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ENTREPRENEURIAL UTILIZATION OF CRUSHED STONE DUST: A COST BENEFIT ANALYSIS

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ABSTRACT

Crushed stone is a by-product of crushing stone which has been considered as unsalable and of no significant value. But entrepreneurs seek to use all resources and reduce waste to increase their profit margin and thus utilization of crushed stones will reduce pollution of; natural habitat, air, water and soil. Not much has been done in stone dust utilization and thus this paper examines not only the technological feasibility of using quarry dust as a concrete building material but also undertakes a cost benefit analysis for the same. The study was a case design of Sirikwa Quarry. The quarry dust was tested experimentally for technical viability in the production of building blocks; an impact assessment was conducted and a cost benefit analysis carried out to determine the commercial viability as well as social cost benefit of utilizing the quarry dust as a raw material in the manufacture of building blocks. The findings from this study are significant to the Ministries of environment and public works, local and international construction companies and quarries and SMEs. The findings indicate stone dust can replace river sand in making of concrete blocks which will lower cost building materials, reduce cost of housing and dispose stone dust leading to clean environment. It is thus recommended strongly that SMEs in the construction industry use stone dust in concrete blocks manufacture in the place of river sand.

Keywords: Crushed stone, Crushed Stone Dust and analysis

INTRODUCTION

According to Environmental act (2004) there is need to manage the crushed stones dust to promote the environmental objectives of reduction of impacts on natural habitats; reduction of discharge to air, water and soil polluting material into environment; decreasing the amount of waste and provision of the information that makes it possible to use the product with minimum environmental effects.

Crushed stone dust at Sirikwa quarry and any other quarry for that matter in Kenya is a by-product of crushing stone. The crushed stone has always been considered as unsalable and a waste product of no known significant value and thus, being stockpiled in huge stacks at production sites. This has led to crushed stone dust occupying valuable space and is an environmental challenge. Stock piled crushed stone dust is easily blown about by wind thereby settling on plants, building roofs and can easily be inhaled by human beings and animals.

At Sirikwa quarry, there are stock piles consisting of an approximately 10, 0000 cubic meters of crushed stone dust that can be sold as sand. Sand used in Eldoret for concrete manufacture and other building works is usually obtained from Malava, Kisumu or Kanyarkwat which are 162Km, 120 and 80 kilometers away respectively. Transporters dealing with the sale of sand overload their trucks beyond the acceptable axle load limits in order to maximize profits. Monthly Axle load data from Eldoret mobile axle load enforcement unit and court fines passed on offending trucks show that overloading by trucks transporting sand to Eldoret Town is increasing at a tremendous rate and hence significantly contributing to damage of key roads leading to Eldoret Town.

Prudent utilization of crushed stone dust therefore may reduce or eliminate dependency on river sand for concrete production. This will have a positive effect of reduction of overloaded trucks transporting sand from various source points and hence reduce damage on key roads leading to Eldoret; ultimately the Kenyan Government may save finances which can be put into more productive uses to improve the lives of Kenyan Citizens, while SMEs in the construction industry will utilize fully available natural resources for commercial benefits.

Since crushed stone dust is a by-product of production of chippings, it is more cost effective than sand sourced from rivers. According to Faber (1979) for crushed stone dust to be utilized as sand in concrete manufacturing it must comply with the chemical and physical British standards. It is however to understand the impacts of all entrepreneurial projects before embarking on them lest the have more negative impacts than positive ones. This paper explores the optimal utilization of quarry dust from a cost benefit point of you looking at the commercial benefits and social benefits as well as costs.

Literature review

According to Neville (1972) aggregates used in concrete making are divided into two groups, course and fine and are covered by BS 882 (1954) British Standards. The Fine aggregates include crushed gravel, sand and naturally occurring sand (e.g. river sand). Fine aggregates comprise of particles mainly passing a 5mm test sieve while the Coarse Aggregates comprise crushed stone, crushed gravel or uncrushed gravel which consists of particles that are mainly retained on a 5mm test sieve. It is a requirement that aggregates should be durable and chemically inert under the conditions to which they are exposed. Aggregates are selected with regard to; Strength, Size, Particle shape, Surface texture, Grading, Impermeability, Cleanliness, Chemical inertness and Cost (Faber and Mead, 1979) and mixed in different proportions when making concrete.

Concrete is mixture of Portland cement, fine aggregates, course aggregates and water. The quality of the formed concrete depends on the properties of the ingredients and how well they fit or blend together. It is therefore important to select well proportioned mixture that is sufficiently workable, that will make the tasks of transporting, handling, placing and finishing of concrete easy (ACI, 2001).

According to Kong and Evans (1987), Mix design is the process of determining the required characteristics of the concrete mixture. This includes desirable aggregate size, workability; required strength, durability and water-cement (w\c) ratio. The mixture is proportioned to determine the appropriate quantities of all ingredients making the necessary adjustment to achieve the required specified strength of concrete.

The strength is the most important performance requirement and measured at 28 days. The compressive strength of concrete is the most common measure for judging the quality of concrete and depends on water/cement ratio and composition (Kong et al 1987). When a construction material is shown to satisfy structural requirements for use in the building and construction industry – technical viablity, the next thing is to show its economic, commercial and social viability which is done by carrying out cost benefit analysis.

According to Dasgupta and Pierce (1978) cost benefit analysis CBA is a way of deciding what the society prefers, where only one option is socially most preferred. The aims of CBA is to reflect the structure of society preference and ranks option based on the benefits (gains) devised from it costs (losses) incurred as a result of the choice of the option. There are two approaches in cost benefit analysis – A private sector approach and a social sector to a project evaluation.

A private firm, when deciding whether to embark on an investment project, would seek to address the question of profitability and would have to answer the question; will the revenue from the project exceed the cost over the life time of the project (Dinnwiddy and Teal, 1996). Similarly, for a social project CBA seeks to determine whether the project leads to an increase in social profitability. The terms social profitability is defined in terms of social welfare (Ibid).

In developed countries there are procedures for evaluating the cost and benefits of the public projects and estimating net benefits of public sector social outputs such as health and education. These procedures, according to Dinwiddy and Teal (1996) are based on cost benefit principals in that they construct and supply values for outputs and inputs that are not in the open market.

In developing countries however the range of subjects discussed under the heading of project evaluation is far more extensive. This is because cost benefit analysis has been more developed in the content of developing economies considering both efficiency and equity.

On efficiency, market failure in developing countries creates need for cost benefit analysis. When markets are distorted or do not exist, the existing structure of prices cannot be relied upon to allocate resources in an efficient manner. In such cases need for public sector intervention arises. In developing countries the extensive use of tariffs to raise revenue in the colonial period and foster import substitution in the post colonial phase has distorted the price of traded and non traded goods (Ibid). Environmental damage such as soil erosions and water pollution has also provided rationale for CBA.

On equity, a concern for distribution of resources has been a powerful force in stimulating interest in policies of economic development. According to Dinwiddy and Teal (1996), in 1960s the richest 20% of the world's population had income 30 times than the poorest20% and by 1990 the richest20% were getting 60 times more. Among countries 20% of the richest world people get at least 150 times more than the poorest 20%. Project evaluation in CBA in particular has been concerned with both aspects of inequitable distribution of income.

Cost-benefit analysis (CBA or COBA) is a major tool employed to evaluate projects. It provides the researcher or the planner with a set of values that are useful to determine the feasibility of a project from and economic standpoint. Conceptually simple, its results are easy for decision makers to comprehend, and therefore enjoys a great deal of favor in project assessments. The end product of the procedure is a benefit/cost ratio that compares the total expected benefits to the total predicted costs. In practice CBA is quite complex, because it raises a number of assumptions about the scope of the assessment, the time-frame, as well as technical issues involved in measuring the benefits and costs.

Before any meaningful analysis can be pursued, it is essential that an appropriate framework be specified. An extremely important issue is to define the spatial scope of the assessment.

