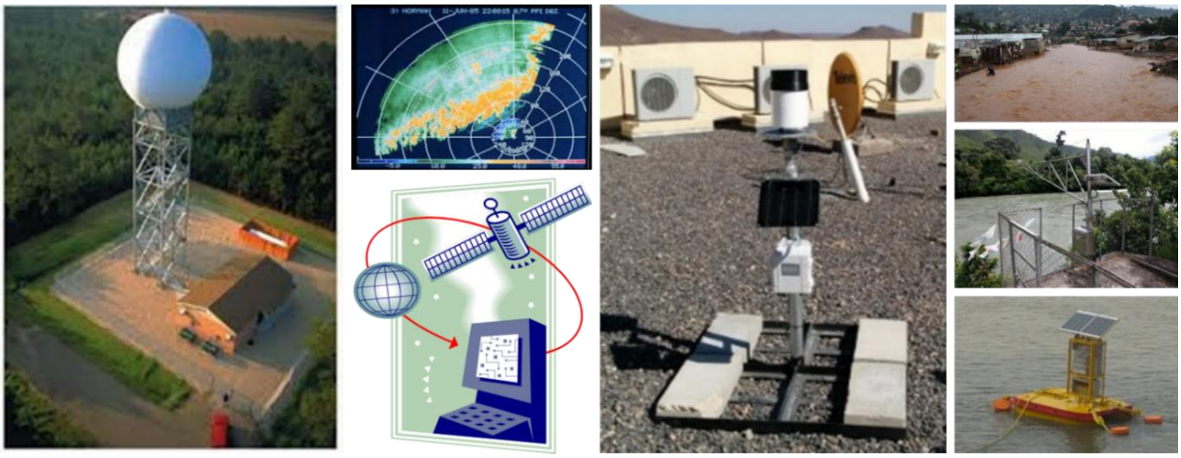

Enhancing Climate Information Systems for Resilient Development in Sierra Leone under the Freetown WASH and Aquatic Environment Revamping Program

ANNEX 10_FINANCIAL AND ECONOMIC ANAYLSIS

1/7/23

TABLE OF CONTENTS

1.0 ECONOMIC ANALYSIS

1.1 CONTEXT

The preparation of the estimates is based on data collection, reading of previous studies, and report and discussion with the project team. A major limitation when it comes to undertaking an economic and financial assessment in Sierra Leone is data limitation. As a result, we rely on a simulation model and make use of the System Dynamics approach to study the economic and financial sustainability of the interventions (components) proposed in the project. The proposed methodology allows us to determine the NPV associated with different scenarios that capture the potential impacts of climate change on the economic structures in Sierra Leone. The fact that investments in hydro-meteorological services are expected to reduce the vulnerability Sierra Leone faces towards climate hazard risks and therefore promote a sustained increase in economic growth and social development.

The system dynamics method offers an excellent ground that can be used to build scenarios that are representative of the context, institutional setups, and technical constraints encountered in a given country. It is also often used in an environment that is characterized by a low level of data availability and complex and non-linear interactions between stakeholders and decision parameters. The approach was initially proposed by Jay Forrester at MIT in the late 1950s, but it has evolved to capture new trends that are characteristics of developing countries that are often materialized by low data availability. This adds to the level of complexity that is often encountered when building system analysis. Additional advantages of the proposed approach are its ability to determine the causal relationship between interventions (components) and impacts (GDP losses, losses in productivity, human death), and therefore track the long-term implications associated with climate hazards on changes in socio-economic attributes. Relationships between variables and their drivers can also be established in such models. This methodological approach is capable of identifying key economic sectors, eliciting the variables of each sector, and illustrating their relationships within and across sectors.

