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Concept Note
San Juan Bautista, Perú

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English Version

Contents

1. Executive Summary

The objective of this concept note document is to analyse suitable options for (GHG) emissions reduction technologies for the San Juan Bautista district landfill within the Loreto district of Peru. Plans for the construction of the San Juan Bautista Landfill have already been made, without provisions for the control of emissions or leachate resulting from its operation. Therefore, this concept note evaluates potential emissions reduction technologies which would be compatible with the pre-existing plans. This presents an interesting opportunity for investment that would serve to both reduce GHG emissions and risks associated with leachate, as well as optimise the operational costs of the landfill.

The project is located in the Peruvian jungle and as such is subject to high humidity and rainfall, year-round. Inadequate leachate management in a landfill in this location could result in significant environmental damage to the nearby Amazonian ecosystem, therefore leachate management is an important consideration in this concept note. Another important criteria taken into consideration is the replicability of the various technologies in other parts of Peru, as the Japan International Cooperation Agency (JICA) and the Inter-American Development Bank (IDB) are currently facilitating the construction of similar landfills across Peru. These landfill projects, especially those located in the Peruvian jungle with similar projections for GHG and leachate generation to the San Juan Bautista Landfill, could be potential candidates for the implementation of similar complementary technologies.

The aim of this analysis is to produce indicators and information on the required levels of investment, operation costs, implementation risks and estimated GHG reductions of the various technologies. This information is to be disseminated among private actors in the waste management sector in order to incentivise involvement, and ultimately mobilise investment, to provide an efficient and sustainable solution to the challenges of final disposal of municipal waste.

2. Baseline information

2.1. Context

As part of the JICA/IDB initiative, the Peruvian government has received loans and technical assistance for the construction of 31 sanitary landfills to aid in addressing the current gap in infrastructure for the final disposal of solid waste in Peru. The analysis in this concept note is focused on infrastructure for a sanitary landfill that is currently being constructed as a result of this initiative in the district of San Juan Bautista (hereinafter SJB) in the province of Maynas in the Loreto department of Peru. Construction of the '*Villa San Juan'* sanitary landfill, is anticipated to be completed by August 2019 and will serve as the final disposal of waste for approximately 120,000 inhabitants of SJB[1].

The decision to construct this sanitary landfill was taken partly in response to environmental and health damages that were caused by the "El Treinta" sanitary landfill, which is located in the buffer zone of the Allpahuayo-Mishana Natural Reserve and has had direct negative impacts on local biodiversity. Although the decision to construct a new sanitary landfill implies a positive step towards addressing some of the environmental issues associated with final disposal of waste in this area, it is apparent that certain risks associated with the generation of leachate may have been underestimated in its design.

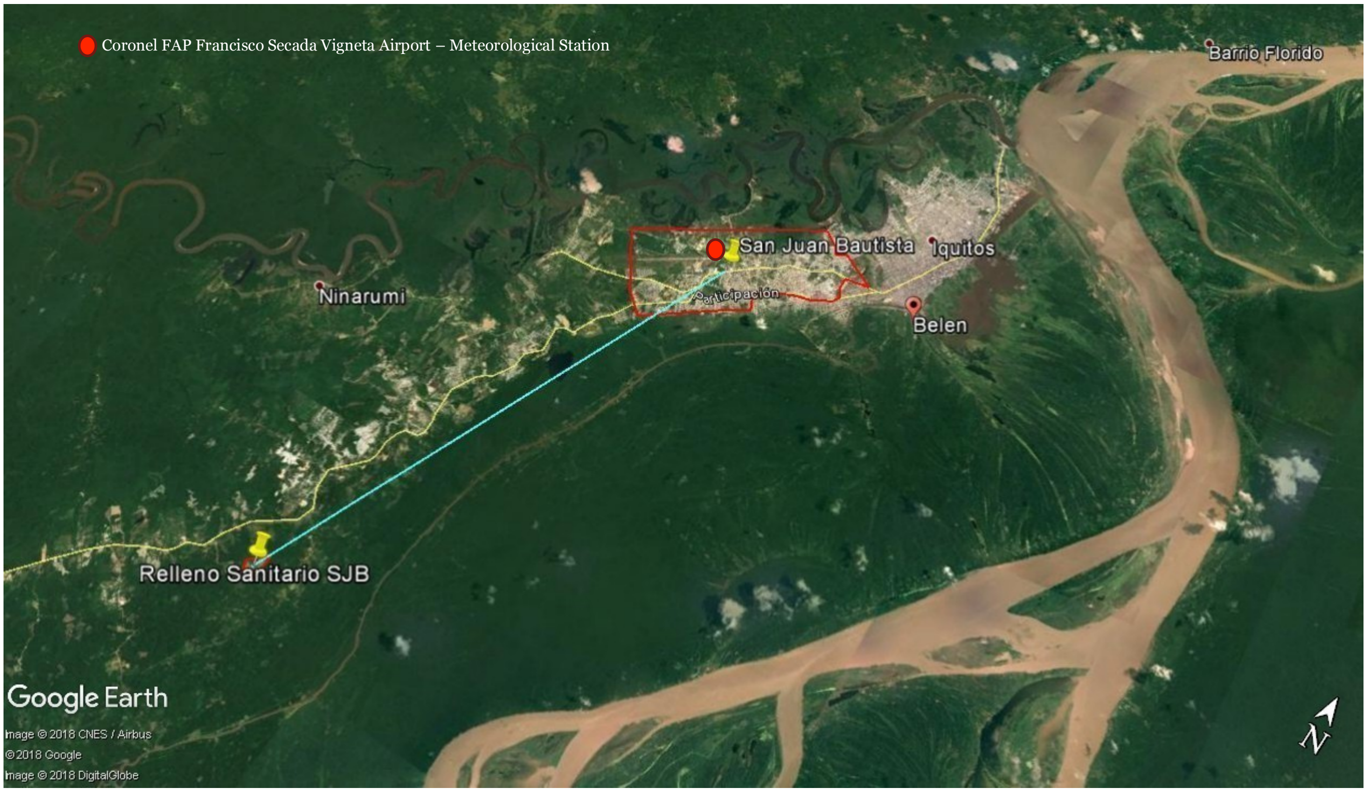
The breakdown of the organic component of municipal solid waste impacts the environment both in terms of liquid leachate escape and also GHG emissions. The objective of this concept note is to consider and evaluate different technologies which could potentially be financed through mobilising private sector investment. The technologies will be evaluated against their ability to complement the existing designs for the Villa San Juan sanitary landfill, and their potential to reduce negative environmental impacts resulting from both GHG emissions and leachate liquids.

2.2. Area of Focus

The focus of this concept note is to propose the implementation of a technology that addresses environmental impacts from GHG emissions and/or leachate liquids for the construction of a sanitary landfill for the Municipality of SJB. The location of the sanitary landfill is a territory within the town of Moralillo in the SJB district. Figure N° 01 shows the Villa San Juan sanitary landfill which is located a straight line distance of 16 Km from the San Juan Bautista district, where the population that will benefit from this sanitary landfill is located.

[1] http://www.minam.gob.pe/notas-de-prensa/la-construccion-de-dos-rellenos-sanitarios-beneficiara-a-mas-de-400-mil-habitantes-de-loreto/

Fig. N° 01. Area of Interest



Source: Google Earth

At the time of the 2017 census carried out by the National Institute of Statistics (Instituto Nacional de Estadística e Informática – INEI), the total population of the SJB district was 127,005[2] and in the prior census which was carried out in 2007 the total population was 102,076[3]. There was a low population growth rate of only 25% over this period.

2.3. Climate and Environmental Factors [4]

Information provided by the meteorological station of Coronel FAP Francisco Secada Vigneta Airport (Peruvian Corporation of Airports and Commercial Aviation, hereinafter CORPAC, marked on the map above) was used to understand the characterization of the local climate for the purpose of this concept note as it is closer to the location of the sanitary landfill (approximately 12km) than the SJB district. The environmental characteristics are a deterministic factor for the viability of the project, given their influence on the generation of leachates.

Table No. 01 shows the average temperature and precipitation in SJB.

[2] http://censos2017.inei.gob.pe/redatam/
[3] http://censos.inei.gob.pe/Censos2007/redatam/#
[4] Informe N°3 – Expediente Técnico de Disposición Final y Reaprovechamiento de la Consultoría para la elaboración de estudios, expedientes y especificaciones técnicas, diseño e implementación de planes y supervisión de obras de los servicios de Gestión Integral de Residuos Sólidos Municipales (Municipalidad Distrital de San Juan Bautista).

