|  |  |
| --- | --- |
| Run Specs | |
| Start Time | 2013 |
| Stop Time | 2040 |
| DT | 1/8 |
| Fractional DT | True |
| Save Interval | 0.125 |
| Sim Duration | 1.5 |
| Time Units | Years |
| Pause Interval | 0 |
| Integration Method | Euler |
| Keep all variable results | True |
| Run By | Run |
| Calculate loop dominance information | True |
| Exhaustive Search Threshold | 1000 |

|  |  |  |
| --- | --- | --- |
| Custom Unit | Aliases | Equation |
| kilowatt hours per day |  | kWh/day |
| kilowatts | kilowatt | kW |

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Equation | Units | Documentation |
| "Dumped\_waste\_into\_drainages\_or\_open\_spaces."(t) | "Dumped\_waste\_into\_drainages\_or\_open\_spaces."(t - dt) + (dumping\_waste) \* dt | tonnes |  |
| "Age\_cohort\_0-19"(t) | "Age\_cohort\_0-19"(t - dt) + (birth\_rate - "Maturing\_0-19" - "death\_rates\_0-19") \* dt | people |  |
| "Age\_cohort\_20-39"(t) | "Age\_cohort\_20-39"(t - dt) + ("Maturing\_0-19" + urbanisation\_rate - "Maturing\_20-39" - "death\_rates\_20-39") \* dt | people |  |
| "Age\_cohort\_40-59"(t) | "Age\_cohort\_40-59"(t - dt) + ("Maturing\_20-39" - "Maturing\_40-59" - "death\_rates\_40-59") \* dt | people |  |
| "Age\_cohort\_60+"(t) | "Age\_cohort\_60+"(t - dt) + ("Maturing\_40-59" - "Maturing\_60+" - "death\_rates\_60+") \* dt | people |  |
| "Attribute\_population\_class\_0-19"(t) | "Attribute\_population\_class\_0-19"(t - dt) + (increasing\_attribute - decreasing\_attribute) \* dt | People | Explanation: people in this age group with some Environmental Attribute |
| "Attribute\_Population\_class\_20-39"(t) | "Attribute\_Population\_class\_20-39"(t - dt) + (decreasing\_attribute + environmental\_knowledge\_increasing\_2 - decreasing\_attribute\_2) \* dt | People |  |
| "Attribute\_Population\_class\_40-59"(t) | "Attribute\_Population\_class\_40-59"(t - dt) + (decreasing\_attribute\_2 + environmental\_knowledge\_increasing\_3 - decreasing\_attribute\_3) \* dt | People |  |
| "Attribute\_Population\_class\_60+"(t) | "Attribute\_Population\_class\_60+"(t - dt) + (decreasing\_attribute\_3 + environmental\_knowledge\_increasing\_4 - decreasing\_attribute\_4) \* dt | People |  |
| Mixed\_waste(t) | Mixed\_waste(t - dt) + (mixed\_waste\_generation - Uncollected\_waste\_flow - Informal\_waste\_collecting - Formal\_waste\_collecting) \* dt | tonnes |  |
| Mixed\_Waste\_Collected\_by\_formal(t) | Mixed\_Waste\_Collected\_by\_formal(t - dt) + (Formal\_waste\_collecting - "waste\_transferring\_-\_formal") \* dt | tonnes |  |
| Mixed\_Waste\_collected\_by\_informal(t) | Mixed\_Waste\_collected\_by\_informal(t - dt) + (Informal\_waste\_collecting - Material\_recovery\_by\_informal\_sector - "waste\_transferring\_-\_informal") \* dt | tonnes |  |
| Recycled\_Material(t) | Recycled\_Material(t - dt) + (Waste\_recycling - "On-Site\_waste\_-\_Material\_Recovered") \* dt | tonnes |  |
| "Source-separated\_waste"(t) | "Source-separated\_waste"(t - dt) + ("on-site\_separation" - "collection\_of\_recyclables\_(formal)" - dumping\_stage\_1) \* dt | tonnes |  |
| Uncollected\_waste(t) | Uncollected\_waste(t - dt) + (Uncollected\_waste\_flow - dumping\_waste) \* dt | tonnes |  |
| Value\_recovered(t) | Value\_recovered(t - dt) + (value\_recovering - Annual\_Value\_Stream) \* dt | Euros |  |
| Waste\_Collected\_for\_Recycling(t) | Waste\_Collected\_for\_Recycling(t - dt) + ("collection\_of\_recyclables\_(formal)" - Waste\_recycling - dumping\_stage\_2) \* dt | tonnes |  |
| Waste\_in\_dumsites(t) | Waste\_in\_dumsites(t - dt) + (waste\_discharging) \* dt | Tonnes |  |
| "Waste\_in\_landfill\_(Kpone)"(t) | "Waste\_in\_landfill\_(Kpone)"(t - dt) + (Waste\_Inventory\_return\_to\_landfill - Decomposition) \* dt | tonnes |  |
| "Waste\_in\_landfill\_(Nsumnia)"(t) | "Waste\_in\_landfill\_(Nsumnia)"(t - dt) + (Waste\_transferring\_to\_Nsumnia) \* dt | tonnes |  |