Costs associated with the project are usually easier to define and measure than benefits. They include both investment and operating costs. Investment costs include the planning costs incurred in the design and planning, the land and property costs in acquiring the site(s) for the project, and construction costs, including materials, labor, etc. Operating costs typically involve the annual maintenance costs of the project.

Benefits are much more difficult to measure, particularly for transport projects, since they are likely to be diffuse and extensive. Safety is a benefit that needs to be assessed, and while there are complex issues involved, many CBA studies use standard measures of property savings per accident avoided, financial implications for reductions in bodily injury or deaths for accidents involving people. One of the most important sets of benefits is efficiency gains as a result of the project. These gains might be assessed by estimating the time savings or increased capacity made possible by the project.

Many other elements relating to social impacts, aesthetics, health and the environment are more difficult to assess. The latter, in particular, is a major factor in contemporary project assessment, and usually separate environmental impact analyses are required. Where possible these factors must be considered in CBA, and a variety of measures are used as surrogates for environmental benefits and costs. For example, the commercial losses of habitat destruction and property damage can be estimated.

According to Hanley and Spash (1993) cost benefit analysis involves several stages. This stages include defining the project, identifying impacts which are economically relevant, physically quantifying impacts, calculating a monetary evaluation, discounting, weighing and sensitivity analysis. These stages are briefly explained as follows

(i) Defining a project

A project involves the re-allocation of resources being proposed and considering the population of gainers and losers. Defining a project allows appraising a project that is known and determines boundaries of the analysis (Hanley and Spash 1963). The population of gainers and losers enables the analyst to determine the population over which cost and benefits are to be generated. In the private sector, when deciding to embark on an investment project, a firm has an overriding consideration, the question of profitability and question whether the revenues from the project exceeds the cost over the lifetime of the project (Dinwiddy and Teal, 1996) and that additional and displacement should be considered when listing the impacts. Additionality refers to net impacts of the project, benefits that would accrue from the project less the benefits. If the project is not undertaken and instead another approach/ project is not undertaken to achieve the same social objectives. Displacement considers the effects of the new project on the distribution of the outputs of another existing facility referred to as "crowding out" (Hanley and Spash 1993). Once the impacts are all identified and recorded, the next stage involves sorting out those which are of economic relevance to the society.

(ii) Determining impacts that are economically relevant

According to Dasgupta and Pearce (1978), decision maker's aims to maximize net social gains so that the choice is one of selecting policies that have the target differences between social benefits and social costs. However, Dinwiddy and Teal (1996) asserts that the theoretical object of cost benefit analysis is not always to describe socially optional states of affairs. They argue that CBA is a tool for deciding whether or not a particular project of policy could be expected to lead to an improvement in social welfare.

Dinwiddy and Teal (1996) quote Herberger (1969) who notes "for given project the question is, does the project move us up or down the utility hill" between the alternative projects the question is which takes us further up the hill?

According to (Dinnwiddy and Teal, 1996) CBA is associated with describing optional solutions for the reasons; first the theoretical lifetime in welfare economics is concerned

With study of optimal states and optimal part of development and secondly, original theory of shadow pricing evolved within the frame work of optimizing model. Assuming therefore that society is interested in maximizing utilities, then a weighing system of projects costs and benefits can be used to discriminate in favor of increasing economic activities in regions and areas where preferential intervention is desirer able. Then maximization of weighed sums of utilities across all its members can be undertaken. The word utility here is used instead of the word "gain" or welfare and indicates a preference that is invincible either ordinary or cardinally (Dasgupta and Pearce, 1978).

The utilities depend on among other variables, consumption levels of marketable and non-marketable goods. The marketable goods are those for which a price exists while not marketable are those essential without price tags such as good clean air fine sceneries

The aim of CBA is to select projects, which add to the total of social utility by increasing the value of consumable by more than any associated depletion in the level of other utility generating goods.

Therefore the economically relevant inputs are; those positive impacts referred to as benefits, that is increase in quality or quantity of goods that generate positive utility or a reduction of goods that generate positive utility or a reduction in the price at which they are supplied, and; negative impacts are costs which include any decrease in the quality or quantity of such goods or increase in their prices. They also include the using up of resources in a project, which cannot, therefore, be available, for use in other projects (opportunity costs). Having determined all relevant impacts the next thing is to quantify and assign a monetary value to them.

(iii) Physical quantification and monetary valuation of relevant impacts

Physical quantification involves determining the physical amounts of cost and benefits flow expected from a project and identifying at what points in time will occur (Hanley and Spash 1993). The calculation involves a certain degree of uncertainty hence appropriate estimating techniques should be used. Cost and benefit are measured as they occur using a common unit. In CBA this unit is money, a device of convenience.

Markets generate the relative values of all traded goods and services as relative prices. CBA, therefore predicts prices for value flows extending into the future; correct market prices where necessary and calculate prices (relative values) where none exists especially for non- traded goods (Harley and Spash 1993). When prices are determined in perfectly competitive market, the prices accurately reflect the marginal cost of production and the marginal cost of production and the marginal value of the consumer. However, rarely do such markets occur: market distortion, imperfectly competitive markets, effects of large projects on existing price of goods and economic outputs with no market prices, all require that CBA supplies alternative prices to be used in impact valuation. Such alternative prices that represent the social opportunity cost of resources are referred to as shadow prices or accounting prices (Dinwddy and Teal, 1996).

Since economic resources are limited the undertaking of a project diverts resources from an alternative use. There is an opportunity cost to carrying out the expenditure (Dasgupta and Pearce 1987). Thus the aim of CBA will be to compare benefits derived from expenditure to those that would have been obtained, if the money would have been invested in the "foregone" project. Therefore a measure is required for the society's willingness to pay for the foregone project and hence compare the preference for the project at hand and the fore gone project.

The concept of "shadow price" comes from the formal theory of optimization where outputs are maximized subject to some constraints (Dinwiddy and Teal, 1996). For every maximization-programming problem, there will always be a dual, minimization problem, which generates a set of shadow prices, giving the opportunity cost of the resources. The shadow price measures how much better we could be, measured by the stated objectives if the constraint was relaxed by one unit (Richard and Stephen, 1994). It measures the marginal effects on social welfare of a change in a government control variable. The purchased inputs in a project such as labor, capital, raw materials or outputs of the project. Where pricing policies exists any tax or subsidy or administered price is also regarded as government control variables.

It should be noted that the prices p: are the actual market prices facing the consumer. They may be distorted prices, including taxes, and the welfare significance comes from the fact that the relative marginal utilities of the consumer (Dinwiddy andTeal, 1996).

In summary valuation of costs and benefits to be made under CBA fall under four categories according to (Richard and Stephen, 1994).

1. The relative of costs and benefits as the time when they occur
2. The relative valuation of costs and benefits occurring at various points in time taking cognizance of the time preference and the opportunity cost of capital.
3. The valuation of risk outcomes.
4. The relative valuation of cost and benefits occurring to people with different outcomes.

The following section looks at the social time preference and discounting of costs and benefits flows.

(iv) Discounting of projects costs and benefits flows

Once all relevant costs and benefits flows have been expressed in monetary amounts, they have to be converted into their present value (pv) terms. Present values recognize the facts that a shilling today is no the same as a shilling tomorrow and that consumers in general prefer current consumption to differed consumptions.

