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Research paper

Feasibility and acceptability of environmental management strategies among artisan miners in Taita Taveta County, Kenya

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ABSTRACT

Artisanal mining employs many people across the globe. In Kenya, it provides vocational jobs which represent the livelihood of poor communities. In spite of the economic value that could be attached to the artisanal mining activities in Taita Taveta County, these activities have resulted in environmental degradation; thus, calling for necessary interventions. It is for this reason that this study intends to examine effective strategies that could be adopted to reduce environmental degradation in the county as a result of artisan mining. The key objective therefore is to test the feasibility and acceptability of community participation, partnerships, modern technology and quarry management strategies on the reduction of environmental degradation by artisan miners in Taita Taveta County. A descriptive case study research design was adopted, and the target population for the study was 451 registered artisan miners and 13 environmental bodies operating in the area. A simple random sampling technique was used to draw a sample of 218 artisan miners and 13 environmental body heads. Questionnaires were the main tool for data collection from which a response rate of 95% was achieved. The study deduced that community participation, partnerships, modern technology adoption and quarry management strategies, are key influences on the reduction of environmental degradation in the artisanal mining sector if adopted, going based on the high level of agreement and the reasoning exhibited among the artisan miners in the findings. The following policies may be inferred from the study: to set a framework to enable the community to participate in environmental conservation, to enhance partnerships between NGOs, CBOs, the Government and Universities within artisan mining areas, to introduce Government subsidies for modern technology for affordability and to introduce a framework for quarry management.

1. Introduction

Mining is defined as the extraction of valuable minerals or other geological materials. This is done from the earth, ore body, lode, vein, seam, and reef or placer deposits. These valuable minerals are of economic interest to the miner (Organization for Economic Cooperation Development (OECD, 2015). Artisanal mining is largely informal mining which involves the use of basic technologies.

Mining or quarrying of stone and metals has been carried out since pre-historic times and has been and still is vital for the development of any society. To achieve rapid economic development, many countries resort to the exploitation of natural resources through mining. Numerous studies underscore the economic benefits of mining to the world today. For example, the African Development Bank (2014) showed that mining was an important economic activity with the potential to contribute to the development of areas endowed with the resource in question. Artisanal and small-scale mining (ASM) had been important in fighting poverty in counties like Ghana, Lesotho, Sierra Leone and Gambia. About 13 million people in about 30 countries are directly engaged in small-scale mining, a significant proportion of whom are women and children (Hentschel, Hruschka, & Priester, 2003). However, continuous extraction of a raw material, especially through artisanal mining, has massive impact on the environment.

According to UNEP (2012), small-scale mining can be extremely damaging to the environment and often has serious health and safety consequences for workers and surrounding communities. It can lead to erosion, the formation of sinkholes, a loss of biodiversity, and contamination of soil, groundwater and surface water by chemicals from mining processes. As well as creating environmental damage, the contamination resulting from the leakage of chemicals also affects the health of the local population (Nuss &

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Eckelman, 2014). The situation is even worse in Kenya, because the ASM sector has never been well structured until recently when the mining bill was amended in 2016, which states that mining operations need to be undertaken in a sustainable manner to prevent harmful effects on the environment. Although the National Environment Management and Coordination Act (1999) provides for initial environmental assessment and environmental audits, the challenge is to harmonize and align the regulatory policies and practices in the country's mining sector with existing environmental legislation.

In Kenya, the mining of gemstones is dominated by artisanal miners for reasons that range from the low technology required to start the mining process, scarcity of capital, poverty of the residents, poor policies regulating mining in the country and an increase in population that constrains agricultural activities (Soekarno & Damayanti, 2012). Poor mining technology has greatly polluted the environment in most parts of the country. This has made bodies like the National Environmental Management Authority (NEMA), United Nations Environmental Protection (UNEP) and other Non-Governmental Organizations (NGOs) request strategies to help check environmental pollution across the country. Some of the strategies that have been developed in various parts of the country, such as Embu, Kisii, Migori and Kitui, have included the involvement of the local community through education, adoption of environment-friendly technology, partnering with relevant research experts for informed decisions, and rehabilitation of destroyed lands through afforestation and reforestation.

