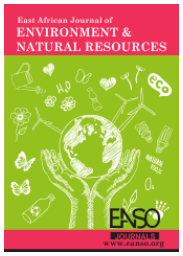
Article DOI: https://doi.org/10.37284/eajenr.6.1.1619



East African Journal of Environment and Natural Resources
eajenr.eanso.org
Volume 6, Issue 1, 2023
Print ISSN: 2707-4234 | Online ISSN: 2707-4242
Title DOI: https://doi.org/10.37284/2707-4242

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Gaps between Stakeholders` Concerns and Mitigation Measures in ESIA Reports of Geothermal Energy Projects: A Case Study of Geothermal Energy Projects in Djibouti, Ethiopia and Kenya

Abdek M. Abdi[1], Dr. Takehiko Murayama, PhD[1] Dr. Shigeo Nishikizawa, PhD[1]& Dr. Kultip Suwanteep, PhD[1]*

[1] Tokyo Institute of Technology, Meguro City, Tokyo 152-8550, Japan.
[*] Correspondence ORCID: https://orcid.org/0009-0002-3744-0061; Email: abdekm.abdi90@gmail.com

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

Date Published: *24 December 2023*

Keywords: *ESIA, Impact Mitigation, Stakeholder's concerns, Geothermal Energy, East-Africa*

ABSTRACT

Geothermal energy serves as a viable alternative to fossil fuels in developing countries, catering to electricity needs, supporting socio-economic development, and striving towards sustainable development goals. It also poses potential negative impacts on the environment and society. This study conducted a comparative analysis of mitigation measures and stakeholders' concerns across eight environmental and social impact assessment reports (ESIA) for geothermal energy development projects in Djibouti, Ethiopia, and Kenya. Mitchell's mitigation hierarchy guideline (1997) was used to examine the purpose of 708 proposed mitigation measures for eight environmental and nine social criteria extracted from the literature and then a deductive qualitative content analysis were used to categorize these measures according to 18 criteria collected from the literature. Additionally, using an inductive qualitative content analysis, the study analysed 680 stakeholders' concerns sourced from public participation materials in the ESIA reports, identifying four main thematic categories and twenty-two subcategories. Stakeholders expressed concerns predominantly about socio-economic (53%) and development matters (19%), while ESIA reports offered fewer social mitigation measures (28.7%) compared to environmental ones (71.3%). Nonetheless, a strong correlation between the environmental and social mitigation measures proposed for our 17 criteria demonstrates a higher proportion of measures in power plant construction projects. Despite this, communities voiced apprehensions about new involuntary resettlement plans, economic opportunities, and unrealized corporate social responsibility (CSR) projects. Furthermore, the study revealed that local communities complained about the adverse effects of previous geothermal development projects, including air, water, and soil pollution, impacting their health, crop production, and livestock. This research highlights the discrepancy between stakeholders' concerns and mitigation measures in ESIA reports, attributed to possible inadequacies in the conduct of social impact assessment and public participation, leading to misunderstandings regarding project impacts and benefits among local communities. To address these issues, this paper recommends a more comprehensive understanding of social aspects, the consideration of cumulative impacts from other geothermal projects in the same area, and transparent

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

communication to avoid unrealistic or costly promises during the realization of ESIA reports for geothermal energy projects.

APA CITATION

Abdi, A. M., Murayama, T. Nishikizawa, S. & Suwanteep, K. (2023). Gaps between Stakeholders` Concerns and Mitigation Measures in ESIA Reports of Geothermal Energy Projects: A Case Study of Geothermal Energy Projects in Djibouti, Ethiopia and Kenya. *East African Journal of Environment and Natural Resources*, *6*(1), 491-513. https://doi.org/10.37284/eajenr.6.1.1619.

CHICAGO CITATION

Abdi, Abdek M., Takehiko Murayama, Shigeo Nishikizawa and Kultip Suwanteep. 2023. "Gaps between Stakeholders` Concerns and Mitigation Measures in ESIA Reports of Geothermal Energy Projects: A Case Study of Geothermal Energy Projects in Djibouti, Ethiopia and Kenya". *East African Journal of Environment and Natural Resources* 6 (1), 491-513. https://doi.org/10.37284/eajenr.6.1.1619.

HARVARD CITATION

Abdi, A. M., Murayama, T. Nishikizawa, S. & Suwanteep, K. (2023) "Gaps between Stakeholders` Concerns and Mitigation Measures in ESIA Reports of Geothermal Energy Projects: A Case Study of Geothermal Energy Projects in Djibouti, Ethiopia and Kenya", *East African Journal of Environment and Natural Resources*, 6 (1), pp. 491-513. doi: 10.37284/eajenr.6.1.1619.

IEEE CITATION

A. M. Abdi, T. Murayama, S. Nishikizawa & K. Suwanteep. "Gaps between Stakeholders` Concerns and Mitigation Measures in ESIA Reports of Geothermal Energy Projects: A Case Study of Geothermal Energy Projects in Djibouti, Ethiopia and Kenya", *EAJENR*, vol. 6, no. 1, pp. 491-513, Dec. 2023.

MLA CITATION

Abdi, Abdek M., Takehiko Murayama, Shigeo Nishikizawa & Kultip Suwanteep. "Gaps between Stakeholders` Concerns and Mitigation Measures in ESIA Reports of Geothermal Energy Projects: A Case Study of Geothermal Energy Projects in Djibouti, Ethiopia and Kenya". *East African Journal of Environment and Natural Resources*, Vol. 6, no. 1, Dec 2023, pp. 491-513, doi:10.37284/eajenr.6.1.1619.

INTRODUCTION

Geothermal energy is the "heat of the Earth," and its use for producing electricity can help mitigate climate change (IPCC, 2011). In addition to power generation, geothermal energy can be used for heating and cooling and many other direct-use applications, such as fish farming, greenhouses heating, milk pasteurization, district heating, and food drying (IRENA, 2020; ESMAP, 2012). The viability of a geothermal system depends on the availability of a significant source of heat, a permeable reservoir, a water or steam source, and an impermeable cap rock layer (DiPippo, 2012).

The East African region is renowned for its significant geothermal energy potential, estimated at 15,000 MW, which resulted from the Great East African Rift System (EARS) initially conceptualized by Suess in 1891 (Chorowicz, 2005). The EARS is one of the most active geological zones globally and is characterized by a wide range of geological phenomena, including earthquakes, volcanic eruptions, and hot springs (Omenda & Teklemariam, 2010, Kandi 2014). The EARS or the Rift Valley, which encompasses Djibouti, Eritrea, Ethiopia, Kenya, Sudan, Eastern Tanzania, and Eastern Uganda, constitutes the Eastern Branch, while the Western Branch includes Burundi, Rwanda, the Democratic Republic of Congo, South-western Tanzania, and Western Uganda (Hardarson, 2016). Despite the strong commitment of East African countries to develop geothermal energy, only Kenya has reached this goal and is generating geothermal energy on a large scale with an installed capacity of almost 900 MW covering nearly half of Kenya's electricity production (IRENA, 2020). Other countries are encountering challenges, such as limited knowledge of the Western Branch, lack of skilled human resources, regulatory gaps, inadequate policies, and shortage of public funding (IRENA, 2020). And, compared to other East-African countries Kenya has a several good points including a very documented and investigated rift system, a well-established geothermal system with clear inflows and outflows and a clear regulatory framework for geothermal energy development (Omenda et al., 2021) that enables public and private investments.

Other East-African countries like Djibouti and Ethiopia are heavily engaging the development of this resource in the EAR, several projects are

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

being developed, and their respective geothermal development organizations are collaborating with international financial institutions and private companies through public-private partnerships. However, geothermal resources are often located in protected areas, and the potential environmental and social impacts of these projects have raised significant concerns for developers, national authorities, and financiers.

Indeed, several environmental and social impacts are associated with the development of geothermal energy (Rybach, 2003), including noise generation, micro-seismicity, and gas emissions (Axtmaan, 1975; Brown, 1995; Navriya et al., 2019), impacts on surface and groundwater resources (Hunt, 2001; Shortall et al., 2015) impacts on land use, forest resources, education, and demographics (Shortall et al., 2015)and impacts on cultural features, economic development, and community health (Arévalo, 2007; Arévalo, 2009, Kubota, 2015; Shortall et al., 2015). According to Cataldi (2001), geothermal energy projects must meet three conditions to achieve social consensus: prevent adverse health effects, minimize environmental impacts and benefit residents directly. Indeed, uncertainties about adverse environmental and social impacts can lead to social acceptance issues and mistrust. In Chile, Payera (2018) showed that a lack of trust, spiritual connections to volcanoes, and uncertainties regarding the environmental impact could influence the public perception of geothermal energy technologies and highlight a lack of understanding. This lack of knowledge was also described by Dowd et al. (2011) in Australia, González Acevedo et al. (2021) in Mexico, and Liu et al. (2018) in China. In Japan, Kabuta et al. (2013) highlighted the opposition of hot-spring resort managers and local governments because of their concerns regarding the adverse effects of geothermal energy projects and long-term resource management. In Switzerland, Ejderyan et al. (2020) explained that communities perceive deep geothermal projects to cause earthquakes, while smaller projects, such as geothermal direct-use projects, are considered "less risky." Environmental Impact Assessment (EIA) and Environmental and Social Impact Assessment (ESIA) reports are typically required to obtain environmental permits and funding for geothermal energy development projects. The primary purpose of these reports is to address the projects' significant environmental and social impacts and to engage local communities.

Moreover, Environmental Impact Assessment (EIA) and Environmental and Social Impact Assessment (ESIA) reports are generally required to obtain environmental permits and funding for geothermal energy development projects. The primary purpose of these reports is to address the projects' significant environmental and social impacts and to engage local communities. However, these reports focus more on environmental and health risks than socio-economic and cultural impacts (Cataldi, 2001). In East Africa, a working paper published by Suliman (2018) analysed the social impact assessment of three ESIA reports of geothermal projects, including two projects in East Africa. The paper revealed the poor quality of these reports and the level of stakeholder engagement by explaining that “the standardized methods applied to ESIA reports of geothermal projects have led to their ground-detachment from the reality and most stakeholders”. Suliman (2018) also added that these studies focused more on the impacts of technical aspects rather than social impacts, local knowledge, and sociocultural factors. Furthermore, in a research paper, Omenge et al. (2022) analysed the quality of fifteen ESIA reports of geothermal energy development projects in Kenya, dating from 1994 to 2019, using the Lee and Colley Review Package (Lee et al., 1999). In addition, Omenge et al. (2022) identified significant gaps in the consultation and public participation process, the impact identification, the analysis of alternatives, and the environmental and social management plans.