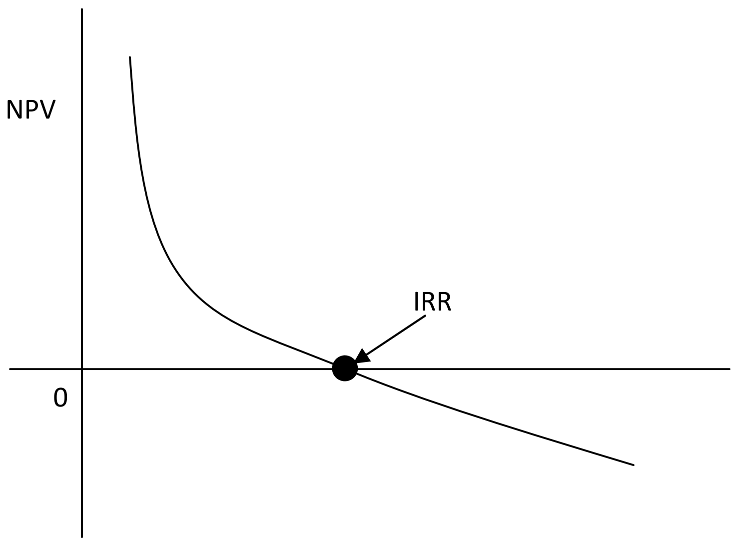
If the net benefits of a project in each year is

$B_0 - C_0, B_1 - C_1 ....B_n C_n$, where B indicates benefits and C costs, and n is the number of periods during which the product produces effect and assuming that the rate of discount (i) this year will remain the same for the next several years, then the net Present Value (NPV) is given by;

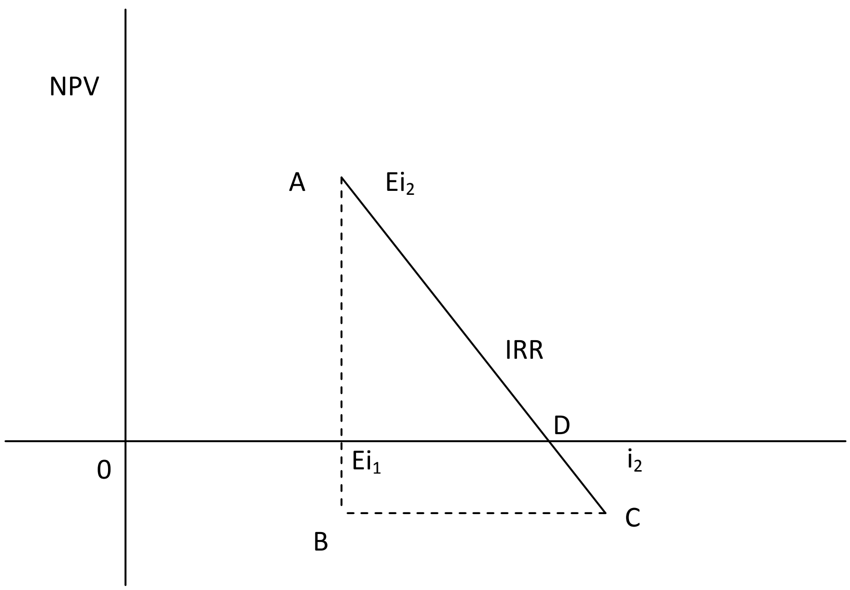
$$NPV = B_0 - C_1 + \frac{B_1 - C_1}{1+i} + \frac{B_1 - C_1}{(1+i)^2} + ... \frac{B_n - C_n}{(1+i)^n}$$

$B_1 - C_1$ is referred to as the Net Benefit and $\frac{1}{(1+i)^t}$ is called the discount factor and lies between 0 and +1. NPV is an aggregate of the discounted impacts of the project over its life and is used as a criterion of the discount rate (i) is left to the cost benefit analysis and is governed by the current cost of the capital, inflation rate, expected returns on capital, and the riskiness of the project.

When the discounting rate (i) results in an NPV equal to zero, the rate (i) that is then denoted by (r) referred to as the internal rate of return (IRR). IRR is used as a criterion or project selection since it comprises the discount rates which measures the opportunity cost of the funds ties up in a project.



IRR can be determined as shown above by plotting values of NPV against several corresponding values of (i) at the intersection of (i) on the x- axis. It can also be determined by interpolation where two values of NPV close to zero are calculated at the assumed discount rates i_1 and i_2 where the value of NPV_i is positive and NPV_{i2} is negative.



$$\frac{AE}{AB}=\frac{ED}{BC}$$

$$\frac{NPV_{i1}}{NPV_{i1}-NPV_{i2}}=\frac{r}{i_1-i_2}$$

$$r=i_2-i_2\left[\frac{NPV_{i1}}{NPV_{i1}-NPV_{i2}}\right]$$

(v) Project acceptance or rejection criterion

The main purpose of CBA is to help select resources. NPV tests ask whether the sum of discounted gains (Benefits) exceeds the sum of discounted losses (costs). If so, the project represents an efficient shift in resources allocation (Halley and Splash, 1993) according to Dinwinddy and Teal (1996), when considering an investment proposal, there are always two questions to be asked;

i. Does the project under represent a good use of the funds employed? In other words, s the project worthwhile?
ii. Is the project under consideration to be preferred to other projects which could be carried out with the funds available?

Both questions are answered by use of the NPV.

If NPV is positive i.e. NPV>0, the project is worthwhile and if the NPV of the project A is greater than the NPV of the project B, then the project A is preferred.

I.e. NPV (A)>NPV (B), A is preferred.

In both case, the concept of opportunity cost is used. When calculating the NPV of a project at a given rate of interest (i) and using the criterion NPV>0, the returns from the investment project are being compared with the returns from depositing the funds in a bank or lending it at an interest rate of (i) to another institution. If NPV $\leq$ 0, then the funds could be equally well or better used elsewhere. When NPV (A)>NPV (B), project B represents the opportunity coast of A, the next best use of funds if A is not undertaken (Dinwiddy and Teal, 1996).

In summary, if CBA is used to decide whether to do project A or not, the rule is "Do A if the benefits exceeds those of the next best alternative of course of action and not otherwise". The benefits of the next best alternative to A are referred to as the costs of A. If A is done, those alternative benefits are lost. Hence, do A if its benefits exceed its costs, and not otherwise (Richard and Stephen, 1994).

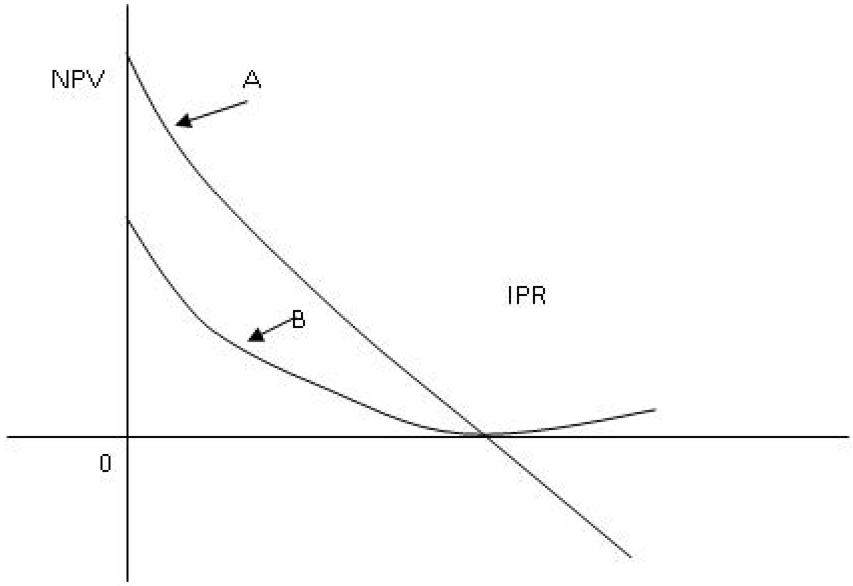
If IRR is the acceptance/rejection criterion, a project is accepted if the internal rate of return (IRR) is greater than the discounting rate (i).

I.e. Proceed if IRR(r)>i.

