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ASSESSMENT OF STRUCTURES FOR WATER STORAGE IN TANATHI WATER SERVICES BOARD, KENYA

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ABSTRACT

This paper examines the cost-effectiveness of the implementation of small Structures for Water Storage (SWSs) in Kenya by the National Water Conservation and Pipeline Corporation (NWCPC). The main study was limited to Tanathi Water Services Board. The study assesses various aspects of cost-effectiveness such as achievement of project objectives, timely completion of projects, and resource utilization among other aspects.

Previous studies were reviewed while various stakeholders were also interviewed during data collection. Field and desk studies were done in Tanathi Water Services Board area using random sampling of the identified population. The results reveal that NWCPC has been deemed to be effective in implementation of Structures for Water storage (SWSs). The main benefit noted was the improved water availability for domestic and livestock uses among several other benefits. The paper notes that NWCPC still has room for improvement such as in the timing of its activities, monitoring and evaluation and community involvement.

This paper also highlights some of the negative issues resulting from the implementation of the SWSs such as conflicts, loss of livestock, diseases and influx of wild animals. It also includes proposals on how the development of SWSs could be rendered more cost-effective. Finally areas identified for further research are included at the end of the paper.

KEYWORDS: Cost-Effective, Water, Dams, Pans, NWCPC

INTRODUCTION

Water is essential for sustaining life, socio-economic development and for maintaining healthy ecosystems (Alphaomega, 2012). Freshwater is a finite and vulnerable resource obtained from various sources such as rivers or lakes, springs, rock catchments, excavated dams, rain water tanks, boreholes (BHs), wells, artesian boreholes among others (Australian Govt., 2010). In this paper, structures for water storage (SWSs) refers to structures constructed on land for the purpose of storing water for use such as pans, dams, ponds, weirs, water tanks.

Despite the growing demand for water, the available water resources are diminishing as a result of several factors such as climate change, man's over-exploitation of the natural resources like forests which help in water conservation. This trend coupled with both population increases, de-commissioning of old SWSs, pollution and demands from development is putting an ever-increasing strain on these diminishing water resources. (UNEP & DHI, 2009) (UN-Water, 2006). This has spurred increased development of water projects. Nevertheless concerns have been raised both regionally and globally, regarding the effectiveness of the implementation of water projects. In Kenya the water demand has been steadily increasing to the current figure of 3.5million m3/day.

This study was aimed at examining how cost-effective the development of structures for water storage (SWSs) has been as undertaken by NWCPC and to establish how their implementation could be improved. The study area within Tanathi Water Services Board encompasses Machakos, Makueni and Kitui Counties.

Reservoirs

According to ICOLD, a small dam is defined as one with a height of less than 15 meters and with an embankment volume generally less than 0.75 million cubic meters (ICOLD, 2007). By 1997, there were an estimated 800,000 dams in the world, 45,000 of which qualify as large dams. (Keller, Sakthivadivel, & Seckler, 2000). It is noteworthy that of all the registered large dams in the world only 5 percent is in Africa where most of the severe economic water scarce countries are located.

Large surface water reservoirs have the advantage of greater yield relative to the available inflow than small reservoirs, and their yield is generally more reliable. (Keller, Sakthivadivel, & Seckler, 2000).

National Water Conservation and Pipeline Corporation

National Water Conservation and Pipeline Corporation (NWCPC) is a state parastatal under the Ministry of Water and irrigation and one of the key institutions charged with the responsibility of constructing structures for water storage in the whole country of Kenya (NWCPC, 2010). It has been operational since 1st July, 1989 and its main mandates are to spearhead large and small dam construction, develop state schemes for water supplies, flood control and other multipurpose uses, land drainage, construction of dykes, drilling of boreholes and to carry out ground water recharge using flood water;

NWCPC receives a budgetary allocation from the Government of Kenya (GoK) of over 5 billion for the construction of SWSs, mostly large and small dams and water pans and thus it is a key institution in the development of the country’s water sector.

Cost-Effectiveness

Cost-effectiveness analysis is a decision-making assistance tool. It identifies the economically most efficient way to fulfil an objective. It presents alternatives in order to identify the most appropriate one to achieve a result at least cost. (Europeaid, 2012). It can therefore be defined as a type of analysis where a measure of effectiveness is in the numerator while the cost is in the denominator (ResearchCORE.org, 2013).

METHODOLOGY

A thorough review of past studies on SWSs in general was done. Information and data was collected by use of interviews and questionnaires. Field data was collected from the CBOs, local residents and Water Services Boards. The site data was partly obtained by use of questionnaires which entailed visiting the respondents and interviewing both the beneficiaries and NWCPC staff using separate questionnaires. The scope of the study was limited to Tanathi WSB and in particular four districts namely Kangundo, Yatta, Matungulu and Mwala Districts.

The tools employed for the research were such as questionnaires, SPSS data analysis software and other software such as

Microsoft Office. A thorough review of past studies on SWSs was undertaken. The cross sectional type of survey was employed in this study as it utilized questions about a particular topic at one point in time (Sincero, 2012).

