CIVIL SOCIETY COALITION ON OIL AND GAS UGANDA

ASSESSMENT OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACT OF KIBIRO SPILL

A reflection on spill management and compliance with the legislative frameworks in Uganda

CSCO Research Paper No.7, 2020

Supported by WWF Norad

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Published by the CSCO Secretariat

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Citation:

CSCO. (2020). *Assessment of Environmental and Socio-Economic Impact of the Kibiro Spill: A reflection on spill management and compliance with the legislative frameworks in Uganda,* Kampala: CSCO. Research Paper Series No. 7.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACODE	Advocates Coalition for Development and Environment
BAPENECO	Bunyoro Albertine Petroleum Network on Environmental Conservation
BDL	Below Detection Limit
CSCO	Civil Society Coalition on Oil and Gas in Uganda
CSO	Civil Society Organization
ESIA	Environment and Social Impact Assessment
IFC	International Finance Corporation
IGA	International Geothermal Association
KHEDA	Kitara Heritage Development Association
MEMD	Ministry of Energy and Mineral Development
NEMA	National Environment Management Authority
SOPs	Standard Operating Procedures
UNEP	United Nations Environment Program
WHO	World Health Organization
WWF	World Wide Fund for Nature

ACKNOWLEDGEMENT

Chemical and geothermal fluids or oil spills can be dangerous to both human life and the environment. The impacts of any spill largely depend on the chemical composition, nature and scale of the spill. The spill which occurred at a geothermal drilling area in Kibiro caused panic among community members, the political and technical leadership of Hoima district, as well as duty bearers at the national level. The spill was of great concern; and thus triggered the Civil Society Coalition on Oil and Gas's (CSCO) to undertake research to establish its impacts. There was fear that the spill involved petroleum hydrocarbons and chemical components which could have far-reaching pollution consequences.

CSCO is grateful Norwegian Agency for Development Cooperation that supported this work under a grant to World Wide Fund for Nature. We are equally indebted to WWF-Uganda Country Office for funding this study under the project, "Limiting Negative Impacts of Oil and Gas Development on Nature, People, and Climate in Uganda through Civil Society Engagement and Advocacy."

We are also grateful to the field team composed of Julius Senyonjo (Team Leader) from Practicing Environmental Managers Organization (PEMO), Joseph Mukasa Ngubwagye and James Muhindo from CSCO Secretariat, Winnie Mirembe from WWF - Uganda Country Office, Sam Mucunguzi from the Citizens Concern Africa, Dickens Amanya from Bunyoro Albertine Petroleum Network on Environmental Conservation (BAPENECO), and Patrick Mugabi from Kitara Heritage Development Agency (KHEDA).

We appreciate the time accorded to the field data collection team by all the respondents. The technical officers at Hoima District Local Government, Bunyoro Kitara Kingdom Officials, Local Council Chairmen and committee members of Kibiro community households where the questionnaires were administered; and spill-affected persons. All these provided valuable information which informed this study.

EXECUTIVE SUMMARY

The Geothermal spill that occurred on the night of 29th March 2020 in Kibiro community, Kigorobya sub-county (Hoima district) raised concerns ranging from readiness of government of Uganda to respond to oil spills; – to the delays and laxity exhibited by concerned authorities in undertaking clean-up and remedial exercises of the affected area. The other major concern was whether the spilled material contained elements of petroleum hydrocarbons and heavy metals in excess of allowable national and 'world average' thresholds in water and surface soils. Thus, the Civil Society Coalition for Oil and gas in Uganda (CSCO) with support from the Norwegian Agency for Development Cooperation (Norad) through a project implemented by World Wide Fund for Nature Uganda Country Office (WWF-UCO) and CSCO, sought to undertake a comprehensive study that aimed at assessing the level of concentration of total petroleum hydrocarbons (TPH) and heavy metals in the spilled material, as well as documenting community members' perspectives regarding the impact of the spill on their socio-economic livelihoods. This study was conducted with the hope that it could be useful in providing baseline data that will help in determining the level of remediation of spill contaminated sites in Kibiro community.