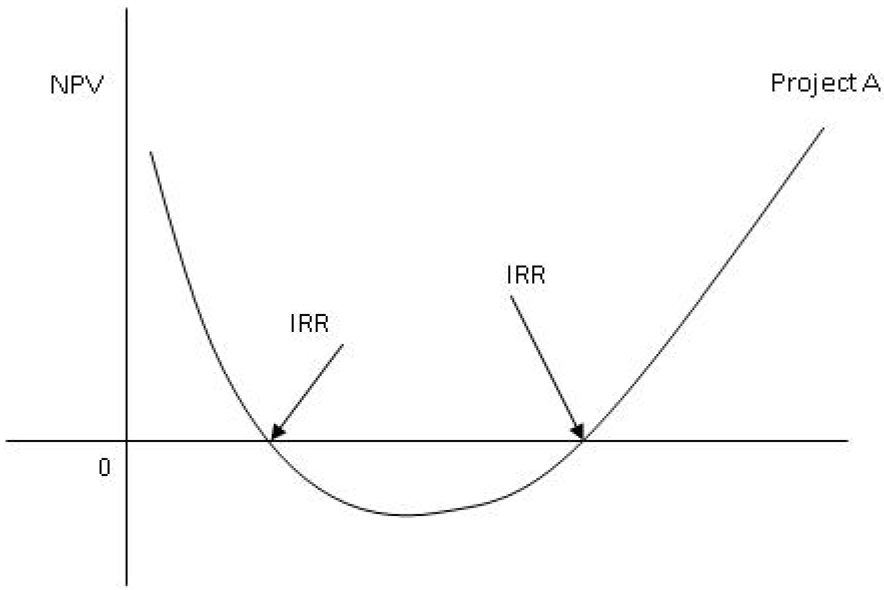
To choose between project A and B, project A is selected if the IRR of A is greater than the IRR of B.

I.e. if IRR (A)>IRR (B) Do A.

A dilemma arises if the two projects have the same IRR. Plotting the NPV against (i) the graph obtaining is as shown in the figure below.



At any rate lower than IRR project, A has a higher NPV and would maximize the return on funds employed. This indicates that calculation of NPV is to be preferred as a basis of appraisal of projects (Dinwiddy and Teal, 1996).



In such circumstances, the project who's NPV has a higher positive value before the IRR point and negative after would be preferred.

(vi) Project sensitivity analysis

Once the NPV of the alternative projects are calculated, the next thing is to recalculate the NPV when the values of certain key parameters are changed. The key parameters including:

i. Discount rate (i)
ii. Physical qualities and qualities of this inputs
iii. Shadow prices of the inputs
iv. Physical quantities and qualities of outputs
v. Shadow prices of the outputs, and

vi. Project lifespan

The intention is to discover to which parameter the NPV outcome is most sensitive (Hanley and Spash 1994).

Costs-Benefit Analysis Flowchart

The figure below provides an overview of the steps involved in the economic evaluation process using a CBA framework. A key point is that in many cases, undertaking a CBA requires 'inputs' from supplementary analytical processes such as operations modeling, engineering studies, user surveys, specific risk and/or safety analyses and modeling. Outputs from these processes are fed into the CBA framework, typically as quantified costs and benefits.

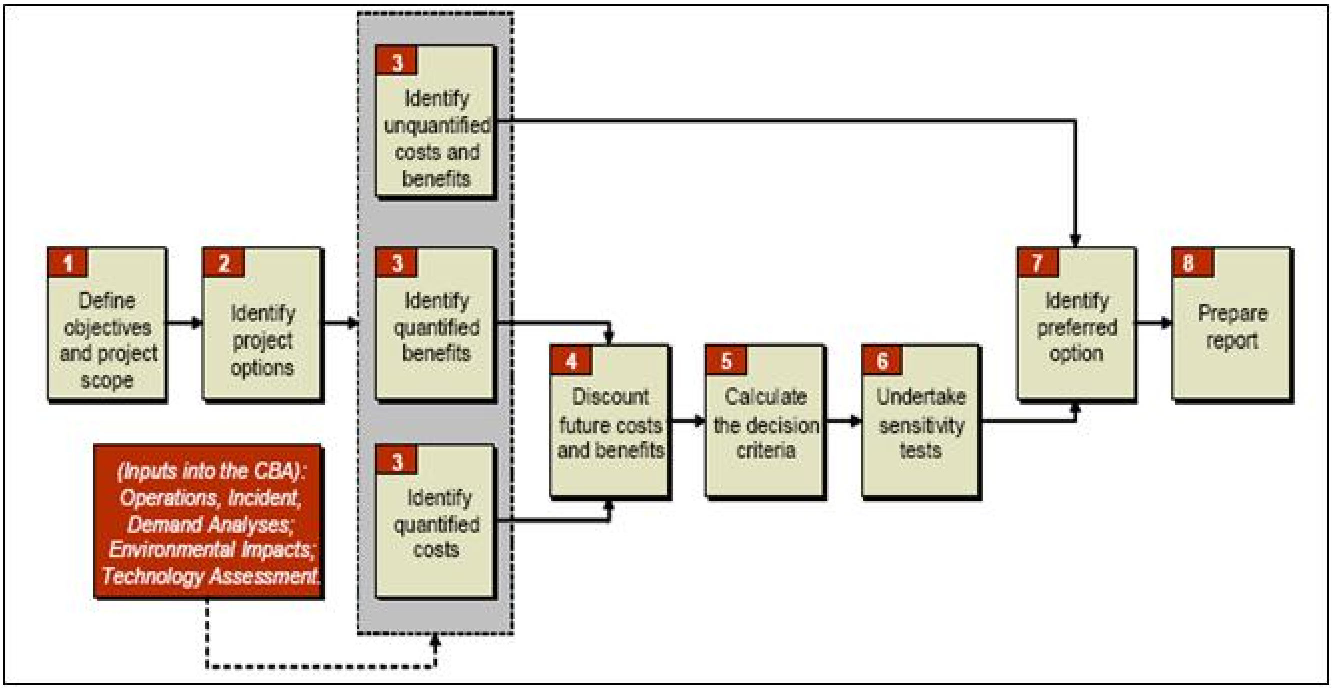


Figure 1*: Costs-Benefit Analysis Flowchart*

Source: Slack B (2004)

Several issues have been raised in the use of CBA in project evaluation. According to Richarch and Stephen (1994), one such issue has to do with whether a project is only worthwhile if and only if it is predicted that the money values of revenues exceeds the money value of costs in a CBA market test. This dilemma has been resolved by recommending the shadow prices be used in calculating values since shadow prices measure the worth of a unit of all the commodities as measured by the objective function.

The other dilemma lies in deciding to undertake a project whose NPV is Negative. Should a project whose total costs exceed total benefits be undertaken? Pareto's unanimity rule attempted to give guidance on this decision and insisted that a project should be supported only if some people gain from it and nobody loses. If a project must be done the NPV must be positive and losers compensated (Richarch and Stephen, 1994). Put differently, project X or policy X is better than project Y or policy Y if every on e present prefers it and project is acceptable if at least one person prefers it and no one "disprefers" it (Dasgupta and Pearce, 1978). But projects do involve gains to some and loses to others. That is, there will usually be at least one person who "disprefers" the project.

Pareto attempted a compromise by devising an optimality rule by which "no ne can be made better off without someone else being made worse off" a state that is resolved by gainers compensating the losers (Ibid). This criterion was thought to be too restrictive and Kaldor and hicks criterion was devised that asserts that a project can be supported provided the gainers could in principle, compensate the losers even if they do not (Richard and Stephen, 1994). Dasgupta and Pearce (1978) puts the Kaldor and Hicks principle differently, that, "a social state Y is socially preferable to an existing social state X if those who gain from the move to Y can compensate those who lose and still have some gains left over. The compensation paid to the losers is defined to be such that it leaves losers "no worse off" then they were before state X, hence preserving Pareto's optimality.

The other limitations of CBA have to do with prices of the resources used in the chosen project. The prices are thought to be inadequate guide to the true opportunity cost of the project for two reasons; Resources prices may rise because often transfer of resources from sector which have imperfectly competitive resources markets or have imperfectly competitive resources markets (Dasgupta and Pearce, 1978).

Study methodology

The study employed case study design of generation and utilization of quarry dust at Sirikwa Quarry. The quarry was within the Eldoret Municipality, Rift Valley Province of Kenya. The quarry dust was tested experimentally for technical viability in the production of quarry dust building blocks; an impact assessment was conducted and finally a cost benefit analysis was carried out to determine the commercial viability as well as social cost benefit of utilizing the quarry dust as a raw material in the manufacture of building blocks.

Study findings

Technical viability

From secondary experimental data from an earlier research by the same authors it was shown that the quarry dust has accept strength characteristics for use in construction as briefly outlined here.