| Waste\_inventory\_of\_formal\_recyclers(t) | Waste\_inventory\_of\_formal\_recyclers(t - dt) + ("waste\_transferring\_-\_formal" + "waste\_transferring\_-\_informal" - "Mixed\_Material\_recovering\_-\_formal" - Waste\_Inventory\_return\_to\_landfill - Waste\_transferring\_to\_Nsumnia) \* dt | tonnes |  |
| Annual\_Value\_Stream | Value\_recovered / year | Euros/Years |  |
| birth\_rate | fractional\_birth\_rate\*Total\_population | people/Years |  |
| "collection\_of\_recyclables\_(formal)" | "Source-separated\_waste"\*"Reference\_collection\_rate\_for\_source-separated\_waste" | tonnes/Years |  |
| "death\_rates\_0-19" | "death\_rate\_0-19"\*"Age\_cohort\_0-19" | people/Years |  |
| "death\_rates\_20-39" | "death\_rate\_20-39"\*"Age\_cohort\_20-39" | people/Years |  |
| "death\_rates\_40-59" | "death\_rate\_40-59"\*"Age\_cohort\_40-59" | people/Years |  |
| "death\_rates\_60+" | "death\_rate\_60+"\*"Age\_cohort\_60+" | people/Years |  |
| Decomposition | "Waste\_in\_landfill\_(Kpone)"\*(Informal\_recovery\_rate\_from\_landfill+Decomposition\_rate) | Tonnes/year |  |
| decreasing\_attribute | ("average\_attribute\_0-19")\*"Maturing\_0-19" | People/Years |  |
| decreasing\_attribute\_2 | ("average\_attribute\_20-39")\*"Maturing\_20-39" | People/Years |  |
| decreasing\_attribute\_3 | ("average\_attribute\_40-59")\*"Maturing\_40-59" | People/Years |  |
| decreasing\_attribute\_4 | "average\_attribute\_60+"\*"Maturing\_60+" | People/Years |  |
| dumping\_stage\_1 | "Source-separated\_waste"\*(1-"Reference\_collection\_rate\_for\_source-separated\_waste") | tonnes/Years |  |
| dumping\_stage\_2 | Waste\_Collected\_for\_Recycling\*(1-"Reference\_recycling\_rate\_for\_source-separated\_waste") | tonnes/Years | MAX(0, (Waste\_Collected\_for\_Recycling\*"Reference\_recycling\_rate\_for\_source-separated\_waste")-"Recycling\_capacity\_(per\_year)") |
| dumping\_waste | Uncollected\_waste \* dumping\_rate | tonnes/Years |  |
| environmental\_knowledge\_increasing\_2 | Constant\_effect\_of\_environmental\_campaigns\_#1\*decreasing\_attribute | People/Years |  |
| environmental\_knowledge\_increasing\_3 | Constant\_effect\_of\_environmental\_campaigns\_#2\*decreasing\_attribute\_2 | People/Years |  |
| environmental\_knowledge\_increasing\_4 | Constant\_effect\_of\_environmental\_campaigns\_#3\*decreasing\_attribute\_3 | People/Years |  |
| Formal\_waste\_collecting | Mixed\_waste \* "collection\_rate\_-\_formal" | Tonnes/year |  |
| increasing\_attribute | ("Marginal\_attribute\_for\_age\_cohort\_0-19" + Delayed\_impact) \* birth\_rate | People/Years |  |
| Informal\_waste\_collecting | Mixed\_waste \* "collection\_rate\_-\_informal" | tonnes/Years |  |
| Material\_recovery\_by\_informal\_sector | Mixed\_Waste\_collected\_by\_informal \* waste\_recovery\_rate\_of\_informal\_sector | tonnes/Years |  |
| "Maturing\_0-19" | "Age\_cohort\_0-19"/"Maturation\_time\_0-19" | people/Years |  |
| "Maturing\_20-39" | "Age\_cohort\_20-39"/"Maturation\_time\_20-39" | people/Years |  |
| "Maturing\_40-59" | "Age\_cohort\_40-59"/"Maturation\_time\_40-59" | people/Years |  |
| "Maturing\_60+" | "Age\_cohort\_60+"/"Maturation\_time\_60+" | people/Years |  |
| "Mixed\_Material\_recovering\_-\_formal" | MIN(Waste\_inventory\_of\_formal\_recyclers/Time\_Converter, Recovery\_capacity\_of\_mixed\_waste) | tonnes/Years |  |
| mixed\_waste\_generation | "Total\_waste\_(tonnes)\_generated\_per\_year"-"on-site\_separation" | tonnes/Years |  |
| "on-site\_separation" | "On-site\_separated\_rate" \* "Total\_waste\_(tonnes)\_generated\_per\_year" | tonnes/Years |  |
| "On-Site\_waste\_-\_Material\_Recovered" | Recycled\_Material/year | tonnes/Years |  |
| Uncollected\_waste\_flow | Mixed\_waste\*uncollected\_waste\_rate | tonnes/Year |  |
| urbanisation\_rate | "Age\_cohort\_20-39" \* "Urbanisation\_rate\_cohort\_20-39" | people/Years |  |
| value\_recovering | Value\_recovered\_by\_formal\_collectors | Euros/Years |  |
| waste\_discharging | ("%\_of\_waste\_redirected\_from\_the\_landfill" \* Waste\_Inventory\_return\_to\_landfill)+dumping\_waste | Tonnes/year |  |