Table N° 01. Temperature and Precipitation in San Juan Bautista

Month	Mean Minimum Daily Temp. (°C)	Mean Maximum Daily Temp. (°C)	Mean Daily Temp. (°C)	Mean Total Rainfall (mm)
Jan	31	23	27	242
Feb	31	23	27	230
Mar	31	23	27	262
Apr	31	23	27	263
May	30	22	26	238
Jun	30	22	26	177
Jul	30	22	26	133
Aug	31	22	26.5	135
Sep	32	22	27	169
Oct	32	22	27	206
Nov	32	23	27.5	207
Dec	31	23	27	237
Total	**31.0**	**22.5**	**26.8**	**2,499**

Source: CORPAC[5] & Weather Spark[6]

The average annual temperature in SJB is 26.8°C and the average annual rainfall is 2499mm. In addition, whilst changes in seasonality, temperature and rainfall occur very frequently in Peru, they are unusual in this area. According to the National Service of Meteorology and Hydrology of Peru (Servicio Nacional de Meteorología e Hidrología del Perú, hereinafter SENAMHI) the rate of evapotranspiration is 564.98mm and the average relative humidity is 85%.

It is important to note that the hydrosphere of the region is made up of a network of small ravines, streams and rivers that converge in higher flow areas. The basins of the Marañón (1,414 km) and Ucayali (1,771 km) rivers converge in the vicinity of the city of Nauta, giving rise to the Amazon River/ río Amazonas (the Peruvian section of which is 713 km), which receives tributaries from other basins such as the Napo and Putumayo rivers (1,380 km.), which form outside the Peruvian territory and flow into the main Amazon River. In addition, according to the Holdridge life zone classification system, the area of focus is located in the tropical moist forest life zone and is a region of particular significance to biodiversity and is a high conservation value area.

[5] http://www.corpac.gob.pe/app/Meteorologia/TRClimatologicas/Tables.html
[6] https://es.weatherspark.com/y/147185/Clima-promedio-en-Aeropuerto-Internacional-Coronel-FAP-Francisco-Secada-Vignetta-Per%C3%BA-durante-todo-el-a%C3%B1o

3. Current Waste Management Situation

3.1. Generation of Municipal Solid Waste

Table N° 02 shows estimations and projections of solid waste generation for the SJB district from the year 2017 to 2049. The population projections in this table include an estimated population growth of 2.21% per year[7]. Linked to this expected increase in the number of habitants, there is an assumption of an expected increase in the level of wealth and consumption, and therefore level of waste, generated in the municipality.

Table N° 02. Generation of Solid Waste - San Juan Bautista District[8]

Year	Population (1)	GPC (kg/hab/day) (2)	Domestic SW (Ton/day) (2)	Commercial SW (Ton/day) (2)	SW from Street Sweeping (Ton/day) (2)	Total SW Generated (Ton/day) (3)	Total SW Generated (Ton/year) (3)
2017	127,005	0.660	83.76	10.12	2.93	97	35,334
2018	129,811	0.666	86.47	10.44	3.02	100	36,476
2019	132,678	0.673	89.26	10.78	3.12	103	37,655
2020	135,609	0.680	92.15	11.13	3.22	106	38,871
2021	138,605	0.686	95.13	11.49	3.32	110	40,127
2022	141,667	0.693	98.20	11.86	3.43	113	41,424
2023	144,797	0.700	101.37	12.24	3.54	117	42,762
2024	147,996	0.707	104.65	12.64	3.66	121	44,144
2025	151,265	0.714	108.03	13.05	3.77	125	45,570
2026	154,607	0.721	111.52	13.47	3.90	129	47,043
2027	158,022	0.729	115.12	13.90	4.02	133	48,563
2028	161,513	0.736	118.84	14.35	4.15	137	50,132
2029	165,081	0.743	122.68	14.82	4.29	142	51,752
2030	168,728	0.751	126.65	15.29	4.43	146	53,424
2031	172,455	0.758	130.74	15.79	4.57	151	55,151
2032	176,265	0.766	134.97	16.30	4.72	156	56,933
2033	180,159	0.773	139.33	16.83	4.87	161	58,772
2034	184,139	0.781	143.83	17.37	5.03	166	60,671
2035	188,207	0.789	148.48	17.93	5.19	172	62,632
2036	192,365	0.797	153.27	18.51	5.36	177	64,656
2037	196,614	0.805	158.23	19.11	5.53	183	66,745
2038	200,958	0.813	163.34	19.72	5.71	189	68,901
2039	205,397	0.821	168.62	20.36	5.89	195	71,128
2040	209,935	0.829	174.06	21.02	6.08	201	73,426
2041	214,572	0.837	179.69	21.70	6.28	208	75,799
2042	219,313	0.846	185.50	22.40	6.48	214	78,248
2043	224,158	0.854	191.49	23.12	6.69	221	80,776
2044	229,110	0.863	197.68	23.87	6.91	228	83,386
2045	234,171	0.871	204.06	24.64	7.13	236	86,081
2046	239,344	0.880	210.66	25.44	7.36	243	88,862
2047	244,631	0.889	217.46	26.26	7.60	251	91,733
2048	250,036	0.898	224.49	27.11	7.84	259	94,698
2049	255,559	0.907	231.74	27.99	8.10	268	96,418

Sources: (1) http://censos2017.inei.gob.pe/redatam/, (2) ECRS Municipalidad de SJB, (3) Own calculations.

The projected generation of solid waste per day in the urban zone of SJB is approximately 97 T/day. Table No. 03 shows the composition of solid waste produced by the SJB district. Of note is the fact that 73.51% of waste is organic material, which has important implications for the volume of gas and leachate liquid that will be generated through decomposition in the sanitary landfill.

[7] Estimación propia, basada en resultados de Censos 2007 y 2017.
[8] MDSJB: *Estudios de caracterización de residuos sólidos MDSJB 2016*

Table N° 03. Solid Waste Composition - San Juan Bautista District

Type of Solid Waste	SW %	Domestic SW (Ton/day)	Non-domestic SW (%)	Non-domestic SW (Ton/day)	Municipal SW Total (Ton/day)	Avg. %
1. Organic Waste	74.53%	69.13	65.44%	7.69	76.82	73.51%
2. Wood, Foliage	3.00%	2.78	0.58%	0.07	2.85	2.73%
3. Paper	3.36%	3.11	6.16%	0.72	3.84	3.67%
4. Cardboard	2.30%	2.14	5.36%	0.63	2.77	2.65%
5. Glass	1.65%	1.53	1.87%	0.22	1.75	1.67%
6. Plastic (PET)	3.39%	3.15	4.15%	0.49	3.63	3.48%
7. Plastic (strong)	3.14%	2.91	1.67%	0.20	3.11	2.97%
8. Bags	2.65%	2.46	4.46%	0.52	2.98	2.85%
9. Tetrapak	0.66%	0.61	0.68%	0.08	0.69	0.66%
10. Polystyrene & similar	0.51%	0.48	0.41%	0.05	0.52	0.50%
11. Metal	0.19%	0.18	0.15%	0.02	0.20	0.19%
12. Fabrics, textiles	2.78%	2.58	0.82%	0.10	2.68	2.56%
13. Tires, leather, rubber	0.12%	0.11	0.90%	0.11	0.22	0.21%
14. Batteries	0.00%	0.00	0.02%	0.00	0.00	0.00%
15. Medicine leftovers, bulbs	0.06%	0.06	0.02%	0.00	0.06	0.06%
16. Sanitary Waste	0.55%	0.51	2.81%	0.33	0.84	0.80%
17. Inert Waste	0.05%	0.04	0.00%	0.00	0.04	0.04%
18. Wrapping	0.36%	0.33	1.71%	0.20	0.53	0.51%
19. Cans	0.44%	0.41	1.00%	0.12	0.53	0.50%
20. RAEE	0.08%	0.08	0.06%	0.01	0.08	0.08%
21. Bones	0.00%	0.00	0.25%	0.03	0.03	0.03%
22. Others	0.18%	0.17	1.49%	0.18	0.34	0.33%

Source: SJB Municipal District: Characterization studies of solid waste *MDSJB 2016*

3.2. Final Disposal of Solid Waste

There are various stages in the waste management cycle, from initial consumption and generation of waste, to segregation, recovery and transport, to the final disposal of waste. Certain aspects of the cycle, such as waste recovery processes and segregation activities, are considered for purpose of estimating the volumes of waste that reach the sanitary landfill for final disposal. However, in general the scope of analysis of this concept note is limited to the final disposal of solid waste.