Similar strategies have been adopted in northern and central parts of Ghana. A report by the African Union (AU) mining control unit has shown that Ghana is among five countries in Africa that have adopted four strategies that could lead local small-scale miners into becoming better placed citizens. This includes; modern mining technology adoption for artisanal miners, quarry management strategy adoptions, waste recovery and elimination strategy, and planning for environment conservation at initial periods of mine initiation.

Artisan mining and its effect on the environment has attracted several studies. This paper reports findings from a survey of formalized artisanal miners in Kenya regarding the feasibility and willingness to adopt various environmental management strategies. Kenya being an understudied country in academic literature with regards to artisanal miners, this paper is therefore novel and offers some useful findings supported by the quantitative survey data.

This study borrows from (Ogola, Mitullah, & Omulo, 2017) who found that environmental planning, quarry management and community involvement were important for curtailing environmental degradation due to artisanal mining. The focus is on assessing the feasibility and acceptability of environmental management strategies among artisan miners in the Taita Taveta County of Kenya. The major objectives of my study were to:

a) Test the acceptability and feasibility of a community participation strategy on the reduction of environmental degradation by artisan miners in Taita Taveta County;
b) Test the accesssssptability and feasibility of a partnership strategy on the reduction of environmental degradation by artisan miners in Taita Taveta County;
c) Test the acceptability and feasibility of a technology adoption strategy on the reduction of environmental degradation by artisan miners in Taita Taveta County;
d) Test the acceptability and feasibility of a quarry management strategy on the reduction of environmental degradation by artisan miners in Taita Taveta County.

2. Materials and methods

2.1. Study area

The study was carried out in Taita Taveta County. About 89% of the County is characterized by semi-arid and arid conditions. Only 2.5% of the County is located in the highlands. The highlands in the County experience high human population pressure and ongoing down-slope migration into the agro-Sahel (semi-arid and lowlands). It is situated between latitudes 20° 46′N and 40°10′N, and longitudes 37° 36′E and 39°14′E. Geological reports of surveys carried out at different times in this region show the presence of mineral deposits in the County and the neighboring areas (Anyona & Rop, 2015).

The focus of this study was in lower zones of Kamtonga, Kasigau, Kishushe, Chungaunga, Mwachabo and Alia where mining is a major activity. Smallholder farmers have always diversified their incomes to guard against risk, many have turned to artisanal mining in the dry season and use the income earned to support their agriculturally based livelihoods (Hilson, 2016). Though well intended, the activities of these miners have often led to extreme environmental impacts.

The target population for the study was 451 registered mine members and the heads of 13 environmental bodies operating in the area, which in total equated to 464 respondents. Simple random sampling of artisan miners was used. The sample size (n) was computed using (Chande, 1977) as shown below:

$$n = \frac{\frac{P\,(1-P)}{\frac{A^2}{Z^2} + \frac{P\,(1-P)}{N}}}{R} \quad (1)$$

where:

n – sample size required
N – the population
P – estimated variance in population, as a decimal: (0.5 for this study)
A – precision desired, expressed as a decimal (0.05 for this study)
Z – based on confidence level: 1.96 for 95% confidence
R – estimated Response rate, as a decimal

Therefore, the sample is given below:

$$n = \frac{\frac{0.5\,(1-0.5)}{\frac{0.05^2}{1.96^2} + \frac{0.5\,(1-0.5)}{451}}}{0.95} \quad (2)$$

$n = 218$.

2.2. Data collection, data analysis and ethical consideration

Questionnaires were used to collect primary data from the target population and they included both open ended and closed ended questions. Before the actual study, the questionnaire was first pretested with 10 artisan miners that did not take part in the study in order to check the validity and reliability of the tool.

The collected data was analysed using descriptive statistics through frequency tables, percentages, measurement of central tendency and measurement of dispersion. All the data was coded before analysis and a Likert scale was used to rate the opinions of the respondents.