The main methods of obtaining data were desk studies for NWCPC and use of interviews and various questionnaires for other stakeholders. Cross-sectional surveys usually utilize questionnaires to ask about a particular topic at one point in time and this is what has been applied in our study thus it may be classified as a cross-sectional survey. This study may be classified as a cross-sectional survey as it utilized questions about a particular topic at one point in time

The results of this study do not have the usual statistical analysis outputs such as median and mode as its data was mainly qualitative in nature (Shuttleworth, 2008). Simple random sampling was used in the research. In this research the researcher used purposive sampling method which allowed the researcher to interview respondents who had the required information. All were over 20 years old.

The formula below was then applied to obtain the sample size needed for the field data collection: -

$n = p*q*z^2/d^2$

Where n = sample size (population >10,0000), z = the standard normal deviate at the required confidence level, p = the proportion in the target population estimated to have the characteristics being measured (q = 1 – p) and d = the level of statistical significance set. In our case the accuracy level was set at 0.1 and p= 50% and the z statistic = 1.96. Using the above formula, the minimum sample size was thus calculated to be 96.04. During this study the total number respondents interviewed was 133 sampled randomly at the points of benefit such as the vicinity of the water projects.

The conceptual framework for this study is shown as a diagram in Figure 1. The study expected a relation between the independent variables and the dependent variable. The diagram highlights the research problem, the approach taken by the study and the study analysis issues as explained in the methodology.

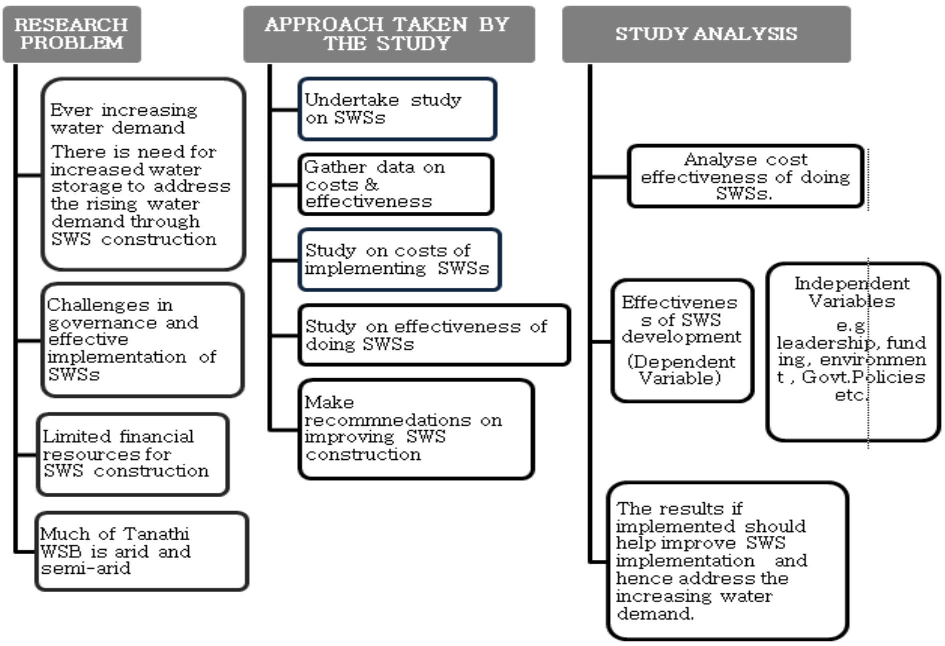

Figure 1: Conceptual Framework

RESEARCH FINDINGS AND ANALYSIS

Data on Cost

In order to examine NWCPC's cost effectiveness, data regarding projects undertaken and the costs involved was sought for and obtained. The following is a detailing of the results obtained in the field investigations on the achievements of the project objectives of the projects done by NWCPC.

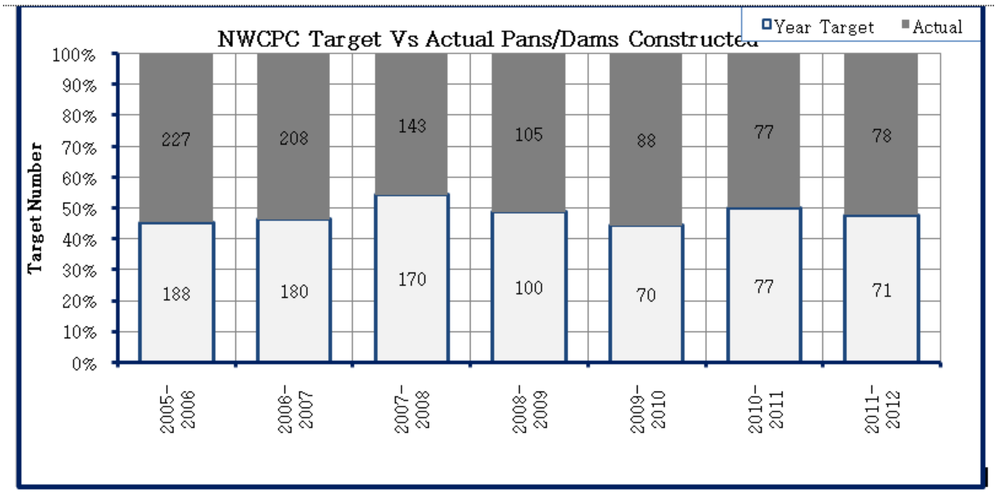

Figure 2: NWCPC Target Vs Actual Pans/Dams Constructed FY 2005 to 2012Figure 2 shows the targeted number of projects versus the actual number of projects constructed by NWCPC between 2005 and 2012. Within that period NWCPC achieved or surpassed its targets in the construction of small pans and dams except for the financial year (FY) year 2007-2008. In this aspect NWCPC was seen to be effective in achieving its targeted number of SWSs constructed.

