	0	0		0.00344	0	2.6	0	0	
		Ferric Chloride		0	3	0	0		739.51	0	2,219	0	0	
		Magnesium Oxide		0	0	0	286		0.66	0	0	0	189	
Energy	Water	Activated Sludge	kWh	25,669	27,396	31,996	32,975	[1]	0.0075	192.5	205.5	239.9	247.3	Assumption
	Sludge	Thickening		2,294	2,427	2,866	2,969	[3]	0.0075	17.2	18.2	21.5	22.3	
		Anaerobic Digestion		17,052	18,040	17,676	18,308	[1]	0.0075	127.89	135.3	132.6	137.3	
		Centrifuge		1,529	1,618	1,911	1,979	[3]	0.0075	11.47	12.14	14.3	14.8	
		THP		0	0	0	11,875		0.0075	0	0	0	89.1	
	Energy Recovery	Biogas Upgrading (H2S)		0	3,291	0	2,944	[5]	0.0075	0	24.68	0	22.1	
		Biogas Methanization (CO2)		0	2,962	0	0		0.0075	0	22.22	0	0	
		Biomethane Gas to Grid		0	7,618	0	0	[1]	0.0075	0	57.12	0	0	
	Nitrogen Abatement	Anammox		0	1,250	0	3,010	[3]	0.0075	0	9.375	0	22.6	
Transport and Waste Transport*	Water Treatment	Cl ₂	t-km	208	222	508	511	[1]	0					[1]
	Biosolids Management *	Biosolids Landfill	kg	20,256	5,130	25,762	3,350		47	151,920	38,475	193,215	25,125	
		Biosolids Agriculture		0	15,400	0	22,413		7.5	0	115,500	0	168,100	

	Energy Recovery	NaOH	t-km		612		1434		0	0	0	0	0	
		Nutrients (Glucose)			6		2		0	0	0	0	0	
		AC			9				0	0	0	0	0	
		Refrigerant					418		0	0	0	0	0	
		Motor Oil Lubricant					71		0	0	0	0	0	
	Nitrogen Removal	H ₂ SO ₄					2		0	0	0	0	0	
		MgO					378		0	0	0	0	0	
		FeCl ₃			463				0	0	0	0	0	
		NaOH			599				0	0	0	0	0	
Products and avoided products	Water	Treated Effluent	m ³	0	26,340	0	0		0.854	0	22,493	0	0	
	Biosolids Management	Fertilizer	Kg	0	7,700	0	11,207		0.65	0	5,005	0	7,285	[6]
	Energy Recovery	Natural Gas	kg	0	31,355	0	0		0.132	0	4,160	0	0	[1]
		Electricity	kWh	0	18,040	0	66,083		0.0075	0	0	0	496	Assumption

Table S6. LCA inventory outputs of Plant A and Plant B normalized to 1,000,000 p.e./ day for scenarios 0: discharge without treatment, 1: conventional wastewater treatment plants and 2: biofactory wastewater circular economies.

				Plant A Scenarios		Plant B Scenarios		
Outputs	System	Description	Unit/FU	1	2	1	2	Sources
Emissions to Air	All	CO ₂	kg	16620	17184	28800	6490	Table E.3 and E.6 Supplementary Data
		CO ₂ Biogenic		124200	125270	209100	192982	
		CO		0	0	0	3	
		CH ₄ Biogenic		24208	25306	25784	25029	
		NO _x		0	0	1	3	
		PM		3	2	4	1	
		H ₂ S		310	0	368	0	
		N-NO ₂		76	99	91	70	
Energy	Sludge Treatment	Anaerobic Digester Boiler	kWh		17076		18627	[1]
	Energy Recovery	DBM Supply			31355			
		Electricity CHP Self-Supply					32692	
		Electricity Injected to Grid					4458	
		Heat Recovery THP Boiler					10306	

Table S7. Type II SLCA stakeholder quantities per product system of Plant A and Plant B normalized to 1,000,000 p.e./ day for scenarios 0: discharge without treatment, 1: conventional wastewater treatment plants and 2: biofactory wastewater circular economies.

Stakeholder	Product System	Description	Plant A Scenarios		Plant B Scenarios	
			1	2	1	2
Workers	Water		8	11	14	19
	Sludge		8	11	14	19
	Biosolids Management		0	1	0	1
	Energy		0	2	0	1
	Anammox		0	0	0	0
Local Community	Water	Community 1	248	248	9	9
		Community 2	579	579	112	112
		Community 3	6,617	6,617	0	0
		Laundry Service	0	1	0	0
		Clothes Recycling	0	1	0	0
		Water Provider	0	1	0	0
	Biosolids	Community 1	0	496	0	398
		Community 2	0	33	0	27
Children	All	Local Communities	1,861	1,901	30	136
		School Supplies	191	191	268	268
		School Visits	1,006	791	1,414	1,112
		School Education	2,188	9,429	3,076	13,253
Farmers	Water		0	34	0	0
	Biosolids		0	66	0	93
Clients	Water	Population Equivalent	1,000,000	1,000,000	1,000,000	1,000,000
	Energy	Gas Company	0	496	0	0
VCA (Maintenance, Laboratory, Chemicals, Transport, Energy)	Water	Total	1.2	1.2	1.6	1.6
	Sludge	Total	1.3	1.3	1.6	1.6
	Biosolids	Total	0.2	0.2	0.2	0.2
	Energy	Total	0.0	0.7	0.0	0.7
	Anammox	Total	0.0	0.8	0.0	0.9
Society	All	Metropolitan Region	1,164,046	1,134,271	1,636,169	1,594,317