The SJB district municipal government provided the services of solid waste collection, sweeping of streets, parks and gardens and security patrolling to all properties and tax payers in the district. The cost of these services is distributed among the properties and tax payers that are deemed by the municipality to be subject to payment. In 2015, the management of the service for final disposal of solid waste was taken over by a private company. Today, the municipality of SJB has received co-financing for the construction of the new sanitary landfill, through the Ministry of the Environment, Ministry of Economy, JICA and ID. This project is executed on land belonging to the municipality of SJB.

In the technical dossier on Final Disposal and Recovery[9] for the construction of the sanitary landfill, it was proposed that leachate from the landfill would be treated by draining the liquid from the landfill and later transferring it to the Wastewater Treatment Plant (WTP) of Loreto. However, the technical dossier does not consider a number of risk factors associated with this form of leachate treatment given its toxicity, and associated negative environmental impacts such as water contaminations.

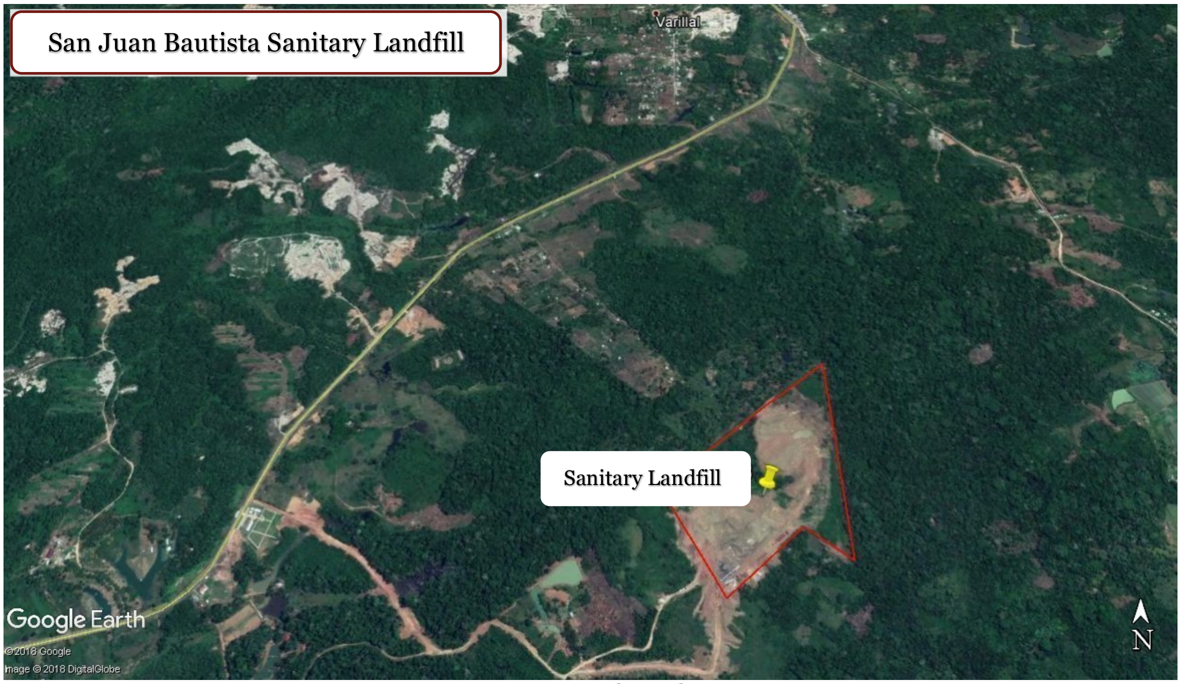
In addition to this, the technical dossier does not take into consideration the added cost of transporting the leachate and treating it at the WTP, which could increase exponentially under unfavourable climate conditions (increased rainfall). Moreover, the composition of the leachate has not been assessed; it could be more difficult, and thus more costly, to treat compared to the wastewater currently being received by the WTP, for which it was designed.

[9] Development Project of a system for solid waste management in Prioritized Areas – San Juan Bautista, BID – June 2014.

3.3. Proposed Solution

This concept note seeks to evaluate the ability of the new Villa San Juan sanitary landfill to meet the needs of the SJB district, and to propose viable options that would enable adequate and more sustainable final disposal of solid waste. The options proposed have been chosen with the goal of reducing the environmental and social risks that could arise in an alternative scenario in which no corrective measures are taken. Figure No. 02 shows the location of the land for the new sanitary landfill of San Juan Bautista, which has an area of 21.3065ha and a perimeter of 2106.406 m. Table No. 06 shows its geographical coordinates.

Fig. N° 02. Location of the New San Juan Bautista Sanitary Landfill



Source: Google Earth

Table N° 04. Coordinates of the New San Juan Bautista Sanitary Landfill[10]

Corner	Longitude (m)	East	North
P1	628.05	683,297.745	9,567,628.407
P2	157.88	683,290.048	9,567,000.405
P3	298.30	683,164.431	9,567,096.004
P4	172.75	682,940.882	9,566,898.501
P5	204.25	682,825.264	9,567,230.292
P6	811.90	682,607.122	9,567,230.292
P7	33.31	683,265.286	9,567,635.886

Table N° 05 shows a projection of waste generation from 2019, which is the year that the landfill would come into operation, to 2049. Based on various assumptions (see Annex 1 for assumptions used in projections and estimations) we can estimate that the total demand for final disposal for solid waste in this landfill will be 34,443 tons / year in 2019. Projections have been made for 30 years in order to then estimate the volume required to dispose of the waste in the landfill and the useful life of the landfill.

[10] Municipality of San Juan Bautista: Technical report #252-2014-GRL-DL-Loreto/30.09.04, regarding the favorable technical opinion of the site selection study by Diresa Loreto

Table N° 05: Projection of Demand for Final Disposal in the San Juan Bautista Sanitary Landfill

Nº	Year	Population (1)	Total SW Generation (Ton/year) (2)	SW recovered in city (paper, cardboard, plastic, metals, glass & rubber) (Ton/year) (2)	Compostable SW (markets & Green Areas (Ton/year) (2)	Total SW Demand Final Disposition (ton/year) (3)
0	2019	132,678	37,655	1,752	1,460	34,443
1	2020	135,609	38,871	1,809	1,507	35,555
2	2021	138,605	40,127	1,867	1,556	36,704
3	2022	141,667	41,424	1,927	1,606	37,890
4	2023	144,797	42,762	1,990	1,658	39,115
5	2024	147,996	44,144	2,054	1,712	40,379
6	2025	151,265	45,570	2,120	1,767	41,683
7	2026	154,607	47,043	2,189	1,824	43,030
8	2027	158,022	48,563	2,260	1,883	44,421
9	2028	161,513	50,132	2,333	1,944	45,856
10	2029	165,081	51,752	2,408	2,007	47,338
11	2030	168,728	53,424	2,486	2,071	48,867
12	2031	172,455	55,151	2,566	2,138	50,446
13	2032	176,265	56,933	2,649	2,207	52,076
14	2033	180,159	58,772	2,735	2,279	53,759
15	2034	184,139	60,671	2,823	2,352	55,496
16	2035	188,207	62,632	2,914	2,428	57,289
17	2036	192,365	64,656	3,008	2,507	59,140
18	2037	196,614	66,745	3,106	2,588	61,051
19	2038	200,958	68,901	3,206	2,672	63,024
20	2039	205,397	71,128	3,309	2,758	65,060
21	2040	209,935	73,426	3,416	2,847	67,163
22	2041	214,572	75,799	3,527	2,939	69,333
23	2042	219,313	78,248	3,641	3,034	71,573
24	2043	224,158	80,776	3,758	3,132	73,886
25	2044	229,110	83,386	3,880	3,233	76,273
26	2045	234,171	86,081	4,005	3,338	78,738
27	2046	239,344	88,862	4,135	3,446	81,282
28	2047	244,631	91,733	4,268	3,557	83,908
29	2048	250,036	94,698	4,406	3,672	86,620
30	2049	255,559	97,757	4,548	3,790	89,419

Sources: (1) Estimation, http://censos2017.inei.gob.pe/redatam/ , (2) Estimation, from "Informe N°3. Expediente Técnico de Disposición Final y Reaprovechamiento", (3) Own calculations.