Four iterative stages were followed to run the analysis. **First**, we define the purpose of the model. This enabled us to identify the model boundary and potential operating limits that influence relationships between variables. **Second**, the assumptions are introduced to capture potential non-linearity between decision variables and model feedback. The assumptions are based on economic literature, realistic observation of current analytical frameworks, a retrospective of historical data, and the experience of the analyst. They take into consideration both direct and indirect effects associated with climate change. Most investment decisions are not only uncertain but also non-linear. The non-linearity arises from the fact that several factors may simultaneously contribute to influencing the evolution of a particular variable, and it becomes difficult to clearly identify which one of the contributing factors has stronger and more direct effects. A practical example is both population growth and technology adoption influence economic growth. Parameters that influence the dynamics between the variables are operated in this stage.

Third, we simulate the model and test the dynamic hypothesis set earlier. The simulation is based on the assumptions introduced in the previous stage, through the different scenarios. The stage illustrates how economic principles can be applied to help identify cost-effective adaptation and mitigation options in a context characterized by low data availability and high uncertainty related to weather variability. **Finally**, the financial sustainability of the model is then assessed to inform on the cost-effectiveness of the proposed interventions. Important parameters that influence investment decisions are introduced. These are the cashflows, discount rate, the lifetime of the project, and allocation of the funding structure between capital expenditure (CAPEX) and operating expenditure (OPEX). Given the fact that this sub-program 2, which we are investigating, is one of the existing programs under the project Freetown WASH and Aquatic Environment Revamping Program, we followed the allocative assumptions made under program 1. This allows us to maintain consistency in the way in which investment and operational decisions are coordinated across the two programs. An additional step is often to conduct sensitivity analysis or parameters switching assumption to evaluate the extent to which changes in some variables (i.e interest rates) influence the investment decisions.

Figure 1 shows the relationship between the decision (or output) variables in the described model. We borrow the structure from the Liberia Climate Risk Assessment Simulation Model (LICRASIM) developed by the Bank two years ago. The direction and causes of the effects of climate hazards on economic variables are depicted throughout various decision centers organized around loops. Four loops are integrated: the economic growth loop, the climate impact loop, the climate loss loop, and the social impact loop. The terms “s: same” and “o: opposite” represent a situation when inputs influence the decision variables within each loop and the main output variable of the loop has a positive (increasing) and negative (decreasing) relationship respectively. This is the case between the GDP growth rate and nominal values of GDP. This is also the case between annual and cumulative climate losses due to climate hazards and the GDP ratio expressed as a portion of economic growth. The different stages encountered in a loop determine the relationship and causal impacts between inputs and outputs in the model. The same causal relationship is also encountered between per capita income and people impacted by climate change. Alternative specifications that provide quantitative measurements of phenomena that affect decision variables could also be explored, under sufficient data availability. In the existing setting, loops can be reinforcing (R1) or balancing (B1). In the former, the net outcome of the relationships is positive whereas it is negative under the latter.