Public participation is a fundamental part of the EIA process (IAIA, 2002) and plays a crucial role in the success of development projects (Hasan et al., 2018). Impact assessments and mitigation measures are essential for successful development projects, providing robust guidelines for reducing

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

or avoiding potential environmental and societal impacts (IAIA, 1998). However, gaps in these processes can lead to significant concerns in local communities and project failures. Therefore, the main objective of this study was to compare stakeholders' concerns expressed during public participation activities with the mitigation measures proposed in ESIA reports.

This study highlights the gaps between stakeholders' concerns and the mitigation measures proposed in ESIA reports. The ESIA reports focused more on the mitigation of environmental impacts and less on the socio-economic effects of geothermal projects. Additionally, fewer enhancement measures were proposed, considering the local socio-economic situation, as geothermal energy projects are mostly located in remote areas with considerable needs and inequalities. Indeed, the inductive analysis of public participation materials, highlighted that concerns were mostly about socio-economic and development matters. And the relationship between the project purpose (geothermal drilling, integrated development, or power plant construction) and stakeholders' concerns underscores the cumulative impacts experienced by local communities.

Moreover, to achieve community acceptance of a geothermal energy project, it is important to recognize that all stakeholder's concerns can be addressed, even the less feasible ones. Some concerns may be unrealistic, and developers must avoid making "unrealistic" promises. Failure to fulfil such promises can lead to conflicts. Developers should also carefully evaluate and prioritize feasibility, technical viability, and cost-effectiveness concerns. Additionally, clear communication regarding the feasibility of addressing these concerns to local communities is essential.

Rational of the Study

Geothermal energy prospect areas are often located in remote regions with specific environmental and social characteristics, such as community lands and wild and protected areas (Ogola, 2005). Geothermal energy development can have different impacts in various countries of the East African region, including impacts on shark reproduction cycles and transhumance corridors in Djibouti (Adaweh, 2015; Abdi, 2018), impacts on vegetation and wildlife near hydrothermal manifestations in Ethiopia (Belaineh, 2006), impacts on human and animal health, the socio-economic income of indigenous communities, and wildlife migration corridors in Kenya (Mariita, 2002; Kinga & Kwasira, 2016). Recent developments in the region, especially in Olkaria, have shown local communities' opposition to geothermal energy development, leading to prolonged durations of geothermal projects. For instance, according to Ngomi (2018), Kenya's Olkaria IV geothermal power plant construction project took 22 years due to various challenges, such as funding delays, land acquisition issues, expropriation of affected communities, and plant commissioning.

Indeed, public engagement and impact mitigation are realized before the implementation of the project through the realization of environmental and social impact assessment (ESIA) reports. Previous studies on ESIA reports have focused more on the general quality of ESIA reports (Omenge et al., 2022) and the quality of social impact assessments (Suliman, 2018). Therefore, mitigating negative impacts and esteeming local communities' opinions or concerns can help gain community acceptance and legitimacy of geothermal energy projects. This study analyses local communities' concerns about geothermal energy projects using an inductive qualitative content analysis of public participation concerns included in the ESIA reports. It also highlights the type of mitigation measures proposed in ESIA reports using a deductive qualitative content analysis with 17 criteria and Mitchel's mitigation hierarchy guidelines (1998) to identify the type and the nature of proposed mitigation measures.

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

METHODOLOGY

Data Collection

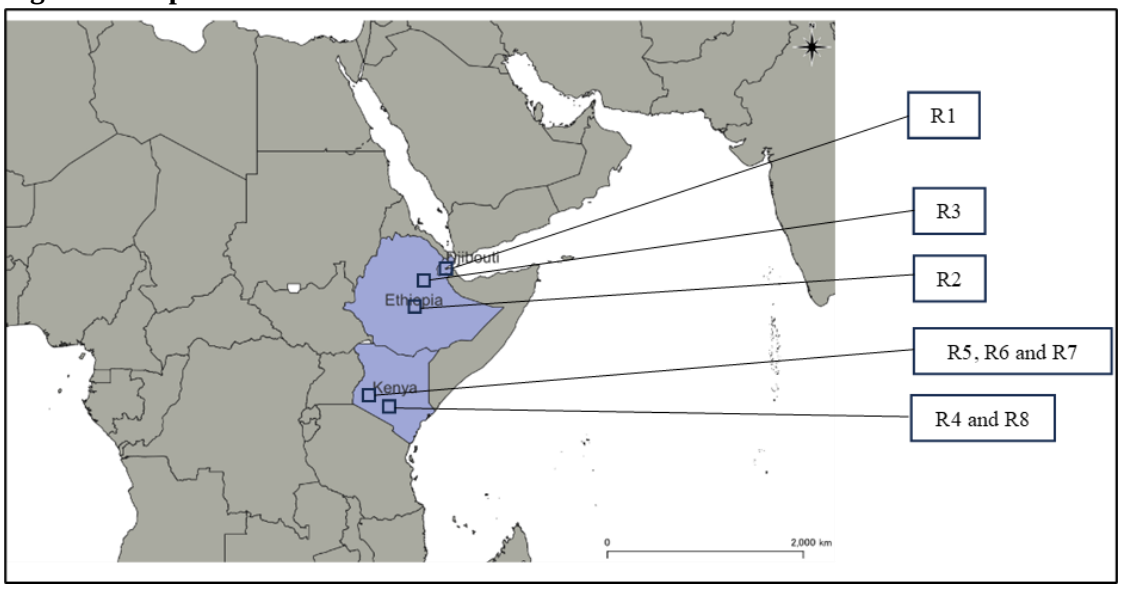
The ESIA reports for recent geothermal development projects (less than 12 years) in Djibouti, Ethiopia, and Kenya were collected online from reliable sources including developers (like the Gothermal Development Company, and the Ethiopia Electric Power), environmental agencies (like the National environmental authority of Kenya), international finance institutions (World Bank) and consultant websites (Redplan consultants). Recent reports were collected to highlight the ongoing concerns of local communities and recent of environmental and social considerations established in ESIA reports. The reports collected were on geothermal drilling, integrated development, and power plant construction projects. Eight projects (one in Djibouti, two in Ethiopia, and five in Kenya) were analysed, including four geothermal drilling projects (R1, R4, R5, and R7), two integrated development projects (R2 and R3), and two power plant construction projects (R6 and R8). Two projects, R1 and R8, are located in protected areas. According to the R3 report, the project is located "far from two national parks," and R4 mentioned "the existence of traditional caves in the area."

Table 1: Description of collected ESIA reports.

Countries	Project site	Description of projects	Date	Development status	Development	Code
Djibouti	Assal Fiale	Drilling of 4 geothermal wells	2012	Completed	Geothermal drilling	R1
Ethiopia	Aluto-Langano	Drilling of 20 geothermal wells, and a 70 MW power plant,	2013	Ongoing	Integrated development	R2
	Alalobad Tendaho	Drilling of 4 test wells, several production wells, and a 70 MW power plant	2013	Ongoing	Integrated development	R3
Kenya	Suswa	Drilling of 4 geothermal test wells	2013	Planned	Geothermal drilling phase	R4
	Menengai West	Drilling of 5 geothermal wells	2019	Planned	Geothermal drilling	R5
	Menengai	Construction of one 35 MW geothermal power plant	2019	Completed	Powerplant construction phase	R6
	Menangai caldera	Drilling of 3 geothermal test wells	2019	Planned	Geothermal drilling	R7
	Olkaria 4	Construction of two 70MW geothermal power plants	2009	Completed	Powerplant construction	R8

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

Figure 1: Map of the research area



Analysis Methods

Analysis of Mitigation Measures

Eight environmental and nine social criteria collected from the literature on geothermal energy projects in East Africa (*Table 2)* were used to analyse the mitigation measures included in the ESIA reports.

Table 2: Benchmark impact criteria

Environmental impacts	Social impacts	Reference
E1: Natural habitat E2: Solid waste generation E3: Noise Emission E4: Soil and vegetation E5: Gazes emission E6: Waste geothermal brine E7: Aesthetic and visual E8: Water resource and quality	S1: Health and safety of workers S2: Involuntary Resettlement S3: Tourism, archaeological, and wildlife conservation S4: Education S5: Agriculture S6: Employment and Economic Opportunities S7: Livelihoods, migration, and land use of communities S8: Indigenous community and culture S9: Community Health	Ogola (2005), Oduor (2010), Mwangi (2007), Kebede (2005), Adaweh (2015), Mariita (2002), Mariita (2009) Barasa (2014), Kurgat and Omwenga (2016), Oyugi and Keny (2018)

Our analysis of mitigation measures was based on Mitchell's mitigation hierarchy guidelines (1997), which allowed us to categorize mitigation measures according to their purpose of avoiding, minimizing, repairing, compensating adverse impacts, or enhancing positive impacts on society and the environment.