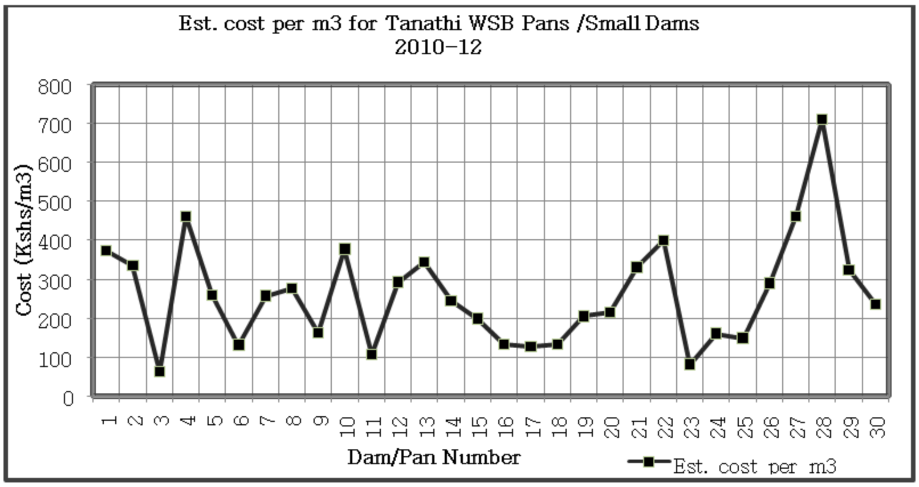

Figure 3: Cost per m3 of Pans/Small Dams by NWCPC in Tanathi WSB 2010-12

The Figure 3 shows the estimated cost per m3 for Tanathi WSB Pans /Small Dams for the FY 2010-12 for the 30 SWSs implemented within that period. The average cost of construction within this period was found to be Kshs 296.86/m3.

In the FYs 2010-11 to 2011-12 NWCPC was able to add a total of 1,000,553 m3 of water storage to the Tanathi WSB area alone. Note that these figures do not include the rehabilitated SWSs which also added some storage volumes but which could not be precisely quantified.

These considerable increases in volume of water storage coupled with the on-site research findings indicate that NWCPC projects have benefited much more people and have made an impact in the communities for which it undertakes projects.

Increasing Accessibility to Water

From the field study it was inferred that the Corporation has largely managed to achieve the objectives of increased accessibility to water because a majority of the respondents rated it as being above average.

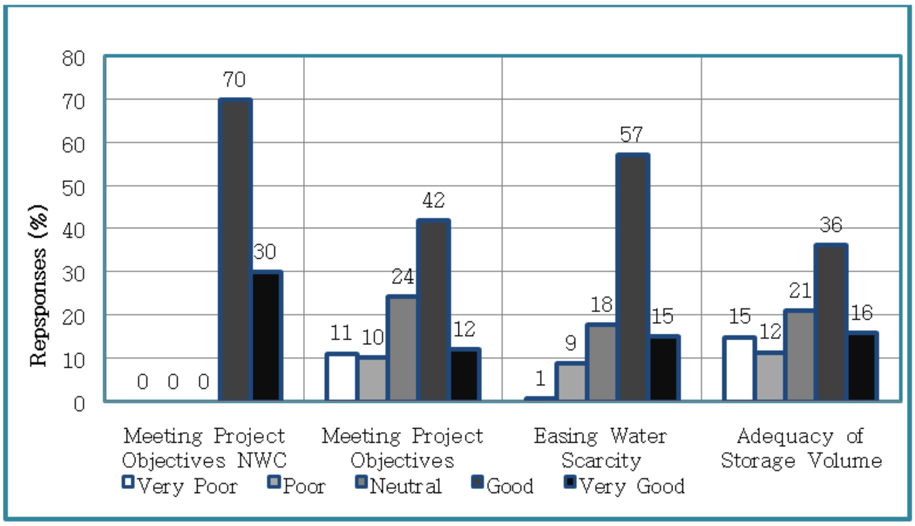

Figure 4: Assessment of Success in Meeting Objectives, Storage Adequacy &Easing Water Scarcity

As may be noted from the field survey results NWCPC is deemed to have achieved its goal of enhancing social and economic well being of Kenyans through improved access, and availability of water. Most of the small SWSs lasted up to for four months before drying up hence the need for larger storage SWSs.

78 percent of the respondents travelled less than one km to obtain water. However, some three percent of the respondents travelled over three kilometres in search water with some one percent travelling over 5 kilometres. This indicates that most of the SWSs done by NWCPC are within one kilometre distance to the users.

73% of the respondents benefiting from water projects undertaken by NWCPC are within one hour's reach to the water sources. That there are some 5.8% of locals travelling over 3 hours to get water is a serious issue that requires addressing. The challenge to NWCPC may be in balancing between addressing the needs of these few who are located far away and the many that are near located close the water sources.

NWCPC Resource Utilization

The main resources used by NWCPC in SWS implementation are staff, funding, machinery and equipment. From the research carried out 70% of the NWCPC staff considered the methods used by NWCPC in constructing SWSs to be effective in achieving the results that are intended on site. The survey results generally were inclusive of the whole process of undertaking the implementation of the SWSs encompassing the planning, survey, design, tendering, supervision, construction among others.