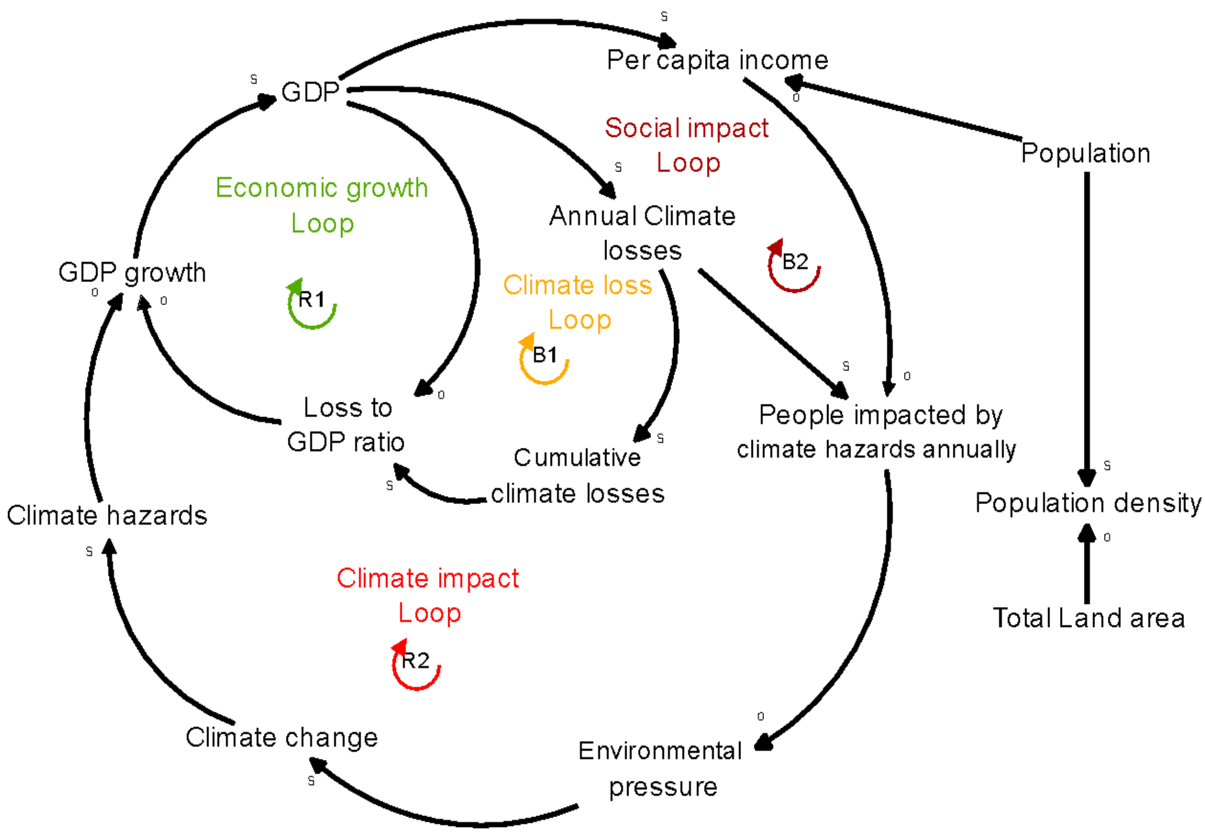

FIGURE 1: CAUSAL LOOP DIAGRAM

1.2 SCENARIO ASSESSMENT

The model developed for the assessment is labeled the Sierra Leone Climate Risk Assessment Model (SLCRAM), which is a simulation model that is derived from a set of tangible scenarios (Table 1). A total of seven scenarios are analyzed, and all relate to the magnitude and extent to which climate change affects economic and financial performance. Scenario 1 is the business-as-usual one. No change is expected in the system and Sierra Leone just carries out as it used to do, and the country will face all the losses that are associated with the climate hazards. Scenario 2 assumes an increase of 25% of the expected losses between 2023 and 2027, whereas scenario 3 assumes a decrease of 25%. Scenarios 4 and 5 assume a 50% loss increase and decrease respectively that takes place within a 10-year timeframe. The last two scenarios assume an increase and decrease of 75% of the expected losses within fifteen years. Losses are captured through decreases in the ratio of the GDP since no micro-economic data were available to conduct disaggregated micro-assessment at the household level.

Table 1: list of scenarios and their descriptions

Scenarios	Description
Baseline	This refers to the business-as-usual case where no different action is taken to cause a change in the current path.
25% loss increase	This captures the situation where there is a 25% increase in the share of GDP that is lost annually as a result of climate change. This occurs between 2023-2027
25% loss decrease	This captures the situation where there is a 25% decrease in the share (portion) of GDP that is lost annually as a result of climate change within a five-year period. This occurs between 2023-2027
50% loss increase	The captures the situation where there is a 50% increase in the share (portion) of GDP that is lost annually as a result of climate change within a ten-year period. This occurs between 2023-2032
50% loss decrease	The captures the situation where there is a 50% decrease in the share (portion) of GDP that is lost annually as a result of climate change within a ten-year period. This occurs between 2023-2032