Table 3: Mitigation measures categories and explanation

Impact category	Explanation
Avoid	Avoiding a negative impact on nature and society arise
Minimize	Minimizing a negative impact on nature on the society
Repair	Repairing a negative impact on nature and society after it has occurred
Compensate	Compensating for an unavoidable negative impact on nature and on society
Enhance	Enhancing a positive impact on nature and society

Source: (Mitchell, 1997; Larsen et al., 2018)

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

Analysis of Public Participation Materials

In addition, public participation materials, including minutes of meetings, were collected from each ESIA report, and analysed using a qualitative content analysis (Haggarty, 1996; Mayring, 2014). An inductive approach was used to analyse the concerns of local communities, four thematic categories and twenty-two thematic subcategories were generated and used as mentioned in the table below:

Table 4: Table for thematic analysis of public participation materials

Thematic categories	Environmental issues	Socio-economic issues	Development and facilities issues	Resettlement and land issues	Other
Thematic Subcategories	• Acid rain • Air pollution • Biodiversity • Geohazards • Landscape change • Noise and vibration • Soil pollution • Water pollution • Weather change	• Agriculture and crop production • CSR activities • Economic opportunities • Employment • Engagement and communication • Health issues • Local culture	• Development • Project facilities • Public facilities	• Resettlement and compensation • Land ownership	• Other

Various statistical analysis methods were used based on the frequency and trend of shared concerns (Elo & Kyngäs, 2008). A correlation test was used to analyse the relationship between environmental and social mitigation measures (*Figure 4*), a descriptive analysis was used to analyse the mean and the variance of each benchmark criteria, a chi square test of independence was used to analyse the relationship between local communities' concerns and project purpose.

RESULTS

Analysis of Stakeholders' Concerns

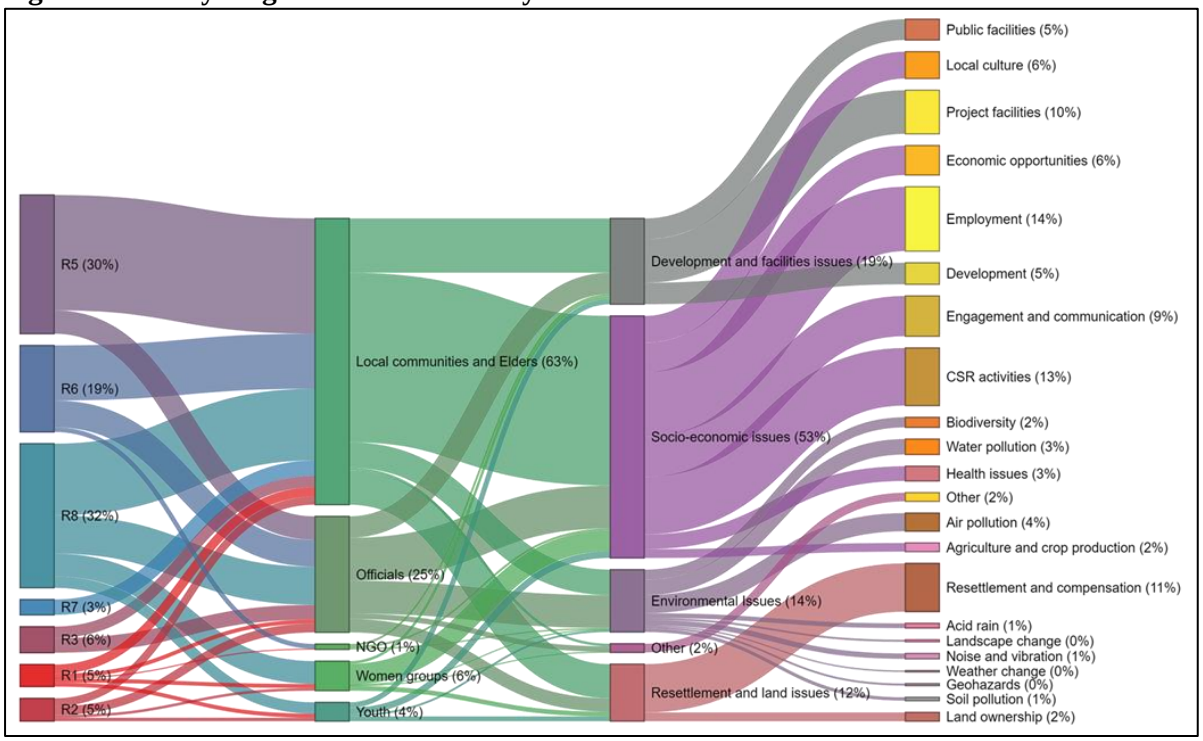
The analysis of public participation materials included in ESIA reports revealed the use of multiple terminologies for consultation and community engagement activities, including "focus groups, public consultations, stakeholder meetings, dissemination of information meetings, public meetings, consultation meetings with lead agencies, kick-off public information meetings, key informant interviews, one-on-one interviews, and community public forums and workshop". Stakeholders were informed about the project components, and their opinions were gathered. However, upon a detailed reading of the minutes of these meetings, it appears that their opinions were not considered when making decisions, choosing alternatives, designing the project, or utilizing the technologies for it. Although several social organizations, including youth and women groups, were consulted for R1, R2, R5, and R8, almost all reports ignored the significance of involving local social organizations (community associations) or NGOs (non-governmental organizations). Additionally, some reports did not provide adequate or complete disclosure of public participation minutes or related materials, such as R4 (no disclosure).

The majority of the concerns were related to employment (14%), corporate social responsibility (13%), resettlement and compensation (11%), project facilities (10%), engagement and communication (9%), economic opportunities (6%), and public facilities (5%). Concerns related to environmental issues included air pollution (4%), water pollution (3%),

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

biodiversity (2%), and noise and vibration (1%). Comments relating to landscape change, weather change, and geohazards were fewer but very specific.

Figure 2: Sankey diagram of content analysis results



The most important concerns, based on their mean ratings, appear to be "Employment" with a mean rating of 13.71, closely followed by "CSR activities" with a mean rating of 12.29, and "Resettlement and compensation" with a mean rating of 10.29 (see *Table 5*). These concerns have relatively higher average ratings, suggesting they are significant concerns. And, the most shared concerns, in terms of the highest sums are "Employment" with a sum of 96, followed by "CSR activities" with a sum of 86, “Resettlement and Compensation” with a sum of 72 and "Project facilities" with a sum of 65. The concern "Employment" seemed to be the most variable concern, as it has the highest standard deviation (19.830) and variance (393.238) among all concerns (see *Table 5*). This implies that a considerable number of participants expressed concerns about these issues and specially about “Employment” , “CSR” and “Resettlement and Compensation” matters during public participation activities of R5, R6 and R8.

> *-"We are grateful for the new project. However, most of the promises we made in the 1st ESIA have not been met. If our promises are not met, we have the power to stop further engagement with the developer. - I agree with the new project, but we need to hear the first promises made by the developer - A majority of our people are yet to get employment* "(R5).

> *"Our youth have not been employed, and our initial agreements have not been implemented. - We cannot have a new project before this is met*" (R5).

On the other hand, the concerns with the lowest sum ratings, indicating the least shared themes, include "Weather change" with a sum of only 2, followed by "Landscape change" with a sum of 3, "Soil pollution" with a sum of 5 and “Acid rain” with a sum rating of 7. The themes with the lowest mean ratings (indicating less important concerns) are "Weather change" and " Landscape change " with means of 0.29 and 0.43, respectively, followed by “Geohazards” with a mean of 0.43, " Soil pollution " with a mean of 0.71 and “Acid rain” with a mean of 1.00. "Geohazards" and "Weather change" seem to be the less variable concerns, have the lowest standard deviation

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

(0.787 and 0.756 respectively) and variance (0.619 and 0.571, respectively) among all concerns (see *Table 5*). These issues appeared only in a very small number of reports.

> *"The emissions from the stations mix with rainwater forming sulphuric acid which corrodes the roofs of their houses ... Shortage of crop harvest has been experienced due to sulphuric acid from the holes being washed down to the soils that make the soil infertile"* (R8)

> *"There is a feeling that if the project goes ahead, the air quality may be affected. Dust and gaseous emissions will also be common"* (R5).

> *"The steam is harming farmers' crops, and there is a decrease in crop production. It also harms natural vegetation"* (R2).

> *"Past evictions have pushed the community members to the limits"* (R8)

> *"Based on the experience of Phase II Project compensation payment should be paid on time"* (R2)

In additon, concerns like “Air pollution" and "Water pollution" are perceived as relatively important environmental concerns, with mean ratings of 3.86 and 3.29, respectively, with a corresponding sum rating of 27 and 23. Additionally, "Noise and vibration" and “Biodiversity” had a mean rating of 1.14 and 2.14 and a sum rating of 8 and 15 respectively, suggesting that these concerns are less critical concerns for participants of public participation meetings (see *Table 5*).

Table 5: Descriptive statistic of thematic sub-categories

	N	Min	Max	Sum	Mean	Std. Dev	Variance
Acid rain	7	0	4	8	1.14	1.574	2.476
Agriculture and crop production	7	0	7	13	1.86	2.673	7.143
Air pollution	7	0	7	27	3.86	2.610	6.810
Biodiversity	7	0	6	15	2.14	1.952	3.810
CSR activities	7	0	44	86	12.29	16.398	268.905
Development	7	0	12	32	4.57	3.952	15.619
Economic opportunities	7	0	13	44	6.29	5.090	25.905
Employment	7	2	57	96	13.71	19.830	393.238
Engagement and Communication	7	1	26	60	8.57	9.253	85.619
Geohazards	7	0	2	3	.43	.787	.619
Health issues	7	0	9	22	3.14	3.024	9.143
Land Ownership	7	0	11	13	1.86	4.059	16.476
Landscape change	7	0	3	3	.43	1.134	1.286
Local culture	7	0	24	40	5.71	8.240	67.905
Noise and vibration	7	0	3	8	1.14	1.215	1.476
Other	7	0	9	14	2.00	3.266	10.667
Project facilities	7	3	22	65	9.29	6.873	47.238
Public facilities	7	1	13	31	4.43	4.077	16.619
Resettlement and compensation	7	0	43	72	10.29	15.074	227.238
Soil pollution	7	0	3	5	.71	1.254	1.571
Water pollution	7	0	10	23	3.29	4.309	18.571
Weather change	7	0	2	2	.29	.756	.571
Valid N (listwise)	7						