Table N° 06, shows the volume requirements of the landfill needed to meet the demand for final disposal of waste in SJB. Here it is assumed that the density of the solid waste once compacted is 0.55ton / m^3 and that the landfill will have a platform depth of 4m with 60cm of cover material that will be added on top. It is also estimated that due to decomposition of solid waste inside the landfill, the volume of waste will reduce by up to 60% over the useful life of the landfill. The projections estimate that in the year 2019 the volume of the landfill that will be occupied will be 43,123 m^3 and by the end of 2049 it would be 2,585,661 m^3.

Table N° 06: Volume Requirement for Solid Waste in the San Juan Bautista Sanitary Landfill

Nº	Year	Accumulated SW (ton/year) (1)	Compacted SW (m3/year) (1)	Stabilized SW (m3) (1)	SW Platform Depth (m) (2)	Cover Material Thickness (m) (2)	Cover Material Volume (m3/year) (2)	Total Volume (m3/year) (3)	Accumulated Occupied Volume (m3/year) (3)
0	2019	34,443	62,623	33,730	4.00	0.60	9,393	43,123	43,123
1	2020	69,998	64,646	34,819	4.00	0.60	9,697	44,516	87,639
2	2021	106,702	66,735	35,945	4.00	0.60	10,010	45,955	133,594
3	2022	144,593	68,891	37,106	4.00	0.60	10,334	47,440	181,034
4	2023	183,707	71,118	38,305	4.00	0.60	10,668	48,973	230,006
5	2024	224,086	73,415	39,543	4.00	0.60	11,012	50,555	280,561
6	2025	265,769	75,788	40,820	4.00	0.60	11,368	52,189	332,750

Nº	Year	Accumulated SW (ton/year) (1)	Compacted SW (m3/year) (1)	Stabilized SW (m3) (1)	SW Platform Depth (m) (2)	Cover Material Thickness (m) (2)	Cover Material Volume (m3/year) (2)	Total Volume (m3/year) (3)	Accumulated Occupied Volume (m3/year) (3)
7	2026	308,799	78,237	42,139	4.00	0.60	11,735	53,875	386,625
8	2027	353,220	80,765	43,501	4.00	0.60	12,115	55,616	442,241
9	2028	399,075	83,374	44,907	4.00	0.60	12,506	57,413	499,653
10	2029	446,413	86,068	46,358	4.00	0.60	12,910	59,268	558,921
11	2030	495,280	88,849	47,856	4.00	0.60	13,327	61,183	620,104
12	2031	545,726	91,720	49,402	4.00	0.60	13,758	63,160	683,264
13	2032	597,802	94,684	50,998	4.00	0.60	14,203	65,201	748,465
14	2033	651,561	97,743	52,646	4.00	0.60	14,662	67,308	815,773
15	2034	707,057	100,902	54,347	4.00	0.60	15,135	69,482	885,255
16	2035	764,346	104,162	56,103	4.00	0.60	15,624	71,728	956,983
17	2036	823,487	107,528	57,916	4.00	0.60	16,129	74,045	1,031,028
18	2037	884,538	111,002	59,787	4.00	0.60	16,650	76,438	1,107,466
19	2038	947,562	114,589	61,719	4.00	0.60	17,188	78,908	1,186,373
20	2039	1,012,622	118,292	63,714	4.00	0.60	17,744	81,457	1,267,831
21	2040	1,079,785	122,114	69,971	4.00	0.60	18,317	88,288	1,356,118
22	2041	1,149,118	126,060	76,842	4.00	0.60	18,909	95,751	1,451,869
23	2042	1,220,691	130,133	84,388	4.00	0.60	19,520	103,908	1,555,778
24	2043	1,294,577	134,338	92,676	4.00	0.60	20,151	112,826	1,668,604
25	2044	1,370,850	138,679	101,777	4.00	0.60	20,802	122,579	1,791,183
26	2045	1,449,588	143,160	111,772	4.00	0.60	21,474	133,246	1,924,428
27	2046	1,530,870	147,785	122,748	4.00	0.60	22,168	144,916	2,069,344
28	2047	1,614,778	152,561	134,803	4.00	0.60	22,884	157,687	2,227,031
29	2048	1,701,398	157,490	148,041	4.00	0.60	23,624	171,664	2,398,695
30	2049	1,790,816	162,579	162,579	4.00	0.60	24,387	186,966	2,585,661

Source: (1) Own calculations (See annex 01), (2) Volume of material covered (3) Calculation of total volume, a product of the sum of stabilised municipal solid waste and the coverage material, and calculation of the total volume accumulated per year.

The useful life of the landfill is based on both the demand for disposal of solid waste, the volume requirements of the landfill and the fact that there are 21 hectares of land available for its construction. Of the 21 hectares, 17 hectares will be used to build sanitary landfill cells, leaving four hectares for access roads and other required landfill infrastructure. Table N° 07 shows the total volume available for the disposal of solid waste in the landfill cells. Given the total available volume of 1'391,040.00m^3, the useful life of the sanitary landfill has been estimated in Table N° 08 as 21.74 years.

Table N° 07. Volume Available for Disposal of Solid Waste in the Sanitary Landfill

Projected Cells	Levels per Cell	Platform depth (m)	Service area %	Total Available Area / Cell (he)	Available Volume (m^3)	Total Available Volume (m3)
8	2	4.6	80%	3.65	167,885	1,391,040

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Table N° 08. Calculation of the Useful Life of the Sanitary Landfill

Useful Life		
A. Cell	2.03	He
A. Terrain	21	He
A. Available	17	He
N° of Cells	8.3	
Total Volume	1,391,040	m3
Useful Life	**22**	**Years**

In order to estimate the generation and potential emissions reductions from capturing gas generated through the decomposition of solid waste in the sanitary landfill, tools developed by the Clean Development Mechanism (CDM) of the United Nations Framework Convention on Climate Change have been used (UNFCCC)[11]. Based on the estimated volume of solid waste, the composition of the solid waste and the climatic characteristics of the site, it is estimated that by 2019 there would be a volume of approximately 224,571 Nm3 of "Landfill Gas" (LFG).

Methodology and Tools
ACM0001 / Version 15.0.0 "Flaring or use of landfill gas"
Emissions from solid waste disposal sites" (Version 06.0.1)
Project emissions from flaring" (Version 02.0.0)
Tool to calculate baseline, project and/or leakage emissions from electricity consumption" (Version 01)

From the LFG projections and knowing the composition of the waste, the amount of GHG emissions from the solid waste can be estimated. With this information, it is possible to estimate how many tons of CO2 equivalent (tCO2e) could be mitigated through the incorporation of emissions reductions technologies. Table N° 09 shows the estimated LFG emissions from the beginning of the landfills life (2019 – year 1) until the end of its useful life in (2041 – year 22).

Table N° 09. Estimated Volume of Landfill Gas Generated from the Sanitary Landfill

Year	LFG (Nm3/year)	Year	LFG (Nm3/year)	Year	LFG (Nm3/year)
1	224,571	9	1,947,023	17	3,689,208
2	445,846	10	2,159,939	18	3,916,905
3	664,421	11	2,373,602	19	4,147,786
4	880,842	12	2,588,344	20	4,382,136
5	1,095,612	13	2,804,487	21	4,620,238
6	1,309,195	14	3,022,344	22	4,862,376
7	1,522,024	15	3,242,219		
8	1,734,506	16	3,464,409		

Source: Own Estimation

[11] https://cdm.unfccc.int/methodologies/index.html

4. Selection Criteria and Classification Levels

4.1. Analysis of Options

Eight selection criteria have been established which cover cost, risk, flexibility, and suitability and impact aspects. Table N° 11 shows the percentage weighting, the decision criteria and the scoring for each technology alternative to be chosen based on judgement by experts. In the scoring a '1' is considered the worst and a '3' the best.

