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Analysis of different impact rates on the forecasts cost of building project using sensitivity analysis techniques

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Abstract

Over the years, Life Cycle Costing (LCC) has been recognized and used as an important technique for evaluating, forecasting and discounting the future costs of building to the present day value, from conception, design to completion, operation, maintenance, down to decommissioning. This work presents a study of Analysis on different discount rate of the forecasts cost of building project using sensitivity analysis techniques, the case study being Calabar International Conference Center (CICC) building project. Life cycle cost analysis wasconducted and forecast for 51 years using Net present value (NPV) with the following discount rates 4%, 5%, 6%, 8%, 10%, 12% and 13% respectively. Results showed that the lower the discount rates, the higher the cost value and via vasa. The building had a positive value >0 indicating a significant benefit at the end of the study period. The percentage contribution of the discount rate on the initial cost, salvage value and the life cycle cost indicates that at 4% the initial cost accounted for 85% of the discounted cost, life cycle cost 13% and salvage value 2%. The salvage value recorded 0% at 12% and 13% discount rate The higher the discount rates the higher the discounted initial cost and the lower the life cycle cost.

Keywords: Life cycle cost; Discount rates; Sustainability assessment; Forecasting; Building industry, Sensitivity analysis

1. Introduction

The concept of building life cycle costing (LCC) was first applied in the procurement of military equipment by the United StateDepartment of Defense in the mid-1960s. [1] Since then, researchers and academia had further developed LCC frameworks used in many sectors including the building industry. The LCC concept is also used in evaluating the total cost of project ownership and how best it can minimize project cost for good return of investment. The project ownership cost consist of the design and construction, operation, maintenance, replacement and decommissioning of the building, and there are the most costs oriented stages to be considered during life cycle analysis. Furthermore, LCC can be used to evaluate future cost of operation, maintenance and replacement of buildings. Sensitivity analyses of different discount rates are used in life cycle analysis to discount the future cost of a building project to its present value. This paper, attempt to using different discount rate to evaluate the future cost of CICC building project for a forecast period of 51 years.

1.1. Basic Steps of Life Cycle Cost

There have been numerous research works on possible steps to generate an efficient LCC analysis such as [2]; [3]; [4]; [5], as quoted by [6]. However, in every set of steps the same essential points can be identified. The basic LCC steps used in making decisions about options are as follows;

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- Identify project objectives, options and constraints and developing a framework
- Establish basic assumptions with respect to the period of study and the discount rate
- Compile data;
- Discount cash flows to a comparable time base, then carry out analysis, iteration required;
- Compute total life cycle costs, compare options and make decisions.

1.2. Life cycle cost of building project

[7] work on life cycle cost calculation models for buildings highlighted six different methods for economic evaluation of life cycle costing. The methods identify what it could calculate,it advantages and disadvantage and when it should be used. The study also highlights different typesof data for life cycle costing calculation, such as occupancy data, physical data, performance data and quality data. The approach identify net present value (NPV) methodology as one of the most suitable tool for life cycle costs analysis, but in cases were alternative scheme with different life cycle has to be compared, the equivalent annual cost (ECA) is the best alternative. The concept oflife cycle costing technique is used in evaluating the net cost of building component and the cost comparison of different materials throughout their service life. The concept gives a guide on its analysis to forecast its parameters, explain its results, bring out the limitations associated in its practice that highlight the disadvantages and uncertainty in the economic evaluation [8]. A framework from [9] suggest that building frames, upper floor, external/internal walls and partitions, roofs, doors, windows, floor finishes and decorations and building services are the most important component for which LCC analysis can be applied. Life- cycle cost (LCC) of a building is the total cost of owning, operating, and maintaining a planned project over its useful life from cradle to grave. That is, it includes not only the acquisition and energy costs, but also the maintenance cost and the salvage value for a better performance [10].

The life cycle cost analysis method can be used to determine whether proceeding with energy conservation is cost effective, or to compare the economic consequences of alternative design solutions. [1] approach attempt to examine the practical usefulness of LCC approach and the theoretical perceptions in achieving environmentally responsible investment.

Theapproach outlines the following limitations of LCC: inability to absorb common decision, negatingfuture generation costs, unreliable data, complexity and failure to take into account the decision- maker unprofessional ability to handle risk. Findings from [5] outline the limitations surrounding the used of LCC data analysis such as difficulties in downloading data, non- accurate data, missing data, high data variation and limited data. [11] believed that the neoclassical economic theory has fail to handle decision-making uncertainty, available findings anduse of discounting techniques in estimating future costs. Hence, unreliable, non-availability and poor quality of data are assumed to be the major limitation of LCC analysis. Developing an LCC data base was suggested by [12] to eradicate the data challenges such as Open system for construction (OSCON) data base system created to enhance information integration. Hence, the data base for this research work will be gotten from Calabar International Conference Centre (CICC) project, the central bank of Nigeria, the project quantity surveyor and order relevant sources.

Life cycle costs generally consist of the following. Acquisition cost: It is the purchasing cost or first cost and includes taxes, fees, delivery,installation an initial start-up. Annual owning and operating costs: Include those for maintenance, taxes, insurance, interest on borrowed money, and any other recurring costs over the useful life. Some ofthose costs may vary with age and inflation. Terminal value: It is the disposal cost or deduction form costs if a salvage value, computed at the end of the useful life of a project [13].