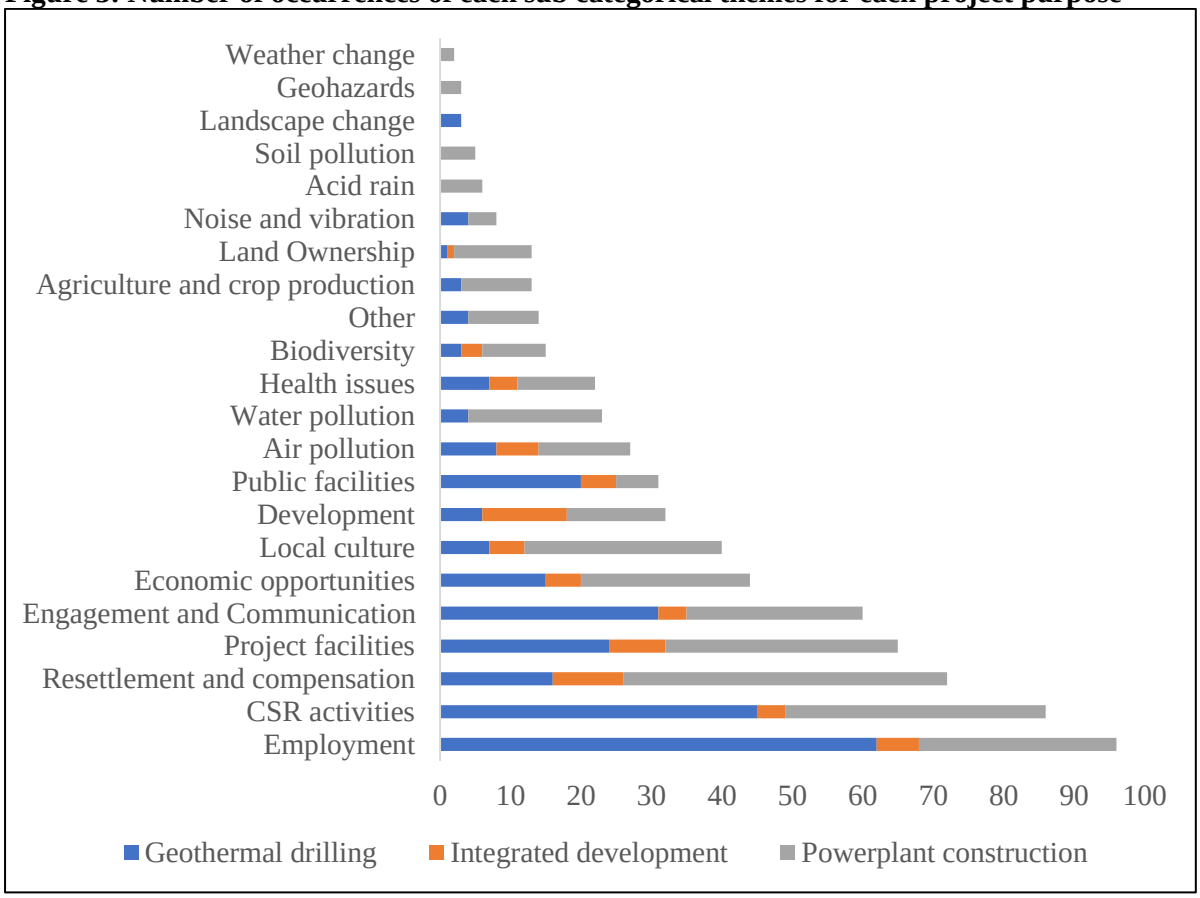
Moreover, a chi-square test of independence was conducted to assess the relationship between concerns and project purpose. The results indicated a significant relationship between concerns and project purpose ($p < 0.001$). Concerns about weather changes, acid rain, soil pollution, and geohazards are exclusive to power plant construction projects. In contrast, concerns

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

about water pollution, resettlement and compensation, air pollution, project facilities, local culture, and economic opportunities are essential for power plant construction projects.

The most significant theme for geothermal drilling projects is "Employment," with 62 occurrences. This highlights the critical focus on generating job opportunities and addressing the socio-economic aspects of the drilling activities. The second most important concern is "CSR activities," which appears 45 times, indicating a strong emphasis on implementing corporate social responsibility initiatives to benefit the local communities. For integrated development projects, "Resettlement and compensation" is the most important concern, with 10 occurrences. This suggests a major focus on addressing the impact on local communities and ensuring fair compensation and resettlement during development projects. The second most important concern is "Development," with 12 occurrences, emphasising balanced and sustainable development practices. And for powerplant construction projects, the most important theme was "Resettlement and compensation" with 46 occurrences, emphasizing the significance of mitigating the impact on affected communities and providing appropriate compensation during the construction phase. The second most important concern was "Project facilities" with 33 occurrences, indicating the concerns of communities relating to the infrastructures and facilities resulting from the project.

Figure 3: Number of occurrences of each sub categorical themes for each project purpose



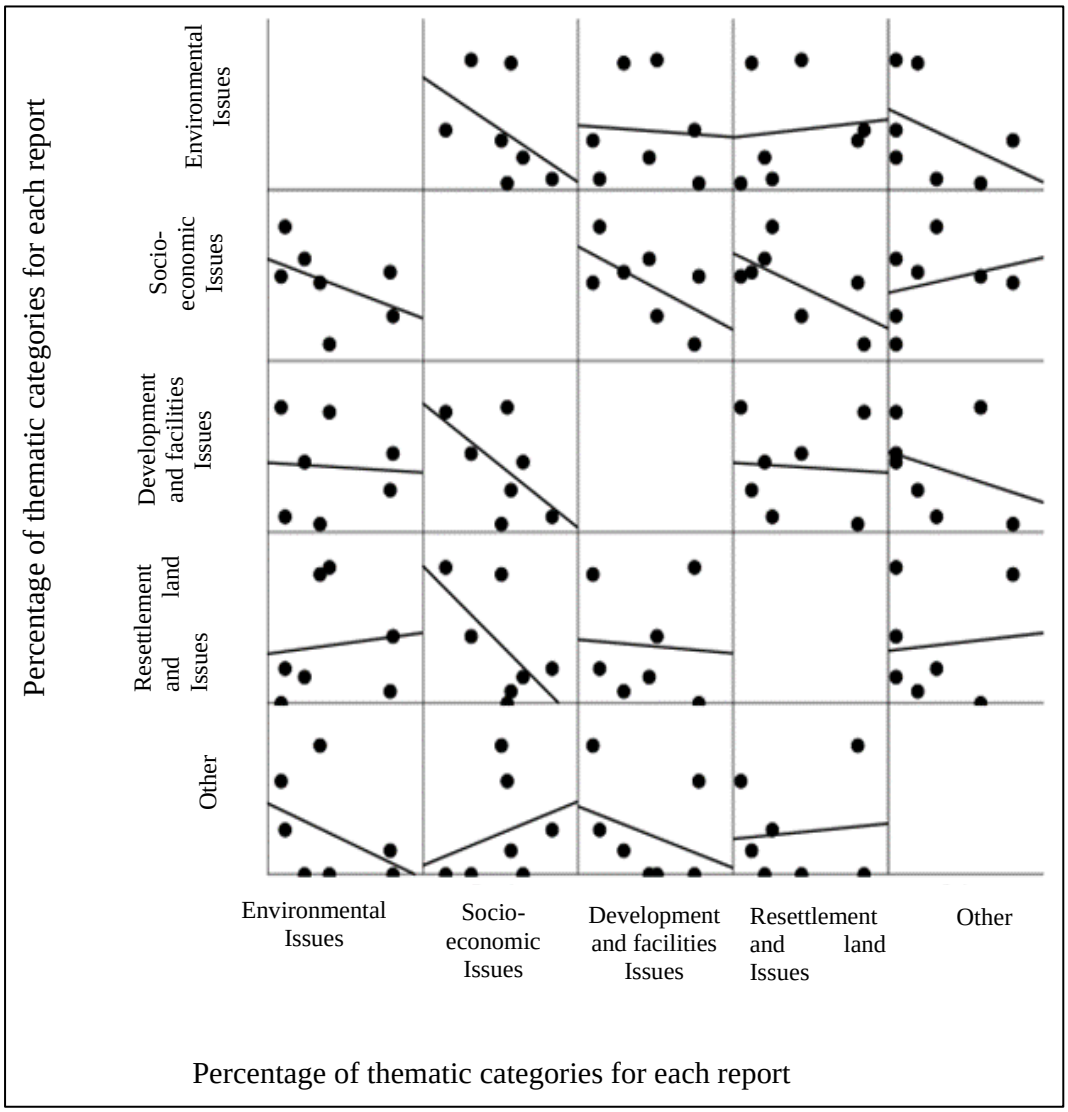
Significant concerns were related to socio-economic issues (53%) and development and facility issues (19%). Most reports indicate that socio-economic and development issues are major concerns, while resettlement and land issues are also crucial for projects that require partial or total resettlement of local communities (R2, R7, and R8). However, environmental impacts were not significant and essential for R1, R3, and R5 and became more meaningful for R2, R6, R7, and R8. It is also interesting to note that these reports relate to projects located on existing development sites

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

where previous projects were operated, such as R2 and R8, and R5, R6, and R7 are all located in the same area.

Figure 4 shows the linear relationships between socio-economic and development issues, resettlement and land and development issues, and environmental and socio-economic issues.

Figure 4: Correlation of thematic categories



Note: The figure represents the relationship between thematic categories for each reports, each point represents a report and the percentage of each category was used for the correlation.

Additionally, the correlation between thematic categories shows that there is a moderate negative correlation between environmental issues and socio-economic issues (-0.450), socio-economic issues and development issues (-0.585), and resettlement and land issues and socio-economic issues (-0.634). There was also a very weak negative correlation between environmental and development issues (-0.072) and a weak positive correlation between environmental and resettlement issues (0.110) (see *Table 6*). Thus, it is evident from these results that socio-economic, development, and resettlement issues are linked. These categories of concern can be classified as social issues, reflecting the impact of projects on social dimensions.