Prior approvals were first sought before data collection from relevant authorities such as the Ministry in charge of mining, the local leaders, and the respondents themselves was carried out. Furthermore, the identities of the respondents were neither disclosed nor used at any point of the study.

3. Results and discussion

3.1. Response rate

Out of the selected 218 sample respondents (miners), 208 respondents completed the questionnaires, a 95.87% response rate. From the environmental management bodies' heads, all 13 questionnaires were returned resulting in a 100% response rate. The high response was because at the time the survey was done, it was dry season and the main activity was artisanal mining so most artisanal miners were at work. Also, there was information passed to the villagers by the area chiefs prior to the survey, creating awareness that the survey will result in sustainability in mining (see Table 1).

Table 1
Response rate.no

	Sample size	Response	%
Miners	218	209	95.87%
Heads	13	13	100%

3.2. Characteristics of the respondents

79% of the respondents were men while 21% were women. Among the environmental management bodies, 10 of the respondents were men while the remaining 3 were female, making up 76.9% and 23.1% respectively (see Table 2).

49.3% of respondents were aged between 30 and 39 years were, while those aged less than 30 years old made up 22.0% of the respondents. Those aged above 50 were the minority, represented by 12.4% of the respondents, followed by those aged between 40 and 49 years at 16.3%. Among the environmental management bodies 69.2% were aged between 30 and 39 years, and 30.8% were of ages between 40 and 49 years. Factors such as unemployment, lack of alternative livelihoods in the rural areas where artisanal mining take place, high commodity/mineral price and mining being a strenuous activity which requires a lot of energy can explain the high percentage of young people who are involved in mining activities.

Table 2
Respondents' information.

	Artisan miners		Environmental heads	
	Frequency	Percentage	Frequency	Percentage
Male	164	78.5	10	76.9
Female	45	21.5	3	23.1
Age				
Below 30 yrs.	46	22.0	0	0
30 to 39 yrs.	103	49.3	9	69.2
40 to 49 yrs.	34	16.3	4	30.8
Above 50 yrs.	26	12.4	0	0
Education Levels				
Secondary Level	46	22.0	0	0
Diploma	40	19.1	2	15.4
Degree	35	16.7	6	46.2
Others	88	42.1	5	38.5
Total (average)	209	100%	13	100%

The percentage of artisan miners who had attained other levels of education was 42.1%, 22% had attained a secondary level, and 19.1% hold a diploma while the remaining 16.7% have a degree. 46.2% of the environmental heads who participated in the study had a degree, 38.5% had other levels of education, and 15.4% had a diploma. This could be because most educated people are based in cities looking for white collar jobs hence the reason for the majority of artisan miners being less educated.

3.3. Community participation

Key:

A. The community has enough human labour resource and time for environmental degradation management.
B. The community has adequate expertise and capital to be used in environmental degradation management.
C. Community members can always be involved in budgeting and financial management for environmental degradation management.
D. Community members can always be involved in environmental monitoring and evaluation
E. The community can perform the major role of providing human resource for environmental degradation management when involved.
F. The community can be involved in providing land for environmental management site locations.

Responses were given on a five-point Likert scale, where 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree and 1 = Strongly Disagree.

45% of the artisan miners were in agreement with item **A**, while 62.7% of the artisan miners disagreed with independent variable **B**. 52.6% of the miners agreed with independent variable **C**; 69.3% supported independent variable **D**; 72.2% of the respondents supported independent variable **E**. Finally, 80.4% of the respondents agreed with independent variable **F**.

The high agreement levels concerning community participation being vital in the reduction of environmental degradation is due to the community being emotional reciprocators than wealth maximizers, if involved, would help reduce environmental degradation because they would have a sense of belonging to the process of environmental conservation and that would make it easy to provide all the resources available for environmental degradation. Chegenye (2011) agrees with this as she highlights the importance of Community Participation (CP) on environmental management across the country. According to her, CP has been considered vital for the efficiency and effectiveness of controlling and managing environmental pollution caused by mining in various parts of Kenya with Bamburi cement being quoted as the best example where this has been effectively applied (see Fig. 1).