Table N° 12. Description and Scoring for Selection Criteria

Score (A)	Weight (B)	Descripción	Descision Criteria
Cost Optimization (Score 1-3)	20%	Costs of the alternative taking into account CAPEX and OPEX. The potential income flows generated by the alternative (in relation to other technologies) over its useful life are considered as an additional benefit.	The alternative with the lowest net costs over the course of its useful life will receive the highest score (3). The alternative with the highest net costs will receive the lowest score (1).
Risk Level (Construction) (Score 1-3)	5%	Risk associated with delays in the implementation and deviations of the project plan / schedule. Simplicity in the implementation of the technologies is awarded a higher score than technologies which are more complex to implement.	The alternative with the lowest level of risk will receive the highest score (3). The alternative with the highest level of risk will receive the lowest score (1).
Rick Level (Operation) (Score 1-3)	5%	Level of risk regarding the ability of the technology to provide satisfactory operation without failures during its useful life/over long periods of time.	The alternative with the lowest level of risk will receive the highest score (3). The alternative with the highest level of risk will receive the lowest score (1).
Suitability (Score 1-3)	10%	Capacity of the technology to adapt well to the physical characteristics and requirements of the chosen site. Technologies tested locally and / or internationally in similar locations obtain higher scores, as well as technologies with specific benefits for the environment in which it will be implemented.	The alternative with the highest level of suitability will receive the highest score (3). The alternative with the lowest level of suitability will receive the lowest score (1).
Flexibility (Score 1-3)	10%	Flexibility of the alternative in terms of potential to adapt to future demands e.g. scalability potential in the case of increased demand. If the scalability does not require more investment or effort, the technology gets higher score.	The alternative with the highest level of flexibility will receive the highest score (3). The alternative with the lowest level of flexibility will receive the lowest score (1).
Emissions Reduction (Score 1-3)	20%	The potential reductions in projected emissions relative to the levels of reference GHG emissions (baseline) over the lifetime of the technology. The more emission reduction generated, the higher the score.	The alternative with the greatest potential for GHG emission reduction will receive the highest Score (3). The alternative with the lowest GHG emission reduction potential will receive the lowest Score (1)
Environmental and Social Impact (Score 1-3)	15%	Potential for generating social impact e.g. employment opportunities for the local community and greater access to energy as a result of energy generation, among others. Potential for reducing environmental damage.	The alternative with the highest level of possible positive environmental and/or social impact will receive the highest Score (3). The alternative with the lowest positive impact potential will receive the lowest score (1)
Replicability (Score 1-3)	15%	Possibility for replicating the use of the technology in other landfills in the country. If the technology can be applied in a greater number of places with similar benefits, it is awarded a higher score.	The alternative with the highest level of replicability will receive the highest score (3). The alternative with the lowest GHG emission reduction potential will receive the lowest Score (1).

Source: Own elaboration

4.2. Analysis of Viability

For each alternative presented, a multi-criteria analysis is carried out using the framework above. The overall score is determined by the total scores (AxB) of eight criteria to which a score (A) and a weighted weight (B) have been assigned. Scores that are greater than 2 deem the project to be very viable; between 1 and 2 viable and less than 1 not viable (Table N ° 12).

Table N°13. Scale of Viability Scores for the Options Analysis

Viability Score	Description
Greater than 2	Very Viable
Between 1 and 2	Viable
Less than 1	Not Viable

Source: Own elaboration

5. Technology Options

This concept note evaluates technologies which could be added to the existing design for the sanitary landfill to both reduce GHG emissions and take advantage of the biogas it will generate for the treatment of leachates, or for electricity generation for auto consumption. Three potentially appropriate technologies were chosen for evaluation based on the characteristics of the San Juan Bautista sanitary landfill:

- Option 1: Biogas capture and centralised flare
- Option 2: Biogas capture, centralised flare and electricity generation
- Option 3: Landfill leachate treatment through evaporation

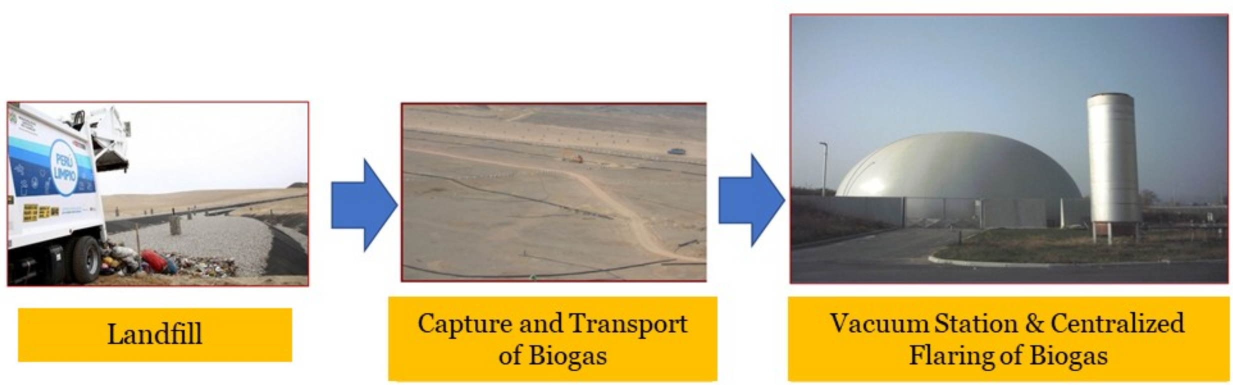
These three alternatives were chosen for evaluation based on their maturity, prior experience of the technology within the country, the volume of waste at this location and the potential for operating cost reductions, energy recovery and GHG emissions reductions. These technologies are all available in the global market and have the potential to be replicated at other landfill site in Peru and internationally. Assuming a certain level of technical management of the final disposal process, and a constant stream of waste disposal throughout the useful life of the landfill, projections of financial and non-financial impacts of the technology alternatives can be made.

5.1. Option 1: Biogas capture and centralised flare

5.1.1. Technology Overview

This technology involves the construction of biogas wells in the platforms of the sanitary landfill in order to capture biogas which is then transported to a controlled combustion station through an active suction system. GHG emissions are destroyed in the controlled combustion station via flaring in line with the ACM0001 methodology of the UNFCCC[12]. Figure N° 03 illustrates the flow of activities involved in the capture and centralised flaring of biogas.

Fig. N° 03. Biogas capture and centralised flare diagram



5.1.2. Cost Optimization

Costs are incurred for this technology in the construction of the biogas capture wells, the biogas transport duct, the suction stations and the controlled combustion station. The estimated cost of installing these at the scale required for the SJB site, including a reserve for contingencies and management, would be approximately US$ 0.1 million

[12] https://cdm.unfccc.int/methodologies/documentation/meth_booklet.pdf#ACM0001

(for more details see Annex No. 03). This estimation was reached using the "Perú: Huaycoloro Landfill Gas Recovery" CDM Project as a reference (*"World Bank Documents"*).[13]

5.1.3. Risk Level

The construction and implementation of this technology is relatively straightforward and its operation would be simple and automatable. The selection of suppliers for construction and installation of the technology would be made through a private tender through the landfill operator and the installation of the technology should require a maximum of 12 months. However, potential implementation delays and have been identified as project risks. Given these risks, a contingency reserve of 10% of the estimated overall cost of the project has been built into the budget.

5.1.4. Suitability and Flexibility

This technology is well suited to this site in that it provides a low cost option for achieving the objective of reducing GHG emissions. However, this technology does not address any other issues associated with the site such as the treatment of leachate. It is fairly flexible with respect to the volume of additional GHG that could be generated, either by unexpected climatic factors that increase or by an increase in the generation and disposal of solid waste. This is because any unanticipated additional volume of gas could be stored in the gas pipes of the landfill, or an alternative storage facility that could be installed, until it is ready to be burned.

5.1.5. GHG Emissions Reduction Potential

It has been estimated that over the useful life of this landfill (22 years), this technology could achieve emissions reductions of 441,664 tCO_2e. The GHG emissions reduction potential of this technology was estimated the Clean Development Mechanism (CDM) from the United Nations Framework Convention on Climate Change (UNFCCC) (for more details of the assumptions used in this estimation see Annex No. 03).

5.1.6. Track Record, Potential Suppliers & Private Sector Interest

Modelo del Callao and Ancón. There are a variety of suppliers of this technology, including: ABISA, Haug, Jhon Zink, Jorvex, Cidelsa and TDM. It is also possible to include the cost of operating the technology into the landfill operational costs in order to attract private sector interest from waste service provider companies such as Petramás, KDM, Veolia, Proactiva, and Acciona.