Staff, Machinery and Timeliness in SWS Construction

The utilization of staff as a resource by NWCPC was well rated as good or very good by 67% of the respondents. Rating of timeliness is as shown in Figure 5.

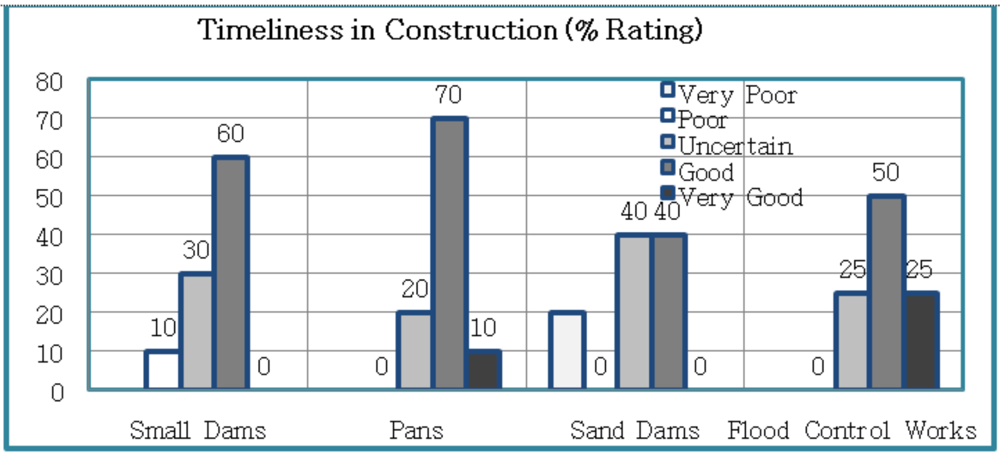

Figure 5: NWCPC Timeliness in construction

Community Involvement

From the study 64.4% of the respondents positively stated that they were aware of the projects in advance, while 50.5% positively stated that NWCPC involved the community during the SWS development.

Financial Utilization

The study sought to establish whether the use of funds has been effective in realising the objectives of SWS construction.

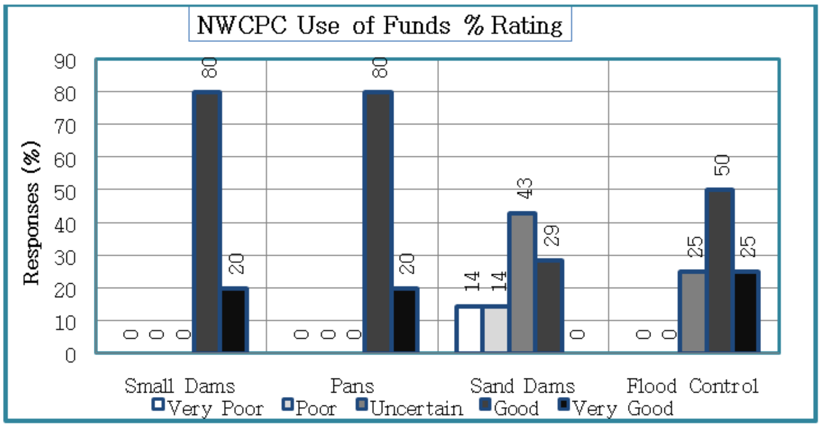

Figure 6: NWCPC's Use of Funds (% Rating)

All the respondents stated that NWCPC has used its financial resources for implementing of small dams and pans effectively for its activities. Nevertheless when it came to sand dams, 28% rated it poor or very poor.

Comparison of Capacities and Costs of Construction

During the financial year 2010-2011 the average cost of de-silting an existing pan/small dam was Kshs. 265.12 per m3 versus Kshs 318.83 per m3 for the cost of constructing a new pan.

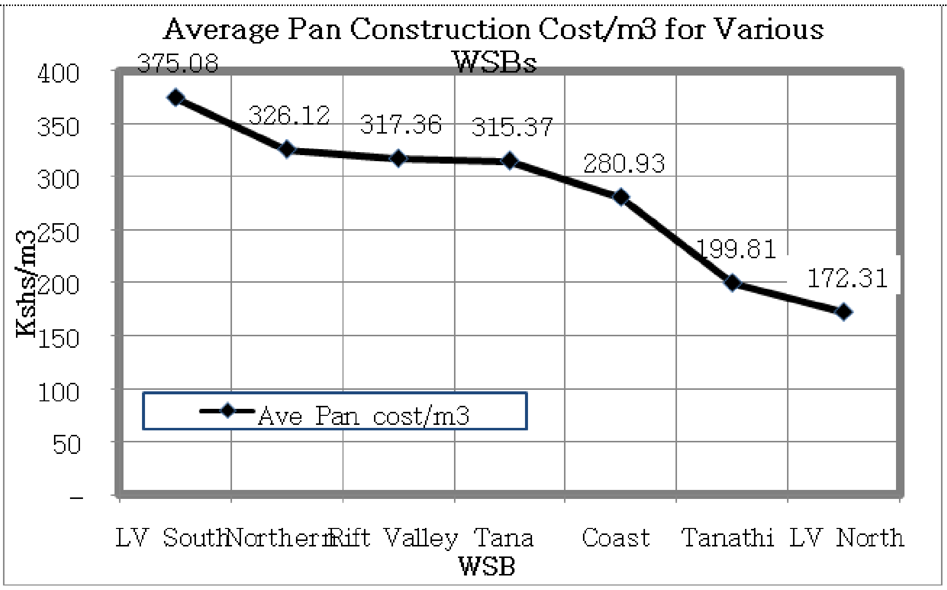

Figure 7: Pan Construction Cost per m3 per WSB.