3.4. Influence of partnerships in environmental degradation

Respondents were asked many questions in relation to the influence of partnership on environmental degradation management and responses are shown in Fig. 2.

Key:

A. Partnerships will result in improvement of access to expertise and capital for environmental degradation management.
B. There can be effective environmental management in this area due to partnerships between the artisans and research organizations

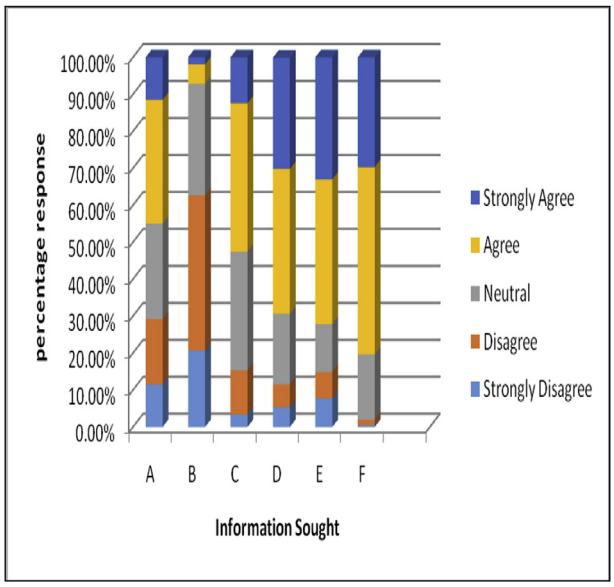

Fig. 1. Rating the Response on the Influence of Community Participation.
Key:
A. The community has enough human labour resource and time for environmental degradation management.
B. The community has adequate expertise and capital to be used in environmental degradation management.
C. Community members can always be involved in budgeting and financial management for environmental degradation management.
D. Community members can always be involved in environmental monitoring and evaluation.
E. The community can perform the major role of providing human resource for environmental degradation management when involved.
F. The community can be involved in proving land for environmental management site locations.

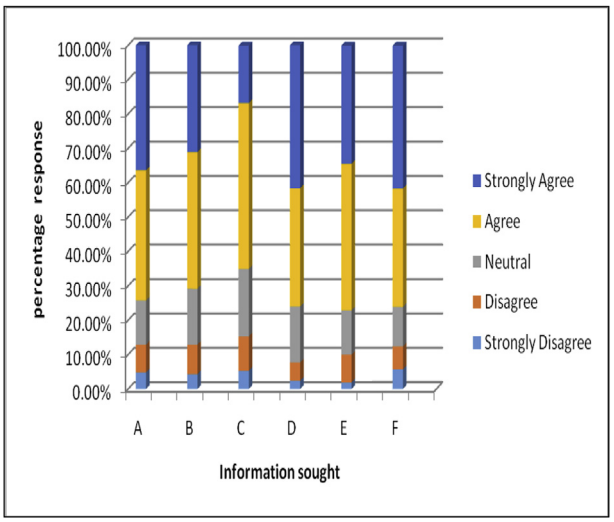

Fig. 2. Rating the Response on the Influence of Partnership.
Key:
A. Partnerships will result in improvement of access to expertise and capital for environmental degradation management.
B. There can be effective environmental management in this area due to partnerships between the artisans and research organizations.
C. There can be effective environmental management in this area due to partnerships between the artisans and NGOs.
D. There can be effective environmental management in this area due to partnerships between the artisans and CBOs.
E. There can be effective environmental management in this area due to partnerships between the artisans and international bodies like UNEP.
F. There can be effective environmental management in this area due to partnerships between the artisans and government.

C. There can be effective environmental management in this area due to partnerships between the artisans and NGOs.
D. There can be effective environmental management in this area due to partnerships between the artisans and CBOs.
E. There can be effective environmental management in this area due to partnerships between the artisans and international bodies, like UNEP.
F. There can be effective environmental management in this area due to partnerships between the artisans and government.

74.2% of the artisan miners agreed with independent variable **A**, 70.8% agreed with idea **B**, and 65% agreed with item **C**. Items **D**, **E** and **F** were agreed with by 76%, 77% and 76% of the artisan miners respectively.