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

Table 6: Correlation between thematic categories

		1	2	3	4	5
1. Environmental Issues	Pearson Correlation	1	-.461	-.062	.113	-.433
	Sig. (2-tailed)		.298	.894	.809	.332
	N	7	7	7	7	7
2. Socio-economic Issues	Pearson Correlation	-.461	1	-.595	-.634	.278
	Sig. (2-tailed)	.298		.159	.126	.547
	N	7	7	7	7	7
3. Development and facilities issues	Pearson Correlation	-.062	-.595	1	-.068	-.327
	Sig. (2-tailed)	.894	.159		.884	.475
	N	7	7	7	7	7
4. Resettlement and land issues	Pearson Correlation	.113	-.634	-.068	1	.097
	Sig. (2-tailed)	.809	.126	.884		.836
	N	7	7	7	7	7
5. Other	Pearson Correlation	-.433	.278	-.327	.097	1
	Sig. (2-tailed)	.332	.547	.475	.836	
	N	7	7	7	7	7

Analysis of Mitigation Measures

Mitchell's mitigation hierarchy guidelines were used to categorize the 708 proposed mitigation measures for the benchmark criteria (*Table 7*). Additionally, a descriptive statistical analysis was used to analyse the proportions and the distribution of our eight environmental (E1 to E8) criteria and our nine social (S1 to S9) criteria among the proposed mitigation measures (see *Table 7*). For the environmental criteria, "E1: Natural habitat" had a mean of 12.25, with a minimum value of 1 and a maximum value of 36. "E2: Waste generation" had a mean of 10.75, ranging from 1 to 37. "E3: Noise emission" had a mean of 5.75, with values ranging from 2 to 10. "E4: Soil and vegetation" had a mean of 13.88, with values ranging from 4 to 36. "E5: Gazes emissions" had a mean of 7.25, ranging from 3 to 11. "E6: Waste geothermal brine" had a mean of 2.00, with values ranging from 0 to 7. "E7: Aesthetic and visual" had a mean of 2.88, with values ranging from 0 to 9. "E8: Water resource and quality" had a mean of 8.38, ranging from 2 to 18. And, for the social benchmark criteria, "S1: Health and safety of workers" had a mean of 9.25, with a minimum value of 2 and a maximum value of 37. "S2: Involuntary resettlement" had a mean of 0.75, ranging from 0 to 4. "S3: Tourism, archaeological and wildlife conservation" had a mean of 3.87, with values ranging from 1 to 10. "S4: Education" had a mean of 0.63, ranging from 0 to 2. "S5: Agriculture" had a mean of 0.75, with values ranging from 0 to 2. "S6: Employment and economic opportunities" had a mean of 2.38, ranging from 0 to 7. "S7: Livelihood, migration, and land use of communities" had a mean of 2.50, with values ranging from 0 to 7. "S8: Indigenous community and culture" had a mean of 0.88, ranging from 0 to 5. Finally, "S9: Community health" had a mean of 4.38, with values ranging from 1 to 10. The most shared environmental criteria are "E1: Natural habitat" with a standard deviation of 14.695, and the most widely shared social criteria is "S1: Health and safety of workers" with a standard deviation of 11.659.

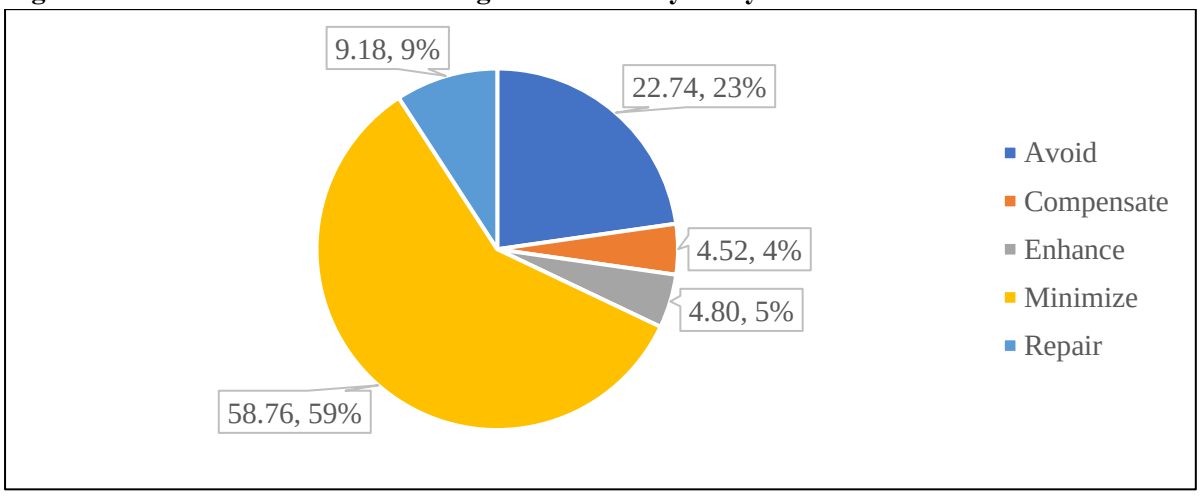
Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

Table 7: Descriptive statistic of benchmark impact criteria

	N	Min	Max	Mean	Std. Dev	Variance
E1: Natural habitat	8	1	36	12.25	14.695	215.929
E2: Waste generation	8	1	37	10.75	12.174	148.214
E3: Noise emission	8	2	10	5.75	2.964	8.786
E4: Soil and vegetation	8	4	36	13.88	11.077	122.696
E5: Gazes emissions	8	3	11	7.25	2.315	5.357
E6: Waste geothermal brine	8	0	7	2.00	2.138	4.571
E7: Aesthetic and visual	8	0	9	2.88	3.720	13.839
E8: Water resource and quality	8	2	18	8.38	6.116	37.411
S1: Health and safety of workers	8	2	37	9.25	11.659	135.929
S2: Involuntary resettlement	8	0	4	.75	1.389	1.929
S3: Tourism, archeological and wildlife conservation	8	1	10	3.87	3.643	13.268
S4: Education	8	0	2	.63	.744	.554
S5: Agriculture	8	0	2	.75	.707	.500
S6: Employment and economic opportunities	8	0	7	2.38	2.387	5.696
S7: Livelihood, migration and land use of communities	8	0	7	2.50	2.726	7.429
S8: Indigenous community and culture	8	0	5	.88	1.808	3.268
S9: Community health	8	1	10	4.38	3.543	12.554
Valid N (listwise)	8					

Figure 5 demonstrates that the majority of mitigation measures are intended to minimize or avoid negative impacts (58.76% and 22.74%, respectively), while a smaller number aim to compensate or repair negative impacts (4.52% and 9.18%) or enhance positive impacts (4.80%). Most mitigation measures are related to natural habitats-E1 (14.55%), waste management-E2 (11.86%), noise emissions-E3 (5.79%), soil and vegetation-E4 (15.68%), gas emissions-E5 (8.33), workers' safety-S1 (10.59%), and community health-S9 (5.08%). The majority of avoidance measures were related to natural habitats-E1 (5.93%), soil and vegetation-E4 (3.11%), and the water resource and quality-E8 (2.68%). Repair measures focus on restoring natural habitats-E1 (2.12%), soil, and vegetation-E4 (2.82%), waste generation-E2 (1.69%) and Aesthetic and visual-E7 (1.27%). The majority of the compensation measures are related to involuntary resettlement-S2 (0.28%), agriculture-S5 (0.56%), and land use-S7 (0.28%). Enhancement measures are primarily related to economic and employment opportunities-S6 (1.98%) and community health-S9 (0.85%).

Figure 5: Result of the Mitchell's mitigation hierarchy analysis

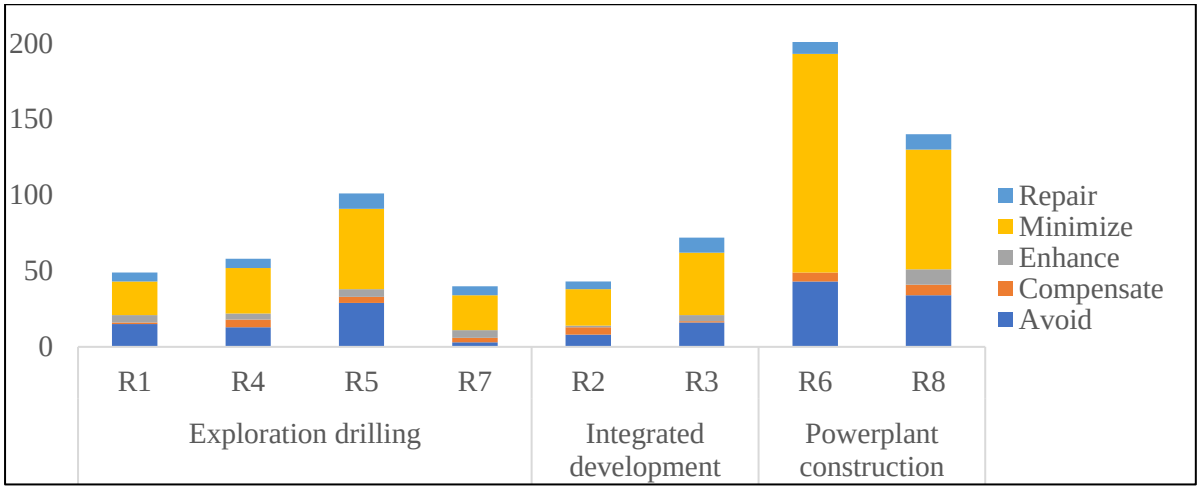


R6 had the highest number of Avoid (43), Minimize (144), and Repair (12) measures, indicating a strong emphasis on mitigating potential negative impacts. Following closely, R8

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

also demonstrates significant attention to mitigation efforts with Avoid (34), Enhance (10), and Minimize (79) measures. On the other hand, R5 also proposed significant focus on Avoid (29), Compensate (5), Enhance (4), Minimize (53), and Repair (10) measures, showing a balanced approach to addressing various aspects of impacts. In contrast, R1, R2, R3, R4 and R7 have relatively lower numbers of measures across most categories.

Figure 6: Type of mitigation measures proposed for each project purpose.