Concrete cubes of size 150X150X150 were made, 32 from river sand and 32 from Sirikwa quarry crushed stone dust. The only deference between the cubes being the type of fine aggregate, river sand from Kanyarkwat for the samples labeled Kanyarkwat and quarry dust for the samples labeled Quarry dust (SQ). All other variables were maintained constant for the experiment. The quarry dust was extracted from four different heaps at Sirikwa quarry and in order to ensure that there was nothing special in one heap.

Density of the concrete cubes

The density of test cubes was found to be 2432.5 Kg/m^3 for the sand concrete cubes and 2422.41 Kg/m^3 for the quarry dust ones (Table 2). Analysis of Variance (ANOVA) and T test shows that the difference between the means is not significant ($t=1.109$, $p=0.272$, $\alpha=0.05$) as shown in table 1 and the comparative trend in figure 1.

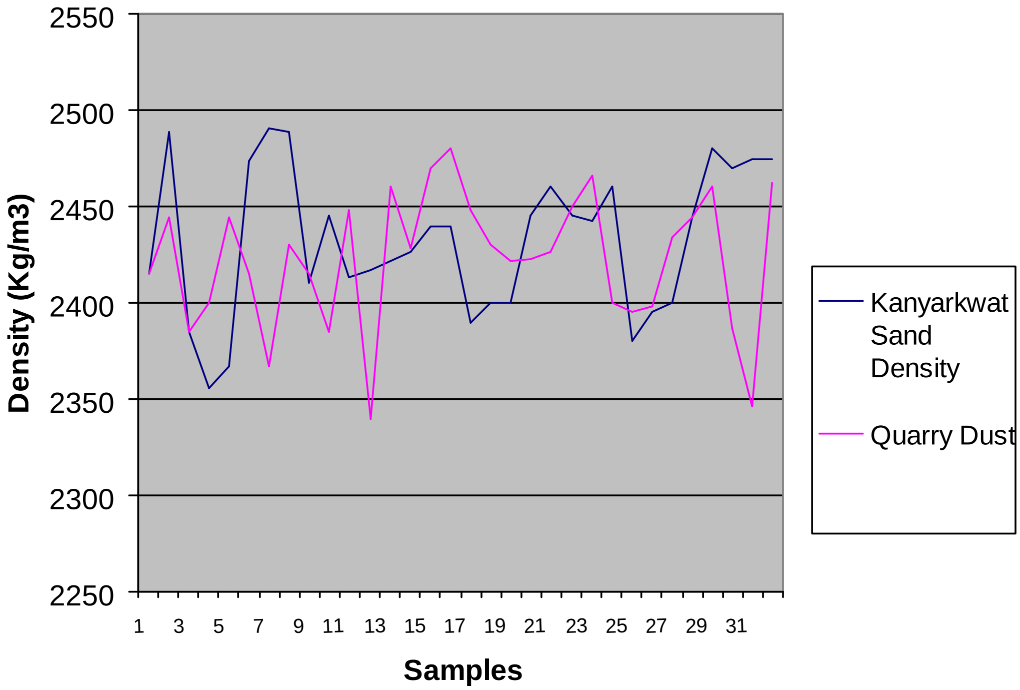


Figure 2: Density of concreate cubes made Kanyarkwat sand and quarry dust

For structural design purposes, the unit weight of concrete made with normal aggregates covered by BS 882 is usually taken as 24kN/m^3. Hence the values obtained above of 2432.5 Kg/m^3 and 2422.41 Kg/m^3 for sand concrete cubes and quarry dust cubes respectively are satisfactory and comply with the required standard.

Maximum load

The mean maximum load on the cubes $\bar{x}$ = 531.65 (KN) for river sand and $\bar{x}$ =472.06 for quarry dust was found to be significantly different (t =5.109, p=0.000, α=0.05) as shown in table 6b and the comparative trend in figure 2.

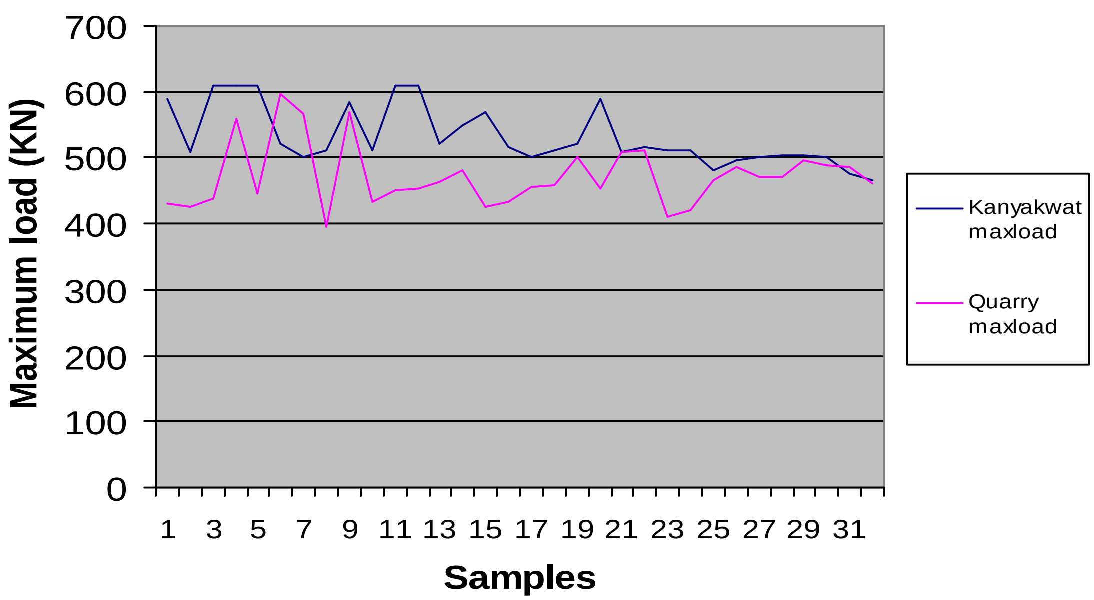


Figure 3: Maximum Load of concreate made from Kanyarkwat sand and quarry dust

This suggests that the quarry dust concrete blocks would withstand slightly lower loads than the river sand and consequently should be used carefully especially where the wall is a load bearing wall.

Compressive strength

The mean compressive strength of the cubes $\bar{x}$ =23.59 (N/mm^2) for river sand concrete and $\bar{x}$ =20.96 (N/mm^2) for quarry dust was found to be significantly different (t= 5.27, p=0.00, α=0.05) as shown in table 6b and the comparative trends shown in figure 3.

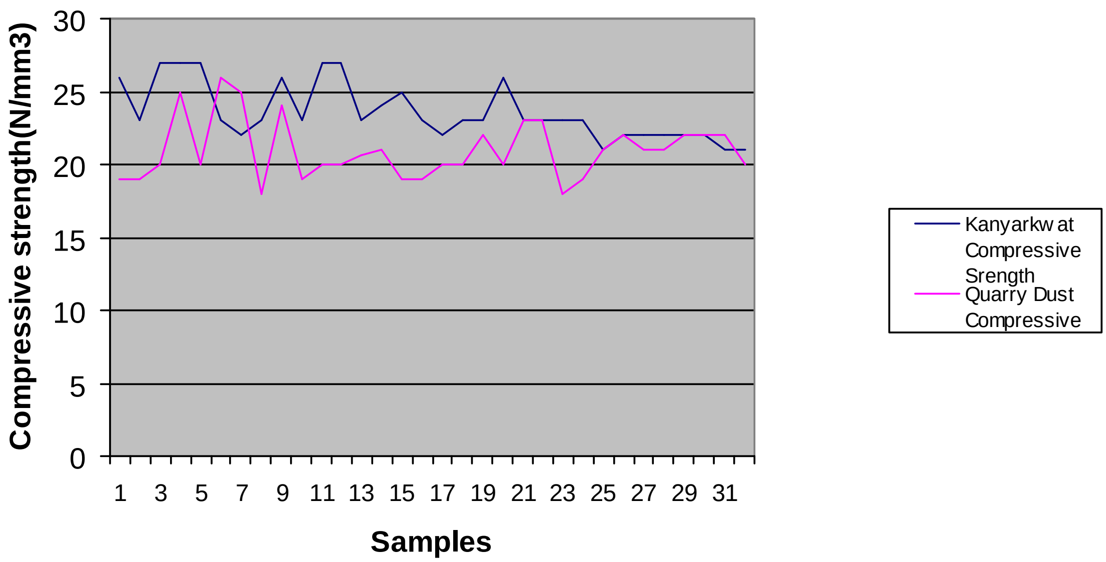


Figure 4: Compressive strength for Kanyarkwat sand and quarry dust

The compressive strength is the most common measure for judging the quality of concrete. The above characteristic strength is based on 28 day cube strength. The practice is to design concrete mixes that will give 1% probability that an individual strength test result will fail below a certain specified value f_{spec} (in this case 20N/mm^2). Using the normal distribution curve and tables, the z value is found to be 2.33

Thus the target mean strength = $f_{spec} \pm 2.33\pm$.