1.3. Present worth method

This process incorporates the cost benefit that is acquired during the project life cycle. However, the net present value (NPV) is the difference between the cost benefits against the assessments. The cost benefit analysis is used to weigh all expected cost base on discounting principles. This method is called NPV method. This method is carried out by reducing each cash flow and out flow at certain interval, to its closest present value, [14].

The mathematical relation is:

$$NPV = \sum_{t=0}^{N} \frac{C_t}{(1+r)^t} \quad (1)$$

Where

t = time of the cash flow
N = the total time of the cash inflow/ out flow in the project
R = the discount rate (the rate of return that could be earned on an investment in the financialmarket with similar risk)
C_t = the net cash flow (the amount of cash) at time, t

2. Methodology and sampling technique

The net present value (NPV) technique was used to analysis all cash inflow and out flow of the project. The parameters for the study were gotten from the CICC project, they includethe Initial cost (Construction cost), Operation cost, Maintenance/Repair cost and Replacement cost, why the salvage value and the life cycle cost is determined at the end of the study period. The Initial cost of the project consist of the design cost and construction cost. Since CICC project is a government project the cost of land and taxation is not included. The Operation cost (PC) of the project includethe cost of water bills, electricity bills (independent power source and National power source) cleaning and garbage disposal wages of staffs and other costs. The Maintenance and Repair cost (M/RC) consist of the maintenance and repair of doors, windows, plaster of Paris (POP), roofs, electrical fittings, plumbing, fire protection system, fumigation and other costs. Replacement cost (RC) include the cost of doors and windows, appliances, chairs and tables, electrical services, plumbing and other costs.

This costs drivers are collected for each month and sum up to obtain the yearly costs of the facility for every year. The sum of PC+ M/RC+ RC represent thesustaining cost of CICC project. An estimated discount rate r was adopted for the project life cycle costs (LCC), where it was discounted to a forecasted point time.

2.1. Discounted cash flow techniques

The equation for discounted cash flow is obtained by integrating future cash into respective NPV. The discounted cash flow relation is given as follows:

DPV=FV=FV(1-d) t=FV〖(1+i)-〗^t (1+i)^t (2)

Where

DPV = the discounted present value of the future cash flow (FV) at the time point t;

FV = the nominal value of the cash flow amount in a future period; FV can be substituted with Ct

i = the interest rate, the interest rate shows the cost of putting down the capital and not carrying out any other investment. It could also give room for payment related risks

d =the discount rate, i/ (1+ i), i.e., the interest rate presented as a substitute at the beginning in place of adding at the end of the said year;

t = the number of years' entail for the future cash flow to take place In many occasions, there are usually many future cash flow lingering in project assessment. The following relation is use to express discounted cash flow in different time:

$$NPV = \sum_{t=0}^{N} \frac{FV_t}{(1+r)^t} = \sum_{t=0}^{N} \frac{C_t}{(1+r)^t} \quad (3)$$

Equation (3) above represents the future cash flow (FV) at time (t), which demonstrate the effect of the interest rate on products and services throughout the period of study.

3. Results and discussion

This section presents detail results on the sustainability assessment of building life cycle cost and the development of LCC model of CICC project Calabar including the discussion of findings.

3.1. Inflation rate

This represent consumer price index (CPI) for various price of product and services. The consumer price index (CPC) shows the percentage change of price of products and services of various commodities World bank (2019). The analysis was carried out from 2000 to 2018 to show the rate of inflation on market commodities.

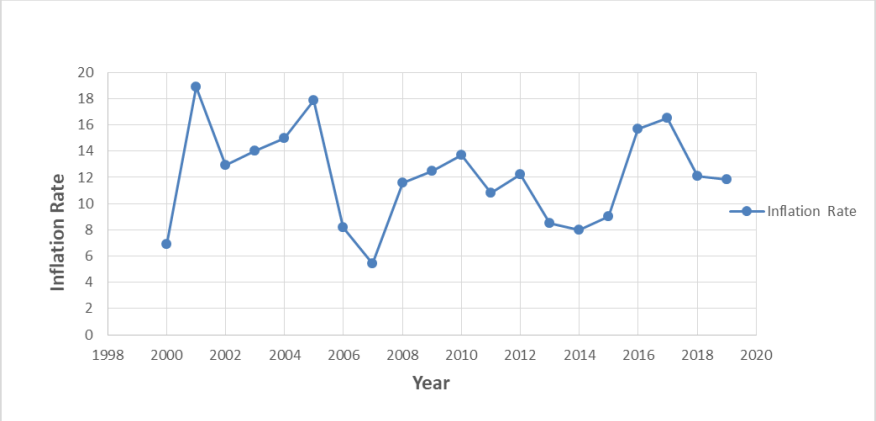

Figure 1 Inflation rate

3.2. Total forecast cost of the case study

Total forecast cost showing the cost of operation, maintenance and replacement of the project for the period of 51 years under review.