| Waste\_Inventory\_return\_to\_landfill | (Waste\_inventory\_of\_formal\_recyclers/year)-"Mixed\_Material\_recovering\_-\_formal" | Tonnes/year |  |
| Waste\_recycling | "Reference\_recycling\_rate\_for\_source-separated\_waste"\*Waste\_Collected\_for\_Recycling | tonnes/Years |  |
| "waste\_transferring\_-\_formal" | Mixed\_Waste\_Collected\_by\_formal \* "waste\_transferring\_-\_formal\_rate" | Tonnes/year |  |
| "waste\_transferring\_-\_informal" | Mixed\_Waste\_collected\_by\_informal \* "waste\_transferring\_-\_informal\_rate" | tonnes/Years |  |
| Waste\_transferring\_to\_Nsumnia | Nsumnia\_receiving\_amount | tonnes/Years |  |
| "%\_of\_material\_recovered\_per\_tonne" | 0.25 | Dimensionless |  |
| "%\_of\_people\_with\_Env\_Knowledge\_that\_separate\_waste" | 0.719 | Dimensionless | Source: Amoah & Addoah, 2021 |
| "%\_of\_population\_that\_separate\_waste" | "%\_of\_people\_with\_Env\_Knowledge\_that\_separate\_waste"\*"%\_of\_population\_with\_Environmental\_knowledge" | Dimensionless | under the assumption that all people generate the same amount of waste |
| "%\_of\_population\_with\_Environmental\_knowledge" | Total\_Weighted\_Average\_Attribute | Dimensionless |  |
| "%\_of\_value\_recovered\_for\_CE\_investments" | 0.2+STEP(0.0, 2024) | 1/(Tonnes) | Scenario test parameter. Takes the value of 0.4 under Scenario 3 and 5 |
| "%\_of\_waste\_recovered\_per\_year" | SAFEDIV((Material\_recovery\_by\_informal\_sector+ "On-Site\_waste\_-\_Material\_Recovered"+ Material\_recovered\_by\_ACARP\_&\_IRECOP), "Total\_waste\_(tonnes)\_generated\_per\_year", 0) | Dimensionless |  |
| "%\_of\_waste\_redirected\_from\_the\_landfill" | 0.1 +STEP(0.9, 2021) | Dimensionless |  |
| "average\_attribute\_0-19" | "Attribute\_population\_class\_0-19" / "Age\_cohort\_0-19" | Dimensionless |  |
| "average\_attribute\_20-39" | "Attribute\_Population\_class\_20-39"/"Age\_cohort\_20-39" | Dimensionless |  |
| "average\_attribute\_40-59" | "Attribute\_Population\_class\_40-59"/"Age\_cohort\_40-59" | Dimensionless |  |
| "average\_attribute\_60+" | "Attribute\_Population\_class\_60+"/"Age\_cohort\_60+" | Dimensionless |  |
| Boost\_of\_environmental\_campaigns | STEP(0, 2024) | Dimensionless | Scenario test parameter. Takes the value of 0.5 under Scenario 2a and 1 under scenario 2b and 5. |
| Collection\_coverage\_for\_calibration | (Informal\_waste\_collecting+Formal\_waste\_collecting+"collection\_of\_recyclables\_(formal)")/"Total\_waste\_(tonnes)\_generated\_per\_year" | Dimensionless |  |
| Collection\_coverage\_gap | (mixed\_waste\_generation - (Informal\_waste\_collecting+Formal\_waste\_collecting)) /MAX(1, mixed\_waste\_generation) | Dimensionless |  |
| collection\_gap\_to\_cover | 1-"collection\_rate\_-\_formal" | Per Year |  |
| "collection\_rate\_-\_formal" | MAX((Reference\_collection\_rate\_formal \*(1+ Resource\_gain\_rate\_f\*year)), Reference\_collection\_rate\_formal) | Per Year |  |
| "collection\_rate\_-\_informal" | Informal\_collection\_increases\_due\_to\_collection\_GAP | Per Year |  |
| Constant\_effect\_of\_environmental\_campaigns\_#1 | 0.2\*(1+Boost\_of\_environmental\_campaigns) | Dimensionless |  |
| Constant\_effect\_of\_environmental\_campaigns\_#2 | 0.2\*(1+Boost\_of\_environmental\_campaigns) | Dimensionless |  |
| Constant\_effect\_of\_environmental\_campaigns\_#3 | 0.2\*(1+Boost\_of\_environmental\_campaigns) | Dimensionless |  |
| Convert\_kg\_to\_Tonnes | 1000 | Kilograms/Tonnes |  |
| Daily\_material\_recover\_by\_informals | (Material\_recovery\_by\_informal\_sector/365) \* year | Tonnes |  |
| Data\_waste\_generation\_tonnes | GRAPH(TIME) Points: (2013.00, 657000.0), (2014.00, 728789.9225), (2015.00, 780808.0), (2016.00, 822875.8005), (2017.00, 871282.3749), (2018.00, 970397.3767), (2019.00, 1024224.398), (2020.00, 1126118.178), (2021.00, 1253830.898), (2022.00, 1359824.394), (2023.00, 1430233.236), (2024.00, 1430233.236), (2025.00, 0.0), (2026.00, 0.0), (2027.00, 0.0), (2028.00, 0.0), (2029.00, 0.0), (2030.00, 0.0), (2031.00, 0.0), (2032.00, 0.0), (2033.00, 0.0), (2034.00, 0.0), (2035.00, 0.0), (2036.00, 0.0), (2037.00, 0.0), (2038.00, 0.0), (2039.00, 0.0), (2040.00, 0.0) | Tonnes/year |  |