75% loss increase	This captures the situation where there is a 75% increase in the share (portion) of GDP that is lost annually as a result of climate change within a fifteen-year period. This occurs between 2023-2037
75% loss decrease	This captures the situation where there is a 75% decrease in the share (portion) of GDP that is lost annually as a result of climate change within a fifteen-year period. This occurs between 2023-2037

1.3 LOSSES DUE TO CLIMATE CHANGE/HAZARDS

Climate change generates several losses that affect all sectors of a given economy. Developing countries remain the most vulnerable to climate change, despite their low contribution to the phenomenon. Examples range from damages experienced by the agricultural and industrial sectors given rainfall variability and increase in temperature, additional adaptation costs needed or spent to recover from flooding, drought, and various forms of climate hazards, losses in human lives directly or indirectly caused by climate hazards, etc. Despite these potential impacts, very few empirical studies have been conducted in Sierra Leone to evaluate the long-term implications associated with the occurrence of climate hazards given the data limitation that prevents detailed analyses of such impacts. Instead, we rely on tangible assumptions and macroeconomic patterns to elucidate potential patterns associated with climate change in Sierra Leone. Kreft, Eckstein et al (2013) assume that Sierra Leone loses approximately 0,017 per unit GDP from 1994 to 2013 because of climate change. Relatively, similar figures are found by the African Development Bank (AFDB, 2017). We use the figures to determine the annual cumulative losses (costs) associated with climate change. The costs avoided represent the benefits associated with the investment in the targeted hydrometeorological services. These are the opportunity costs associated with the provision of hydrometeorological services.

The annual cost of climate in SLCRAM was computed using GDP and fraction losses rate. The results of the simulation are shown in Table 2. We notice that Sierra Leone is already losing around USD 7.5 million in 2022 due to climate hazards and the losses will nearly triple by 2040 and reach USD 22 million if no intervention is implemented to mitigate and adapt to the potential impacts of climate change. This represents a huge economic cost for a developing country, and it may jeopardize most of the efforts the government is currently undertaking to alleviate poverty and reduce inequality.

However, the loss in GDP can be eliminated by 2027 if interventions are provided, under the scenarios of a decrease in GDP losses decreases. The losses may eventually go as high as USD 128 million under the scenario of a 75% loss increase.

Table 2: Annual losses due to climate hazards (USD)

Scenarios	Time frame			Annual losses due to climate change (USD)					
Change in portion GDP losses	2023-2027	2023-2032	2023-2037	2022	2023	2027	2032	2037	2040
Baseline				7,516,492	7,947,000	10,674,000	14,040,487	18,207,187	22,212,082
25% loss increase	X			7,516,492	7,947,000	21,247,153	26,906,388	32,202,404	35,654,314
25% loss decrease	X			7,516,492	7,947,000	0	0	0	0
50% loss increase		X		7,516,492	7,947,000	37,919,250	72,804,960	73,838,922	74,887,570
50% loss decrease		X		7,516,492	7,947,000	0	0	0	0
75% loss increase			X	7,516,492	7,947,000	47,099,700	98,909,370	128,582,121	128,582,121
75% loss decrease			X	7,516,492	7,947,000	0	0	0	0

1.4 People impacted by climate hazards

Here also there is very limited data available on the people who are impacted by climate hazards in Sierra Leone. Perhaps, one of the few studies that were conducted came from the World Bank in 2017 when a massive landslide was experienced in the Western Area Rural of the country. Three days of intensive rainfall have dramatically damaged nearly all sectors of the economy. This has led to severe economic, social, and health-related damages which still affect the country today. Nearly all the productive sectors of the country were affected. Estimates show that a total loss of USD 31 million was associated with the landslide (World Bank, 2017). These cover losses experienced by the housing, health, and social protection sectors which were the most affected sectors. Given the fact that these studies were only conducted in a part of the country, they could hardly be generalized across the country to generate country-wide patterns that inform on the number of people impacted by climate hazards. Particularly in a context where people impacted can be those who lost their lives during climate hazards as well as the ones who experienced a decrease in their economic and social conditions.