Lake Victoria South Water Services Board (LVSWSB) had the highest cost per m3 for construction of pans at Kshs. 375.08, followed by Northern Water Services Board at 326.12. Lake Victoria North Water Services Board (LVNWSB) had the least cost per m3 at Kshs. 172.31.

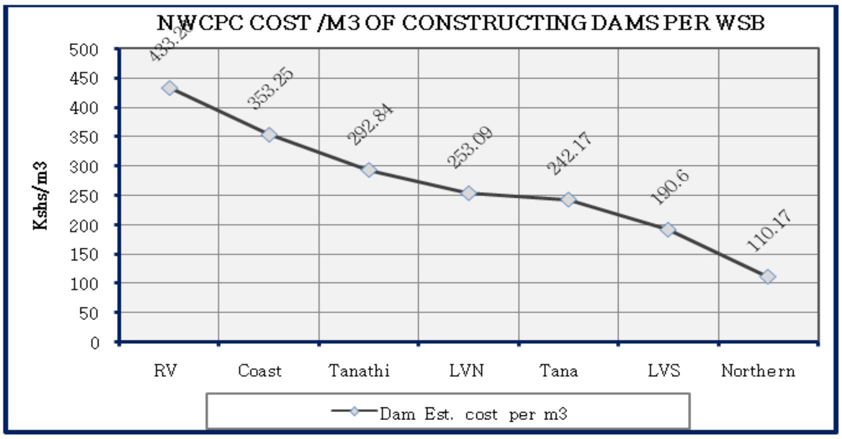

Figure 8: Dam Construction Cost per m3 per WSB

The general average cost of constructing a dam in the various WSBs was found to be as shown in the Figure 8. i.e. Kshs. 433.26 in RVWSB and 110.17 in NWSB. The average cost per cubic meter comes to Kshs. 267.91.

A general trend was noted that with an increase in the dam capacity, there is a corresponding decrease in the cost per cubic meter of water it holds. This indicates that it is more economical to construct a larger capacity dam than it is to construct a smaller capacity one.

Cost-Effective Analysis of NWCPC Projects

In order to calculate the cost-effectiveness one has to consider the cost of a project and also the benefits/effects thereof. As earlier mentioned the method of calculating the Cost-Effectiveness of a project may be done by the identification of ingredients of the project, determination of the value or cost of the ingredients and any interventions and finally its cost-effectiveness by combining costs and effectiveness (Levin, 1995).

The Integrative Dam Assessment Modelling (IDAM) tool is designed to integrate biophysical, socioeconomic, and geopolitical perspectives into a single cost/benefit analysis of dam construction. The different impacts of dam construction are evaluated both objectively (for instance, flood protection, as measured by RYI years) and subjectively (that is the valuation of said flood protection) by a team of decision- makers.

By providing a visual representation of the various costs and benefits associated with two or more dams, the IDAM tool allows decision-makers to evaluate alternatives and to articulate priorities associated with a dam project, making the decision process about dams more informed and more transparent. Brown considers it an important evolutionary step in dam evaluation. One of its limitations, however, is that the tool requires considerable up-front data requirements for the objective assessments of dam impacts. Such data may not available. Other limitations are that the various individual impacts may not be appropriate to every setting and also that the tool's value depends on a balanced treatment of each disciplinary perspective. The tool has been used for assessment of large dams in countries such as China. (Brown, Perspectives on the Salience and Magnitude of Dam Impacts for Hydro-Development Scenarios in China, 2010)

This Civil Engineering IDAM tool and the cost-effective calculation concept as used in the medical field aided the researcher to develop the formulae for calculating CE. For purposes of this study, the Cost Effectiveness was calculated as follows: -

The responses were considered as graded by the respondents on a scale of 1-5 [very poor-very good]

- These were converted into percentages of the total number of responses
- The percentages were then weighted by multiplying each one of them with the respective points assigned to the scale [1-5] and dividing them by the sum total of points i.e. 15
- These weightings were then summed up in order to get a figure for the Effectiveness index (E) for the aspect under consideration.
- The formula below summarizes the calculation for the Effectiveness index (E)

$$E = \left(\frac{1}{15}\right)\sum_{i=1}^{5}\left(i * \left(\frac{R_i}{R_T}\right) * 100\right)$$

Where

- E = effectiveness index;
- i = grading points assigned on a scale of [1 – 5];

R_i = the number of field responses given to a certain grading point (i) in the scale of 1-5;

R_T = the total number of field responses answered for a particular question;

- The cost (or average cost, C) of constructing the pans/dams was then ascertained. This was then divided by the volume (V) of the SWS to obtain the cost of construction per unit volume, C' i.e. $C^{'} = C/V$
- Finally the construction per unit volume, C' was divided by the Effectiveness index (E) in order to obtain the Cost-Effectiveness grade (CE) as shown in the formula hereunder: -

$$CE = \frac{C^{'}}{E}$$

Where CE = cost effectiveness in Kshs/m^3

- The resulting figure was then deemed as the Cost-Effective grade. The higher the figure means the poorer the cost effectiveness of the project while the lower the figure towards zero the better the cost effectiveness of the project.