| DATA:\_Collection\_coverage | GRAPH(TIME) Points: (2013.00, 0.65), (2014.00, 0.67), (2015.00, 0.67), (2016.00, 0.68), (2017.00, 0.69), (2018.00, 0.7), (2019.00, 0.71), (2020.00, 0.72), (2021.00, 0.73), (2022.00, 0.74), (2023.00, 0.77), (2024.00, 0.0), (2025.00, 0.0), (2026.00, 0.0), (2027.00, 0.0), (2028.00, 0.0), (2029.00, 0.0), (2030.00, 0.0), (2031.00, 0.0), (2032.00, 0.0), (2033.00, 0.0), (2034.00, 0.0), (2035.00, 0.0), (2036.00, 0.0), (2037.00, 0.0), (2038.00, 0.0), (2039.00, 0.0), (2040.00, 0.0) | dmnl |  |
| Data:\_Design\_landfill\_capacity | GRAPH(TIME) Points: (2013.00, 123889), (2014.00, 251494), (2015.00, 383424), (2016.00, 520317), (2017.00, 662850), (2018.00, 811741), (2019.00, 967750), (2020.00, 1131687), (2021.00, 1304412), (2022.00, 1486846), (2023.00, 1679970), (2024.00, 1884836), (2025.00, 2102567), (2026.00, 2334370), (2027.00, 2581537), (2028.00, 2845457), (2029.00, 3127620), (2030.00, 3429630), (2031.00, 3753211), (2032.00, 4100218), (2033.00, 4472648), (2034.00, 4872652), (2035.00, 5302547), (2036.00, 5764829), (2037.00, 6262190), (2038.00, 6262190), (2039.00, 6262190), (2040.00, 6262190) | Tonnes | Source: Salifu, 2019 https://documents1.worldbank.org/curated/fr/775731551156835790/pdf/AFR-Environmental-and-Social-Audit-Kpone-Landfill-Feb2019-P164330.pdf |
| DATA:\_waste\_in\_landfill | GRAPH(TIME) Points: (2013.00, 0), (2014.00, 520000), (2015.00, 812500), (2016.00, 1000000), (2017.00, 1240493), (2018.00, 1640493), (2019.00, 1690000), (2020.00, 1771493), (2021.00, 0), (2022.00, 0), (2023.00, 0), (2024.00, 0), (2025.00, 0), (2026.00, 0), (2027.00, 0), (2028.00, 0), (2029.00, 0), (2030.00, 0), (2031.00, 0), (2032.00, 0), (2033.00, 0), (2034.00, 0), (2035.00, 0), (2036.00, 0), (2037.00, 0), (2038.00, 0), (2039.00, 0), (2040.00, 0) | Tonnes |  |
| "death\_rate\_0-19" | 0.044/1000 | Per Year | Source: Ghana Statistical Service, 2014, Population & Housing Census Report (https://www.statsghana.gov.gh/gssmain/fileUpload/pressrelease/Mortality%20in%20Ghana.pdf) |
| "death\_rate\_20-39" | 0.013/1000 | Per Year | Source: Ghana Statistical Service, 2014, Population & Housing Census Report (https://www.statsghana.gov.gh/gssmain/fileUpload/pressrelease/Mortality%20in%20Ghana.pdf) |
| "death\_rate\_40-59" | 0.032/1000 | Per Year | Source: Ghana Statistical Service, 2014, Population & Housing Census Report (https://www.statsghana.gov.gh/gssmain/fileUpload/pressrelease/Mortality%20in%20Ghana.pdf) |
| "death\_rate\_60+" | 0.136/1000 | Per Year | Source: Ghana Statistical Service, 2014, Population & Housing Census Report (https://www.statsghana.gov.gh/gssmain/fileUpload/pressrelease/Mortality%20in%20Ghana.pdf) |
| Decomposition\_rate | 0.03 | Per Year | The rate varies significantly depending on the type of material, the conditions within the landfill. Source: (Sarquah et al., 2023) |
| "delay\_(time\_effect)\_duration" | 0.5+STEP(0.0, 2024) | Years | Scenario test parameter. Takes the value of 0.4 under Scenario 2 and 5. |
| Delayed\_impact | MIN(0.3, DELAYN(Input, "delay\_(time\_effect)\_duration", 2, initial\_value)) \* year | Dimensionless |  |
| dumping\_rate | 0.9 | Per Year | Quartey, V. (2023). Population in Ghana-an analysis of growth trends and implications for development planning In. University of Ghana: POLICY BRIEF. |
| Economic\_value\_per\_tonne\_of\_material\_recovered | 100 | Euros/tonnes | 1500 Ghana cedis per tonne Source: (Amankwaa & Boafo, 2021). |
| first\_pulse | STARTTIME+1 | Years |  |
| formal\_collection\_rate | "collection\_of\_recyclables\_(formal)" / "Total\_waste\_(tonnes)\_generated\_per\_year" | Dimensionless |  |
| Formal\_contribution | Formal\_waste\_collecting / waste\_collected\_per\_year | Dimensionless |  |