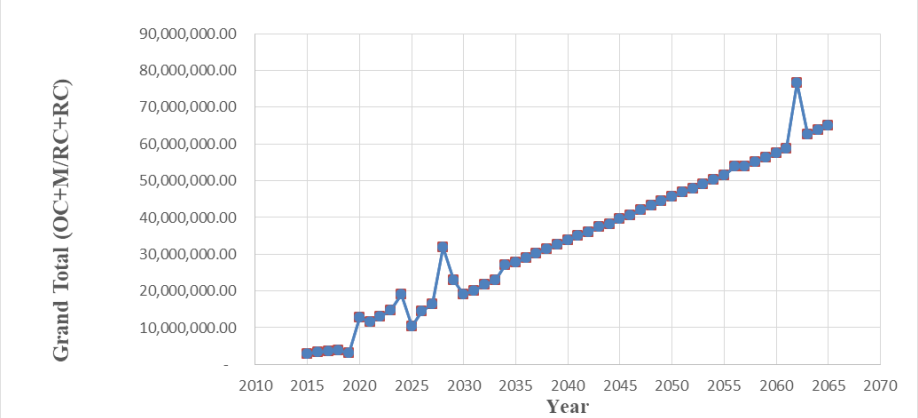

Figure 2 Total forecast cost

3.3. Sensitivity analysis of discount rate

The discount rates adopted for this study are 4%, 4.5%, 5%, 6%, 8%, 12% and 13% respectively.The values were used to discount all future cost to the base year including the annual discount factor which represents the cumulative percentage rate for the discounted values used for economicanalysis when determining the equivalent value of different alternative. The discount process involves the following steps: identifying the requite discount rate, sum total of operational, Maintenance/Repair and Replacement costs, the number of years, the discount factor and the discount rate of the cash flow. While the salvage value of CICC building complex was computed by a professional estate surveyor Egbe and partners Nigeria Ltd. The life cycle cost of the case study was obtained using the adopted discount rates to determine the sensitivity of the analysis for the study. It was observed when discounting the future cost to the present values; the highest discount rate at 13% generated the lowest cost values while the list discount of 4% generated the highest cost value.

Table 1 Discount rate of 4%

YEAR	T	F=(OC+M/RC+RC)	1=(1+r)^t	F=(1+r)^t	Year	t	F(OC+M/RC+RC)	1=(1+r)^t	F(1+r)^t
2015	0	2865400	1						
2016	1	3348600	0.961538	3219807.7	2041	26	34944275.02	0.360689	12604024
2017	2	3640000	0.924556	3365384.6	2042	27	36062822.09	0.346817	12507184
2018	3	3847060	0.961538	3420022.3	2043	28	37313975.68	0.333477	12443370
2019	4	3026000	0.854804	2586637.5	2044	29	38257237.63	0.961538	11964779
2020	5	12720050	0.821927	10454954	2045	30	39660000.16	0.308319	11795421
2021	6	11651476	0.790315	9208330.7	2046	31	40560029.59	0.29646	11757614
2022	7	13066616.29	0.759918	9929554.5	2047	32	41999428.07	0.285058	11561958
2023	8	14673756.57	0.73069	10721970	2048	33	43175672.26	0.274094	11511799
2024	9	18993341.3	0.702587	13344470	2049	34	44370600.89	0.263552	11693965
2025	10	10389272.06	0.675564	7018619.9	2050	35	45556721.14	0.253415	11244197
2026	11	14517669.52	0.649581	9430401.3	2051	36	46742841.39	0.243669	11100748
2027	12	16355050.88	0.624597	10215317	2052	37	47921203.62	0.234297	10951700
2028	13	31882417.3	0.600574	19147754	2053	38	49114265.25	0.225285	10795949
2029	14	22927432.07	0.577475	13240021	2054	39	50300354.09	0.216621	10639162
2030	15	18972446.83	0.555265	10534726	2055	40	51486442.93	0.208289	10477013
2031	16	20017461.6	0.533908	10687486	2056	41	53765790.75	0.200278	10311598
2032	17	21612476.37	0.513373	11095267	2057	42	53962740.52	0.192575	10353943
2033	18	22851568.52	0.493628	11280177	2058	43	55152461.45	0.185168	9992183.7
2034	19	26925820.44	0.474642	12780137	2059	44	56342182.38	0.178046	9819694.4
2035	20	27804571.51	0.456387	12689643	2060	45	57531903.31	0.171198	9645692.1
2036	21	28994522.1	0.438834	12723771	2061	46	58721624.24	0.164614	9470548.5
2037	22	30184472.68	0.421955	12736501	2062	47	76623022.82	0.158283	9294608.7
2038	23	31374423.26	0.405726	12729430	2063	48	62493705.9	0.152195	11661623
2039	24	32564373.85	0.390121	12704062	2064	49	63726058.66	0.146341	9145398.9
2040	25	33754324.43	0.375117	12661814	2065	50	64958411.42	0.140713	9140468
Salvage Value =145707728.80, Initial Cost = 5719455950.50, LCC = 899940966.50									

Table 2 Discount rate of 4.5%

YEAR	t	F=(OC+M/RC+RC)	1(1+r)^t	F=(1+r)^t	Year	t	F=(OC+M/RC+RC)	1(1+r)^t	F=(1+r)^t
2015	0	2861400	1						
2016	1	3102000	0.9569378	2968421.05	2041	26	33992127.25	0.3184025	10823177.78
2017	2	3388400	0.91572995	3102859.37	2042	27	35082512.77	0.3046914	10689338.99
2018	3	3657860	0.8762966	3205370.3	2043	28	36305504.81	0.2915707	10585621.16
2019	4	24818000	0.83856134	20811415.4	2044	29	37207543.66	0.279015	10381463.4
2020	5	11811450	0.80245105	9478110.41	2045	30	38593464.63	0.267	10304455.65