Therefore, the two values for the mean compressive strength are within the acceptable standard range of the design mix.

Mode of failure

It was found out that all samples except I had a "satisfactory" mode of failure.

Table 1: Frequency distribution of samples according to mode of failure

	Frequency	Percent
STF	63	98.4
USTF	1	1.6
Total	64	100.0

As stated above, the target mean strength = $f_{spec} \pm 2.33\pm$. The value of 18 N/mm^2 obtained from one test is within the acceptable limit and thus has not failed the test.

Table 2: Descriptive statistics for strength characteristics of River sand and Quarry dust as fine aggregates

	Sand type	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Density	Kanyarkwat	32	2432.5000	37.7778	6.6782
	Quarry dust	32	2422.4063	34.9690	6.1817
Maximum Load	Kanyarkwat	32	531.6563	45.3784	8.0218
	Quarry dust	32	472.0625	47.9038	8.4683
compressive strength	Kanyarkwat	32	23.5938	1.9652	.3474
	quarry dust	32	20.9563	2.0407	.3607

Table 3: ANOVA and Independent sample t test for strength characteristics of concrete made from river sand and quarry dust

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Density	Equal variances assumed	.717	.400	1.109	62	.272	10.0938	9.1001	-8.0971	28.2846
	Equal variances not assumed			1.109	61.634	.272	10.0938	9.1001	-8.0993	28.2868
Maximum Load	Equal variances assumed	.125	.724	5.109	62	.000	59.5938	11.6645	36.2767	82.9108
	Equal variances not assumed			5.109	61.819	.000	59.5938	11.6645	36.2753	82.9122
compressive strength	Equal variances assumed	.008	.930	5.266	62	.000	2.6375	.5008	1.6364	3.6386
	Equal variances not assumed			5.266	61.912	.000	2.6375	.5008	1.6363	3.6387

The compressive strength of concrete specimens made with quarry dust and river sand at 28 days are 20.96 and 23.59N/mm^2 respectively. The mean unit weight of both concrete cubes made with quarry dust and river sand were found to be 2422.41kg/m3(24.22kN/mm2) and 2432.5Kg/m3(24.33kN/mm2) which compares well with that of structural design purposes(BS8110) of 24kN/m^3. The unit weight of concrete made with normal aggregates covered by BS 882 is usually taken as 24kN/m^3 for structural design purposes. Hence the values obtained above of 2432.5 Kg/m^3 and 2422.41 Kg/m^3 for sand concrete cubes and quarry dust cubes respectively are satisfactory and comply with the required standard which is within the acceptable standard.

Project impact assessment

Crushed stone dust is a by-product of crushed stone that has been lying unutilized and accumulating in most local quarries in Kenya; apparently there are no guidelines in Kenya regulating the management of the crushed stone dust. The accumulation of the dust occupies space, pose health hazard and it can be argued that it may affect the productivity of quarries.

Impact Assessment

According to Gosling and Edwards (2000), impact assessment (IA) is the process of identifying the anticipated or actual impacts of a development project, on the social, economic and environmental factors which the project is designed to affect or may inadvertently affect. It may take place before approval of a project (*ex ante*), after completion (*ex post*), or at any stage in between. *Ex ante* assessment forecasts potential impacts as part of the planning, design and approval of a project. *Ex post* assessment identifies actual impacts during and after implementation, to enable corrective action to be taken if necessary, and to provide information for improving the design of future projects.

A distinction can be made between two separate but interlinked levels of IA:

- *Internal monitoring and evaluation for ongoing learning,* through for example the integration of specific impact indicators into existing management information systems, which makes information immediately available to staff;
- *External impact assessment,* often involving independent investigators. Such assessments produce reports for specific purposes, such as *regulatory impact assessment*, *social impact assessment* or *health impact assessment*. Certain types of *ex ante* assessment may be part of the approval process for certain types of project, including *environmental impact assessment* and *economic impact assessment (cost-benefit analysis)*. These may contain their own *ex post* monitoring activities. Separate *ex post* assessments may be undertaken or commissioned for any particular project or set of projects, to provide fuller information than may be available from routine monitoring and evaluation.

In the context of *sustainable development*, the social, economic and environmental impacts of a project are all interlinked. The various types of impact assessment may therefore need to be combined in an *integrated impact assessment*, whose nature will vary according to the type of project, and the aims and cost-effectiveness of the overall impact assessment package. An impact assessment will include:

i) Quantitative statistical methods

These methods involve baseline studies, the precise identification of baseline conditions, definition of objectives, target setting, rigorous performance evaluation and outcome measurement. Some degree of quantification will be necessary in all impact assessments, in order to evaluate the success of the project and the magnitude of any adverse effects.

ii) Qualitative methods

These methods are suitable for investigating more complex and/or sensitive types of social impacts, e.g. intra-household processes, policy issues and investigation of reasons for statistical relationships and policy implications. Some degree of qualitative interpretation may be necessary in all impact assessments, in order to evaluate the causes of impacts which have been observed.

iii) Participatory approaches

These methods are suitable for initial definition or refinement of the actual or potential impacts which are of concern to stakeholders, questions to be asked, and appropriate frameworks and indicators to be used. Such approaches can contribute to all types of assessment, and are particularly suited to exploratory low budget assessments and initial investigation of possible reasons for observed statistical relationships. They offer a means of involving stakeholders in the research, learning and decision-making processes. These methodologies also require a certain level of skill, depending on the issues to be addressed and ways in which they are integrated with other methods. Some degree of stakeholder participation is likely to be necessary in all impact assessments, in order to achieve a good understanding of stakeholder perceptions of impacts.

In carrying out impact assessment consideration is given to the following aspects:

i) transparency and public accountability
ii) stakeholder involvement
iii) reliability of the information obtained
iv) reliability of inference for policy improvement
v) cost and skill requirements

Impact Assessment for Enterprise Development

Impact assessment for utilization of quarry dust in the manufacture of building blocks seeks to achieve the following objectives:

i) To identify the social, economic, environmental and political impacts of the project.
ii) To provide recommendations about the means by which present and future programme/project performance could be improved.
iii) To provide guidance on exploitation of the opportunity and mitigation of negative impact of the project.

Each of these objectives shapes the design of IA in different directions. Identification of the social impact reveal the perception the society has towards the project and actual effects on the surrounding communities. Economic impact will provide indicators to the financial viability of the project. While environmental impact will facilitate environmentally sound proposals by minimizing adverse aspects and maximizing benefits to the environment.

Considerations in Impact Assessments

i) Social/political

Social impact assessment variables point to measurable change in human population, communities, and social relationships resulting from a development project or policy change. Some of the variables of consideration are:

a) Population Characteristics
b) Community and Institutional Structures
c) Political and Social Resources
d) Individual and Family Changes
e) Community Resources

ii) Economic

Economic impact assessment is an approach to evaluation based on:

a) The interests of various economic entities including, employers, employees, consumers, producers and other stakeholders
b) Weighting of importance and intensity of economic activities such as participation in total employment and GDP);

c) Comparison of different types of effects (direct or indirect).