We rather make use of the per capita income and the annual losses to compute the people impacted by climate change. This allows us to take into consideration the implicit effects of factors affecting GDP on the impacts. These are capital, labor, and technology in the context of rational expectation. The results are shown in Table 3. Under the baseline scenario, the number of people impacted by climate hazards will increase to nearly 14 000 by 2040. This will have detrimental long-term negative effects. Investments in hydro and meteorological services yielding a decrease of losses to 25% will eliminate these negative economic impacts. Notwithstanding, under all the other scenarios associated with increases in losses there is a steady growth in the number of people impacted, which can go as high as 159,912 by 2040. This is clear evidence that climate hazards have long-term and lasting impacts on people and the structure of the economy.

Table 3: People impacted by climate hazards annually

Scenarios	Time frame			Annual losses due to climate change (USD)					
Change in portion GDP losses	2023-2027	2023-2032	2023-2037	2022	2023	2027	2032	2037	2040
Baseline				8,554	8,567	9,693	11,148	12,614	13,922
25% loss increase	X			8,554	8,567	19,386	21,934	24,816	27,392
25% loss decrease	X			8,554	8,567	0	0	0	0
50% loss increase		X		8,554	8,567	33,926	60,727	68,708	75,840

50% loss decrease		X		8,554	8,567	0	0	0	0
75% loss increase			X	8,554	8,567	46,042	93,465	144,871	159,912
75% loss decrease			X	8,554	8,567	0	0	0	0

1.5 PER CAPITA INCOME

Sierra Leone has made significant economic progress over the past decades. The war and civil unrest experienced a few decades ago had left several key sectors unexploited or badly exploited. The per capita income has increased by more than 2,5% over the past two decades. This is mainly due to the huge effort devoted to reforming institutions and investing in critical basic public services (water, electricity) to promote the development of small businesses. The growth experienced in the mining industry has also contributed to explaining the rise of the overall and per capita income. Therefore, one of the potential benefits of the project is to support the country maintain the rise of its income to reduce poverty and inequality. Under the baseline scenario, the per capita income is expected to grow from USD 527 to USD 941 by 2040. An increase in the losses associated with climate hazards is expected to drastically affect the per capita income growth and leads to USD 756, USD 542, and USD 506, for a 25%, 50%, and 75% loss increase scenarios respectively. We show that the more the losses are decreased the higher the per capita income.

Table 4: Per capita income

Scenarios	Time frame			Annual losses due to climate change (USD)					
Change in portion GDP losses	2023-2027	2023-2032	2023-2037	2022	2023	2027	2032	2037	2040
Baseline				527	541	639	743	851	941
25% loss increase	X			527	541	636	712	753	756

25% loss decrease	X			527	541	642	774	953	1163
50% loss increase		X		527	541	633	668	599	542
50% loss decrease		X		527	541	644	783	969	1161
75% loss increase			X	527	541	631	632	556	506
75% loss decrease			X	527	541	645	785	973	1167

2.0 FINANCIAL ANALYSIS

The project aims to strengthen the capacity of the country to measure and monitor climate data to be better prepared to deal with climate hazards. This covers (i) enhancement of climate information services, (ii) establishment of impact-based multi-hazard early warning systems and early action, (iii) CIEWS for investment and financial decisions, and (iv) project management. We assume a physical contingency rate of 12% and a financial contingency rate of 8%. 2% of the investment is allocated to operation and maintenance costs (O&M).

The project offers several benefits which can take many different forms. Some benefits are measurable whereas others are not although they affect positively human and eco-stem functionalities in the country. Better weather forecasting facilitates the anticipation of and anticipation for extreme climate-related events that can have detrimental economic and social consequences on economies and organizational structures. From a practical point of view, this facilitates the protection of persons, businesses, and assets (prevention) as well as the acceptance of emergency measures implemented by national authorities to mitigate and adapt to climate change. For instance, farmers can decide to change their planting dates and/or the types of crops seeded if they know well in advance the intensity of rainfall and temperature that can be expected in the near future. Insurance companies can modify the way they set premiums and cover risks associated with climate hazards if information about potential climate change patterns is presented to them; people can adjust their behavior to match their current and future local conditions depending on the type of climate they are going to face. Therefore, the avoided asset and human losses are often seen as the major benefits associated with investing in hydro and meteorological services. For a developing country like Sierra Leone, potential localized benefits may cover rural development, growth in the informal sectors, women empowerment, growth in children's enrolment to school given the time saved in labor farming, etc..