| fractional\_birth\_rate | 32/1000 | Per Year |  |
| Increases\_in\_formal\_recovery\_capacity | STEP(584000,2024)\*0 | Tonnes/year | Scenario test parameter. It takes the value of (= 800\*365)=292.000 under Scenario 4a and the value of (= 1600\*365) = 584.000 under Scenario 4a and 5 |
| Increases\_in\_other\_recovery\_capacities | DELAY1( Overflow\_of\_waste\_in\_landfill\*Sensitivity\_to\_waste\_overflow, 1) /year | tonnes/Years |  |
| Informal\_collection\_increases\_due\_to\_collection\_GAP | MAX(0, collection\_gap\_to\_cover\*Informal\_collectors\_sensitivity\_to\_the\_collection\_gap) | Per Year |  |
| Informal\_collectors\_sensitivity\_to\_the\_collection\_gap | GRAPH(TIME) Points: (2013.00, 0.4744), (2014.00, 0.4924), (2015.00, 0.5068), (2016.00, 0.5212), (2017.00, 0.5356), (2018.00, 0.5500), (2019.00, 0.5644), (2020.00, 0.6148), (2021.00, 0.6580), (2022.00, 0.6580), (2023.00, 0.6544), (2024.00, 0.6526), (2025.00, 0.6508), (2026.00, 0.6508), (2027.00, 0.6508), (2028.00, 0.6544), (2029.00, 0.6580), (2030.00, 0.6580), (2031.00, 0.6580), (2032.00, 0.6580), (2033.00, 0.6616), (2034.00, 0.6580), (2035.00, 0.6580), (2036.00, 0.6580), (2037.00, 0.6580), (2038.00, 0.6580), (2039.00, 0.6580), (2040.00, 0.6544) | Dimensionless | Scenario test parameter. Takes the value of 0.8 under Scenario 3 and 5 |
| Informal\_recovery\_rate\_from\_landfill | 0.05 | Per Year |  |
| Informals\_contribution | Informal\_waste\_collecting / waste\_collected\_per\_year | dmnl |  |
| "INITIAL\_Age\_cohort\_0-19" | 0.39\*3600000 | people | Age Distribution rates: https://www.citypopulation.de/en/ghana/admin/03\_\_greater\_accra/ Initial population = 3.6 millions, based on World Bank, 2020a |
| "INITIAL\_Age\_cohort\_20-39" | 0.38\*3600000 | people | Age Distribution rates: https://www.citypopulation.de/en/ghana/admin/03\_\_greater\_accra/ Initial population = 3.6 millions, based on World Bank, 2020a |
| "INITIAL\_Age\_cohort\_40-59" | 0.17\*3600000 | people | Age Distribution rates: https://www.citypopulation.de/en/ghana/admin/03\_\_greater\_accra/ Initial population = 3.6 millions, based on World Bank, 2020a |
| "INITIAL\_Age\_cohort\_60+" | 0.06\*3600000 | people | Age Distribution rates: https://www.citypopulation.de/en/ghana/admin/03\_\_greater\_accra/ Initial population = 3.6 millions, based on World Bank, 2020a |
| "INITIAL\_Attribute\_Population\_class\_0-19" | "INITIAL\_Age\_cohort\_0-19"\*0.2 | people |  |
| "INITIAL\_Attribute\_Population\_class\_20-39" | "INITIAL\_Age\_cohort\_20-39"\*0.2 | people | Source: Adjei-Mantey, K., Inglesi-Lotz, R., & Amoah, A. (2024). Environmental consciousness and household energy poverty in Ghana. Global Environmental Change, 88, 102896. |
| "INITIAL\_Attribute\_Population\_class\_40-59" | "INITIAL\_Age\_cohort\_40-59"\*0.2 | people | Source: Adjei-Mantey, K., Inglesi-Lotz, R., & Amoah, A. (2024). Environmental consciousness and household energy poverty in Ghana. Global Environmental Change, 88, 102896. |
| "INITIAL\_Attribute\_Population\_class\_60+" | "INITIAL\_Age\_cohort\_60+"\*0.2 | people | Source: Adjei-Mantey, K., Inglesi-Lotz, R., & Amoah, A. (2024). Environmental consciousness and household energy poverty in Ghana. Global Environmental Change, 88, 102896. |
| initial\_value | 0 | Per Year |  |
| "INITIAL\_VALUE\_Collected\_by\_formal\_-\_Mixed\_2013" | INITIAL\_VALUE\_Mixed\_waste\_2013\*0.7 | Tonnes | About 70% of generated waste (Oteng-Ababio et al., 2013) |
| "INITIAL\_VALUE\_Collected\_by\_informal\_-\_Mixed\_2013" | INITIAL\_VALUE\_Mixed\_waste\_2013\*0.01 | Tonnes | About 10% of generated waste (Oteng-Ababio et al., 2013) |
| INITIAL\_VALUE\_Dumpsite\_2013 | 100 | Tonnes |  |
| INITIAL\_VALUE\_Mixed\_waste\_2013 | 657000 | Tonnes | (GSS/EPA, 2020) 657000 tonnes |
| "INITIAL\_VALUE\_Source-separated\_Waste\_Collected\_for\_Recycling\_2013" | 1 | Tonnes | Initial value of source-separated waste collected is close to zero. |
