Economic Evaluation of Small Scale Salt Mining Projects in Ghana – A Case Study

Banson, A. K. and Eshun, P. A.

Abstract

The marine salt mining industry has about 20 Small Scale and over 120 Micro-small scale projects scattered over the coast of Ghana. With oil find, Ghana can produce over 6 million t/yr of salt worth over US$1.2 billion and overtake gold at US$0.73 billion. This study investigates the economic viability of the small scale salt industry and suggests ways to make it more economical. In this study, relevant Ghanaian legislation and established technical data from operating Small and Micro-small Scale mines in Ghana and abroad was used to determine the economic viability using Net Present Value (NPV) and Internal Rate of Returns (IRR) as profitability indicators. The results infer that unless government support with co-operative iodisation plants and produce buying centres, these Small and Micro-small scale salt projects will at best operate at breakeven, have almost 100% risk of failure and be sensitive to revenue, operating cost, capital investment and interest rates.

1. Introduction

1.1 Background to Study

Ghana is endowed with a 550 km stretch of coastline, numerous lagoons and lakes with salinity of some lagoon as high as 60% (Kesse, 1985). Consequently, solar salt mining is very predominate along the coastline of Ghana. Salt has been identified as a product to be developed as a major addition to Ghana's export portfolio (Anon., 2005a). It is then clear that if the salt mining sector is given a revamp, salt will overtake gold which currently contributes US$0.73 billion and stands as the highest foreign exchange earner (Anon., 2005a). With oil find in Ghana, there is the need to review all salt mining projects to determine their economic viabilities. The objectives of this research are to analyse whether small scale salt mining projects are economically viable; and analyse the sensitivity and risks associated with investing in the project.

1.2 Methodology of Study

The methodology adopted to achieve the above objectives included:

- field visits;
- generation of cash flow model; and
- sensitivity and risk analysis.

In generating the cash flow model for the project, the following was studied and reviewed:

- Investment laws and other legislation relevant to salt mining in Ghana was studied to obtain information on tax rates, royalty, incentives, benefits, allowances and other relevant parameters; and
- Established technical data was obtained from Ajua Salt, Capricorn Salt, other operating salt mines in Ghana and abroad to estimate the capital cost, operating cost and revenue.

Economic Analysis was conducted using NPV and IRR as profitability indicators. Sensitivity Analysis by noting the effect of 10% changes in Capital Cost, Operating Cost, Royalty, Income Tax, Interest rate and Revenue to the profitability indicators. Risk Analysis due to variables such as grade, tonnage, dilution, salt loss, capital cost, operating cost, revenue, royalty, income tax and interest rate using the Monte Carlo simulation approach was carried out to determine the risk on the mineral project.

2 Relevant Information about the Salt Project

2.1 Location and Accessibility of the Salt Mine

The Salt concession covers an area of 4.54 hectares at Adwoa near Apowa in the Ahanta West District of the Western Region of Ghana. The site is easily accessible by motor road through Apowa which lies on the Takoradi Tarkwa trunk road. A secondary road branches off from Apowa to Adwoa village and a third class road leads from Adwoa village directly to the concession. The site is also accessible by the sea on canoes. During rainy seasons the lagoon overflows and floods the whole site.

2.2 Relief and Climate

The project location spans two major ecological zones, classified as tropical and humid. Temperatures vary with season and elevation. Two rainy seasons occur from April to July and from September to November. Annual rainfall ranges from about 1 100 mm (43 in.) to about 2 100 mm (83 in.). The harmattan blows from the northeast from December to March, lowering the humidity and creating hot days and cool nights (Kesse, 1985).

2.3 Geology of the Salt Mine

The concession lies within the Lower Birimian formation consisting of tuffs, greywackes phyllites and schists, mixed with carbonaceous, ferriferous and calcareous material.

2.4 Salt Production Techniques for the Project

The main technology to be used for the salt mining project is the Solar Evaporation Technology. Sea water (brine) is pumped through pipelines into designed plain ponds. The brine is left to evaporate using solar energy.

2.5 Project's Major Economic Benefits

The project's major economic benefits include:

- Generation of employment;
- Net generation of foreign exchange through export of salt;
- Provision of stable ready market for raw and iodated salt; and
- Increase in revenue base of the District Assemblies through its corporate tax payments.

2.6 Available Resource for the Project

The Western Regional Development Commission facilitates acquisition of land from the traditional chiefs in the Western Region of Ghana to prevent or minimise land litigation. They also facilitates access to credit for the supply of equipment and machinery through the European Union, UNDP, UNIDO, Ministry of Trade and Industry, Ministry of Private Sector Development as well as key local companies and banks. Salt Mining does not require much skilled labour. Generally a Mechanic, Electrician and a few mining technicians are required for the project.