For ease of comparison and assessment of the Cost effectiveness of the projects, a lower threshold CE figure, an upper threshold CE figure and an average CE figure were calculated using the average cost per m^3 of the pans/dams construction for the financial year 2010-2011 also used as a benchmarking year. In order to do this, a theoretically best possible grading of 5points receiving 100% responses and a poorest possible grading of 1point receiving 100% responses was employed. Thus:-

Lower threshold effectiveness, E_L = ([5points] x 100%)/15 = 500/15 = 33.33

Upper threshold effectiveness, E_U = ([1point] x 100%/15 = 100/15 = 6.66

Hence:

Lower threshold CE, $CE_L = C'_{2010\text{-}11}/E_L = C'_{2010\text{-}11}/33.33$

Upper threshold CE, $CE_U = C'_{2010\text{-}11}/E_U = C'_{2010\text{-}11}/6.66$

Middle threshold CE, $CE_{ave} = 0.5 \times (CE_L + CE_U)$

Where $C'_{2010\text{-}11}$ is the average cost per unit volume for the financial year 2010-11.

- For ease of appreciation these CE figures are tabulated as percentages using the formula below: -

$$CE_{\%} = 100 * {}^{(CE \quad - CE_U)}\Big/_{(CE_L - CE_U)}$$

Which from basic data the following formula may alternatively be used: -

$$CE_{\%} = 18.75\left(\frac{C}{V}\right) * \left[1 - 1/\left(\sum_{i=1}^{5}\left(i * \left(\frac{R_i}{R_T}\right)\right)\right)\right]$$

The threshold gives an indication of how good the calculated CE is and provides a benchmark to gauge the CE calculated for other SWSs and in other years.

The higher the figure towards the upper threshold CE_U, the poorer the cost effectiveness while the lower the figure towards Lower threshold CE_L, the better the cost effectiveness of the project.

These calculations helped gauge the CE index of the projects since there were no previous studies conducted on cost-effectiveness of small SWSs to help provide a standard or benchmark by which to gauge their cost-effectiveness. Nevertheless, these standards and benchmarks may now be developed from the results of this study and from comparative studies in other areas.

The year 2010-11 was taken as a representative year. The average cost of the pans/dams construction for Tanathi WSB during this year was 265.25/= per m^3 ($C'_{2010-11}$)

The lower threshold CE was therefore calculated to be

$E_L = 33.33$

$C'_{2010-11}/E_L = 265.25/33.33 = 7.95$ Kshs/m^3

The upper threshold CE was therefore calculated to be

$E_U = 6.66$

$C'_{2010-11}/E_U = 265.25/6.66 = 39.82$ Kshs/m^3

The middle threshold CE, CE_{ave} was therefore calculated to be

$CE_{ave} = 0.5 \text{ x } (CE_L + CE_U) = 0.5*(7.95 + 39.82) = 23.885$ Kshs/m^3

In order to determine the effectiveness of a project, one has to look at the benefits accruing from the project. In this case we were able to measure cost-effectiveness by considering both the costs and benefits gained from the project. The higher the figure the poorer the cost effectiveness while the lower the figure the better the cost effectiveness of the project. The resulting ratios for the projects are as shown in