We made use of the Excel sheet made available to us to strengthen the financial analysis. We use the information on flood hazard the annual loss of life (in Freetown, Makeni, and Bo), the Landslide annual loss of life, the proportion of lives saved by EWS, and the value of a statistical life. These assumptions allow us to determine the annual value of lives saved and the assumed reduction due to the project. These values are determined for each of the scenarios highlighted above. Our results are not different from the Excel sheet received from the GCF. We found a significant impact of the project is saving lives and reducing economic losses. This allows us to go beyond the simple cost-benefit analysis and look at the life-saving implications associated with the investment in all the components that exist in the project. For instance, in all three scenarios, lives saves have registered a study increase between 2023 and 2040. Under the baseline scenario, around 5 150 850 $ USD Dollar is saved given the implementation of the project. This value reaches 2341 750 $ USD when a 25% loss is assumed. The yearly values of lives saved reach 7 025 252 $ USD when a 75% loss is assumed. The project allows a steady reduction in the values. This is reflected in the total value of reduced losses.

Table 5: Values of lives saved (USD)

Annual values of lives saved	2023-2027	2023-2032	2023-2037	2022	2023	2027	2032	2037	2040
Baseline				936 700	5151 851	5151851	5151851	5151851	5151851
25% loss	X			2341751	2341751	2341751	2341751	2341751	2341751
50% loss		X		4683501	4683501	4683501	4683501	4683501	4683501

75% loss			X	7025252	7025252	7025252	7025252	7025252	7025252

Table 6: Values of reduced losses (USD)

The total value of reduced losses	2023-2027	2023-2032	2023-2037	2022	2023	2027	2032	2037	2040
Baseline				2815823	7138601	7820351	8661972	9703647	10704871
25% loss	X			4220874	4328500	7653538	9068347	10392351	11255328
50% loss		X		8441747	8657001	23643126	41085981	41602962	42127286
75% loss			X	12662621	12985502	42350027	81207279	103461843	103461843

Table 7: values of assumed reduction (USD)

Assumed reduction due to project	2023-2027	2023-2032	2023-2037	2022	2023	2027	2032	2037	2040
Baseline				1879123	1986750	2668500	3510121	4551796	553020
25% loss	X			1879123	1986750	5311788	6726597	8050601	8913578
50% loss		X		3758246	3973500	18959625	36402480	36919461	37443785
75% loss			X	5637369	5960250	35324775	74182027	96436591	96436591

Furthermore, we also work with the losses avoided due to the investment in hydrometeorological infrastructures. This allows us to complement the analysis based on the lives saved given investment in climate-mitigating infrastructures.

We work with the losses avoided due to the investment in hydrometeorological infrastructures. When investments are undertaken these go into the asset capital of the country. The annual cost of climate change was estimated with GDP used as a proxy. The cash flow captures the cumulative differences between the annual losses avoided and the costs invested after having integrated the contingency rates. Different discount rates are used to evaluate the sensitivity of the project to different idiosyncratic risks and identify the one that offers a positive net return given the described time period. Net present values are calculated for the duration of the project lifetime (Table 10). The cash flows associated with various discount rates were estimated through a cost-benefit relationship. This provides us with an overview of the regions in which the project becomes viable given the set of institutional and operational constraints. The project is viable at a discount rate of 10% and 15% given the positive NPV associated with the investment when a length of more than 15 years is considered. The benefit-to-cost (B/C) ratio found is also in the range provided in the Excel sheet for an interest rate of 10%. The B/C ratio is 18,1 for an interest rate of 3,5%; 10,6 for an interest rate of 5%; 3,1 for an interest rate of 10% and 1,4 for an interest rate of 15%.