| "INITIAL\_VALUE\_Source-separated\_waste\_recycled\_2013" | 1 | Tonnes | Initial value of source-separated waste recovered is close to zero. |
| "INITIAL\_VALUE\_Source-seperated\_waste\_2013" | 1 | Tonnes | Initial value of source-separated waste is close to zero. |
| INITIAL\_VALUE\_Uncollected\_waste\_2013 | INITIAL\_VALUE\_Mixed\_waste\_2013\*0.02 | Tonnes | About 20% of generated waste (Oteng-Ababio et al., 2013) |
| INITIAL\_VALUE\_Value\_recovered\_2013 | 100 | Euros |  |
| INITIAL\_VALUE\_Waste\_in\_landfill\_2013 | 0 | Tonnes | Since Kpone was constructed in 2013 (Salifu, 2019) 520000 |
| INITIAL\_VALUE\_Waste\_inventory\_of\_formal\_recyclers\_2013 | "INITIAL\_VALUE\_Collected\_by\_informal\_-\_Mixed\_2013"+"INITIAL\_VALUE\_Collected\_by\_formal\_-\_Mixed\_2013" | Tonnes | This value is close to zero, since the ACARP recovery plants got established in 2012 and IRECOP in 2019 (Source: https://ama.gov.gh/) |
| Input | PULSE (Magnitude, first\_pulse, interval) | Per Year |  |
| interval | 2 | Years |  |
| Investing\_in\_CE | Annual\_Value\_Stream \* "%\_of\_value\_recovered\_for\_CE\_investments" | Euros/(Tonnes\*Years) |  |
| Magnitude | 0.4 | Dimensionless | It reflects the actual impact of the educational intervention  magnitude =1 => Input =8 magnitude =2 => Input =16 magnitude =2 => Input =24 magnitude =8 => Input =64 |
| "Marginal\_attribute\_for\_age\_cohort\_0-19" | 0.19 | Dimensionless | Source: Survey Green Academy Project |
| Material\_recovered\_by\_ACARP\_&\_IRECOP | "Mixed\_Material\_recovering\_-\_formal" \* "%\_of\_material\_recovered\_per\_tonne" | tonnes/Years |  |
| "Maturation\_time\_0-19" | 20 | Years |  |
| "Maturation\_time\_20-39" | 20 | Years |  |
| "Maturation\_time\_40-59" | 20 | Years |  |
| "Maturation\_time\_60+" | 10 | Years |  |
| Maximum\_growth\_rate\_g | 0.2 | Per Year |  |
| Nsumnia\_receiving\_amount | GRAPH(TIME) Points: (2013.00, 0), (2014.00, 0), (2015.00, 2000), (2016.00, 108000), (2017.00, 0), (2018.00, 0), (2019.00, 0), (2020.00, 0), (2021.00, 0), (2022.00, 0), (2023.00, 0), (2024.00, 0), (2025.00, 0), (2026.00, 0), (2027.00, 0), (2028.00, 0), (2029.00, 0), (2030.00, 0), (2031.00, 0), (2032.00, 0), (2033.00, 0), (2034.00, 0), (2035.00, 0), (2036.00, 0), (2037.00, 0), (2038.00, 0), (2039.00, 0), (2040.00, 0) | tonnes/Years | The landfill site, was acquired in 2013 but operations began in August 2014. Occupying a space of 22,000 square metres with a depth of 25,000 metres, the site receives an average of 800 tonnes of municipal solid waste and domestic waste from Accra and Nsawam daily (292.000 tonnes per year). The landfill was decommissioned in 2018. GAMA portion=800\*365 = 292.000 per year |
| "On-site\_separated\_rate" | MAX(0.05, Peer\_Effect\_Dynamics\_for\_a\_Circular\_Economy \* "%\_of\_population\_that\_separate\_waste") | Dimensionless |  |
| "On-site\_separated\_rate!" | "on-site\_separation"/"Total\_waste\_(tonnes)\_generated\_per\_year" | Dimensionless |  |
| "On-site\_separation\_rate" | SAFEDIV("on-site\_separation", "Total\_waste\_(tonnes)\_generated\_per\_year", 0) | Dimensionless |  |
| Other\_private\_sector\_recovery\_facilities | GRAPH(TIME) Points: (2013.00, 23200), (2014.00, 23200), (2015.00, 23200), (2016.00, 23400), (2017.00, 23500), (2018.00, 23500), (2019.00, 23500), (2020.00, 23500), (2021.00, 23500), (2022.00, 23800), (2023.00, 24500), (2024.00, 25000), (2025.00, 25400), (2026.00, 25600), (2027.00, 25800), (2028.00, 26400), (2029.00, 26400), (2030.00, 26500), (2031.00, 26700), (2032.00, 26900), (2033.00, 27100), (2034.00, 27100), (2035.00, 27100), (2036.00, 27100), (2037.00, 27100), (2038.00, 27300), (2039.00, 27600), (2040.00, 27400) | Tonnes/year |  |
| Overflow\_of\_waste\_in\_landfill | IF(Data:\_Design\_landfill\_capacity>"Waste\_in\_landfill\_(Kpone)") THEN 0 ELSE ("Waste\_in\_landfill\_(Kpone)"-Data:\_Design\_landfill\_capacity) | Tonnes |  |