2.7 Mineral Resource for the Project

In principle, production yields vary considerably and could range between 1 000 and 10 000 t/ha of the total evaporation area of the concession. The Ghanaian environment of evaporation, humidity and salinity of the sea, lakes and lagoons is conducive for salt mining at a worst minimum of 1 000 t/ha (Venkatesh, 1995). The project with land of 4.54 hectares is estimated to yield 3261 tonnes per annum from a 3.0% salt solution. The yield potential of the area depends upon the net evaporation rate and intake brine salinity. The following example illustrates how this was determined:

- The intake brine is considered as raw un-evaporated seawater with a salinity of 3 Be, a sodium chloride content of 2.7% and about 0.3% of other salts;
- To recover sodium chloride, 97% of the seawater has to be evaporated. Therefore 97 grams of water are evaporated to yield 2.7 grams of sodium chloride, on a theoretical

basis;

- Taking into account 10% dilution, 10% seepage and other losses, 48 grams of water are evaporated per gram of sodium chloride produced, exclusive of recovery losses;
- Assuming 90% recovery, approximately 90 tonnes of water is evaporated per tonne of sodium chloride or salt recovered;
- For an annual evaporation rate of 500 mm through the system, this gives a yield 1 000 t/ha per annum. This indicates the production capacity of the area;
- If the evaporation area available is 1 hectares, the production capacity can be assessed at 1000 t/yr under normal weather conditions; and
- However, where the site has a natural or man-made lagoon or reservoir, which is the case in this project the annual production could be estimated at 5 000 t/ha (Venkatesh, 1995). Thirty percent of the concession can be used as a concentration pond to yield about 3261 tonnes per annum of salt.

2.8 Salt Iodisation Techniques

Iodine is added as potassium iodate to salt after refining and drying and before packing. Iodisation is normally done by adding a solution of potassium iodate to the salt (wet method). The iodine spray mixing plant can be powered by electricity or diesel engines. The plant can also be made mobile for operational convenience. A spray mixing type of plant operates at 6 t/h or about 12 000 t/yr.

2.9 Cost Estimates

In estimating the capital costs it is assumed that basic mining equipment is exempt from import duties as outlined in the Mining and Mineral Laws of Ghana. The capital cost estimates are based on price quotations of equipment from supply agencies in Ghana and overseas. Operating cost estimates for mining and processing operations are gathered from mines operating under similar conditions in Ghana. Tables 2.1 and 2.2 give a summary of the capital and operating cost estimates of the project.

Table 2.1 Summary of Capital Cost Estimates

Type of Capital Cost	Cost Centre	Cost (US$)
Expensed	**Pre-production Costs**	
	Acquisition and Permitting	10 000
	Prospecting and Exploration	5 000
	Pre-production Development	5 000
	Consultancy	10 000
	Subtotal	30 000
Direct	**Direct Capital Costs**	
	Mining	
	Mine Utility Vehicle(s)	17 000
	Mine Service Vehicle (s)	17 000
	Pumps	10 000
	Roads and Accesses	5 000
	Generator Set	10 000
	Lighting Plant	1 000
	Light Duty Trucks (s)	40 000
	Baskets and Head pans etc	500
	Shovels and Pickaxes etc	500
	Wheel Barrows etc	500
	Table Barrows etc	500
	Mudpand, channels, pipelines etc	20 000
	Chrystallising pans, channels	20 000
	Subtotal	150 000

Table 2.1 Summary of Capital Cost Estimates (continued)

Type of Capital Cost	Cost Centre	Cost (US$)
	Processing and Quality Control	
	Batch Iodisation/Mixer	20 000
	Batch Bagging/Sealing Machine	8 000
	Monoblock (Salt Processing Machine Complete with Quality Control Facility)	40 000
	Salt Packing and Compacting	30 000
	Salt Upgrading and Refinery	40 000
	Transportation/Installation	10 000
	Commissioning	2 000
	Subtotal	150 000

	Plant Treatment Services	
	Water Supply/Reticulation	1 000
	Reagent Preparation	5 000
	Power Reticulation	1 000
	Plant Fuel Tanks	5 000
	Plant Offices and Laboratory	18 000
	1 year Spares and 3 month Consumables	20 000
	Subtotal	50 000
	Supporting Infrastructure and Site Works	
	Storage Shed	3 000
	Site Development	5 000
	Access Roads and Drainage	3 000
	Administration Offices	5 000
	Portable water	20 000
	Ablutions and Amenities	1 000
	Clinic and First Aid Centre	1 000
	Workshop and Equipment	5 000
	Administration vehicles	17 000
	Subtotal	50 000
Indirect	**Indirect Costs**	
	Compensation	2 000
	Commissioning	500
	Environmental Management	2 000
	Legal Fees	1 000
	Engineering Fees	1 000
	Contractor Fees	1 000
	Subtotal	7 500
Allowances	**Allowances**	
	Contingency (15%)	65 625
	Subtotal	65 625
Total Capital Investment		503 125