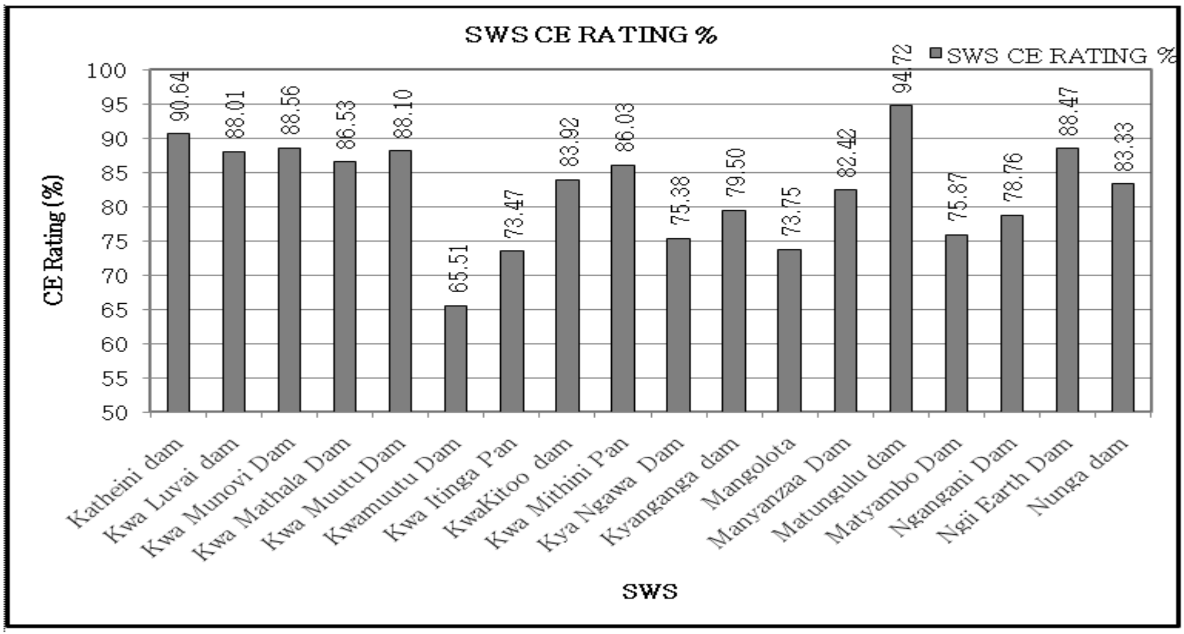

Figure 9: Cost-Effective Rating per SWS Projects for Tanathi WSBError! Reference source not found. and Figure 10. The resulting ratios for the individual projects that were assessed for the various aspects are as shown in. These figures are the averaged values of Cost-effectiveness calculated for each aspect such as is the ones shown in Table 1 such as Construction Method Suitability, Meeting Objectives, Collaboration, General Construction Rate.

From Figure 9 it may be deduced that the most cost effective dam project was the Matungulu dam with a grading of 94.72% (9.64 Kshs/m^3. This is closely followed by Katheini dam at 90.64% (10.94 Kshs/m^3). The Kwamuutu Dam had the poorest CE rating at 65.51% (18.94 Kshs/m^3), meaning that the implemented project was least cost-effective. Also for the same figure, it can be deduced how cost effective the various aspects of the SWSs undertaken by NWCPC are. The small SWSs undertaken by NWCPC were found to be most cost-effective in the aspects of cattle watering at 95.13% (or 9.51 Kshs/m^3), prior community awareness of the project at 91.99% and water for domestic use at 91.77%. The SWSs undertaken by NWCPC were least cost-effective in the aspects of timeliness in construction of pans at 37.45% (or 27.87 Kshs/m^3) and in the general rate of construction at 59.72%.

The overall grading for NWCPC has been taken as the average of all the individual grading considering the crucial objectives of NWCPC as given in the performance contracts and the strategic plans.

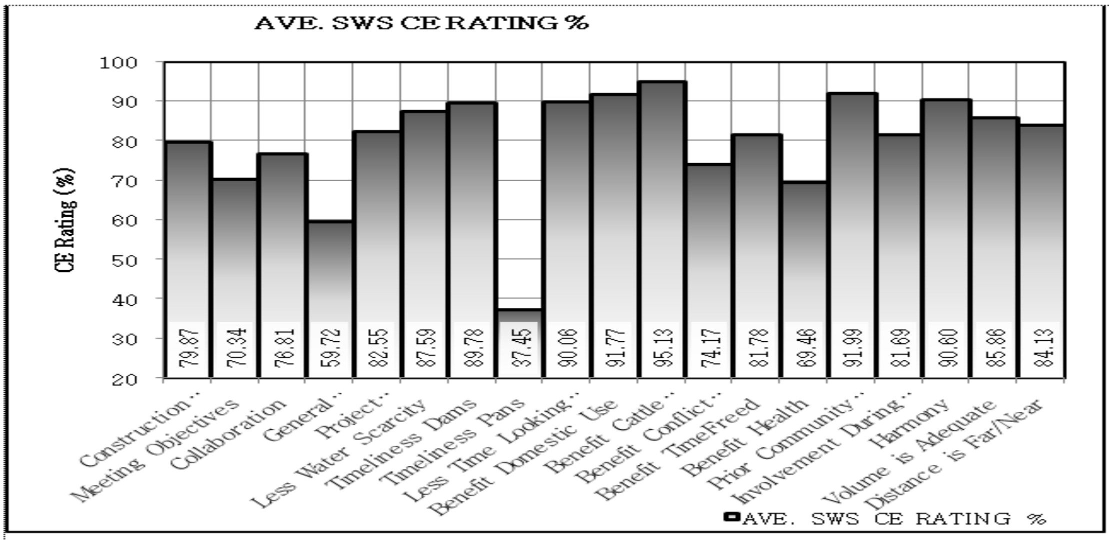

Figure 10: Average Cost-Effective Analysis for Various Aspects

Table 1: Average Cost Effectiveness

S/No	Project Name	AVE. SWS CE RATING %	AVE CE PER ASPECT, Kshs/m^3	POSITION
11	Cattle Watering	95.13	9.51	1
15	Prior Community Awareness	91.99	10.51	2
10	Domestic Use	91.77	10.58	3
17	Harmony	90.60	10.95	4
9	Less Time Looking for Water	90.06	11.12	5
7	Timeliness Dams	89.78	11.21	6
6	Less Water Scarcity	87.59	11.91	7
18	Volume is Adequate	85.86	12.46	8
19	Distance is Far/Near	84.13	13.01	9
5	Project Satisfactorily Done	82.55	13.51	10
13	Time Freed	81.78	13.76	11
16	Involvement During Construction	81.69	13.79	12
1	Construction Method Suitability	79.87	14.36	13
3	Collaboration	76.81	15.34	14
Table 1: contd.,				
12	Conflict Resolution	74.17	16.18	15

2	Meeting Objectives	70.34	17.40	16
14	Health	69.46	17.68	17
4	General Construction Rate	59.72	20.78	18
8	Timeliness Pans	37.45	27.87	19
	General Average CE	**80.04**	**14.31**	

Using the Formula

$$CEave = \frac{\sum_{i=1}^{n} CE_i}{n}$$

We get that the average comes to 80.04% (14.31 Kshs/m^3). (See Table 1)

The average CE value of **80.04%** indicates that NWCPC is noted to be cost-effective in its small SWS undertakings in the Tanathi WSB area that was surveyed. Nevertheless it still has room for improvement especially in the areas with unsatisfactory CE rating such as the timeliness in construction of pans and general construction rate for small SWSs.