Partnerships provide financial support and knowledge concerning the reduction of environmental degradation, hence the reason for the high level of agreement to the reduction of environmental degradation. If the artisan miners partnered with universities like Taita Taveta University, they would gain expertise on environmental degradation, considering most of the artisan miners are not highly educated. Partnering with UNDP and governmental institutions like NEMA and county government would also result in financial support and knowledge which would make implementation and follow up on the environmental strategies effective.

In Kenya the mining and minerals policy of 2016 was done in a consultative manner as required by the Constitution, involving all stakeholders down to grass roots level. It also benefitted from inputs of key players, including the Kenya Chamber of Mines, mining companies, academic and research institutions, government ministries and departments, parliament, development partners, civil

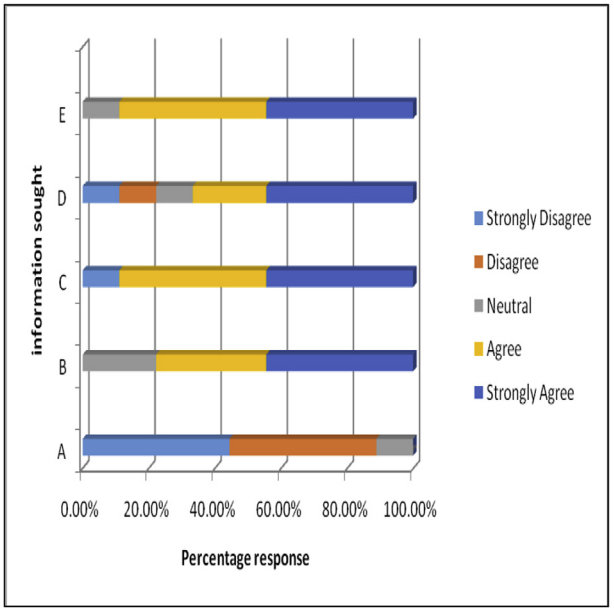

Fig. 3. Rating the Response on the Influence of Technology Adoption.
Key:
A. ASM can afford to buy technology to help manage environmental degradation.
B. An adoption of cleaner production technology can help manage environmental degradation.
C. An adoption of environmental control technologies can be a better strategy for managing environmental pollution among the artisans.
D. Waste recycling technology can limit the rates of environmental degradation.
E. Process re-engineering technology if adopted can greatly help in reducing the amount of environmental pollution.

society, mining communities and the public, showing further that partnership is vital.

3.5. Technology adoption and environmental degradation management

Respondents were asked several questions in relation to technology adoption as a strategy of checking on environmental degradation and the results are shown in Fig. 3:

Key:

A. Artisan miners can afford to buy the technology to help manage environmental degradation.
B. An adoption of cleaner production technology can help manage environmental degradation.
C. An adoption of environmental control technologies can be a better strategy of managing environmental pollution among artisan miners.
D. Waste recycling technology can limit the rates of environmental degradation.
E. Process re-engineering technology if adopted can greatly help in reducing the amount of environmental pollution.

In order to establish the influence of a modern technology adoption strategy on environmental degradation control across the study areas, respondents were asked to indicate the extent to which they agreed or disagreed with a number of statements on a rating scale. Responses were given on a five-point Likert scale, where 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree and 1 = Strongly Disagree. 88.8% disagreed with variable **A;** 77% agreed with variable **B;** 88% agreed with variable **C;** 66.6% agreed with variable **D;** 88.8% agreed with variable **E.**

Technology can help contribute towards green solutions for mining that would result in less environmental degradation, hence the high agreement levels. As such, it can be noted that most of the artisan miners reached have the feeling that modern technology adoption is a strategy that can be adopted to check environmental degradation in Taita Taveta County. If technology is adopted in environmental management and conservation by various mining bodies in Kenya, the effects of pollution could be reduced. Therefore, if the artisanal sector in Kenya adopts technology, it stands to benefit in several ways that include: using cleaner production techniques that will increase the cleanliness of the environment, access to environmental control technologies that check on destabilizations in environmental pollution and recommend remedies, the ability to use waste as a raw material for more production rather than dumping it into the environment, and the ability to reduce the amount of waste produced through process re-engineering.