Table 2.2 Summary of Operating Cost Estimates

Types	**Cost Centre**	**Small Scale (US$)**
Direct	Mining	
	Mining Consumables	20 350
	Labour and Supervision	12 000
	Loading and Hauling	28 765
	Subtotal	61 115
	Processing and Quality Control	
	Reagents and Others ($0.90/t)	543
	Laboratory and Analysis ($0.75/t)	45
	Labour and Supervision	1 200
	Plant and QC Consumables	35 310
	Subtotal	37 098
Indirect	Utilities, Technical and Engineering Services	
	Power	
	Fuel / Lubricant ($6069/vehicle)	8 956
	Water	18 207
	Medical and Health Services	500
	Vehicle Maintenance ($10000/veh.)	7 066
	Workers Buses (Fuel and Maint.)	30 000
	Communication	
	Labour and Supervision	1 000
	Consumables	5 400
		14 135
	Subtotal	64 564
	Overheads: Finance, Admin. Security etc.	1 200
	Managerial and Other Services, Labour & Supervision	21 000
	Consumables	1 045
	Subtotal	23 245
Total Operating Cost		196 022
Total Working Capital		49 006

3 Economic Viability Of The Small Scale Salt Project

Relevant information was used to build a Cash Flow model. Table 3.1 shows a typical Cash Flow model at 30% Equity and 70% Loan. A summary of Cash Flow on Table 3.2 shows that

all the NPV and IRR values are negative. Consequently, it can be said that the Small Scale Project is not economically viable.

Table 3.1 Cash Flow of Scale Salt Project at 30%Equity and 70% Loan (Amount in US$1000)

Equity :	150.94	30%				
Loan :	352.19	70%				
Total Capital Investment	503.13					
Working Capital (25% of Op cost)	49.01					
Operating Ratio, Or = (Se-Op cost)/Se)	0.00	0.46	0.46	0.46	0.46	0.46
Annual Production t/yr =	3261					
Average Salt Grade = 20 833 g/t						
Salt Price = $0.000111/g ($111/t)						
Year	0	1	2	3	4	5
Gross Revenue (R e)	0.00	362	362	362	362	362
Less: Royalty , Rt = Or*Re	0.00	23.76	23.76	23.76	23.76	23.76
Operating Cost (Op cost)	0.00	196.02	196.02	196.02	196.02	196.02
Net Revenue (Rn)	0.00	142	142	142	142	142
Less:						
Capital Allowance	377.34	50.31	25.16	12.58	6.29	3.14
Investment Allowance (1st year only)	25.16	0.00	0.00	0.00	0.00	0.00
Interest, i=(17.0% of loan)	0.00	59.87	47.90	35.92	23.95	11.97
Loss Forward	0.00	377.34	50.31	0.00	0.00	0.00
Taxable Income (Ti)	-402.50	-345.34	18.82	93.68	111.95	127.07
Less : Tax, T = (35% of Ti)	0.00	0.00	6.59	32.79	39.18	44.47
Net Income	-402.50	-345.34	12.23	60.89	72.77	82.59
Add:						
Capital Allowance	377.34	50.3125	25.16	12.58	6.29	3.14
Investment Allowance (1st year only)	25.16	0.00	0.00	0.00	0.00	0.00
Loss Forward	0.00	377.34	50.31	0.00	0.00	0.00
Working Capital (last year only)	0.00	0.00	0.00	0.00	0.00	49.01
Less:						
Loan Repayments (Lr)	0.00	70.44	70.44	70.44	70.44	70.44
Equity Capital	150.94	0.00	0.00	0.00	0.00	0.00
Working Capital (first year only)	0.00	49.01	0.00	0.00	0.00	0.00
Additional Profit Tax (AT)	0.00	0.00	33.90	27.35	25.75	24.43
CASH FLOW (CF)	-150.94	-37.13	-16.64	-24.31	-17.13	39.88
NPV @ 0.73%	-204.68					
IRR	*					

* Value too high or too low

Table 3.2 Gear Ratio, Costs of Capital and Profitability Indicators

Gear Ratio	**Loan (US$)**	**Interest Rate (%)**	**k_d**	**k_e**	**k_o**	**NPV (US$) @$k_o$**	**IRR (%)**
0.00	0	0.00	0.00	-3.80	-3.79	-0.06	-3.80
0.10	50 313	16.10	10.47	-5.80	-4.22	-24.05	-5.75
0.20	100 625	16.30	10.60	-8.53	-4.71	-48.99	-8.13
0.30	150 938	16.30	10.60	-11.38	-4.79	-80.31	-11.14
0.40	201 250	16.50	10.73	-15.40	-4.95	-112.70	-15.18
0.50	251 563	16.50	10.73	-20.55	-4.91	-169.25	*
0.60	301 875	17.00	11.05	-23.47	-2.76	-171.44	*
0.70	352 188	17.00	11.05	-23.36	0.73	-204.68	*
0.80	402 500	17.30	11.25	-9.49	7.10	-140.22	*
Mean						-105.74	-8.8
Standard Deviation						71.66	4.50

* Did not return values. Value is too high or too low.