5.1.7. Impact and Replicability

This alternative does not have any additional environmental benefits beyond GHG emissions reductions and does not have any social impacts such as additional generation of employment. This technology is the most simple, low cost and replicable of the three alternatives and can be applied to landfill sites of varying sizes.

5.1.8. Analysis Results

Using the methodology described in section 4, the following scoring (shown in Table N° 14) was established through a working session between PwC and the Department of Waste Management (Dirección de Gestion de Residuos Solidos- DGRS) and the Department of Climate Change and Desertification (Dirección de Cambio Climático y Desertificación – DGCCD) of the Ministry of Environment (MINAM).

Table N° 14. Score for Alternative 1

Score (A)	Weight(B)	Score out of 3	Weighted Score
Cost Optimization	20%	3	0.6
Risk Level (Construction)	5%	3	0.15
Rick Level (Operation)	5%	3	0.15
Suitability	10%	1	0.1

[13] http://documents.worldbank.org/curated/en/951071468293396238/pdf/337610PAD0P0941aycoloro0PAD0Sept030.pdf (See annex 5 of this document)

Flexibility	10%	3	0.3
Emissions Reduction	20%	1	0.2
Environmental and Social Impact	15%	1	0.15
Replicability	15%	2	0.3
Total	**100%**	**-**	**1.95**

Source: Own calculation

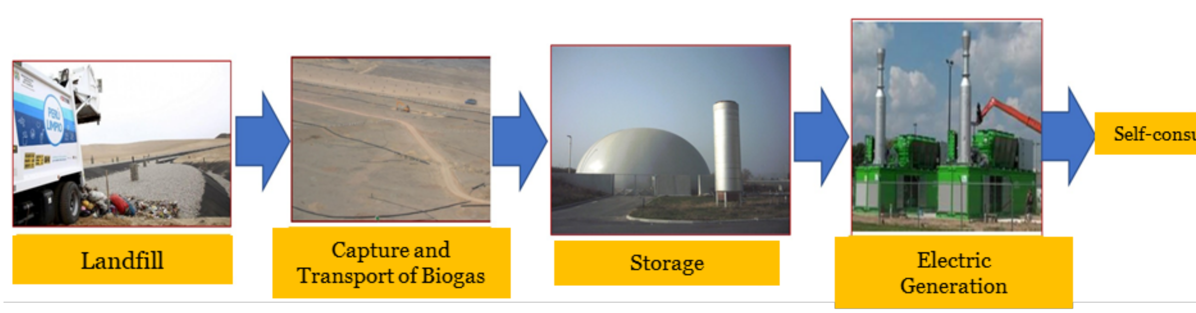
5.2. Option 2: Biogas capture, centralised flare and electricity generation

5.2.1. Technology Overview

This technology alternative involves the construction of biogas wells in the platforms of the sanitary landfill in order to capture biogas which is then transported to be cleaned and compressed. The treated gas is converted into electricity in high efficiency combustion engines and will then be used for operations at the landfill site, reducing the cost that would otherwise be incurred for the purchase of electricity (which would be generated with diesel). This alternative also integrates centralised flaring as a safety measure to be used in the case the combustion engines need to be stopped for maintenance.

Figure N° 04 illustrates the flow of activities involved in the biogas capture, centralised flare and electricity generation.

Figure. N° 04. Biogas capture, centralised flare and electricity generation diagram



5.2.2. Cost Optimization

Costs are incurred in the construction of the biogas capture wells, the biogas transport duct, the stations for the compression and cleaning of the biogas, the combustion engines, the electricity generation station and the internal electricity distribution grid. It is projected that from the third year for the useful life of the landfill, sufficient landfill gas will have been produced to install a 50kW combustion engine to produce electricity for self-consumption and there will be sufficient gas to increase this capacity 500kW from the tenth year.

It has been estimated that the cost of installing these at the scale required for the Trujillo site, including a reserve for contingencies and management, would be approximately US$0.2 million (for more details see Annex No. 04). This estimation was reached using the "Perú: Huaycoloro Landfill Gas Recovery" CDM Project as a reference in a similar approach to that used for the previous alternative.[14] A return on this investment would be achieved through savings from using the electricity generated for self-consumption which would offset costs that would otherwise be incurred for the purchase of diesel generated electricity.

[14] http://documents.worldbank.org/curated/en/951071468293396238/pdf/337610PAD0P0941aycoloro0PAD0Sept030.pdf
(Revisar Annex 5 de este documento)

5.2.3. Risk Level

The selection of suppliers for construction and installation of the technology would be made through a private tender through the landfill operator. The installation of the technology should require a minimum of 12 months. However, potential implementation delays and have been identified as project risks. Given these risks, a contingency reserve of 10% of the estimated overall cost of the project has been built into the budget.

5.2.4. Suitability and Flexibility

This technology alternative is suitable for the site as it achieves both the goal of reducing emissions and reducing costs of the sanitary landfill through the use of self-generated electricity. However, this technology does not address any other issues associated with the site such as the treatment of leachate. The alternative is fairly flexible with respect to the volume of additional GHG that could be generated, because any unanticipated additional volume of gas could be stored in the gas pipes of the landfill, or an alternative storage facility that could be installed, until it is ready to be burned.

5.2.5. GHG Emissions Reduction Potential

It has been estimated that over the useful life of this landfill (22 years), this technology could achieve emissions reductions of 446,426 tCO2e. The GHG emissions reduction potential of this technology was estimated using tools provided by the CDM from the UNFCCC. This figure includes the direct emissions reductions from the landfill and the indirect emissions reductions achieved through displacing consumption of conventional, non-renewable energies that generate GHG emissions that would otherwise be used for the operations of the landfill. In this region where the landfill site is based, the energy mix is mainly composed of energy generated in thermal power plants through burning oil. Using the CDM model, it is estimated that each MWh of biomass generated electricity that replaces conventional non-renewable energy consumption would result in a reduction of de 0.45 tCO2eq[15].

5.2.6. Track Record, Potential Suppliers & Private Sector Interest

As of October 2018, this technology has be implemented at the Huaycoloro sanitary landfill in Peru with electricity being generated for both self-consumption and sale to the SEIN. There are a variety of suppliers of this technology, including: Caterpillar, Jenbacher and Perennial Energy. As a complementary technology to the centralised capture and flare technology which lowers operating costs, this could increase the likelihood of private sector interest from waste service provider companies such as Petramás, KDM, Veolia, Proactiva, Acciona.

5.2.7. Impact and Replicability

The positive environmental impact of this technology is greater compared to the first alternative due to the generation of renewable energy that would displace consumption of non-renewable energy for landfill operations in addition to the GHG emissions reductions from the gas capture at the landfill site. Like the former technology, this alternative does not have any social benefits such as additional generation of employment. This technology is less replicable for cities like SJB than the former due to the additional costs which are not completely offset by the savings generated from the self-consumption of the electricity generated.

5.2.8. Analysis Results

Using the methodology described in section 4, the following scoring (shown in Table N° 15) was established through a working session between PwC and the DGRS and the DGCCD of the MINAM.

Table N° 15. Score for Alternative 2

Score (A)	Weight(B)	Score out of 3	Weighted Score
Cost Optimization	20%	3	0.6

[15] UNFCCC: Project 0708

Risk Level (Construction)	5%	3	0.15
Rick Level (Operation)	5%	2	0.1
Suitability	10%	1	0.1
Flexibility	10%	3	0.3
Emissions Reduction	20%	2	0.4
Environmental and Social Impact	15%	1	0.15
Replicability	15%	2	0.3
Total	**100%**	**-**	**2.1**

Source: Own elaboration

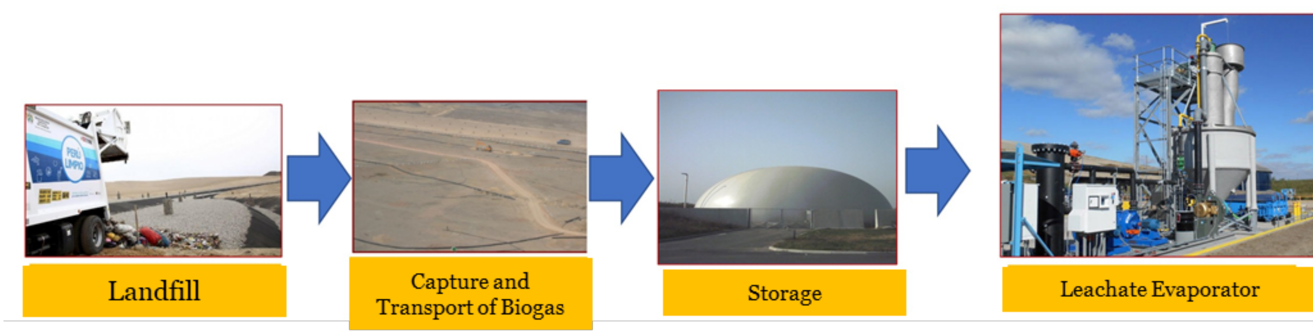
5.3. Option 3: Landfill leachate treatment through evaporation

5.3.1. Technology Overview

This option involves the installation of the biogas capture, centralised flare and electricity generation technology described in the form as well as a complementary leachate evaporation technology. This alternative involves the installation of an additional leachate evaporation plant on site to treat leachate produced by the landfill that would have otherwise been taken to the Wastewater Treatment Plant (WWTP) situated in Iquitos. The leachate evaporator would be powered by biogas captured from the landfill.