2021	6	10941156	0.76789574	8401667.06	2046	31	39464760.81	0.2555024	10083341.39
2022	7	12681433.43	0.73482846	9318678.17	2047	32	40876339.97	0.2444999	9994261.492
2023	8	13969639.43	0.70318513	9823242.68	2048	33	42024335.56	0.2339712	9832484.51
2024	9	19633845.43	0.67290443	13211701.5	2049	34	43191015.6	0.2238959	9670290.952
2025	10	11109375.24	0.64392768	7153634.25	2050	35	44348887.25	0.2142544	9501946.085
2026	11	12519669.52	0.61619874	7714604.57	2051	36	45506758.91	0.2050282	9330167.685
2027	12	15640118.08	0.58966386	9222412.47	2052	37	46656956.81	0.1961992	9154058.049
2028	13	31117556.53	0.56427164	17558754.7	2053	38	47821694.45	0.1877504	8978544.166
2029	14	22112643.34	0.53997286	11940227.3	2054	39	48979535.04	0.1796655	8799932.292
2030	15	18807730.15	0.51672044	9718338.64	2055	40	50137375.63	0.1719287	8620053.868
2031	16	19852816.95	0.49446932	9816608.95	2056	41	52406521.35	0.1645251	8622186.74
2032	17	21447903.76	0.47317639	10148641.6	2057	42	52558895.39	0.1574403	8274886.211
2033	18	22678575.65	0.45280037	10268867.4	2058	43	53720428.02	0.1506605	8093548.528
2034	19	25859604.06	0.43330179	11205012.7	2059	44	54881960.65	0.1441728	7912483.883
2035	20	27021393.09	0.41464286	11204227.7	2060	45	56043493.28	0.1379644	7732005.025
2036	21	28183182.11	0.39678743	11182732.3	2061	46	57205025.91	0.1320233	7552397.262
2037	22	29344971.14	0.37970089	11142311.5	2062	47	73661644.31	0.1263381	9306272.351
2038	23	30506760.17	0.36335013	11084635.3	2063	48	60802681.66	0.1208977	7350904.701
2039	24	31668549.2	0.34770347	11011264.6	2064	49	62003232.36	0.1156916	7173252.178
2040	25	32830338.22	0.3327306	10923658	2065	50	70599151.62	0.1107096	7816007.364
Salvage Value = 145707728.80, Initial Cost = 5719455950.50, LCC = 676986105.50									

Table 3 Discount rate of 5%

YEAR	T	F=(OC+M/RC+RC)	1(1+r)^t	F=(1+r)^t	Year	t	F=(MC+M/RC+RC)	1(I+r)^t	F(1+r)^t
2015	0	2865400	1						
2016	1	3348600	0.95238095	3189142.86	2041	26	34944275.02	0.2812407	9827753.588
2017	2	3640000	0.90702948	3301587.3	2042	27	36062822.09	0.2678483	9659366.276
2018	3	3847060	0.8638376	3323235.07	2043	28	37313975.68	0.2550936	9518557.773
2019	4	3026000	0.82270247	2489497.69	2044	29	38257237.63	0.2429463	9294455.137
2020	5	12720050	0.78352617	9966492.01	2045	30	39660000.16	0.2313774	9176429.65
2021	6	11651476	0.7462154	8694510.78	2046	31	40560029.59	0.2203595	8937786.822
2022	7	13066616.29	0.71068133	9286200.24	2047	32	41999428.07	0.2098662	8814258.968
2023	8	14673756.57	0.67683936	9931776.04	2048	33	43175672.26	0.1998725	8629631.264
2024	9	18993341.3	0.64460892	12243277.2	2049	34	44370600.89	0.1903548	8446156.841
2025	10	10389272.06	0.61391325	6378111.81	2050	35	45556721.14	0.1812903	8258990.975
2026	11	14517669.52	0.58467929	8488180.7	2051	36	46742841.39	0.1726574	8070498.146
2027	12	16355050.88	0.55683742	9107104.31	2052	37	47921203.62	0.1644356	7879953.45
2028	13	31882417.3	0.53032135	16907926.6	2053	38	49114265.25	0.1566054	7691557.424
2029	14	22927432.07	0.50506795	11579911.2	2054	39	50300354.09	0.149148	7502195.523
2030	15	18972446.83	0.4810171	9126071.32	2055	40	51486442.93	0.1420457	7313426.916