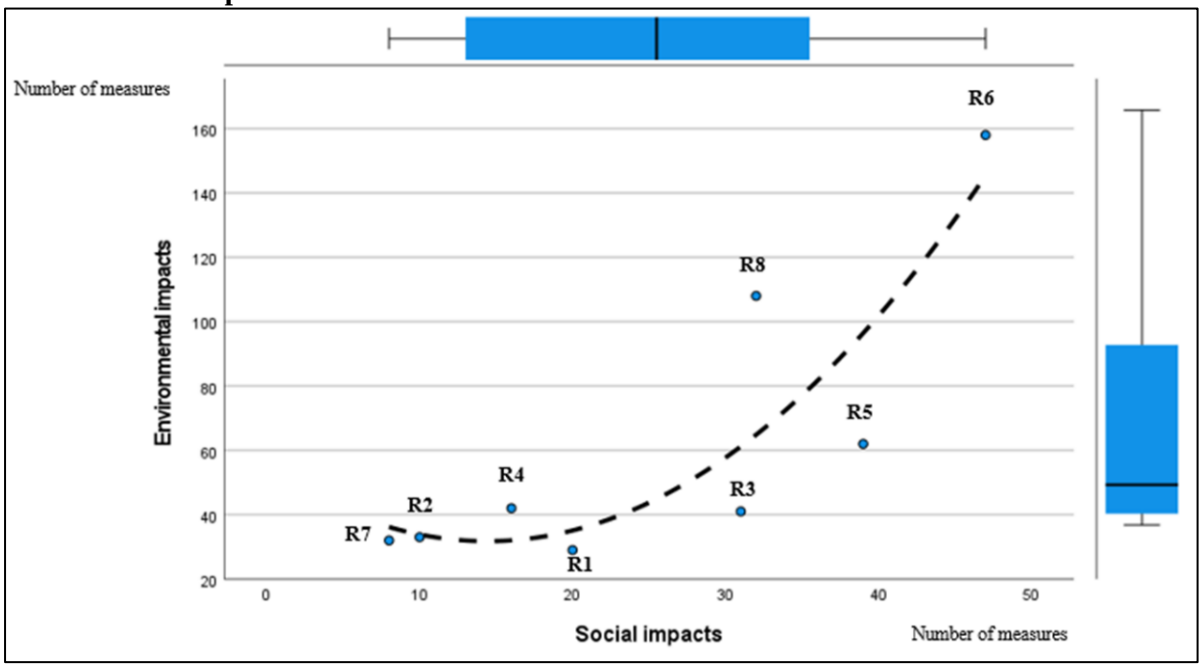


In addition, R5, R6, and R8 provided the highest number of mitigation measures (101, 205, and 140, respectively), followed by R3 and R4 (72 and 58, respectively). R1, R2, and R7 provided the lowest mitigation measures (49, 43, and 40, respectively). Also, significant disparities were identified between the environmental and social mitigation measures. Thus, the total number of mitigation measures proposed for environmental impact criteria (E1–E8) accounted for 71.3%, whereas the total number of mitigation measures proposed for social impact criteria (S1–S9) accounted for only 28.7% of all analysed measures. *Figure 7* shows a positive, strong, and significant correlation between the number of environmental and social mitigation measures proposed in the reports (two-tailed Pearson's correlation R-value was 0.789, and the Sig value was 0.020). The relationship analysis also showed a positive, strong, and significant association of ranks (two-tailed Spearman's correlation R-value was 0.786, and the Sig value was 0.021). The figure also reveals that the ESIA reports for power plant construction projects (R6 and R8) proposed more environmental mitigation measures than others. In addition, R3, R5, R8, and R6 proposed a more significant number of social mitigation measures than other reports, and interestingly, these projects were located near other geothermal development facilities.

Furthermore, power plant construction projects proposed more mitigation measures for natural habitat, waste generation, soil and vegetation, health and safety of workers, and community health than other categories. However, few mitigation measures have been proposed for involuntary resettlement, education, agriculture, employment, and economic opportunities. Additionally, the number of mitigation measures proposed for exploration drilling and integrated development projects was similar but less than those proposed for power plant construction projects.

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

Figure 7: Correlation between the number of mitigation measures proposed for social and environmental impacts.



DISCUSSION

The analysis of mitigation measures highlighted "E1: Natural habitat" and "S1: Health and safety of workers" as the most significant criteria, attracting considerable attention for environmental impact and social impact assessment, respectively. This observation emphasizes the importance of ecological conservation and the protection of worker well-being in geothermal development projects. Additionally, the analysis uncovered a robust positive correlation between environmental and social mitigation measures, underscoring the interdependence of environmental and social considerations in project planning and execution. Indeed, power plant construction projects proposed more environmental and social mitigation measures, especially for natural habitat, waste management, worker safety, and economic opportunities. However, the analysis also showed that mitigation measures for environmental impacts were more important than those for social impacts. This reveals that the weight given to social considerations was less than the weight given to environmental considerations.

ESIA reports normally encompass an equitable consideration of social and environmental factors (Dendena& Corsi, 2015). But the difference observed between environmental and social considerations in the reports highlights an appropriate conduct of social impact assessment, which was also pointed out by Suliman (2018). The proposition of fewer enhancement measures compared to other types of and actions, considering the local expectations expressed during the public participation activities, also highlighted a lack of financial dispositions to cover the financial cost of enhancement measures. Indeed, the role of corporate social responsibility (CSR) in enhancing the socio-economic livelihoods of rural communities in Africa is undeniable (Skinner& Mersham, 2008; Uduji et al., 2021). However, implementing CSR projects and enhancement measures have a cost that could be difficult for the project developers to cover. In addition, the analysis of public concerns showed that local communities request the implementation of socio-economic measures or CSR projects due to the evident lack of public infrastructure in these areas. The failure to meet these needs or the delay of CSR projects can lead to misunderstandings with local communities, as highlighted in R5 and R8, where local concerns

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

about the failure to meet previous promises about the implementation of these projects were expressed. On the other hand, developers' intention is to gain a "temporary" social license by making unrealistic or costly promises they cannot keep.

Furthermore, geothermal prospect sites can host several geothermal projects at different development stages, developed simultaneously or consecutively by a single developer or multiple developers. These developments create unpredictable impacts and consequences for local communities, greater than those related to a single project implemented in spatial and temporal isolation from other projects (Braid et al., 1985). R5 is an excellent example of this situation. Even though the project was related to geothermal drilling activities (the initial stage of development), community concerns were mainly related to socio-economic issues related to similar projects in the same area developed by the same operator. Local communities complained about a lack of job opportunities, unrealized corporate social responsibility projects, broken socio-economic promises, and a lack of basic infrastructure. These concerns differ from those of similar projects, such as R1, which focused more on the benefits of the project and the lack of basic public infrastructure. This reveals that socio-economic impacts can accumulate over the temporal and spatial extent of one or more geothermal projects, leading to what is known as cumulative social impacts (Franks et al., 2011). The analysis of these concerns also suggested that concerns were more diversified for power plant construction projects and projects in existing development sites, revealing the cumulativeness of environmental and social impacts. However, these reports focused on the cumulative effect on the receiving environment, not the socio-economic aspects of receiving project areas and local communities.

In addition, local communities experience cumulative environmental impacts. For example, in R8, complaints were made regarding the impact of other projects generating gas emissions causing acid rain, adversely affecting crop production and community health, and corroding roof sheets. The situation faced by rural communities explains the lack of attention paid to impact mitigation, monitoring, and stakeholder engagement in these ESIA reports, as described by Omenge et al. (2022). This may lead to fear and powerlessness in rural communities, which are already affected by many local issues, including unemployment, lack of facilities, and poverty. Consequently, these feelings may lead to the rejection and opposition of new geothermal projects proposed by developers who fail to meet local socio-economic and impact management expectations and, therefore, become unsuccessful.

Additionally, unlike other extractive energies, such as oil and gas, geothermal energy cannot be moved, and its exploitation is spatially limited to the availability and geological characteristics of the resource. Therefore, multiple geothermal development projects can be developed in a particular area, resulting in multiple involuntary resettlements of local communities (as was the case with the R8 project). Thus, involuntary resettlement is a critical process that requires the displacement of communities, expropriation of land, and construction of new dwellings and related facilities, such as roads, waste treatment facilities, and drinking water and electricity supply. These activities require massive logistical efforts and are considered "projects within a project" (Vanclay, 2017). Consequently, resettlement activities consider socio-economic impacts that must be mentioned in ESIA reports and not only in involuntary resettlement action plans. These activities can also delay geothermal projects and lead to unexpected expenses. For example, the Olkaria IV project (R8) took 22 years to be fully operational, and one of the reasons for this was the resettlement activities. According to Kong'ani et al. (2021), local communities, especially project-affected persons (PAPs), complained about inadequate communication and participation in decision-making, unsatisfactory relocation logistics, and unfulfilled compensation promises. These complaints were also found in the analysis of public participation materials in previous

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

resettlement activities for projects R8 and R2. Indeed, the experience of previously unsuccessful involuntary resettlement activities by local communities may be linked to the success of future resettlement efforts. This is because such experiences can cause communities to refuse to cooperate with developers and local governments, leading to land disputes and social acceptance issues.

Furthermore, compensating these communities in cash is inappropriate because they depend on agricultural and livestock production and may have limited knowledge of handling large sums of money. Therefore, more sustainable, and appropriate ways of compensating these communities, considering their livelihoods and lifestyles, must be considered.

CONCLUSION AND RECOMMENDATIONS

Geothermal energy projects are highly complex and can have diverse and multiple environmental and social impacts, which are often overlooked in ESIA reports by respecting the international standards set by international development organizations. Despite ESIA reports aiming to consider both environmental and social aspects of projects equitably, the analysis of mitigation measures showed that social impacts are not given enough attention. Social mitigation measures only represent 28.7% of all collected measures, compared to 71.3% for environmental measures. This raises concerns about the lack of consideration for social impact assessment. Moreover, the study found a strong and positive correlation between the number of environmental and social mitigation measures, with power plant construction projects proposing more measures for both aspects. However, the analysis of public participation materials in ESIA reports revealed that stakeholders' concerns mostly revolve around socio-economic and development issues, indicating a lack of local socio-economic and public facilities and the willingness of communities to benefit from the projects. Additionally, fewer enhancement measures were proposed compared to minimization and avoidance measures, highlighting a disconnect between projects and local expectations. This disconnect can lead to misunderstandings and conflicts with local communities. It is concerning that unfulfilled socio-economic promises suggest developers might be seeking temporary social licenses and local support for their projects.