This research paper came out of data collected through: document reviews, field visits, focus group discussions with affected persons, interviews with local leaders, and laboratory analysis of water and soil samples (for presence of petroleum hydrocarbons and heavy metals). The heavy metal elements considered for this study included Aluminum (Al), Chromium (Cr), Lead (Pb), Iron (Fe), Manganese (Mn), and Nickel (Ni). These heavy metal elements were considered over others because of their toxicological profiles and danger on environment and human health. Secondly, unlike other metal elements, Cr, Fe, Mn, and Ni are among metal elements which are not distributed in a similar manner between geothermal waters and other sources of water (apart from hot springs),[1] thus, making selection of such elements relevant for this study. The TPH elements considered included those in the category of

1 Birkle P. and Merkel B. (2000). Environmental impact by spill of geothermal fluids at the geothermal field of Los Azufres, Michoacán, Mexico. Article in Water Air and Soil Pollution, Technical University of Freiberg, Institute of Geology, Freiberg/ Saxony, Germany

C10-C40 (this is because unlike other petroleum hydrocarbon elements, C10-C40 can still be detected in soil and water resources even after a long period of time – based on nature and type of oil spilled).

Key Findings

The study established that the project and management of the spill exhibited some best practices, weaknesses, and lapses as well.

Best practices exhibited

The study established that; (a) there was quick response by the responsible Ministry. There was relatively a quick response by the Multi-stakeholder Committee spearheaded by Uganda's Ministry of Energy and Mineral Development (MEMD) and the National Environment Management Authority (NEMA) by conducting a preliminary assessment of the challenge; (b) information about the spill was timely shared with the community to allay the fears. The report concerning the spill was produced on time and shared with Local Leaders by MEMD and NEMA; (c) there were prior community consultations about the project. There was general acknowledgement among community members that the Geo-Thermal Company (M/s Royal Techno Industries Ltd) and MEMD consulted them before implementation of the project in compliance with international best practices for geothermal energy development.[2]

Lapses and areas of improvement

From the study, some lapses related to management of the spill incident were observed. These included; (a) low levels of preparedness by district Local Governments to deal with spills; (b) absence of a formal and structured national spill management framework; (c) contradiction among government MDAs in regard to the mandate of cleaning-up a contaminated site; (d) delayed compensation of the spill affected persons; (e) delays in cleaning-up of the affected area; (f) none-compliance with Environmental and Social Impact Assessment (ESIA) requirements contrary to both Schedule 3(4)(d) of the repealed National Environment Act Cap 153 and Schedule 5(3)(b) of the substantive National Environment Act 2019 all of which require geothermal

2 See Sec.3.2 of the International Geothermal Association (IGA) & IFC World Bank (2014) Best Practices Guidelines for geothermal development.

exploration and drilling projects to undergo mandatory ESIA process before implementation; and (g) laxity by the geo-thermal drilling company and MEMD to create awareness among community members on the negative impact of drilling operations on people and the environment. The awareness campaigns only emphasized the positive impacts of the project contrary to Section 3.2 of the IGA & IFC World Bank (2014). Best Practices guidelines that require geothermal companies and host governments to ensure that local communities are made aware of the impacts, both positive and negative, of any geothermal development.

Levels of pollution

Regarding level of pollution caused by the spill, the study established the following;

a. ***There was no pollution related to petroleum hydrocarbons***

The study established that there was no pollution related to petroleum hydrocarbons (C10-C40) in water and soil samples from the spill area. Secondly, all the petroleum hydrocarbon elements tested (C10-C40) were below detection limits of the atomic absorption spectrometry.

b. ***Existence of heavy concentration of heavy metal elements***

The total concentration of heavy metal elements such as Aluminum (Al), Iron (Fe), and Manganese (Mn) in water sources were several times higher than the recommended national thresholds for portable water and WHO guidelines for drinking water (see section 4.2 for details on levels of heavy metal concentrations and recommended thresholds in drinking water). However, it was established that except for Aluminum, the pollution input of Iron and Manganese in water sources at Kibiro seems to have been a result of both the area's mineralogy and geology and not from the spill. This was because samples from surface water sources at the control area (1 Km distance away from the spill area) were statistically not different from those at the spill-affected area (Lake Water is approximately 80 meters from the spill area).