4 Sensitivity Analysis Of Small Scale Salt Project

Sensitivity analysis was performed on the investment parameters of the Project. A graphical representation of the results is presented on Figures 4.1. A summary of the results of the sensitivity analysis indicate that the Salt Project is not economically viable and will remain so until any of the following conditions cause it to break even:

- An increase of the revenue by 17%;
- A decrease of the operating cost by 24%;
- A decrease of the capital investment by 27%; and
- A decrease of the interest rate by 54%.

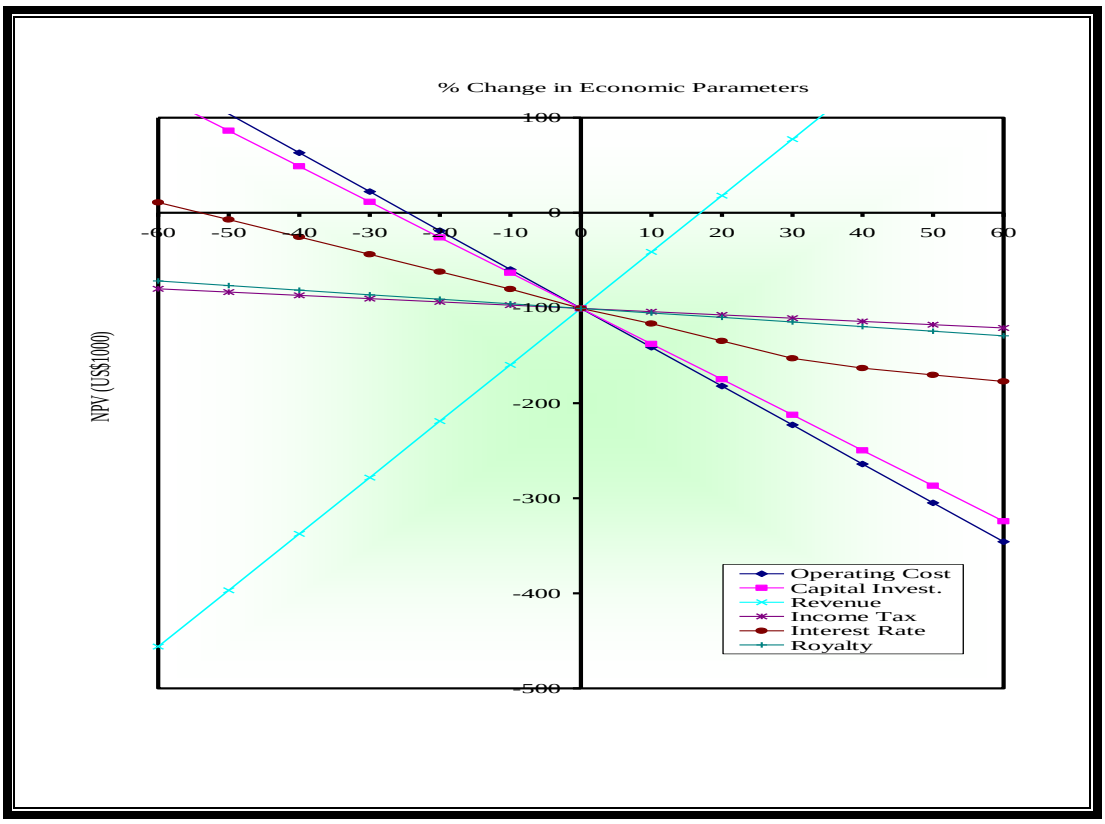

Figure 4.1 NPV against Variations in Investment Parameters

4.2 Risk Analysis of Small Scale Salt Project

Risk analysis was performed by doing 200 iterations of the projects economic parameters. Figures 4.2 and 4.3 give graphical representations of 200 iterations of the risk simulations. A summary of the results of the risks analysis indicate:

- the project's expected mean NPV of -US$182 980 is less than zero, and the expected mean IRR of -2% is less than 11.25% (the minimum rate of return), the project is therefore not economically viable;
- The risk profile indicates that the probability of failure (NPV≤ 0), is almost 100% and the probability of IRR being less than or equal to the minimum rate of return of 11.38% is almost100%; and
- This implies that the project has an almost 100% risk of failure and that it is not a viable venture