Figure N° 05 illustrates the flow of activities involved in the biogas capture, centralised flare and electricity generation and landfill leachate treatment through evaporation.

Figure N° 05: Landfill leachate treatment through evaporation diagram



5.3.2. Cost Optimization

The costs incurred for this alternative are related to the construction of the biogas capture wells, the biogas transport duct, the stations for the compression and cleaning of the biogas, the combustion engines and the leachate evaporation plant. It is projected that from the first year of the useful life of the landfill, sufficient landfill gas will have been produced to install a 50kW combustion engine to feed directly into the leachate evaporation technology to be combusted to fuel the treatment of leachate generated by the landfill. It is estimated that the cost of installing these technologies, including a reserve for contingencies and management, would be approximately US$0.7 million (for more details see Annex No. 05). The method used to calculate the costs of this technology was the same used for the previous two alternative, with additional costs added for the instalment and operation of the leachate evaporation station.

5.3.3. Risk Level

The selection of suppliers for construction and installation of the technology would be made through a private tender through the landfill operator and the installation of the technology should require a minimum of 12 months.

However, potential implementation delays and have been identified as project risks. Given these risks, a contingency reserve of 10% of the estimated overall cost of the project has been built into the budget.

5.3.4. GHG Emissions Reduction Potential

It has been estimated that over the useful life of this landfill (22 years), this technology could achieve emissions reductions of 449,285 tCO2e. The GHG emissions reduction potential of this technology was estimated using tools provided by the CDM from the UNFCCC. This figure includes the direct emissions reductions from the landfill and the indirect emissions reductions achieved through displacing consumption of conventional, non-renewable energies that generate GHG emissions that would otherwise be used for the operations of the landfill and the fuel to power the leachate evaporator.

5.3.5. Suitability and Flexibility

This technology is ideal for the site as it achieves the goals of reducing emissions and reducing costs of the sanitary landfill through the use of self-generated electricity, and also addresses the pressing issue of the treatment of leachates. It is not as flexible as the other options as there is a limited capacity for the treatment of leachates and would not have the capacity to treat excess leachates if the estimated volume increased above the capacity limit. As such, it would be important to have as accurate as possible estimations of the projected leachate generation of the landfill in order to avoid overflows.

5.3.6. Track Record, Potential Suppliers & Private Sector Interest

As of October 2018, this technology has not been implemented at a sanitary landfill in Peru and there are no landfills that treat leachates on site through evaporation. However, there are suppliers that could provide this technology such as John Zink. As this technology is complementary to the centralised capture, flare technology and electricity generation which lowers operating costs, this could increase the likelihood of private sector interest from waste service provider companies such as Petramás, KDM, Veolia, Proactiva, Acciona

5.3.7. Impact and Replicability

This option has an important additional environmental impact of leachate treatment that is not offered but the other alternatives. The issue of leachates is of pressing importance given the location of the landfill in the Amazon rainforest and the potential environmental damage it could do if it were to come into contact with large bodies of water, flora and fauna in this high conservation value area. It represents a new final disposal of waste model that could be replicated at a number of small sanitary landfills in the rainforest regions of the country to lower the cost of leachate treatment.

5.3.8. Analysis Results

Using the methodology described in section 4, the following scoring (shown in Table N° 16) was established through a working session between PwC and the DGRS and the DGCCD of the MINAM.

Table N° 16. Score for Alternative 3

Score (A)	Weight(B)	Score out of 3	Weighted Score
Cost Optimization	20%	2	0.4
Risk Level (Construction)	5%	2	0.1
Rick Level (Operation)	5%	2	0.1
Suitability	10%	3	0.3
Flexibility	10%	2	0.2
Emissions Reduction	20%	3	0.6
Environmental and Social Impact	15%	3	0.45
Replicability	15%	3	0.45
Total	**100%**	**-**	**2.6**

Source: Own elaboration

6. Evaluation of the Technology Options

6.1. Technology Option Scoring

Table N° 17 illustrates the advantages and disadvantages of each technology alternative and the weighted score that were awarded to each alternative by a panel of experts through a working session between PwC and the DGRS and the DGCCD of the MINAM.

Table N° 17. Technology Alternatives Scoring

	Alternative 1: **Biogas capture and centralised flare**	**Alternative 2:** **Biogas capture, centralised flare and electricity generation**	**Alternative 3:** **Landfill leachate treatment through evaporation**
Advantages	• Lowest cost • Most adaptable to deviations/changes • Two existing national examples	• Medium costs • Proven (tried and tested) technology • Four existing national examples	• Lower costs compared to leachate treatment at a WWTP • Greatest potential environmental impact
Disadvatages	• Low labour requirements	• Gradual implementation of infrastructure over the useful life of the landfill • Can be applied on a small scale	• New technology and no local experience
Weighted score	1.95	2.1	2.6

Source: Own elaboration

6.2. Decision on the Most Appropriate Technology

The second technology, landfill leachate treatment through evaporation (in addition to biogas capture, centralised flare and electricity generation), was deemed to be the most appropriate choice. This technology was chosen as it was the only option that provided an onsite solution for leachate treatment. Given that the introduction of this technology would both reduce costs compared to treating the leachate offsite at a WWTP and reduce the potential negative environmental and social impacts that could arise from inadequate treatment, it was considered to be superior to the other two.

7. Conclusions

The composition of the solid waste that will be sent to the sanitary landfill in SJB is an important factor in determining the GHG emissions that will be generated through its decomposition. A greater percentage of organic waste in combination with climatic factors that accelerate decomposition in this region, will result in greater generation of GHG emissions and leachate liquids which could potentially be very harmful to the surrounding high value conservation forest ecosystem.

There is a pressing need for a final disposal of waste technology that mitigates the potential negative impacts associated with the construction and operation sanitary landfills in Amazon zones, while achieving the countries goal of GHG emissions reductions. Given projected population growth in this region and other relevant demographic and climatic variables, the technology must also be adaptable to the specific context and requirements of the sanitary landfill. For these reasons the incorporation of a leachate evaporation technology, in combination with a biogas capture, centralised flare and electricity generation technology to reduce the operating costs of the sanitary landfill, was chosen as the most appropriate technology for the SJB sanitary landfill.

When evaluating suitability of technologies for GHG mitigation in zones in the Amazon, it is important to consider technologies that also have the potential to reduce other impacts associated with the construction and operation of sanitary landfills in those zones, particularly leachate generation. However, it is important to note that given the smaller scale of the majority of the landfills in these zones the implementation of such technologies would increase operating costs and may not generate an economic return sufficient to cover the costs of the technologies. As a result, various financing alternatives (including non-commercial options) should be considered to support the funding of most appropriate technology.

When analysing potential projects for the incorporation of technologies to reduce the environmental impacts of sanitary landfills, it also important to analyse the potential benefits that investments may have on relevant stakeholders, such as solid waste operating companies, which may experience economic benefits from the implementation of these type of technologies even if they are small scale. These benefits could be crucial in drawing interest from the private sector to mobilise much needed private investment into the construction and operation of these technologies and in creating partnerships that aid the country in its ambitions to protect the environment and foster sustainable development.