In soil resources at the spill area and surrounding environments, it was established that concentrations of all heavy metal elements considered for the study were several times higher compared with those at the control area (> 1 Km away/before the spill area) and 'world average' crustal values for surface soils. For instance, at the well-head area, Chromium (Cr) was

240 times higher compared with elemental background concentrations for Cr at the control area, and 12 times higher than recommended 'world average' of 64 mg/kg for Cr in surface soils. Although limited amount of chromium is an essential nutrient that helps the body to use sugar, protein and fat; breathing high levels of chromium can cause irritation to the nose. Ingesting large amounts of chromium can cause stomach upsets and ulcers, kidney and liver damage and even death (Hussain & Gondal, 2008).[3] Skin contact with certain chromium compounds can cause severe redness and swelling of the skin. Some people are extremely sensitive to chromium than others.

c. ***The spill material exhibited concentrations metals higher than the average thresholds***

The heap of spill material at the compound/home of the affected person (Mr. Julius Kiiza) exhibited concentrations of Cr (633.4 mg/kg) 7 times higher than recommended world average thresholds for Cr in surface soils (64 mg/kg), Lead (Pb) was 11 times higher than world average for Pb in surface soils of 15 mg/kg, Nickel (Ni) which exhibited concentration levels of 369.5 mg/kg was 19 times higher compared with the recommended world average of 45 mg/kg for Ni in surface soils. Iron (212926 mg/kg) was 1065 times higher than the world average threshold of 200 mg/kg for Iron (Fe) in surface soils. At the time of this study, the heavily contaminated heap of spill material was still present at the home of the affected person (7 months after the Kibiro spill incident).

d. ***Another unreported mild spill had previously occurred in the same area***

It was further established (through interviews and focus group discussions with Kibiro community members) that besides the spill which occurred on the night of 29th March 2020 (at Kibiro geo-thermal gradient hole-4), another spill had occurred at Kibiro Geo-thermal Gradient Hole-7 (located approximately 500 meters apart). This was confirmed by presence of heavy metals in soils at this site and surrounding areas whose concentration levels were several times greater than those at the control area and higher than the recommended world average thresholds for metals in surface soils. For instance, the concentration

3 Hussain T. & Gondal M. A., (2008). Monitoring and assessment of toxic metals in Gulf War oil spill contaminated soil using laser-induced breakdown spectroscopy. Environ Monit Assess (2008) 136:391–399 DOI 10.1007/s10661-007-9694-2

of Nickel in soil samples at the well-head area was 3 times higher than background values at the control area, and 40 times greater than the recommended 'world average' limit for Ni. Lead (Pb) was 2 times higher compared with elemental background values at the control area, and was 17 times greater than the recommended 'world average' thresholds for Pb in surface soils. See section 4.2.2 for details.

Socio-economic impacts

With regard to socio-economic impacts of the pill, the study established that:

a. *There was loss of property*

The study established that there was loss of property that included 10 fishing nets belonging to 6 different fishermen, 2 domestic animals, and 3 graves which were covered in the spill material (clay, sand, and drilling waste) for those located within a distance of 60 meters-1km from the spill area.

b. *Disruption of fishing activities*

The study found out that there was especially in the first 2 weeks after the spill incident due to fear among fishermen and community members that fish could have been contaminated with the spill material. Community members complained that during this period, fish from the potentially polluted section of the lake (Lake Albert) had a paraffin-like smell which made it hard for them to consume or sell.

c. *Tension and unrest*

There was tension and unrest among community members fearing that the spill could re-occur. This was due to the fact that, at the time of this study, at least 3 of the 8 geothermal gradient holes in Kibiro had been submerged in water due to rising water levels of the lake. This created fear that boats might accidentally collide with the submerged rigs hence triggering-off another spill.

d. *Mistrust and suspicion*

The study established that there was mistrust and suspicion among community members due to unmet promises related to compensation of land taken for the development of geothermal energy fields in Kibiro, delayed compensation for the property lost during the spill incident, and

MEMD's failure to handle grievances emanating from the spill.

Conclusion

The study showed that there were positive and commendable practices by government authorities in dealing with the spill in line with international best practices. At the same time, a number of gaps and lapses were observed. These lapses, if not well addressed, may further negatively impact the process of managing spills in Uganda and leave communities worse-off than they were before the extractive's development projects. The study further revealed that except for hydrocarbons whose concentration levels were below detection limit, natural attenuation processes had not yet reduced pollution levels of some heavy metals such as Aluminum (Al), Chromium (Cr), Lead (Pb), Nickel (Ni), Iron (Fe), and Manganese (Mn) to acceptable levels, especially in soil samples. The polluted area had not yet been cleaned-up or restored to its original state contrary to Sections 79 and 80 of the National Environment Act and requirements of international industry best practices which call for immediate remediation, clean-up, and restoration of the polluted environment.