3.6. Quarry management strategy in environmental degradation management

Respondents were asked many questions in relation to quarry management strategy adoption and environmental degradation management and the results are shown in Fig. 4:

Key:

A. Site selection can be effective among artisan miners as a strategy for checking environmental degradation.
B. Site management can be employed by artisan miners as a strategy for controlling environmental pollution.
C. Quarry Restoration is a strategy that can be used by artisan miners to control environmental pollution.
D. The community has effective capital, labour, time and access to expertise to help in quarry management.
E. Research Partnerships in Quarrying is an effective strategy for environmental degradation management that can be employed by artisan miners in Taita Taveta County.
F. Quarry Rehabilitation is a strategy that can be adopted to manage and control environmental pollution among gemstone miners.
G. Land planning is a strategy that can be adopted by miners in environmental control and management.

In order to establish the influence of quarry management as a strategy for environmental degradation control across the study areas, respondents were asked to indicate the extent to which they agreed or disagreed with a number of statements on a rating scale. Responses were given on a five-point Likert scale, where 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree and 1 = Strongly Disagree.

The majority of the respondents (66.7%) strongly disagreed with variable **A;** a higher percentage of 44.4% the respondents agreed with item **B,** 88.9% agreed to quarry restoration as a strategy for controlling environmental pollution **(C);** 55.5% agreed to research Partnerships in Quarrying strategy **(E)**; 77.8% agreed to quarry Rehabilitation **(F)** and Land planning strategy **(G)**. A majority (66.6%) of the respondents disagreed with the idea that the community has effective capital, labour, time and access to expertise **(D).**

Quarry management could result in high environmental degradation reduction as evidenced by the results. Generally, it can be argued that the respondents support the idea that quarry management can be used as one of the strategies of reducing environmental degradation by artisan miners. Allen supports this idea and states that if artisan miners are to achieve pollution control and management, a proper group of experts must be involved in the site selection process of the mines which would lead to reduction in pollution especially when the site is located away from human beings, the water tables, major rivers, trading centers and farmland. Also, when a site is properly selected and located away from forests and other natural vegetation, it can reduce the effect of deforestation that has been associated with desertification and reduced agricultural produce; leading to threats to food security in Africa.

3.7. Strategies and environmental degradation

Respondents were asked a number of questions in relation to strategy adoption and environmental degradation management and the results are shown in the table below:

Key:

A. Community participation will reduce environmental degradation.
B. Partnership strategy will reduce environmental degradation.
C. Quarry management strategy will reduce environmental degradation.
D. Technology adoption will reduce environmental degradation.

In order to establish the influence of the four strategies of environmental degradation control across the study areas, respondents were asked to indicate the extent to which they agreed or disagreed with a number of statements on a rating scale. Responses were given on a five-point Likert scale, where 5 = Strongly