In summary, NWCPC has been found to be cost-effective in its undertakings in small SWS development in the Tanathi WSB area which was the study area. The overall Cost-Effective rating of NWCPC projects in the Tanathi WSB area that was surveyed, as calculated herein is **80.04%**.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The study has revealed that NWCPC has performed well in the implementation of SWSs in the Tanathi WSB. NWCPC has achieved over 100% of its targets in numbers and volumes for small SWSs as per its records for pans and small dams, thereby achieving the objectives set out by the Corporation in the Tanathi WSB area. 54.2% of the beneficiaries there indicated that the SWSs have successfully achieved their intended purpose.

The overall Cost-Effective rating of NWCPC for the Tanathi WSB small SWSs as calculated herein is 80.04% (14.31 Kshs/m^3). This rating closely approaches 100%. It however still needs to improve on the general rate of construction and especially timeliness in the construction of water pans in order to attain greater overall cost-effectiveness. This may be done by accelerating the pace of its operations and making them more efficient while addressing other factors that will make the projects to be of greater assistance to the beneficiaries.

The small SWSs undertaken by NWCPC in Tanathi WSB were found to be most cost-effective in the aspects of cattle watering at 95.13% (or 9.51 Kshs/m^3), prior community awareness at 91.99% and water supply for domestic use at 91.77%.

Various resources such as staff and machinery have been identified in this report as being utilised by NWCPC in the implementation of small SWSs in achieving the objectives of the firm and its projects in Tanathi WSB. This aspect was rated by over 60% of the NWCPC respondents as good or very good. NWCPC may need to use these resources more efficiently in order to achieve higher cost-effectiveness than has been achieved so far.

Considering NWCPC's mandate, one of the main checks as to whether it has been effective is the increase in volume impounded by the SWSs it constructs. Within the Tanathi area, considering that the volume of water impounded has been substantial, NWCPC has hence made an impact in the communities dwelling there as confirmed by the study. Some 1,000,553 m^3 of water was developed in between the FY 2010-11 and FY 2011-12 in Tanathi WSB area alone and only for small SWSs. This has helped ease water scarcity in the areas studied. However there is still room for even greater impact in this aspect by exploiting the various suggestions as highlighted in this report such as construction of larger SWSs, drilling of boreholes and other methods.

A general trend was noted during the study that with an increase in the capacity small SWS constructed, there was a corresponding decrease in the cost per unit volume of water. This suggests that it is more economical to construct larger capacity SWSs than it is to construct smaller capacity ones. Therefore policies may be made towards making use of this finding.

Some negative effects arising from SWSs construction were such as in-fighting among the communities, conflicts over the use of water, drowning by people trying to access the dams or swim in them, environmental degradation attributed to overgrazing, diseases and danger from wild animals that were attracted to the newly developed watering point.

The results of the study can assist in policy development for example by making it mandatory that high volume SWSs be considered for construction always as a first priority unless it is not feasible. Policy makers may also consider the increased funding for SWSs to ensure adequate funds are availed for large capacity SWSs. Furthermore more studies can be undertaken using the methodology highlighted herein to study cost-effectiveness of other similar projects undertaken.

It could further be the policy that every project that is implemented should be assessed for its cost-effectiveness. The methodology used herein could guide the process and be developed further with increased time and experience.

RECOMMENDATIONS

Various suggestions for improved cost effectiveness have been put forth as a result of this study. These need to be taken up by NWCPC for action as it continues undertaking its mandate. These measures such as treatment of water for reduced risk to health of the users, better and more interaction with the communities, greater community awareness before and during implementation, fencing among other proposed measures will go a long way in improving the cost-effectiveness of SWSs constructed by NWCPC.

The following are various recommendations that if implemented are expected to assist in achieving a greater impact in the cost-effective implementation of SWSs. The main recommendations are the following: -

- There should be should hastened procurement and funding processes as a means to reduce delays on project implementation. Dry seasons should be taken advantage of to implement SWSs as rainy seasons hamper such undertakings thereby reducing cost effectiveness.
- The body mandated to develop SWSs should endeavour to construct as large SWSs as is possible so as to achieve maximum impacts and hence greater cost effectiveness.
- Involve communities in the conception and construction of SWSs and also train the locals on the operation and maintenance of the same for promoting a sense of project ownership and hence project sustainability.

Other recommendations are that: -

- Staff should be trained on project management to boost their management skills and undertake the necessary capacity building.
- Post-construction evaluation should be undertaken to get end-user feedback which would help improve future projects using the lessons learnt from those already implemented.
- NWCPC should undertake more effective monitoring and evaluation.

From this study, areas recommended for further study are the following: -

- A study on the cost-effectiveness of the construction of large dams and/or boreholes in comparison with the smaller SWSs.
- A study on the cost-effectiveness of the other areas having SWSs other than the TANATHI WSB for a more country-wide perspective.

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