The key purpose of economic impact assessment is to determine the impacts of a given project on the economic environment. The results of the impact analysis often determine whether public support should be provided on the grounds of economic benefits to a given area. As with other methods used to quantitatively estimate an impact, economic impact assessment consists of describing what would have happened without the programme with what actually happened. This process involves:

a) **Assessing the Additionality**

The impact of the project will need to be compared with the effects that would have been expected to arise over and above that which would have happened in the absence of the project under consideration being implemented. In order to assess additionally, analyses will be required of the markets affected by the project and the impact on other public and private sector projects.

b) Assessing the Leakage

The leakage is the proportion of outputs that benefit those outside of the project's target area or group. The concept of leakage recognizes that particular weight has been given to ensuring that benefits accrue to the residents of a spatially defined area or to target groups.

c) Assessing the Deadweight

This is an assessment of the output which would have occurred regardless of the project.

d) Assessing the Displacement

This involves examining the degree to which the outputs of the project have occurred at the expense of outputs elsewhere in the target area, for example, does the project outputs, mean a reduction of outputs within the area?

e) Assessing the Substitution

This effect arises where implementation of the project substitutes one activity for a similar one. This, for example, will examine whether the project of utilizing quarry dust for manufacture of building blocks at Sirikwa Quarry will replace the existing bricks making activities in the area.

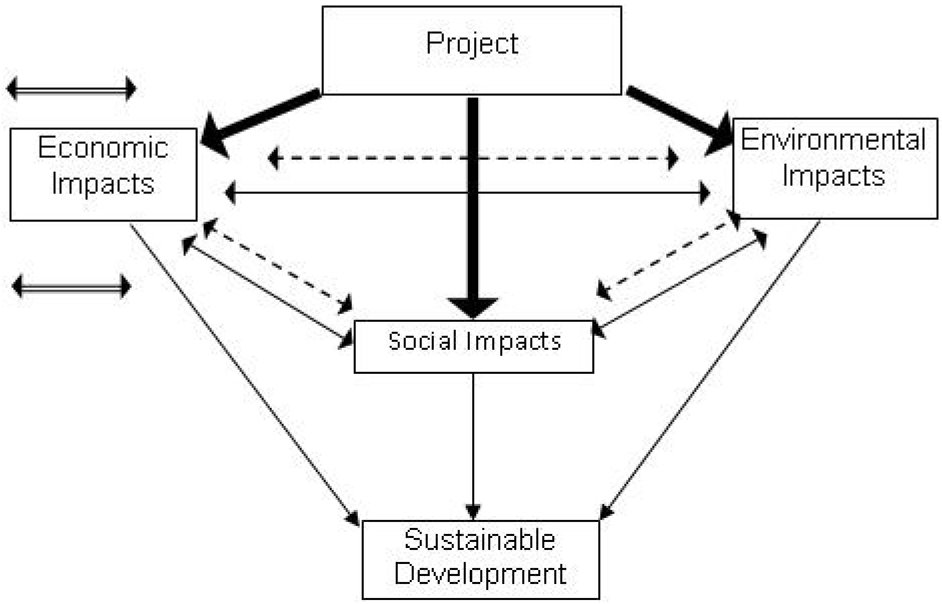
iii) Environment

The purpose of environmental impact assessment is to identity, examine, asses, and evaluate the likely and probable impacts of a proposed project on environment and, thereby, to work out the remedial action plans to minimize the incidence of adverse impact. Its goal is development without damage or least damage to the environment. Environmentalists have identified four types of different stresses or pressures that are being continuously inflicted on environment. They are:

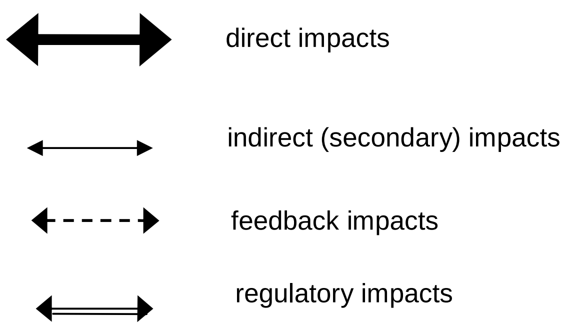
a) ***Eutrophic Stress:*** Refers to the release of various kinds of wastes into the river and other water bodies and their consequent drying.
b) ***Exploitative Stress:*** Refers to the exploitation of natural resources endowment for production and consumption purposes through agriculture, industry, extraction, fishing etc.
c) ***Disruptive Stress:*** Refer to the physical alterations in nature resulting from such activities like forest clearance, highways, railways, factory buildings and so on. These physical changes disturb the environmental and ecological balance.

d) ***Chemical and Industrial Stress:*** this result mainly from the developments in "science and technology" and their applied fields like industry, warfare and agriculture. This comprises mainly the pollutants and effluents of all types, radiation etc.

Figure 5: Types of Impact on Sustainable Development



Source: Gosling et al. (2000)



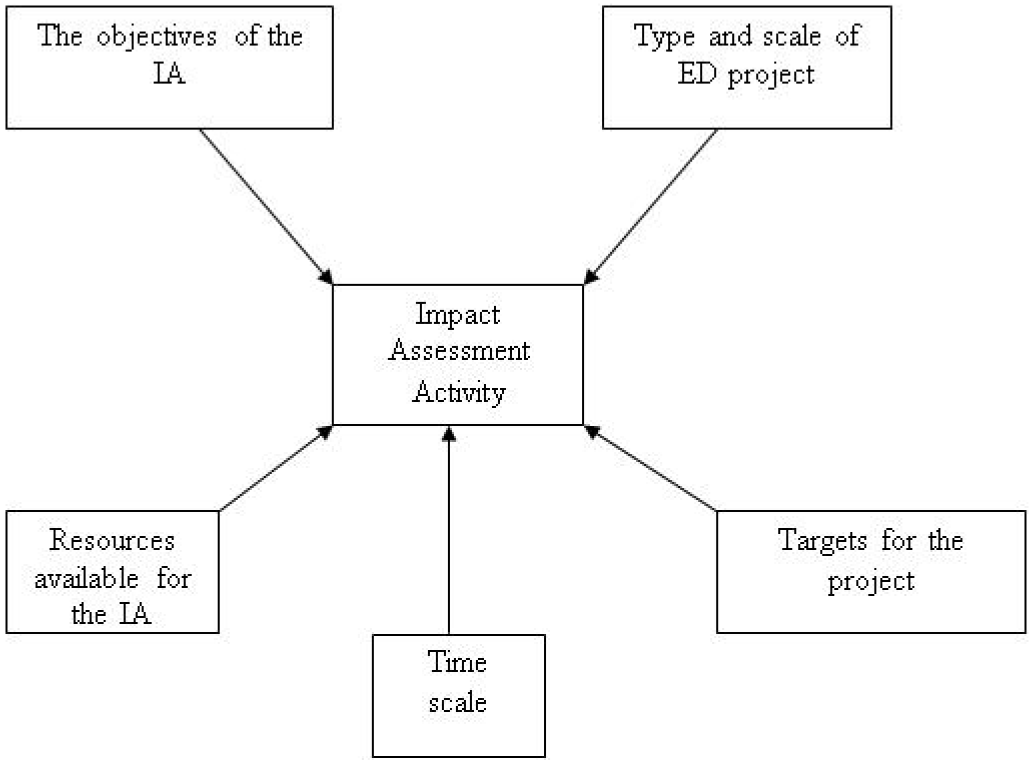
As depicted by the above figure, project impacts are interrelated and therefore none of them can be assessed in isolation. This IA takes a holistic approach to include all discernable potential impacts and their linkages to one another.

Gosling and Edwards (2000) argue that all impact assessment studies have an underlying conceptual framework. In well-planned and well-resourced IAs with long 'lead-in' times such frameworks are usually explicitly identified; by contrast, in many smaller scale exercises the framework is implicit and may be seen as 'common sense'. They assert that there are three main elements to a conceptual framework namely:

i) a model of the impact chain that the study is to examine
ii) the specification of the unit(s) or levels at which impacts are assessed
iii) the specification of the types of impact that are to be assessed.