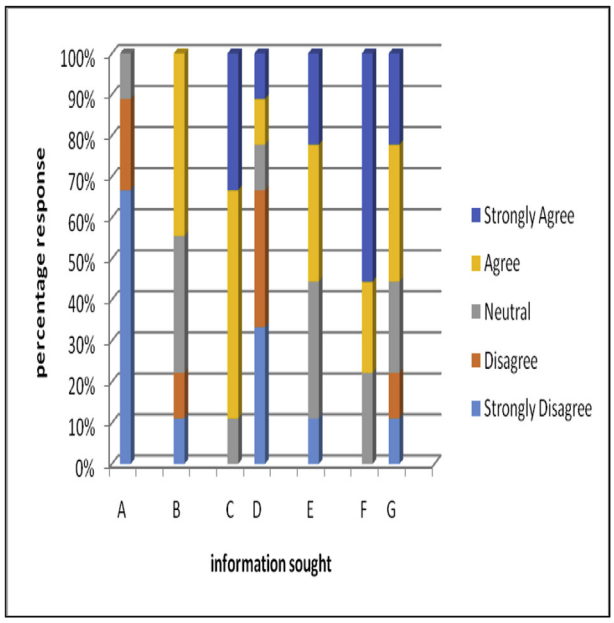

Fig. 4. Rating the Response on the Influence of Quarry Management Strategy.
Key:
A. Site selection can be effective among the artisan miners as a strategy for checking environmental degradation.
B. Site management can be employed by the artisan miners as a strategy for controlling environmental pollution.
C. Quarry Restoration is a strategy that can be used by artisan miners in controlling environmental pollution.
D. The community has effective capital, labour, time and access to expertise to help in quarry management.
E. Research Partnerships in Quarrying is an effective strategy of environmental degradation management that can be employed by artisan miners in Taita Taveta County.
F. Quarry Rehabilitation is a strategy that can be adopted to manage and control environmental pollution among the gemstone miners.
G. Land planning is a strategy that can be adopted by the miners in environmental control and management.

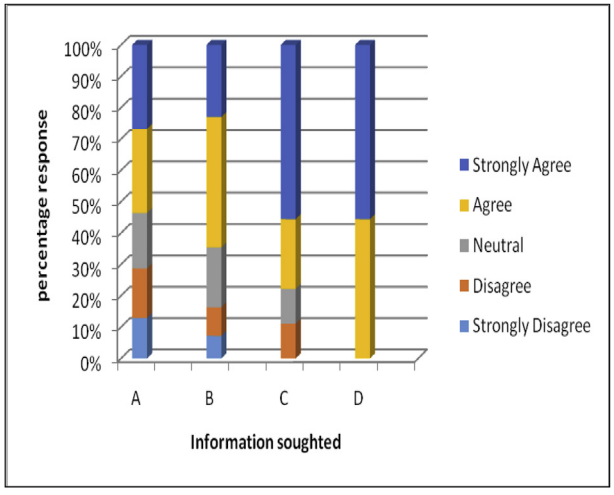

Fig. 5. Strategies and environmental.
Key:
A. Community participation will reduce environmental degradation.
B. Partnership strategy will reduce environmental degradation.
C. Quarry management strategy will reduce environmental degradation.
D. Technology adoption will reduce environmental degradation.

Agree, 4 = Agree, 3 = Neutral, 2 = Disagree and 1 = Strongly Disagree (See Fig. 5).

58.3% agreed to community participation (**A**), while 64.6% agreed to partnership strategy (**B**) as a means of reducing environmental degradation. 77.8% agreed to quarry management strategy (**C**), while 100% agreed to technology adoption (**D**). A greater percentage of the respondents (over 74.05%) were for the idea that if the said strategies are implemented, there can be a decrease in environmental degradation due to activities performed by the artisan miners.

4. Conclusion

The main objective of the study was to be able to test the feasibility and acceptability of environmental management strategies among artisan miners in Taita Taveta. Based on the results the following strategies are feasible and acceptable and are key influences in the reduction of environmental degradation in mining areas: community participation, partnership, adoption of technology and quarry management. Adoption of technology received the highest approval, having been agreed to by all respondents, followed by quarry management (77.8%), partnership strategy (64.6%) and finally community participation (58.3%). In summary, adoption and implementation of a community participation strategy, partnership strategy, modern technology adoption strategy and quarry management strategy can achieve a reduction in environmental degradation and are equally feasible and acceptable among artisan miners in Taita Taveta county.

The following policies may be inferred from the study.

- There is a need for artisan miners with the help of the government; NEMA and county government and other interested parties, such as mining companies and NGOs, to develop strategic plans for reducing degradation, constituted by major strategies including: community participation and involvement, modern technology adoption, partnerships and quarry management.
- These strategies should be documented and passed into law which can either be protected by the county government under county by-laws or community resource protection under the natural resources protection ACT of 2010. These could include: government subsidies on modern technology for affordability and a framework for quarry management.
- Resource allocation is an important aspect in determining how effective the strategic planning process will be and how the strategies can be implemented.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jsm.2017.12.003.

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