A list of actionable mitigation measures and recommendations is provided in this report targeting different categories of stakeholders including relevant Government of Uganda's Ministries, Departments and Agencies (MDAs), and None-Governmental Organizations and CSOs especially those whose work is aligned to energy and the extractives industry, oil and gas, and those whose work is related to promoting environmental and social sustainability within the Albertine Graben Region of Uganda.

Recommendations

The final section of this report provides recommendations aimed at addressing the gaps identified by the study. Among these include;

Subject all Geo-thermal and exploration projects in Uganda to Environmental and Social Impact Assessments (ESIAs)

There is need for MEMD and NEMA to ensure that all Geo-thermal and exploration projects in Uganda are subjected to Environmental and Social Impact Assessments (ESIAs) before implementation, in accordance with

Schedule 5 of the National Environment Act, 2019.

Encourage public participation in the ongoing ESIA studies for Geo-thermal exploration and drilling projects in the country

MEMD and NEMA should ensure that there is wide consultation of all concerned stakeholders including but not limited to the affected community members, local leaders, CSOs and CBOs among others for informed decision making, meaningful input, and public buy-in into the ongoing ESIA studies for Geo-thermal exploration and drilling projects in Kigorobya, Panyimur, and Kasese.

Government should fast track the clean-up exercise of the affected area

There is urgent need for MEMD to fast track the clean-up exercise of the affected community to restore the contaminated environment near to its original condition in accordance with Sections 57, 79, 91, and 130 of the National Environment Act (2019) and in line with international best practices for remediation of contaminated sites. It should be noted that the faster a contaminated site is cleaned-up, the better the chance of limiting negative impacts on the affected area and surrounding communities (Helmy and Kardena, 2015).[4]

As a matter of urgency, in addition to cleaning-up of Kibiro spill Gradient Hole-4 area (the publicized spill incident area), MEMD should as well consider cleaning-up of Kibiro Geo-thermal Gradient Hole-7 and its surrounding areas (unpublicized spill area) that showed extremely high levels of contaminated soil resources with trace and heavy metal elements.

Prior to site clean-up, detailed site plan should be prepared for (a) clean-up of the contaminated soil; (b) risk reduction at the site; and (c) risk reduction in the community. This is because, if not well planned and managed, clean-up exercises tend to result into new forms of contamination and aggravated pollution levels that further threaten public health.

There is urgent need for the Ministry of Energy and Mineral Development (MEMD) together with the Geo-Thermal drilling company in Kibiro to

4 Helmy Q., and Kardena E., (2015). Petroleum Oil and Gas Industry Waste Treatment; Common Practice in Indonesia. Journal of Pet Environ Bio-technology 2015, 6:5 http://dx.doi.org/10.4172/2157-7463.1000241

remove the pile of drilling waste/spill material from the home of Mr. Kiiza Julius (including remediation) with some compensation for the damage caused by the spill which includes loss of 2 fishing nets, and inconvenience caused by the delay to remove the contaminated spill material from his compound.

Government should implement all commitments made in the Press Release dated 15th April, 2020

MEMD and the Multi-stakeholder committee on Kibiro spill should ensure that all commitments made in the Press Release[5] of 15th April, 2020 are implemented (additional information on the commitments made by MEMD is provided in sections I and IV of this report).

Assess the loss and compensate the victims of the spill

There is urgent need to conduct an assessment of loss occasioned and compensate all those who were directly affected by the spill in compliance with Sections 78 and 79(e) of the National Environment Act (2019) which require a developer and the lead agency to ensure that persons affected by any form of pollution or loss occasioned to them by actions or inactions of the developer's operations to be compensated in accordance with the NEA (2019) and any other applicable laws. In the study area, some community members lost their fishing nets while others lost domestic animals due to the spill.

Government should fast track the National Oil Spill Contingency Plan

There is urgent need for Government of Uganda (through Office of the Prime Minister) to fast track the National Oil Spill Contingency Plan (incorporating management of geothermal spills) to guide spill management in the entire extractives industry.

Fencing and controlling access to Drilling Sites

There is need for MEMD to ensure that geothermal drilling sites in Kibiro community and those in other areas of the country are adequately fenced so as to limit grazing animals and community members from accessing the sites, in accordance with international best practices for

5 GoU (2020). Clarification on Oil Spill Incident at Kibiro Kigorobya sub-county, Hoima dostrict. Press Release April 15, 2020 Ministry of Energy and Mineral Development (MEMD), Entebbe.

geothermal drilling and production.