2031	16	20017461.6	0.45811152	9170229.8	2056	41	53765790.75	0.1352816	7273522.316
2032	17	21612476.37	0.43629669	9429451.85	2057	42	53962740.52	0.1288396	6952539.044
2033	18	22851568.52	0.41552065	9495298.72	2058	43	55152461.45	0.1227044	6767449.75
2034	19	26925820.44	0.39573396	10655461.5	2059	44	56342182.38	0.1168613	6584222.613
2035	20	27804571.51	0.37688948	10479250.6	2060	45	57531903.31	0.1112965	6403099.989
2036	21	28994522.1	0.35894236	10407362.3	2061	46	58721624.24	0.1059967	6224296.929
2037	22	30184472.68	0.34184987	10318558.1	2062	47	76623022.82	0.1009492	7735033.961
2038	23	31374423.26	0.32557131	10214612	2063	48	62493705.9	0.0961421	6008276.684
2039	24	32564373.85	0.31006791	10097167.3	2064	49	63726058.66	0.0915639	5835007.312
2040	25	33754324.43	0.29530277	9967745.56	2065	50	64958411.42	0.0872037	5664615.574
Salvage Value = 145707728.80, Initial Cost = 5719455950.50 LCC = 502311378.20									

Table 4 Discount rate of 6%

YEAR	T	F=(OC+M/RC+RC	1(1+r)^t	F(1+r)^t	YEAR	T	F=(OC+M/RC+RC	1(1+r)^t	F(1+r)^t
2015	0	2865400	1						
2016	1	3348600	0.94339623	3159056.6	2041	26	34944275.02	0.21981	7681102.097
2017	2	3640000	0.88999644	3239587.04	2042	27	36062822.09	0.207368	7478273.549
2018	3	3847060	0.83961928	3230065.76	2043	28	37313975.68	0.1956301	7299738.402
2019	4	3026000	0.79209366	2396875.42	2044	29	38257237.63	0.1845567	7060631.011
2020	5	12720050	0.74725817	9505161.32	2045	30	39660000.16	0.1741101	6905207.819
2021	6	11651476	0.70496054	8213830.82	2046	31	40560029.59	0.1642548	6662181.19
2022	7	13066616.29	0.66505711	8690046.11	2047	32	41999428.07	0.1549574	6508122.036
2023	8	14673756.57	0.62741237	9206496.41	2048	33	43175672.26	0.1461862	6311688.466
2024	9	18993341.3	0.59189846	11242129.5	2049	34	44370600.89	0.1379115	6119217.518
2025	10	10389272.06	0.55839478	5801315.26	2050	35	45556721.14	0.1301052	5927167.149
2026	11	14517669.52	0.52678753	7647727.2	2051	36	46742841.39	0.1227408	5737252.437
2027	12	16355050.88	0.49696936	8127959.23	2052	37	47921203.62	0.1157932	5548948.61
2028	13	31882417.3	0.46883902	14947721.4	2053	38	49114265.25	0.1092389	5365185.86
2029	14	22927432.07	0.44230096	10140825.3	2054	39	50300354.09	0.1030555	5183729.096
2030	15	18972446.83	0.41726506	7916539.18	2055	40	51486442.93	0.0972222	5005624.619
2031	16	20017461.6	0.39364628	7879799.37	2056	41	53765790.75	0.091719	4931346.982
2032	17	21612476.37	0.37136442	8026104.72	2057	42	53962740.52	0.0865274	4669255.685
2033	18	22851568.52	0.35034379	8005905.15	2058	43	55152461.45	0.0816296	4502074.665
2034	19	26925820.44	0.33051301	8899333.98	2059	44	56342182.38	0.0770091	4338859.563
2035	20	27804571.51	0.31180473	8669596.83	2060	45	57531903.31	3654324.5	4179697.053
2036	21	28994522.1	0.2941554	8528895.32	2061	46	58721624.24	0.0685378	4024651.289
2037	22	30184472.68	0.2775051	8376345.02	2062	47	76623022.82	0.0646583	4954314.974

2038	23	31374423.26	0.26179726	29598512.5	2063	48	62493705.9	0.0609984	3812016.279
2039	24	32564373.85	0.24697855	8042701.78	2064	49	63726058.66	0.0575457	3667158.33
2040	25	33754324.43	0.23299863	7864711.37	2065	50	64958411.42	0.0542884	3526485.742
Salvage Value = 145707728.80, Initial Cost = 5719455950.50 LCC = 257714200.10									