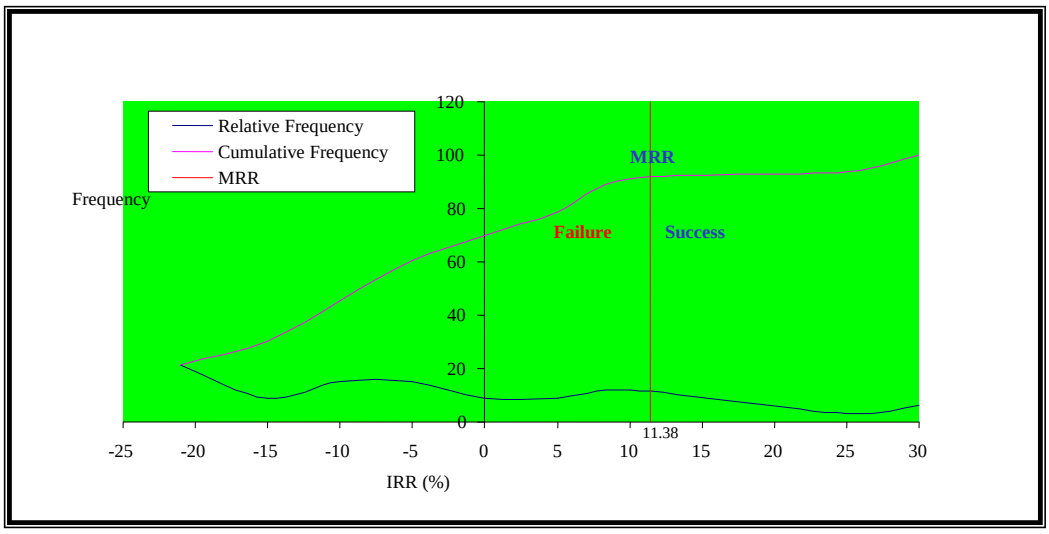

Figure 4.2 Frequency Distribution of IRR

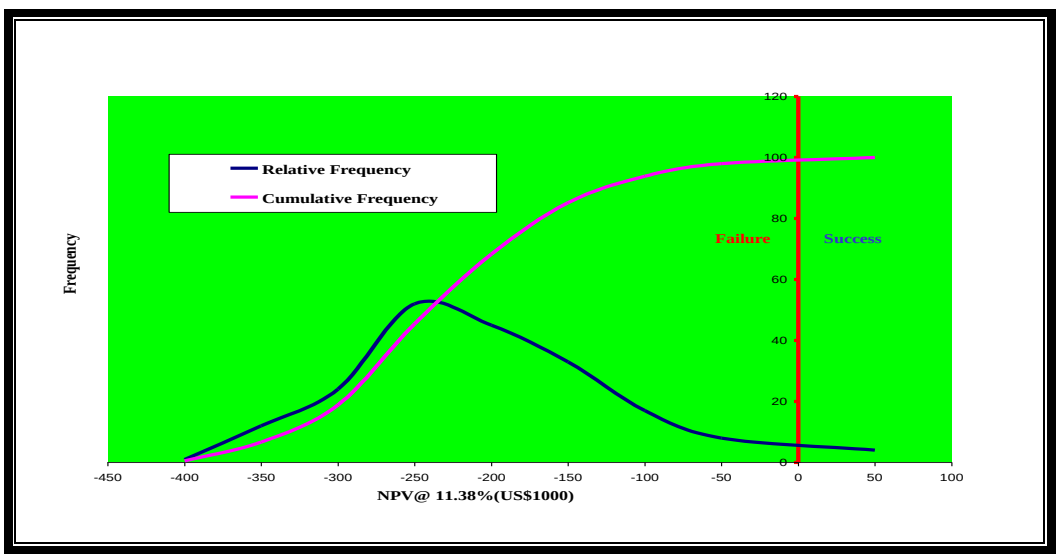

Figure 4.3 Frequency Distribution of NPV

5 Austerity Measures

This study wouldn't have been complete if the parameters used in the analysis of the Small Scale Project were not reviewed by presenting certain austerity measures to rectify the cause of the non viability of the Salt Project. The following measures were taken to re-evaluate the viability of the Small Scale Project:

- Abandoning the development of the processing plant to make available US$200 000. This amount will be diverted to expansion of the mine to increase its capacity by 142%;
- The price of un-iodated salt is reduced to 70% the cost of iodated salt. There will

therefore be a decrease of 30% in revenue without iodisation. This implies the resultant increase in revenue due to the measure will be 112%; and

- Operating cost will however increase with mine expansion by 8.67% (US$17 000 per year). This can however be reduced with stringent control and elimination of wastage and further cost cutting.