Table 8: Present value of modeled climate losses due to hazards (USD)

	Annual costs of climate hazards	Present value of projected annual climate cost with various discount rates			
		3,5%	5%	10%	15%
2023	7 946 898	7678162,3	7568474,29	7224452,73	6910346,09
2024	8 439 436	7878303,8	7654817,23	6974740,5	6381426,09
2025	8958370	8079936,5	7738576,83	6730555,97	5890273,69
2026	9500482	8279121,2	7816070,05	6488957,04	5431931,42
2027	10674000	8987221,6	8363358,3	6627714,2	5306864,47
2028	10663254	8674564	7957084,31	6019128,89	4610018,97
2029	11285202	8870066,8	8020182,37	5791093,02	4242525,43
2030	11936767	9064918,8	8079273,76	5568589,9	3902150,31
2031	12616660	9257234,2	8132811,53	5350695,46	3586442,2
2032	14 040 487	9953565,4	8619641,06	5413215,54	3470593,65
2033	14069160	9636610,8	8225946,47	4931154,75	3024070,59

2034	14843054	9822885,2	8265167,87	4729454,43	2774272,92
2035	15651715	10007772	8300438,64	4533744,32	2543841,26
2036	16495144	10190400	8331168,61	4343686,96	2331236,56
2037	18 207 187	10867699	8757968,26	4358655,81	2237562,87
2038	18301003	10554297	8383900,34	3982831,47	1955732,47
2039	19256891	10730012	8401717,76	3809873,22	1789463,67
2040	22 212 082	11958122	9229578,86	3995038,19	1794849,93

Table 9: estimated cash flow at various discount rates (USD)

	3,5%	5%	10%	15%
2023	268735,681	397344,9	794689,8	1192034,7
2024	295380,26	421971,8	843943,6	1265915,4
2025	313542,95	447918,5	895837	1343755,5
2026	332516,87	475024,1	950048,2	1425072,3
2027	373590	533700	1067400	1601100
2028	373213,89	533162,7	1066325,4	1599488,1
2029	394982,07	564260,1	1128520,2	1692780,3
2030	417786,845	596838,35	1193676,7	1790515,05
2031	441583,1	630833	1261666	1892499
2032	491417,045	702024,35	1404048,7	2106073,05
2033	492420,6	703458	1406916	2110374
2034	519506,89	742152,7	1484305,4	2226458,1
2035	547810,025	782585,75	1565171,5	2347757,25
2036	577330,04	824757,2	1649514,4	2474271,6
2037	637251,545	910359,35	1820718,7	2731078,05
2038	640535,105	915050,15	1830100,3	2745150,45
2039	673991,185	962844,55	1925689,1	2888533,65
2040	777422,87	1110604,1	2221208,2	3331812,3

Table 10: financial viability based on NPV

Period	Project cost	PV - 3,5%	NPV - 3,5%	PV – 5%	NPV - 5%	PV - 10%	NPV - 10%	PV - 15%	NPV - 15%
2027	$31 096 800	$1 583 765	-$29 513 034	$2 275 959	-$28 820 841	$4 551 919	-$26 544 881	$6 827 878	-$24 268 922
2032	$31 096 800	$ 3 702 748	-$27 394 051	$5 303 077	-$25 793 722	$10 606 156	-$20 490 644	$15 909 233	-$15 187 567
2037	$31 096 800	$6 477 067	-$24 619 732	$9 266 390	-$21 830 409	$18 532 782	-$12 564 018	$27 799 172	-$3 297 628
2040	$31 096 800	$8 569 016	-$22 527 783	$12 254 889	-$18 841 910	$24 509 779	-$6 587 021	$36 764 669	$5 667 869
2044	$31 096 800	$12 323 395	-$18 773 405	$17 618 287	-$13 478 513	$35 236 575	$4 139 775	$52 854 862	$21 758 062