The study showed that power plant construction projects and existing development sites generate more controversy than geothermal drilling projects or projects in new development sites. This is likely due to past development projects causing environmental impacts, unsuccessful multiple involuntary resettlements, and limited local socio-economic benefits. These perceived impacts or negative experiences from other projects highlighted in public participation materials can be considered as cumulative environmental and social impacts.

As a recommendation, future ESIA reports of geothermal energy projects should include more socio-economic mitigation measures and monitoring based on experiences from previous or existing developments in the project area. Additionally, the concept of cumulative impacts should be incorporated into the assessments. To foster better relationships with communities, project promoters should avoid making empty promises during public participation and focus on implementing long-term stakeholder engagement plans through project and CSR activities. Finally, it is critical to minimize non-voluntary resettlement of rural communities whenever possible to protect their livelihoods. By implementing these recommendations and giving equal attention to environmental and social aspects, geothermal energy projects can become more sustainable and gain stronger support from the communities they impact.

Declaration Details

This study results from doctoral research by the first author at the School of Environment and Society, Tokyo Institute of Technology. The first

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

author is supported by a scholarship from the JICA SDGs Global Leadership Program, which is gratefully acknowledged.

The authors have no other relevant financial or non-financial interests to disclose.

Data Availability Statement

Data were derived from public domain resources. All ESIA reports are available online.

Limitations

This study used ESIA reports from three different countries in East Africa, covering various stages of geothermal energy development. Mitigation measures and public participation materials included in ESIA reports were analysed. A benchmark content analysis and Mitchell Mitigation hierarchy guidelines were utilized to analyse mitigation measures, and a thematic analysis was employed to study stakeholders' concerns included in public participation materials. The aggregated results obtained provided a broad overview and simplified complex information, making it easier to understand and communicate findings. They allowed us to quickly identify general trends and patterns, aiding in the analysis process. However, it is important to note that aggregate data may not capture specific characteristics of each project's local environmental and social conditions. Therefore, future research should use the findings of this paper as a starting point for further analysis of gaps between mitigation measures and stakeholders' concerns in individual projects.

REFERENCES

Adaweh, AB (2015). Environmental management of Assal-Fiale geothermal project in Djibouti: a comparison with geothermal fields in Iceland. *United Nations University-Geothermal Training Program journal*, Report number 7, pp. 29-68. https://orkustofnun.is/gogn/unu-gtp-report/UNU-GTP-2015-07.pdf

Arévalo, AS, and JA Rodriguez (2007). Environmental Management in Geothermal Energy: Case history from El Salvador. Presented at *Short Course on Geothermal Development in Central America – Resource Assessment and Environmental Management, organized by UNU-GTP and LaGeo, in San Salvador, El Salvador. https://rafhladan.is/bitstream/handle/10802/8138/UNU-GTP-SC-04-17.pdf?sequence=1*

Arévalo, AS, and L Barrios (2009). Environmental Issues in Geothermal Exploration in Central America. *Presented at Short Course on Surface Exploration for Geothermal Resources, organized by UNU-GTP and LaGeo, in Ahuachapan and Santa Tecla, El Salvador*. https://geocom.geonardo.com/assets/elearning/8.32.UNU-GTP-SC-09-03.pdf

Axtmann, RC (1975). Environmental Impact of a Geothermal Power Plant: Chemical and thermal effluents from a New Zealand plant rival those from fossil or nuclear fuel technologies. *Science*, Vol 187, Issue 4179, pp. 795- 803. https://www.science.org/doi/10.1126/science.187.4179.795.

Barasa, PJ (2014). Environmental, social and safety aspects associated with implementation of geothermal power projects: the case of 280MW geothermal power projects at Olkaria in Naivasha sub-county, Kenya. *Proceedings 5th African Rift geothermal Conference in Arusha*, Tanzania.

Belaineh, M (2006). Environmental concerns for geothermal development in Ethiopia. *Proceedings 1st African Rift Geothermal Conference in Addis Abeba*, Ethiopia.

Braid, RB, M Schweitzer, SA Carnes, and EJ Soderstrom (1985). The importance of cumulative impacts for socio-economic impact assessment and mitigation. *Energy* Vol. 10. No. 5. pp. 643-652. https://doi.org/10.1016/0360-5442(85)90096-9.

Brown, K, and J Webster-Brown (1995). Environmental impacts and mitigation. In M.

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

H., Dickson, and M. Fanelli. *Geothermal energy: utilization and technology*, pp 155 – 173. Commissioned by UNESCO and published by John Wiley & Sons. https://unesdoc.unesco.org/ark:/48223/pf0000133254

Cataldi, R (2001). Social acceptance of geothermal projects: problems and costs, International geothermal association. *International Summer School in Romania*, pp 343-351. https://www.geothermal-energy.org/pdf/IGAstandard/ISS/2001Romania/cataldi.pdf.

Chorowicz, J (2005). The East African rift system. *Journal of African Earth Sciences*, 43(1-3), 379–410. https://doi.org/10.1016/j.jafrearsci.2005.07.019.

Dendena, B, and S Corsi (2015). The Environmental and Social Impact Assessment: a further step towards an integrated assessment process. *Journal of Cleaner Production*, Volume 108, Part A, pp 965-977, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2015.07.110.

DiPippo, R (2012). *Geothermal Power Plants - Principles, Applications, Case Studies, and Environmental Impact*. Butterworth-Heinemann. Chapter 1, page 9. ISBN: 9780123947871.

Dowd, AM, N Boughen, P Ashworth, and S Carr-Cornish (2011). Geothermal technology in Australia: Investigating social acceptance. *Energy Policy*, Volume 39, Issue 10, pp 6301-6307. https://doi.org/10.1016/j.enpol.2011.07.029.

Elo, S, and H Kyngäs (2008). The qualitative content analysis process. *Journal of Advanced Nursing,* Volume 62, Issue 1, pp 107-115. https://doi.org/10.1111/j.1365-2648.2007.04569.x .

Ethiopian electric power corporation (2013). Environmental and social impact assessment report of Alalobad tendaho geothermal project site. The *World Bank website*. https://documents1.worldbank.org/curated/en/496311468257673067/pdf/E43920V20P133600Box382090B00PUBLIC0.pdf.

Ethiopian electric power corporation (2013). Environmental and social impact assessment report of Aluto Langano geothermal site. The *World Bank website.* https://documents1.worldbank.org/curated/pt/151581468038142238/pdf/E43920V10P13360Box382090B00PUBLIC0.pdf.

Ejderyan, O, F Ruef, and M Stauffacher (2020). Entanglement of Top-Down and Bottom-Up: Sociotechnical Innovation Pathways of Geothermal Energy in Switzerland. *The Journal of Environment & Development*, 29(1), 99–122. https://doi.org/10.1177/1070496519886008

ESMAP (2012). Geothermal handbook: planning and financing power generation. *ESMAP website*, technical report. https://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf.

Fichtner (2012). Etude cadre environnementale et sociale du projet d'évaluation des ressources géothermiques de Djibouti. The *World Bank* website. https://documents1.worldbank.org/curated/en/743681468246003355/pdf/Djibouti1.pdf.

Franks, DM, B David, and CJ Moran (2011). Cumulative social impacts, *New Directions in Social Impact Assessment-Conceptual and Methodological advances.* Edwar Elgar, Chap 12, pp 202-220. ISBN: 978 1 84980 117 1.

Geothermal development company and Redplan consultants (2015). Suswa geothermal development project in Narok and Kajiado counties. *GITPA website*. https://gitpa.org/web/RAPPORT%20ESI%20SUWA%20.pdf.

Geothermal development company and LOG associates (2019). Environmental and social

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

impact assessment for the proposed geothermal drilling project in West Menengai. *NEMA Kenya website.*

https://www.nema.go.ke/images/Docs/EIA_14601469/EIA%201569%20%20Menengai%20West%20Geothermal%20Drilling%20Project%20Report-min.pdf).

González Acevedo, ZI, AMA Sánchez Vázquez, JCA González Troncoso, S Lee Sánche, and AMA García Zarate (2021). Social acceptance/resistance of geothermal power plants in Mexico. *Proceedings, First EAGE Workshop on Geothermal Energy in Latin America*, Volume 2021, pp 1 – 5, https://doi.org/10.3997/2214-4609.202182033

Haggarty, L (1996). What is content analysis? *Medical Teacher*, Volume 18, Issue 2, 99-101. https://doi.org/10.3109/01421599609034141.

Hasan, MdA, KhMd Nahiduzzaman, and AS Aldosary (2018). Public participation in EIA: A comparative study of the projects run by government and non-governmental organizations. *Environmental Impact Assessment Review*, Volume 72, pp 12-24, ISSN 0195-9255. https://doi.org/10.1016/j.eiar.2018.05.001.

Hardarson (2016). The western branch of the East African rift: a review of tectonics, volcanology, and geothermal activity. Presented at *SDG Short Course I on Exploration and Development of Geothermal Resources, by UNU-GTP, GDC and KenGen, at Lake Bogoria and Lake Naivasha*, Kenya

Intergovernmental Panel on Climate Change (IPCC) (2011). Renewable Energy Sources and Climate Change Mitigation. *IPCC website*. https://www.ipcc.ch/site/assets/uploads/2018/03/SRREN_Full_Report-1.pdf.

International Association for Impact Assessment (IAIA) (1998). Principles of environmental impact assessment best practice. *The Environment Institute of Australia and New Zealand (EIANZ) website*. https://www.eianz.org/document/item/2744.

International Association for Impact Assessment (IAIA) (2002). Public involvement. *EIA training resource manual*, Topic 3, pp 159-187. https://www.iaia.org/pdf/south-eastern-europe/Sec_E_Topic_3.PDF.

International Renewable Energy Agency (IRENA) (2020). Geothermal development in Eastern Africa. IRENA website. https://www.irena.org/publications/2020/Nov/Geothermal-development-in-Eastern-Africa.