5.1 Economic Analysis of Revised Salt Project

Relevant information was used once again to build a Cash Flow model. Table 5.1 shows a typical Cash Flow model at 30% Equity and 70% Loan for the revised Salt Project. A summary of Cash Flow on Table 5.2 shows that all the NPV and IRR values are positive. Consequently, the Revised Salt Project is economically viable

Table 5.1 Cash Flow of Revised Salt Project at 30%Equity 70% Loan (Amount in US$1000)

Equity :	151	30%				
Loan :	352.19	70%				
Total Capital Investment	503.13					
Working Capital (25% of Opcost)	53.25					
Operating Ratio, Or = (Se-Opcost)/Se)	0.00	0.65	0.65	0.65	0.65	0.65
Tonnage Production Yearly/t =	7891.62					
Average Mill Head Grade = 20833 g/t						
Salt Price = $0.000077/g (US$77/t)						
Year	0	1	2	3	4	5
Gross Revenue (R e)	0.00	607.65	607.65	607.65	607.65	607.65
Less: Royalty , Rt = Or*Re	0.00	66.01	66.01	66.01	66.01	66.01
Operating Cost (Opcost)	0.00	213.00	213.00	213.00	213.00	213.00
Net Revenue (Rn)	0.00	328.64	328.64	328.64	328.64	328.64
Less:						
Capital Allowance	377.35	50.31	25.16	12.58	6.29	3.14
Investment Allowance (1st year only)	25.16	0.00	0.00	0.00	0.00	0.00
Interest, i=(17% of loan)	0.00	59.87	47.90	35.92	23.95	11.97
Loss Forward	0.00	377.35	50.31	0.00	0.00	0.00
Taxable Income (Ti)	-402.50	-158.89	205.28	280.14	298.41	313.53
Less : Tax, T = (35% of Ti)	0.00	0.00	71.85	98.05	104.44	109.73
Net Income	-402.50	-158.89	133.43	182.09	193.96	203.79

Add:						
Capital Allowance	377.35	50.31	25.16	12.58	6.29	3.14
Investment Allowance (1st year only)	25.16	0.00	0.00	0.00	0.00	0.00
Loss Forward	0.00	377.35	50.31	0.00	0.00	0.00
Working Capital (last year only)	0.00	0.00	0.00	0.00	0.00	53.25
Less:						
Loan Repayments (Lr)	0.00	70.44	70.44	70.44	70.44	70.44
Equity Capital	150.94	0.00	0.00	0.00	0.00	0.00
Working Capital (first year only)	0.00	53.25	0.00	0.00	0.00	0.00
Additional Profit Tax (AT)	0.00	0.00	64.20	57.65	56.05	54.73
CASH FLOW (CF)	-150.94	145.08	74.26	66.58	73.76	135.02
NPV @ 27.24%	86.37					
IRR	65.05					

Table 5.2 Gear Ratio, Costs of Capital and Profitability Indicators for Revised Salt Project

Gear Ratio	**Loan (US$)**	**Interest Rate (%)**	**k_d**	**k_e**	**k_o**	**NPV (US$) @$k_o$**	**IRR (%)**
0.00	0	0.00	0.00	30.5	30.5	0.04	30.46
0.10	50 313	16.10	10.47	32.2	30.0	13.66	32.24
0.20	100 625	16.30	10.60	34.1	29.4	28.06	34.42
0.30	150 938	16.30	10.60	37.2	29.2	39.49	37.22
0.40	201 250	16.50	10.73	38.9	27.6	58.32	40.82
0.50	251 563	16.50	10.73	45.8	28.3	64.43	45.90
0.60	301 875	17.00	11.05	53.0	27.8	74.49	52.84
0.70	**352 188**	**17.00**	**11.05**	**65.0**	**27.2**	**86.37**	**65.05**
0.80	402 500	17.30	11.25	159.0	40.8	168.52	158.99
Mean						59.26	55.33
Standard Deviation						49.85	40.41

5.2 Sensitivity Analysis of the Revised Small Scale Salt Project

Sensitivity analysis was once again performed on the investment parameters of the Revised Small Scale Salt Project. A graphical representation of the results is presented on Figures 5.1 and 5.2. A summary of the results of the sensitivity analysis indicate that the Revised Small Scale Project is economically viable and will remain so until any of the following conditions render it unprofitable or a break-even state is achieved:

- Decrease of 44% of revenue;
- Increase of over 60% of capital investment; and
- Increase of over 60% of operating cost.