| Peer\_Effect\_Dynamics\_for\_a\_Circular\_Economy | 1/(1+Mixed\_waste/MAX(1, "Source-separated\_waste"))^Sensitivity\_to\_Waste\_Ubiquity | Dimensionless | MIN(SAFEDIV((Mixed\_waste/year), "Total\_waste\_(tonnes)\_generated\_per\_year", 0)^Sensitivity\_to\_Peer\_Effects, 0.12)   0.2\*(Mixed\_waste / "Total\_waste\_(tonnes)\_generated\_per\_year") |
| Population\_Data | GRAPH(TIME) Points: (2013.00, 3650000.000), (2014.00, 3700000.000), (2015.00, 3820000.000), (2016.00, 3950000.000), (2017.00, 4140000.000), (2018.00, 4330000.000), (2019.00, 4490000.000), (2020.00, 4680000.000), (2021.00, 4890000.000), (2022.00, 5080000.000), (2023.00, 5240000.000), (2024.00, 5400000.000), (2025.00, 5590000.000), (2026.00, 5780000.000), (2027.00, 5990000.000), (2028.00, 6210000.000), (2029.00, 6350000.000), (2030.00, 6457913.000), (2031.00, 6957913.000), (2032.00, 7280000.000), (2033.00, 7630000.000), (2034.00, 8040000.000), (2035.00, 8360000.000), (2036.00, 8680000.000), (2037.00, 8980000.000), (2038.00, 9540000.000), (2039.00, 9730000.000), (2040.00, 10000000.000) | People |  |
| "Processing\_capacity\_in\_the\_recovery\_facilities\_(ACARP\_+\_IRECOP)\_per\_year" | 109500+STEP(182500, 2019) | tonnes/Year | ACARP has a design capacity of 600 metric tons per 16-hours (started in 2012) IRECOP has a capacity to handle 400 tonnes of solid waste on a sixteen (16) hour shift  => 1000 tonnes per day  Sarquah, K., Narra, S., Beck, G., Bassey, U., Antwi, E., Hartmann, M., ... & Nelles, M. (2022). Characterization of municipal solid waste and assessment of its potential for refuse-derived fuel (RDF) valorization. Energies, 16(1), 200. |
| Quality\_of\_waste\_material\_index | DELAY1((formal\_collection\_rate\*0.4) + ("On-site\_separation\_rate"\*0.6), 1) | Dimensionless |  |
| Rate\_processed | "Mixed\_Material\_recovering\_-\_formal"\*Time\_Converter/Waste\_inventory\_of\_formal\_recyclers | Dimensionless |  |
| rate\_remaining\_to\_landfill | (Waste\_inventory\_of\_formal\_recyclers-"Mixed\_Material\_recovering\_-\_formal"\*year)/Waste\_inventory\_of\_formal\_recyclers | Dimensionless |  |
| Recovery\_capacity\_of\_mixed\_waste | (Working\_capacity\_of\_the\_recovery\_facilities+Increases\_in\_formal\_recovery\_capacity)+(Other\_private\_sector\_recovery\_facilities+Increases\_in\_other\_recovery\_capacities) | tonnes/Years |  |
| "Reference\_collection\_rate\_for\_source-separated\_waste" | 0.99 | Per Year | (World Bank, 2018) |
| Reference\_collection\_rate\_formal | GRAPH(TIME) Points: (2013.00, 0.3008), (2015.70, 0.2960), (2018.40, 0.3080), (2021.10, 0.3080), (2023.80, 0.3080), (2026.50, 0.3152), (2029.20, 0.3200), (2031.90, 0.3272), (2034.60, 0.3416), (2037.30, 0.3440), (2040.00, 0.3488) | Per Year |  |
| "Reference\_recycling\_rate\_for\_source-separated\_waste" | 0.99 | Per Year |  |
| Resource\_cost\_c | 1000 | Euros/tonnes |  |
| Resource\_gain\_rate\_f | Maximum\_growth\_rate\_g\*Investing\_in\_CE /(Resource\_cost\_c\*Maximum\_growth\_rate\_g+Investing\_in\_CE) | Per Year | Diminishing returns  equation 6 in Wibbens, P.D. 2021. The role of competitive amplification in explaining sustained performance heterogeneity. Strategic Management Journal 42(10), 1769 – 1792.  Equation 12 in Wibbens, P.D. 2021. A formal framework for the RBV: Resource dynamics as a Markov process. Strategic Management Journal 44(6), 1562-1586 |
| Sensitivity\_to\_waste\_overflow | GRAPH(TIME) Points: (2013.00, 0.07184), (2014.00, 0.06935), (2015.00, 0.06686), (2016.00, 0.06437), (2017.00, 0.06348), (2018.00, 0.06152), (2019.00, 0.05974), (2020.00, 0.05903), (2021.00, 0.05689), (2022.00, 0.05618), (2023.00, 0.05511), (2024.00, 0.0544), (2025.00, 0.05369), (2026.00, 0.05333), (2027.00, 0.05262), (2028.00, 0.05226), (2029.00, 0.05155), (2030.00, 0.05084), (2031.00, 0.05013), (2032.00, 0.04906), (2033.00, 0.04835), (2034.00, 0.04692), (2035.00, 0.04657), (2036.00, 0.04586), (2037.00, 0.04479), (2038.00, 0.04372), (2039.00, 0.04265), (2040.00, 0.0398) | dmnl |  |
| Sensitivity\_to\_Waste\_Ubiquity | 0.3 | Dimensionless |  |