Table 5 Discount rate of 8%

YEAR	t	F=(OC+M/RC+RC	1(1+r)^t	F(1+r)^t	Year	t	F=(OC+M/RC+RC)	1.08	F(1+r)^t
2015	0	2865400	1					1(1+r)^t	
2016	1	3348600	0.92592593	3100555.56	2041	26	34944275.02	0.1352018	4724527.617
2017	2	3640000	0.85733882	3120713.31	2042	27	36062822.09	0.1251868	4514589.958
2018	3	3847060	0.79383224	3053920.26	2043	28	37313975.68	0.1159137	4325201.755
2019	4	3026000	0.73502985	2224200.33	2044	29	38257237.63	0.1073275	4106054.404
2020	5	12720050	0.6805832	8657052.3	2045	30	39660000.16	0.0993773	3941305.025
2021	6	11651476	0.63016963	7342406.28	2046	31	40560029.59	0.092016	3732173.656
2022	7	13066616.29	0.5834904	7624245.1	2047	32	41999428.07	0.0852	3578353.164
2023	8	14673756.57	0.54026888	7927774.09	2048	33	43175672.26	0.0788889	3406082.613
2024	9	18993341.3	0.50024897	9501399.37	2049	34	44370600.89	0.0730453	3241064.125
2025	10	10389272.06	0.46319349	4812243.17	2050	35	45556721.14	0.0676345	3081208.001
2026	11	14517669.52	0.42888286	6226379.62	2051	36	46742841.39	0.0626246	2927250.65
2027	12	16355050.88	0.39711376	6494815.73	2052	37	47921203.62	0.0579857	2778745.45
2028	13	31882417.3	0.36769792	11723098.7	2053	38	49114265.25	0.0536905	2636968.506
2029	14	22927432.07	0.34046104	7805897.4	2054	39	50300354.09	0.0497134	2500602.024
2030	15	18972446.83	0.3152417	5980906.49	2055	40	51486442.93	0.0460309	2369969.021
2031	16	20017461.6	0.29189047	5842906.23	2056	41	53765790.75	0.0426212	2291564.378
2032	17	21612476.37	0.27026895	5841181.33	2057	42	53962740.52	0.0394641	2129591.315
2033	18	22851568.52	0.25024903	5718582.84	2058	43	55152461.45	0.0365408	2015317.211
2034	19	26925820.44	0.23171206	6239037.43	2059	44	56342182.38	0.0338341	1906287.603
2035	20	27804571.51	0.21454821	5965420.98	2060	45	57531903.31	1575803.4	1802352.548
2036	21	28994522.1	0.19865575	5759928.46	2061	46	58721624.24	0.0290073	1703355.54
2037	22	30184472.68	0.18394051	5552147.21	2062	47	76623022.82	0.0268586	2057987.693
2038	23	31374423.26	0.17031528	#NAME?	2063	48	62493705.9	0.0248691	1554161.033
2039	24	32564373.85	0.15769934	5135380.18	2064	49	63726058.66	0.0230269	1467415.291
2040	25	33754324.43	0.1460179	4928735.74	2065	50	64958411.42	0.0213212	1384993.136
Salvage Value = 145707728.80, Initial Cost = 5719455950.50 LCC = 158440057.20									

Table 6 Discount rate of 10%

YEAR	t	F=(OC+M/RC+RC)	1(1+r)^t	F+(1+r)^t	Year	t	F=(OC+M/RC+RC)	1(1+r)^t	F(1+r)^t
2015	0	2865400	1						
2016	1	3348600	0.88495575	2963362.83	2041	26	34944275.02	0.0368877	1289015.265
2017	2	3640000	0.69305016	2522702.59	2042	27	36062822.09	0.032644	1177235.342
2018	3	3847060	0.61331873	2359473.94	2043	28	37313975.68	0.0288885	1077945.151
2019	4	3026000	0.54275994	1642391.57	2044	29	38257237.63	0.0255651	978048.3033
2020	5	12720050	0.48031853	6109675.68	2045	30	39660000.16	0.0226239	897265.4881
2021	6	11651476	0.42506064	4952583.89	2046	31	40560029.59	0.0200212	812059.9119
2022	7	13066616.29	0.37615986	4915136.58	2047	32	41999428.07	0.0177179	744140.1569
2023	8	14673756.57	0.33288483	4884671.01	2048	33	43175672.26	0.0156795	676974.0633
2024	9	18993341.3	0.29458835	5595217.04	2049	34	44370600.89	0.0138757	615672.5464
2025	10	10389272.06	0.26069765	2708458.85	2050	35	45556721.14	0.0122794	559407.7691
2026	11	14517669.52	0.23070589	3349311.84	2051	36	46742841.39	0.0108667	507940.3334
2027	12	16355050.88	0.2041645	14473496.4	2052	37	47921203.62	0.0096165	460836.4953
2028	13	31882417.3	0.18067655	5760405.19	2053	38	49114265.25	0.0085102	417973.1224
2029	14	22927432.07	0.15989075	3665884.38	2054	39	50300354.09	0.0075312	378820.3517
2030	15	18972446.83	0.14149624	2684529.92	2055	40	51486442.93	0.0066647	343144.2341
2031	16	20017461.6	0.12521791	2506544.76	2056	41	53765790.75	0.005898	317111.0759
2032	17	21612476.37	0.11081231	2394928.48	2057	42	53962740.52	0.0052195	281657.2454
2033	18	22851568.52	0.09806399	2240916.06	2058	43	55152461.45	0.004619	254749.5271
2034	19	26925820.44	0.08678229	2336684.49	2059	44	56342182.38	0.0040876	230305.1811
2035	20	27804571.51	0.07679849	2135349.14	2060	45	57531903.31	0.0036174	208113.5424
2036	21	28994522.1	0.06796327	1970562.43	2061	46	58721624.24	0.0032012	187979.8142
2037	22	30184472.68	0.06014448	1815429.52	2062	47	76623022.82	0.0028329	217067.0949
2038	23	31374423.26	0.05322521	31374423.3	2063	48	62493705.9	0.002507	156672.4189
2039	24	32564373.85	0.04710195	1533845.6	2064	49	63726058.66	0.0022186	141382.2487
2040	25	33754324.43	0.04168314	1406986.37	2065	50	64958411.42	0.0019634	127536.5832
Salvage Value = 145707728.80, Initial Cost = 5719455950.50 LCC = 6330215674									