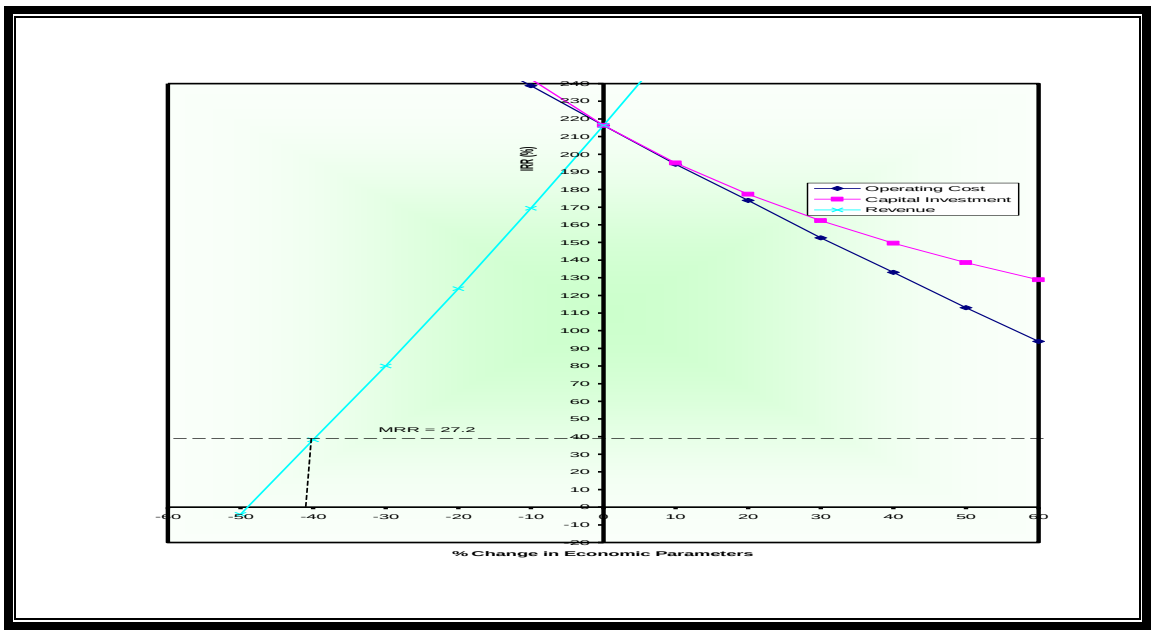

Figure 5.1 IRR against Variation in Investment Parameters (Revised Salt Project)

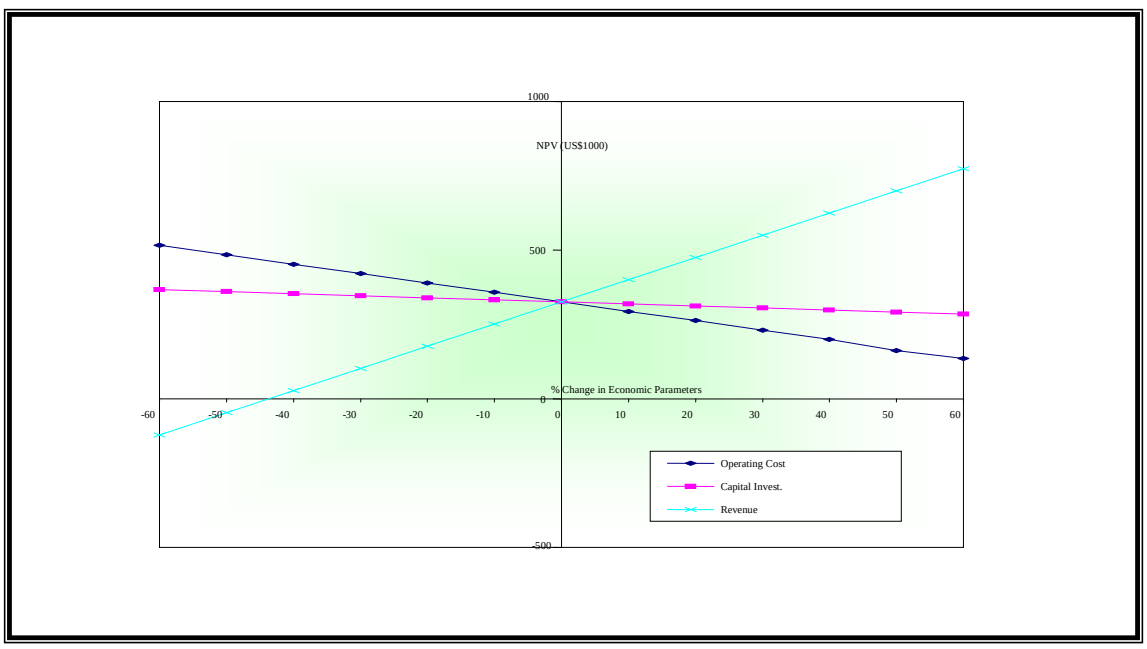

Figure 5.2 NPV against Variation in Investment Parameters (Revised Salt Project)

5.3 Risk Analysis of the Revised Small Scale Salt Project

Risk analysis was once again performed by doing 200 iterations of the Revised Small Scale Salt Projects economic parameters. Frequency charts were then plotted for IRR and NPV as shown in Figures 5.3 and 5.4. Results of the risks analysis shows:

- the project expected mean NPV of US$48 600 is greater than zero, and the expected mean IRR of 32.08**%** is greater than 27.24% (the minimum rate of return), the Revised Small Scale Project is viable; and
- the probability of failure, i.e. the probability that NPV is less than or equal to zero (NPV≤ 0) is 36.4% and the probability that IRR is less than or equal to the minimum rate of return of 27.24% is 35.2%.