Annexes

Annex 01: Assumptions for the estimation of SW

Assumption	Estimation	Source
Population Growth	2%	Annual avg. growth http://censos2017.inei.gob.pe/redatam
Growth	1%	Conservative assumption
Domestic SW Volume	86.53%	Estudio de caracterización de RRSS municipales (Municipal study)
Commercial SW Volume	10.45%	Estudio de caracterización de RRSS municipales (Municipal study)
SW from Street Sweeping Volume	3.02%	Estudio de caracterización de RRSS municipales (Municipal study)
Recyclable SW Volume	4.65%	Fichtner
SW Volume	3.88%	Fichtner
Compacted SW Density	0.55 ton/m^3	Standard assumption
Volume reduction from stabilization	6% annual	Standard assumption

Annex 02: Assumptions for the estimation of gas emissions

Physical parameters of compounds				
Parameters	Unit	Value	Explanation	Source
Φ	-	0.75	Model correction factor to account for model uncertainties	According to the ""Emissions from solid waste disposal sites" (Version 06.0.1)", page 2
f	%	0.0	Fraction of CH4 captured to the SWDS	Considered 0 since the Tool - Annex 13 also considers an Adjustment Factor
GWP (1st Crediting Period)	tCO2e/tCH4	25	Global Warming Potential	According to the "Emissions from solid waste disposal sites" (Version 06.0.1), page 2
GWP (2nd Crediting Period)	tCO2e/tCH4	25	Global Warming Potential	According to the "Emissions from solid waste disposal sites" (Version 06.0.1), page 2
OX	-	0.1	Oxidation factor	According to the "Tool v.6" page 3, considering the material utilized for covering the landfill (at the closure)
F	%	0.5	Fraction of CH4 in the SWDS gas	According to the "Emissions from solid waste disposal sites" (Version 06.0.1), page 2
DOC_f	%	0.5	Fraction of degradable organic carbon that can decompose	According to the "Emissions from solid waste disposal sites" (Version 06.0.1), page 3
MCF	-	1.0	Methane Correction Factor	According to the "Emissions from solid waste disposal sites" (Version 06.0.1) page 4, considering the management of the landfill
r_{CH4}	tonnes/m^3	0.0007168	Density CH4	According to the ""Emissions from solid waste disposal sites" (Version 06.0.1), page 9 (density of methane at normal conditions)
OX_{top_layer}	-	0.1	Fraction of methane that would be oxidized in the top layer of the SWDS in the baseline	Consistent with how oxidation is accounted for in the methodological tool Emissions from solid waste disposal sites
CH4 (%v/v)	%	50%	CH4 concentration	To be monitored (this value as a default per PDD calculations)
Equipment Details				
Parameters	Unit	Value	Explanation	Source
η_{PJ}	%	0.75	GCE of the equipment installed	Default value as per page 10/23 of ACM0001 / Version 13.0.0 "Flaring or use of landfill gas"
Blower	HP	30	1 blower engine 60HP; 3,600 RPM; 03Phase; 60HZ	Project Developer
Compressor	HP	4.00	1 compressor INGERSOLL RAND; 7,5HP; 1,800 RPM; 480V; 03 Phase; 60HZ.	Project Developer
Blower purge	HP	0.50	1 blower purge that functions only when the system is operating: 3/4 HP; 1,800 RPM; 01 Phase.	Project Developer
Cooler	HP	1.50	1 cooling system of 3 HP	
Electronic System	kW	2	Various	Project Developer
$EC_{PJ,y}$	MWh/yr	252.7	Electricity Consumption, yearly	Calculated
hflare,m	%	1.0	Flare Efficiency in the minute m	Default value according to the tool "Project emissions from flaring" version 02.0.0
CEG	MW	1.137	Capacity of Each Generator	Project Developer
GE	%	40.20%	Generator efficiency	"ESTUDIO DE DETERMINACIÓN DE LA POTENCIA EFECTIVA Y RENDIMIENTO DE LOS GRUPOS CAT 1, 2 Y 3 DE LA CENTRAL TÉRMICA HUAYCOLORO"
FLGE	m3/h	510.74	Flow LFG each generator	Calculated
Tcn	m3/h	0	Thermal Consumption	NA
ε_{boiler}	%	0	Boiler efficiency	NA
Electrical considerations				
Parameters	Unit	Value	Explanation	Source
EFgrid,y	tCO2e/MWh	0.45338	Grid Emission Factor	Provided to DOE as per the "Tool to calculate the emission factor for an electricity system" Version 4.0
TDLy	ratio	5.00%	Technical losses in the grid	Default value

Working times				
Parameters	Unit	Value	Explanation	Source
helec	h/year	8,000	Hours of generators	Project developer
hbl	h/year	8,000	Hours of blowers	Project developer
hth	h/year	0	Hours of thermal consumption	NA
Other parameters				
Parameters	Unit	Value	Explanation	Source
$PE_{FC,j,y}$	tCO2e/year	CALCULATED	Emissions from heat consumption by the project activity	Project evaluator
CH_{4LHV}	KJ/mol	890	Methane LHV	IPCC
FCi,j,y	m3/year	0.0000	Fuel consumption	Project developer
NCVi,y	GJ/ m3	26.3000	Weighted average net calorific value of the fuel type i (LPG)	Values from the fuel supplier will be used.
EFCO2i,y `	tCO2/GJ	0.0656	Weighted average CO2 emission factor of fuel type i (LPG)	Values from the fuel supplier will be used.
Site characteristics				
Parameters	Unit	Value	Explanation	Source
MAT	ºC	26.8	Mean Average Temperature	http://www.worldweather.org/029/c00108.htm
MAP	mm/year	2,499	Mean average Precipitation	http://www.worldweather.org/029/c00108.htm
PET	mm^3/mm^2	565	Potential evapotranspiration	http://www.fao.org/geonetwork/srv/fr/graphover.show?id=12739&fname=aridity_index.gif&access=public
Waste basis	-	wet	Waste basis (wet / dry)	Project developer

Source: https://cdm.unfccc.int/methodologies/index.html. Datos planteados de acuerdo a las características del relleno

Annex 03: Alternative Budget 01

Item	Amount (US$)	Participation
Project Management	820	1%
Project Supervision & Quality Assurance	4,098	4%
Basic Engineering (Studies & Design)	820	1%
Detailed Engineering (Studies & Design)	3,278	3%
Licensing	4,098	4%
	33,907	32%
Centralized Capture and Flaring System	44,651	43%
Electric work & Instrumentation	3,395	3%
Commissioning-ITF	2,459	2%
Project Estimates	**97,522**	
Contingency Reserves	4,876	5%
Costs Line	**102,398**	
Management Reserves	2,048	2%
Total Budget	**104,446**	**100%**

Source: Based on CDM Project “Perú: Huaycoloro Landfill Gas Recovery” (*“World Bank Documents”)*

Annex 04: Alternative Budget 02

Item	Amount (US$)	Participation
Project Management	1,703	1%
Project Supervision & Quality Assurance	8,517	4%
Basic Engineering (Studies & Design)	1,703	1%
Detailed Engineering (Studies & Design)	6,813	3%
Licensing	8,517	4%
Centralized Capture and Flaring System	81,951	38%
Biogas Cleaning & Conditioning System	6,114	3%
Electric Generation System	48,232	22%
Electric Sub Station System	6,912	3%
Transmission System	24,236	11%
Others	2,891	1%
Commissioning-ITF	3,407	2%
Project Estimates	**200,996**	
Contingency Reserves	10,050	5%
Costs Line	**211,046**	
Management Reserves	4,221	2%
Total Budget	**215,267**	**100%**

Source: Based on CDM Project “Perú: Huaycoloro Landfill Gas Recovery” (*“World Bank Documents”)*

Annex 05: Alternative Budget 03

Item	Amount (US$)	Participation
Project Management	5,397	1%
Project Supervision & Quality Assurance	26,985	4%
Basic Engineering (Studies & Design)	5,397	1%
Detailed Engineering (Studies & Design)	21,588	3%
Licensing	26,985	4%
Centralized Capture and Flaring System	81,951	12%
Biogas Cleaning & Conditioning System	6,114	1%
Electric Generation System	48,232	7%
Electric Sub Station System	6,912	1%
Transmission System	24,236	4%
Others	2,891	0%
Leachate Evaporator	369,364	55%
Commissioning-ITF	3,407	1%
Project Estimates	**629,458**	
Contingency Reserves	31,473	5%
Costs Line	**660,931**	
Management Reserves	13,219	2%
Total Budget	**674,150**	**100%**

Source: Based on CDM Project “Perú: Huaycoloro Landfill Gas Recovery” (*“World Bank Documents”)*

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

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