Table 7 Discount rate of 12%

Year	t	F=(OC+M/RC+RC	1(1+r)^t	F(1+r)^t	Year	T	F=(OC+M/RC+RC)	1.12	F(1+r)^t
2015	0	2865400	1					1(1+r)^t	
2016	1	3348600	0.892857	2989821.4	2041	26	34944275.02	0.052521	1835301.608
2017	2	3640000	0.797194	2901785.7	2042	27	36062822.09	0.046894	1691114.827
2018	3	3847060	0.71178	2738261.3	2043	28	37313975.68	0.041869	1562308.837

2019	4	3026000	0.635518	1923077.7	2044	29	38257237.63	0.037383	1430180.825
2020	5	12720050	0.567427	7217698	2045	30	39660000.16	0.033378	1323768.466
2021	6	11651476	0.506631	5903000.3	2046	31	40560029.59	0.029802	1208758.554
2022	7	13066616.29	0.452349	5910673.6	2047	32	41999428.07	0.026609	1117549.197
2023	8	14673756.57	0.403883	5926484.2	2048	33	43175672.26	0.023758	1025756.695
2024	9	18993341.3	0.36061	6849189.3	2049	34	44370600.89	0.021212	941201.3456
2025	10	10389272.06	0.321973	3345067.6	2050	35	45556721.14	0.01894	862822.9048
2026	11	14517669.52	0.287476	4173483.1	2051	36	46742841.39	0.01691	790435.2369
2027	12	16355050.88	0.256675	4197934.2	2052	37	47921203.62	0.015098	723537.2231
2028	13	31882417.3	0.229174	7306627.2	2053	38	49114265.25	0.013481	662098.7835
2029	14	22927432.07	0.20462	4691406.9	2054	39	50300354.09	0.012036	605435.8844
2030	15	18972446.83	0.182696	3466195.1	2055	40	51486442.93	0.010747	553314.4113
2031	16	20017461.6	0.163122	3265281.6	2056	41	53765790.75	0.009595	515901.877
2032	17	21612476.37	0.145644	3147734.9	2057	42	53962740.52	0.008567	462314.0001
2033	18	22851568.52	0.13004	2971608.6	2058	43	55152461.45	0.007649	421880.9593
2034	19	26925820.44	0.116107	3126270.2	2059	44	56342182.38	0.00683	384804.9656
2035	20	27804571.51	0.103667	2882410	2060	45	57531903.31	0.006098	350830.8064
2036	21	28994522.1	0.09256	2683721.7	2061	46	58721624.24	0.005445	319719.4203
2037	22	30184472.68	0.082643	2494520.6	2062	47	76623022.82	0.004861	372487.9395
2038	23	31374423.26	0.073788	28012878	2063	48	62493705.9	0.00434	271250.902
2039	24	32564373.85	0.065882	2145409.4	2064	49	63726058.66	0.003875	246964.1692
2040	25	33754324.43	0.058823	1985541	2065	50	64958411.42	0.00346	224767.8866
Salvage Value = 145707728.80, Initial Cost = 5719455950.50 LCC = 25712933.78									

Table 8 Discount rate of 13%

Year	t	F=(OC+M/RC+RC)	1(1+r)^t	F(1+r)^t	Year	t	F=(OC+M/RC+RC)	1(1+r)^t	F(1+r)^t
2015	0	2865400	1						
2016	1	3348600	0.88495575	2963362.83	2041	26	34944275.02	0.0416831	1456587.25
2017	2	3640000	0.78314668	2850653.93	2042	27	36062822.09	0.0368877	1330275.937
2018	3	3847060	0.69305016	2666205.56	2043	28	37313975.68	0.032644	1218078.02
2019	4	3026000	0.61331873	1855902.47	2044	29	38257237.63	0.0288885	1105194.583
2020	5	12720050	0.54275994	6903933.52	2045	30	39660000.16	0.0255651	1013910.002
2021	6	11651476	0.48031853	5596419.79	2046	31	40560029.59	0.0226239	917627.7004
2022	7	13066616.29	0.42506064	5554104.33	2047	32	41999428.07	0.0200212	840878.3773
2023	8	14673756.57	0.37615986	5519678.24	2048	33	43175672.26	0.0177179	764980.6915
2024	9	18993341.3	0.33288483	6322595.25	2049	34	44370600.89	0.0156795	695709.9774
2025	10	10389272.06	0.29458835	3060558.5	2050	35	45556721.14	0.0138757	632130.7791
2026	11	14517669.52	0.26069765	3784722.37	2051	36	46742841.39	0.0122794	573972.5768
2027	12	16355050.88	0.23070589	3773206.53	2052	37	47921203.62	0.0108667	520745.2397
2028	13	31882417.3	0.2041645	6509257.87	2053	38	49114265.25	0.0096165	472309.6283
2029	14	22927432.07	0.18067655	4142449.35	2054	39	50300354.09	0.0085102	428066.9975