| Time\_Converter | 1 | Years |  |
| Total\_population | "Age\_cohort\_0-19"+"Age\_cohort\_20-39"+"Age\_cohort\_40-59"+"Age\_cohort\_60+" | people |  |
| "Total\_waste\_(tonnes)\_generated\_per\_year" | (Data\_waste\_generation\_tonnes) \*(1-STEP(1,STARTTIME+11)) + STEP(1,STARTTIME+11) \*(Population\_Data\*waste\_generated\_per\_person\_per\_year/Convert\_kg\_to\_Tonnes) | Tonnes/year |  |
| Total\_Weighted\_Average\_Attribute | ("average\_attribute\_0-19"\*"Age\_cohort\_0-19"/Total\_population +"average\_attribute\_20-39"\*"Age\_cohort\_20-39"/Total\_population +"average\_attribute\_40-59"\*"Age\_cohort\_40-59"/Total\_population +"average\_attribute\_60+"\*"Age\_cohort\_60+"/Total\_population) | Dimensionless |  |
| uncollected\_waste\_rate | 1-("collection\_rate\_-\_formal"+"collection\_rate\_-\_informal") | Per Year |  |
| "Urbanisation\_rate\_cohort\_20-39" | GRAPH(TIME) Points: (2013.00, 0.033866), (2014.00, 0.033866), (2015.00, 0.033845), (2016.00, 0.033803), (2017.00, 0.033739), (2018.00, 0.033634), (2019.00, 0.033571), (2020.00, 0.033487), (2021.00, 0.033445), (2022.00, 0.033424), (2023.00, 0.033382), (2024.00, 0.033319), (2025.00, 0.033277), (2026.00, 0.033214), (2027.00, 0.033172), (2028.00, 0.033109), (2029.00, 0.033046), (2030.00, 0.033004), (2031.00, 0.032941), (2032.00, 0.032878), (2033.00, 0.032815), (2034.00, 0.032752), (2035.00, 0.032626), (2036.00, 0.032563), (2037.00, 0.0325), (2038.00, 0.0325), (2039.00, 0.0325), (2040.00, 0.0325) | 1/Years |  |
| Value\_recovered\_by\_formal\_collectors | ("Mixed\_Material\_recovering\_-\_formal"\*"%\_of\_material\_recovered\_per\_tonne" +"On-Site\_waste\_-\_Material\_Recovered") \*Economic\_value\_per\_tonne\_of\_material\_recovered | Euros/Years |  |
| "Waste\_collected\_(as\_%\_of\_mixed\_waste)" | SAFEDIV((Informal\_waste\_collecting+Formal\_waste\_collecting) , mixed\_waste\_generation, 0) | Dimensionless |  |
| waste\_collected\_per\_year | Informal\_waste\_collecting + Formal\_waste\_collecting | tonnes/Years |  |
| waste\_generated\_per\_person\_per\_year | GRAPH(TIME) Points: (2013.00, 183.00), (2015.70, 198.77), (2018.40, 211.04), (2021.10, 224.62), (2023.80, 261.85), (2026.50, 266.67), (2029.20, 270.61), (2031.90, 271.92), (2034.60, 273.24), (2037.30, 278.50), (2040.00, 280.25) | Kilograms/people/year | - Accra Metropolitan Assembly Accra’s per Capita Waste Generation Rate Is 0.70kg per Day—Report. Available online: https: //ama.gov.gh/news-details.php?n=OTU3NTU5MjUxNXMwNTcwcDYxczhxczFzb3Izc3M0MHI2cHMyNDFycw== (accessed on 12 January 2024).  - Miezah, K.; Obiri-Danso, K.; Kádár, Z.; Fei-Baffoe, B.; Mensah, M.Y. Municipal SolidWaste Characterization and Quantification as a Measure towards EffectiveWaste Management in Ghana. Waste Manag. 2015, 46, 15–27. [CrossRef] |
| Waste\_landfilled\_or\_dumped | dumping\_waste + Waste\_Inventory\_return\_to\_landfill | tonnes/Years |  |
| waste\_receiving | "waste\_transferring\_-\_formal" + "waste\_transferring\_-\_informal" | Tonnes/year |  |
| waste\_recovery\_rate\_of\_informal\_sector | 0.05 | Per Year |  |
| "waste\_transferring\_-\_formal\_rate" | 0.99 | Per Year |  |
| "waste\_transferring\_-\_informal\_rate" | 0.99 | Per Year |  |
| working\_capacity | GRAPH(TIME) Points: (2013.00, 0.305), (2014.00, 0.354), (2015.00, 0.381), (2016.00, 0.412), (2017.00, 0.429), (2018.00, 0.447), (2019.00, 0.460), (2020.00, 0.469), (2021.00, 0.478), (2022.00, 0.491), (2023.00, 0.513), (2024.00, 0.558), (2025.00, 0.593), (2026.00, 0.655), (2027.00, 0.673), (2028.00, 0.677), (2029.00, 0.690), (2030.00, 0.695), (2031.00, 0.695), (2032.00, 0.695), (2033.00, 0.695), (2034.00, 0.695), (2035.00, 0.695), (2036.00, 0.695), (2037.00, 0.699), (2038.00, 0.699), (2039.00, 0.704), (2040.00, 0.704) | dmnl | Based on experts inputs |
| Working\_capacity\_of\_the\_recovery\_facilities | "Processing\_capacity\_in\_the\_recovery\_facilities\_(ACARP\_+\_IRECOP)\_per\_year" \* working\_capacity | tonnes/Years |  |
| year | 1 | year |  |