Table S8. Social Life Cycle Assessment Type II midpoint characterization inventories of Plant A and Plant B normalized to 1,000,000 p.e./ day for scenarios 0: discharge without treatment, 1: conventional wastewater treatment plants and 2: biofactory wastewater circular economies.

				Plant A Scenarios		Plant B Scenarios	
Impact Category	Subcategory Description	Indicator	Measure/Stakeholder/ FU	1	2	1	2
Working Conditions	Equal Opportunities \$	Training	Hours	0.16	6.67	0.26	4.16
		Fair Wage	%	73.58	96.00	99.16	140.99
	Inclusion %	Gender Equality	%	3.71	3.54	6.29	4.27
		Indigenous	%	0.00	0.00	0.00	0.00
		Disability	%	0.00	0.41	0.00	0.25
	Health and Safety (\$)	Accidents	$Days_{Lost}$	-137.71	-68.13	-233.42	-91.40
		Training Health and Safety	Hours	3.38	12.90	5.72	11.59
	Risk	Risk Level	Risk	-516.15	-555.92	-519.74	-1310.91
Socio-cultural Responsibility	Access to Immaterial Resources and Security %	Local Jobs/ VCA	%	19.21	30.60	31.76	39.02
		Promotion of Corporate Social Responsibility (CSR) with VCA	%	0.00	0.00	0.00	0.00
	Investigation and Development \$	Investigations and Development	\$	0.00	408.34	0.00	573.95
	Education \$	Education	Hours	1.84	16.08	4.05	34.05
		Participation in Farmers Organization	Hours	0.00	0.00	0.00	0.00
		Contribution to Preservation of Culture	Hours	0.00	0.00	0.00	0.00
		Community Initiatives and Corporate Social Responsibility (CSR)	\$	59.55	218.09	16.08	60.19
Environmental Responsibility	Access to Material Resources (\$)	Infrastructure with Community Access	\$	22.33	22687.61	48.36	1353.71
		Quality Assurance and Crop Yield	%	100.00	220.00	100.00	120.00
		End of Life Management	%	0.00	135.00	0.00	163.00
	Data (\$)	Legislative Compliance	N_{Events}	-11.91	-0.71	-0.19	-0.11
		Data Monitoring	Hours	7.00	9.02	7.00	7.49
		Management Systems	$N_{Systems}$	42.00	84.00	42.00	84.00
	Conservation (Ha)	Contribution to Ecological Conservation	Ha	2.23	2.23	0.04	0.04
Governance	Feedback Mechanisms (\$)	Feedback Mechanisms	Hours	1.95	65.92	7.49	49.93
		Complaints	$N_{Complaints}$	-6252.80	-20637.78	-29.02	-148.90
	Engagement (\$)	Inclusion of first nations	Hours	0.00	0.00	0.00	0.00
		Engagement	Hours	447.03	750.07	3.02	10.77
	Collective Bargaining (%)	Collective Bargaining	%	6.58	9.67	11.16	14.87

Table S9. Summary of the relationships between social impact categories, inventory categories and subcategories to relevant stakeholders [7].