2030	15	18972446.83	0.15989075	3033518.81	2055	40	51486442.93	0.0075312	387752.9845
2031	16	20017461.6	0.14149624	2832395.58	2056	41	53765790.75	0.0066647	358335.5158
2032	17	21612476.37	0.12521791	2706269.18	2057	42	53962740.52	0.005898	318272.6873
2033	18	22851568.52	0.11081231	2532235.15	2058	43	55152461.45	0.0052195	287866.9656
2034	19	26925820.44	0.09806399	2640453.47	2059	44	56342182.38	0.004619	260244.8547
2035	20	27804571.51	0.08678229	2412944.52	2060	45	57531903.31	205608.51	235168.3029
2036	21	28994522.1	0.07679849	2226735.54	2061	46	58721624.24	0.0036174	212417.19
2037	22	30184472.68	0.06796327	2051435.36	2062	47	76623022.82	0.0032012	245285.8172
2038	23	31374423.26	0.87100643	27764976.3	2063	48	62493705.9	0.0028329	177039.8333
2039	24	32564373.85	0.05322521	1733245.53	2064	49	63726058.66	0.002507	159761.941
2040	25	33754324.43	0.04710195	1589894.6	2065	50	64958411.42	0.0022186	144116.3391
Salvage Value = 145707728.80, Initial Cost = 5719455950.50 LCC = 16526662.08									

3.4. Sensitivity analysis on the impact of discount rate in percentages

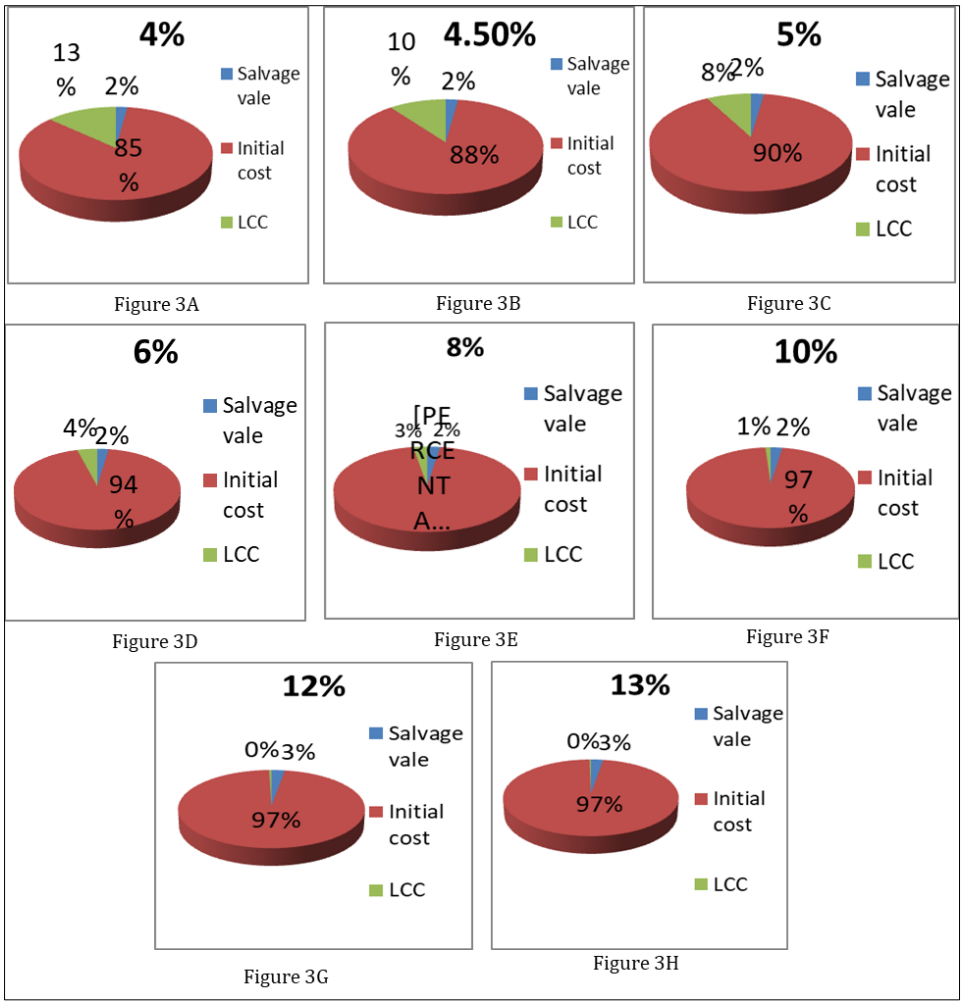

Figure 3A - 3H Percentage representation of discount rate

Percentage representation on the impact of different discount rate on the salvage value, initial cost and the life cycle cost of the project. The results from the pie chart which is obtain from table 3.1 to 3.1.8 implies that the initial cost (construction cost) outweighed the life cycle cost and salvage value. Results from the discount rates literally shows that the life cycle cost decreases as the discount rate increases likewise the initial cost increases as the discount rate increases as show in figure 3.3.

4. Conclusion

Life cycle costing enables the quantification of costs for relatively long period of time considering price changes. However, its implementation in real time is associated with some difficulties in obtaining the required cost data, particularly, if the analysis is conducted to develop life cycle cost in the nominal terms, in which future inflation and interest rates and the discount rates cannot be disregarded. The discount rates were applied to discount present value of the future cash flow. Thisresearch explains a theory in practice and demonstrates how the life cycle cost of a sustainable building was analyzed, estimated and discounted for a period of 51 years using different discount rates. Findings shows that the future costs associated with building operation, maintenance/repair and replacement at different discount rate generates different discount values.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest between the authors of this work and concerns exist anywhere pertaining to this work .

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