Kandie, JR (2014). Eastern rift structural geology – tectonics, volcanology and geothermal, Presented at *Short Course IX on Exploration for Geothermal Resources, organized by UNU-GTP, GDC and KenGen, at Lake Bogoria and Lake Naivasha*, Kenya. https://rafhladan.is/bitstream/handle/10802/9126/UNU-GTP-SC-19-0303.pdf

Kebede, S. (2005). Preliminary Environmental Impact Assessment for the development of Tendaho geothermal area, Ethiopia. United Nations University Geothermal Training Program (UNU-GTP), report number 11, pp 137-162. https://gogn.orkustofnun.is/unu-gtp-report/UNU-GTP-2005-11.pdf

Kenya electricity generating company (KenGen) and GIBB Africa (2009). Environmental and social impact assessment report for Olkaria IV(Domes) geothermal energy project in Naivasha district. The *World Bank website*. https://documents1.worldbank.org/curated/en/932731468048839074/pdf/E23370EA0V60P1030370Box345601B01PUBLIC1.pdf

Kinga, WF, J Kwasira (2016). Analysis of the Environmental Impacts of Geothermal Drilling on Livelihoods of Adjacent Communities in Menengai Geothermal Power Project. *OSR Journal of Environmental Science, Toxicology and Food Technology (IOSRJESTFT)* e-ISSN: 2319-2402, p- ISSN: 2319-2399.Volume 10, Issue 4, Ver. I, pp 71-

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

76. https://www.iosrjournals.org/iosr-jestft/papers/vol10-issue4/Version-1/I1004017176.pdf

Kong'ani, LNS, RG Wahome, T Thenya (2021). Variety and management of developmental conflicts: the case of the Olkaria IV geothermal energy project in Kenya. *Conflict, Security & Development*, 21:6, pp 781-804. https://doi.org/10.1080/14678802.2021.2000806

Kubota, H (2015). Social Acceptance of Geothermal Power Generation in Japan. *Proceedings World Geothermal Congress 2015 in Melbourne*, Australia. https://www.geothermal-energy.org/pdf/IGAstandard/WGC/2015/02055.pdf

Kubota, H, H Hondo, S Hienuki, and K Hideshi (2013). Determining barriers to developing geothermal power generation in Japan: Societal acceptance by stakeholders involved in hot springs. *Energy Policy* Volume 61, pp 1079-1087. https://doi.org/10.1016/j.enpol.2013.05.084.

Kurgat, IK, and J Omwenga (2016). Impact of Power Generation Project on the Livelihoods of Adjacent Communities in Kenya: A Case Study of Menengai Geothermal Power Project. *International Journal of Scientific and Research Publications*, Volume 6, Issue 10, ISSN 2250-3153, pp 610 – 624. https://www.ijsrp.org/research-paper-1016/ijsrp-p5883.pdf.

Larsen, SV, L Kørnøv, and P Christensen (2018). The mitigation hierarchy upside down – a study of nature protection measures in Danish infrastructure projects. *Impact Assessment and Project Appraisal*, 36:4, pp 287-293. https://doi.org/10.1080/14615517.2018.1443260

Lee, N, R Colley, J Bonde, and J Simpson (1999). Reviewing the Quality of Environmental Assessments and Environmental Appraisals. *EIA Centre Department of Planning and Landscape University of Manchester*. Occasional Paper No 55.

Liu, H, H Wang, Y Gou, and M Li (2018). Investigation on Social Acceptance of the Geothermal Energy Utilization in China. *GRC Transactions*, Vol. 42. https://publications.mygeoenergynow.org/grc/1034087.pdf

M. Abdi, A (2018). Environmental, Health and Safety Assessment of Geothermal Drilling Operation using the RIAM Method: The case of Assal Fiale Geothermal Development Project. *Proceedings 7th African Rift Geothermal Conference in Kigali*, Rwanda.

Mariita, NO (2002). The impact of large-scale renewable energy development on the poor: environmental and socio-economic impact of a geothermal power plant on a poor rural community in Kenya. *Energy Policy*, 30 (11-12), pp 1119–1128. https://doi.org/10.1016/s0301-4215(02)00063-0

Mariita, NO (2009). The socio-economic and environmental impact of geothermal energy on the rural poor in Kenya - The Impact of a Geothermal Power Plant on a Poor Rural Community in Kenya. *Report of the AFREPREN Theme Group on Special Studies of Strategic Significance*.

Mayring, P. (2015). Qualitative Content Analysis: Theoretical Background and Procedures. In: Bikner-Ahsbahs, A., Knipping, C., Presmeg, N. (eds) Approaches to Qualitative Research in Mathematics Education. Advances in Mathematics Education. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-9181-6_13

Mitchell, J. (1997). Mitigation in environmental assessment-furthering best practice. EA-LINCOLN-, 5, 28-29.

Mwangi, MN (2007). Environmental Management in geothermal development: Case History from Kenya, Presented at Short Course on Geothermal Development in

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

Central America – Resource Assessment and Environmental Management, organized by UNU-GTP and LaGeo, in San Salvador, El Salvador. https://gogn.orkustofnun.is/unu-gtp-sc/UNU-GTP-SC-04-16.pdf.

Navriya, M, P Agarwal, J Thomas, and DK Doda (2019). Environmental Impact of Geothermal Power Plant. *International Journal of Trend in Scientific Research and Development (IJTSRD)*, Volume 3, Issue 3, ISSN 2456 – 6470, pp 140-143. https://doi.org/10.31142/ijtsrd21663.

Ngomi, G, 2018. Development Phases of Olkaria IV Geothermal Power Plant Project in Kenya. *Proceedings, 7th African Rift Geothermal Conference Kigali*, Rwanda

Oduor, JA (2010). Environmental and Social Considerations in Geothermal Development. *FIG Congress 2010 Facing the Challenges – Building the Capacity, Sydney*, Australia. https://www.fig.net/resources/proceedings/fig_proceedings/fig2010/papers/ts01e/ts01e_oduor_3857.pdf.

Ogola, APF (2005). Environmental and social considerations in geothermal development. *Presented at the workshop for Decision Makers on Geothermal Projects and Management, organized by UNU-GTP and KenGen in Naivasha,* Kenya. https://gogn.orkustofnun.is/unu-gtp-sc/UNU-GTP-SC-01-15.pdf.

Omenda, P and M Teklemariam (2010). Overview of geothermal resource utilization in the East-African rift system. Presented at Short Course V on Exploration for Geothermal Resources, organized by UNU-GTP, GDC and KenGen, at Lake Bogoria and Lake Naivasha, Kenya.

Omenda, P, P Mangi, C Ofwona, M Mwangi (2021). Country Update Report for Kenya 2015-2019. *Proceedings World Geothermal Congress 2020+1*, Iceland. https://www.geothermal-energy.org/pdf/IGAstandard/WGC/2020/01055.pdf.

Omenge, PM, GO Obwoyere, GW Eshiamwata, and SM Makindi, (2022). A review of the quality of environmental and social impact statements: The case of geothermal energy projects in Kenya. *East African Journal of Environment and Natural Resources*, Volume 5, Issue 2, pp 144 – 163. https://doi.org/10.37284/eajenr.5.2.1027.

Oyugi, P, and F Keny, (2018). Evaluation and Control of Accident Risk Factors in Geothermal Drilling Sites. *Proceedings, 7th African Rift Geothermal Conference Kigali*, Rwanda.

Payera, SV (2018). Understanding social acceptance of geothermal energy: Case study for Araucanía region, Chile. *Geothermics*, Volume 72, pp 138-144, https://doi.org/10.1016/j.geothermics.2017.10.014.

Rybach, L (2003). Geothermal energy: sustainability and the environment. *Geothermics*, Volume 32, Issue 4-6, pp 463–470. https://doi.org/10.1016/s0375-6505(03)00057-9.

Shortall, R, B Davidsdottir, and G Axelsson (2015). Geothermal energy for sustainable development: A review of sustainability impacts and assessment frameworks. *Renewable and Sustainable Energy Reviews*, Volume 44, pp 391-406, ISSN 1364-0321. https://doi.org/10.1016/j.rser.2014.12.020.

Skinner, C, and G Mersham (2008). Corporate social responsibility in South Africa: emerging trends. *Society and Business Review*, Vol. 3 No. 3, pp. 239-255. https://doi.org/10.1108/17465680810907314.

Sosian energy and GIBB international (2019). Updated environmental and social impact assessment report for the development of 1x35 MW geothermal power plant in Menengai, *The African Development Bank website*.

Article DOI: https://doi.org/10.37284/eajenr.6.1.1619

https://esa.afdb.org/sites/default/files/Sosian%20Menengai%20GeothermalUpdated%20ESIA%20Report.pdf

Sosian energy (2019). Environmental and social impact assessment study for the proposed geothermal exploration drilling energy Makongenu/Menengai geothermal project. *The NEMA-Kenya website*, https://www.nema.go.ke/images/Docs/EIA_16701679/ESIA_1671%20Sosian%20Energy%20report%20_SR%201671-min.pdf

Suliman, NN (2018). Working paper on developing evaluation criteria for SIA reports: Application on Geothermal Project Studies from Ethiopia, Indonesia, and Kenya. Future Energy Systems of University of Alberta, *IAIA website.* https://conferences.iaia.org/2019/uploads/draft- presentations/100_Suliman_Developing%20Evaluation%20Criteria%20for%20SIA.pdf.

Uduji, JI, EN Okolo-Obasi, VA Onodugo, JO Nnabuko and BA Adedibu (2021). Corporate social responsibility and the role of rural women in strengthening agriculture-tourism linkages in Nigeria's oil producing communities, *Journal of Tourism and Cultural Change*, Volume 19, Issue 6, pp 754-780. https://doi.org/10.1080/14766825.2020.1826500

Vanclay, F (2017). Project-induced displacement and resettlement: from impoverishment risks to an opportunity for development? *Impact Assessment and Project Appraisal*, 35:1, 3-21. https://doi.org/10.1080/14615517.2017.1278671