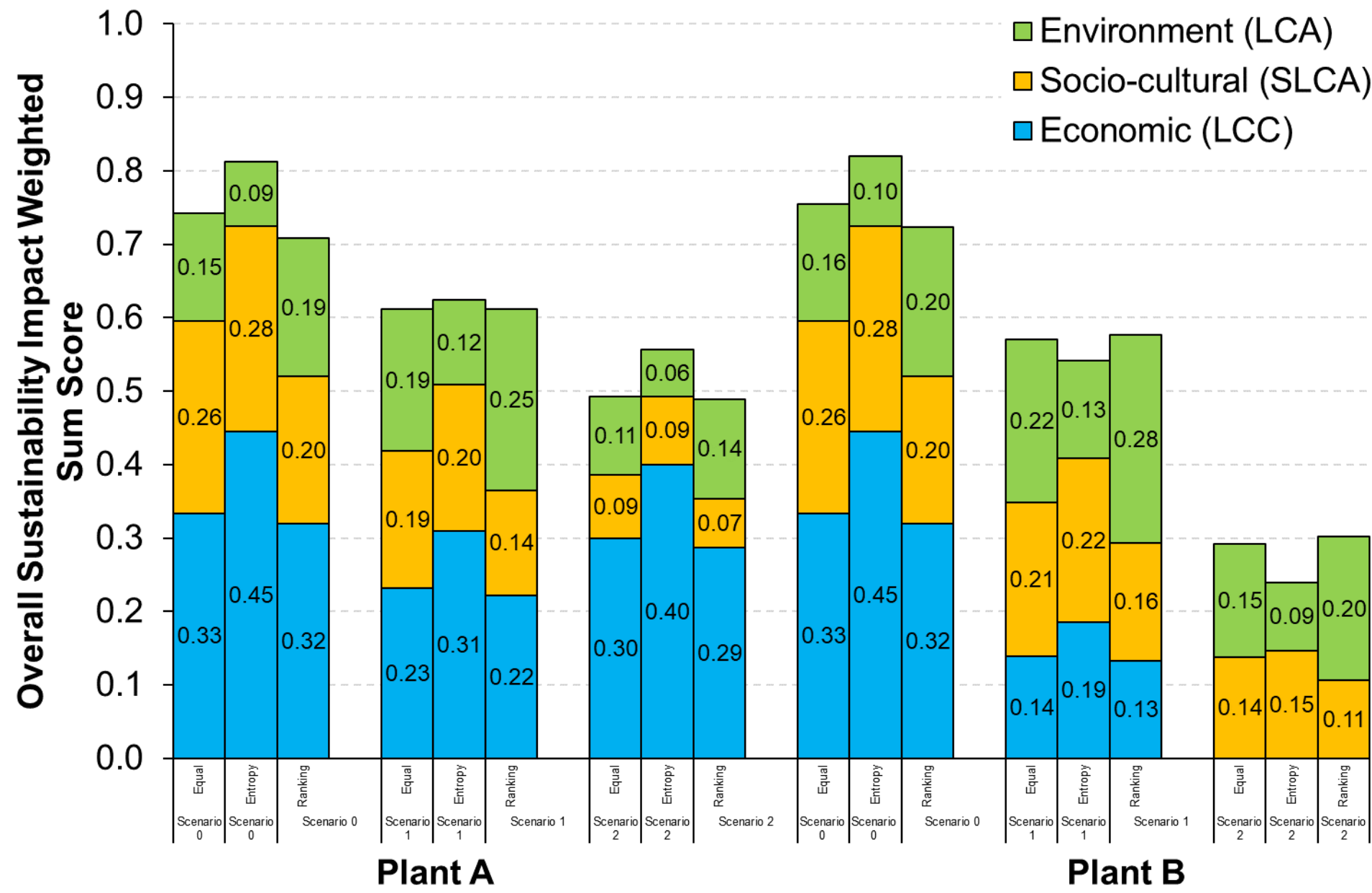
Impact Category	Abbreviation	Inventory Subcategory	Inventory Subcategory Indicators	Monetized Factors (USD/ Unit)	Unit/ FU	W	LC	F	VC A	C	S
Working Conditions	WC	Equal Opportunities (\$)	Training	2	Hours	✓					
			Fair Wage	2	%	✓					
		Inclusion (%)	Gender Equality	1	%	✓					
			Indigenous	1	%	✓					
			Disability	1	%	✓					
		Health and Safety (\$)	Accidents*	12	Days _{Lost}	✓					
			Training Health and Safety	2	Hours	✓					
		Risk	Risk Level*	1	Risk	✓					
Socio-cultural Responsibility	SR	Access to Immaterial (%)	Local Jobs/ VCA	1	%		✓		✓		
			Promotion of CSR	1	%						
		Technology (\$)	Investigations and Development	1	\$						✓
		Education (\$)	Education	2	Hours		✓	✓	✓		
			Participation in Farmers Organization	2	Hours			✓			
			Contribution to Preservation of Culture	2	Hours		✓				
			Community Initiatives and CSR	1	\$		✓				
Environmental Responsibility	ER	Access to Material Resources (\$)	Infrastructure with Community Access	1	\$		✓				
			Quality Assurance and Crop Yield	1	%			✓		✓	
			End of Life Management	1	%					✓	
		Data (\$)	Legislative Compliance*	80	N _{Events}		✓				
			Data Monitoring	2	Hours		✓			✓	
			Management Systems	14	N _{Systems}						✓
		Conservation (Ha)	Contribution to Ecological Conservation	1	Ha		✓				
Public Governance	PG	Feedback Mechanisms (\$)	Feedback Mechanisms	2	Hours		✓	✓	✓	✓	
			Complaints*	12	N _{Complaints}						
		Engagement (Hours)	Inclusion of First Nations	1	Hours			✓			
			Engagement	1	Hours		✓	✓	✓		
		Collective Bargaining (%)	Unionized workers	1	%	✓					

*Measures/ activity variables considered negative values to represent social risk

Supplementary Data S1

[Link to LCSA WW-CE survey Spanish](#)

Figure S1. Comparison of equal, entropy and ranked reciprocal weighted sum methods for overall sustainability impact.



References

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