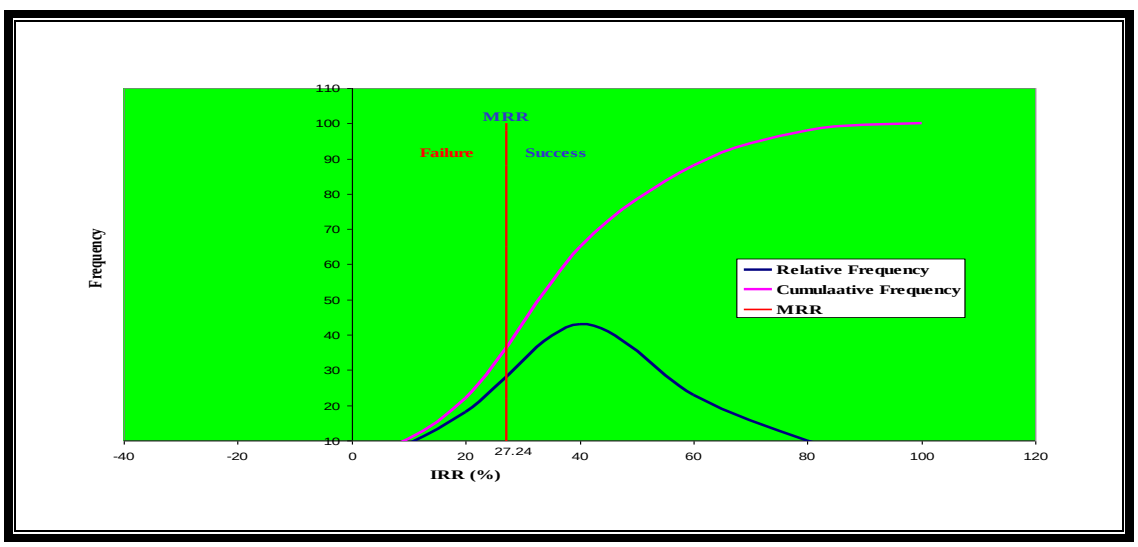

Figure 5.3 Frequency Distribution of IRR (Revised Small Scale Project)

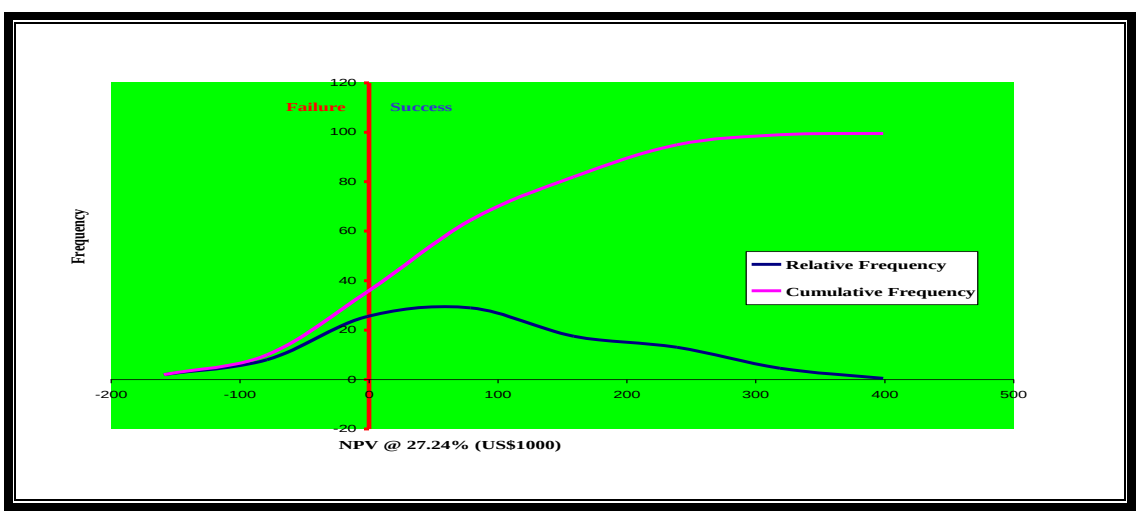

Figure 5.4 Frequency Distribution of NPV (Revised Small Scale Project)

6 Conclusion and Recommendations

Based on analysis stated above the following conclusion can be drawn about the project:

- The Small Scale Salt Project is not economically viable;
- To make the project economically viable, the salt iodisation plant needs to be abandoned and the mine expanded to produce more salt and generate more revenue; and
- The project has an almost 100% risk of failure unless it is revised to lower the risk to 35.8% with a corresponding NPV of US$48 600 and IRR of 32.08%.

For small-scale salt mining in the district to be more successful, the following are suggested:

- All small and micro-small scale salt mines should consider selling their products to medium scale salt mines or salt buyers for iodisation; and
- The Government of Ghana should set up Small Scale Salt Offices similar to that for small scale gold mining and Salt Produce Buying Centres similar to COCOBOD, to provide technical support and co-ordinate the production, buying, processing and marketing of salt produced in Ghana for local and export purposes.

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