Good practice impact assessments will be based on the principles identified which must also seek to achieve a 'fit' with the objectives that are set, the project type and its goals, and the resources and time available. Inevitably, this entails compromises and trade-offs (e.g. if results are required rapidly then levels of rigour may need to be reduced).

Figure 6: Achieving 'Fit'



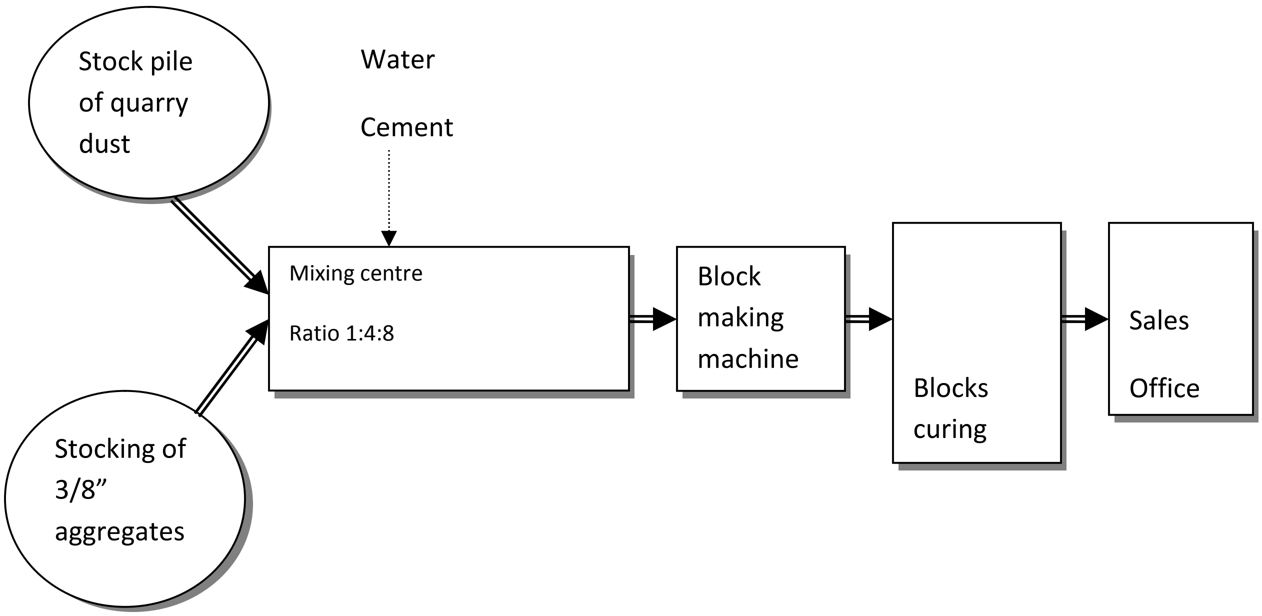
Source: Gosling et al 1995

The figure above illustrates the how a successful impact assessment must fit within the context of the project objectives, type and scale, targets, time scale and resources available.

Quarry Dust Building Blocks Project Work Breakdown Structure

A Work Breakdown Structure (WBS) is a results-oriented family tree that captures all the work of a project in an organized way. The WBS is commonly used at the beginning of a project for defining project scope, organizing Gantt schedules and estimating costs. It lives on, throughout the project, in the project schedule and often is the main path for reporting project costs. On larger projects, the WBS may be used throughout the project to identify and track work packages, to organize data for Earned Value Management (EVM) reporting and for tracking deliverables. The accumulation and the treatment of the quarry dust for manufacture of building blocks, which is the focus of this IA, is shown illustrated by the figure below:

Figure 7: Work breakdown structure flowchart



Resource planning in quarry dust building block project

The quarry dust project resource planning is based on the investment level and the projected sales volumes expected. The human resource, equipment and the financial requirements are summarized below:

Table 4: Summary of capital investment requirements of quarry dust building blocks project

Human resource	Number	Labour cost/day KES	Equipment	Equipment prices KES
Equipment operator	1	300	Block making machine	400,000
Operatives	12	200	Motorized bucket transporters	250,000
Secretary	1	500	Long wheel base lorry	4,000,000
Sales person	2	600	Office	100,000
TOTAL				4,750,000

Quarry dust building block project Cost / Benefit Analysis

The cost benefit analysis for the utilization and commercialization of quarry dust for manufacture of building blocks was carried out using the projected investment costs, cash inflows and the budgeted operational expenses. Project viability appraisal was carried out using Net present value (NPV) and Internal rate of return (IRR) techniques as follows:

Table 5: Quarry dust building block project Cost / Benefit Analysis

INVESTMENTS	COST	BLOCKS	PRICE/UNIT	REVENUE
BLOCK MAKING MACHINE	400,000.00			
MOTORIZED BUCKET	250,000.00			
LONG WHEEL TRUCK	4,000,000.00			
OFFICE BUILDING	100,000.00			
TOTAL	**4,750,000.00**			
CASH FLOWS				
BLOCK SOLD PER MONTH		25,000.00	33	**825,000.00**
EXPENSES PER MONTH				
SALARY	9,000.00			
Equipment operator	72,000.00			
Operatives	15,000.00			
Secretary	36,000.00			
Sales person	132,000.00			
Misceleneous Expenses	100,000.00			
Loan interest	123,750.00			
Principle	13,750.00			
Total Expenses	**369,500.00**			
PROFITS				
profits availabl to shareholders				455,500.00
Dividends 60%				273,300.00

CONCLUSION

The development of a project impact assessment methodology for the utilization of quarry dust for the manufacture of building blocks will form a guide for the project planning process. The feasibility of the project will be determined through the application of the defined methodology while the viability of the project will be informed by the cost/benefit analysis carried out using the projected cash inflows and outflows.

Comparison of compressive strength of concrete mixes made with river sand and quarry dust show that quarry dust can be used to replace river sand in general concrete structures, hence it is technically viable. Finally, efficient utilization of crushed stone dust will improve the overall profitability of a crushing plant, increase operating efficiency, reduce production costs and improve the health of employees.

From the outset the project is technologically viable given that the resultant blocks meet the desired strength and functional characteristics and that the equipments that will be used currently exist in the market and that the skill of labor required is readily available. The project will use a block making machine and a motorized bucket that are currently in the Kenyan market.

The financial viability carried out through a cost benefit analysis shows that the project has a positive NPV of over Ksh. 2,000,000 after dividend payout of 60% of the net profits. This was with an assumption of 15% cost of capital. The calculated IRR of 36% is way above the cost of capital.

RECOMMENDATIONS

The management of Sirikwa quarry currently should use the CSD wherever they can. Their aim must be to maximize resource use, to increase profitability and reduce both wastes and environmental impact. CSD must therefore not to be considered as a waste material but treated as residue of crushing and screening process which can be sold into certain markets. These markets would include the following:

1. Construction of landscaping features or in site restoration
2. Construction of concrete blocks
3. Utilization as "manufactured sand"
4. Revision of specifications that permits increased fines to be used in concrete
5. Soil remineralisation
6. Compensation for soil erosion
7. Landscape restoration
8. opportunities to reduce extraction of sand and gravel for some applications

Obstacles to utilization of CSD

- Excess local production and hence swamping the local demand
- Inherent low value
- Lack of specifications for non-construction uses
- Current specifications limit use in construction applications
- Need to treat CSD as a product in the quarry (costs, training, space)
- Lack of understanding of non-construction uses/markets
- Customer ignorance
- Customer prejudice

As far as environmental issues are concerned, the utilization of quarry dust can only help clean the environment since it has already been produced since it is a by product of another process that has already occurred and thus utilization will benefit not only the source who get value for what currently go to waste but also the new SMEs who will get business for using it as a raw materials and also the low income earners who would not otherwise afford permanent housing due to cost.

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