SECTION I: BACKGROUND

1.1. Introduction

The spill that occurred at Kibiro, Kigorobya sub-county (Hoima district) from a geothermal drilling operation attracted the attention of not only the community members but also the technical and political leadership of Hoima district and the respective Ministries, Departments and Agencies. The situation was not helped by the location of the area in a region of high oil and gas potential. As such, fear was rife that the blow-out and the resultant spillage contained petroleum hydrocarbons which have far-reaching pollution consequences.

This research paper therefore presents findings of a study that was commissioned by the Civil Society Coalition on Oil and Gas on the environmental and socio-economic impacts of the Kibiro spill that occurred in March 2020. It is organized under four sections, that is; Section 1 which presents background to the study, and the study objectives; Section 2 provides a description of the study area, scope, the approach and methodology applied; Section 3 presents findings of the study; and Section 4 presents conclusion and recommendations aimed at improving management of spills in Uganda's geothermal energy sub-sector and the extractives industry in general.

1.2. Background

1.2.1 Overview of geothermal exploration spills and blowouts around the world

Geothermal energy is the natural heat from the earth's interior stored in rocks and water within the earth's crust. This energy can be extracted by drilling wells to tap concentrations of steam at high pressures and at depths shallow enough to be economically justifiable. Part of this enormous amount of heat (contained in water or steam transported to the surface) can be extracted and used for various purposes, i.e., to generate electricity, and for drying of agricultural products. In addition, geothermal water is a resource used to extract carbon dioxide, edible salt and other chemicals. It is also useful in cosmetics and in therapeutics business (GeoCom, 2015).

Geothermal fields are fairly widespread in the world and are exploited in Italy, the USA, New Zealand, Kenya, Japan, Mexico, El Salvador, China, Indonesia, Iceland, the Philippines and Turkey among other countries. Italy pioneered the use of geothermal energy for generating electricity in 1904 at Lardarello, near Pisa. In Africa, Kenya was the first country to use geothermal energy (Bw'Obuya, 2002).[1] Generally, geothermal energy is considered to be an environmentally friendly source of energy, especially in comparison to fossil fuels (oil and gas, or coal). However, the use of geothermal energy in the past 40 years has shown that it is not devoid of adverse impacts on the environment and human health (Mladen et al, 2019).

Experiences from other countries show that such adverse impacts are usually a result of spills and blowouts. For instance, at the geothermal field of Lahendong and Dieng in Indonesia, severe contamination of surface water sources was reported as a result of the spill that occurred at those fields (Radja and Sulasdi, 1995). Similarly, at Wairakei geothermal energy plant in Croatia, impacts of continued geothermal spill had resulted in ground deformation, atmospheric pollution, soil and ground water contamination, and a loss of confidence from the public and financial sectors to invest in geothermal energy production (Mladen et al, 2019).

Blowouts are attributed mainly to deep drilling, increase in temperature, and human error.[2] For instance, blowouts that occurred in countries such as Iceland, Italy, Kenya, Japan, Greece, USA, and Mexico during the early 1990s were all attributed to drilling into deeper zones in the face of critical temperatures. In the majority of these cases, highly corrosive and hostile fluids were released into the environment and led to well abandonment. Any effective reduction in blowout risks is primarily contingent upon the operator's accurate interpretation of monitoring data, and ultimately depends on the decisions made based on such data which involves identification and analysis of the potential for hot and over-pressured fault and fracture conduits, and adequate preparation for penetration of such conduits to reduce impacts of kicks

1 Bw'Obuya (2002). The socio-economic and environmental impact of geothermal energy on the rural poor in Kenya. A report of the AFREPREN Theme Group on Special Studies of Strategic Significance

2 The major cause of most blowouts is human error; either none of the crew or the Operator's advisors recognizes an existing well control problem, or steps to control the situation are not performed soon enough (Patterson & Associates, 1994).

and lost circulation (Rowley, 1991; Sandrina et al, 2017; and Peterson and Associates, 1994).

1.2.2 The Kibiro spill/blowout incident

Kibiro community where the geo-thermal spill occurred is located within Kigorobya sub-county, Hoima district in the Albertine Graben Region of Uganda. The community is situated in a sedimentary environment, and the geothermal project is located between two oil well discoveries, that is; Waraga and Taitai. Moreover, the spill area (KB-4) is located a few meters (approx. 80m) from the shorelines of Lake Albert (Lake Albert is a shared resource between Uganda and the Democratic Republic of Congo). The blow-out and spill occurred on the night of March 29th, 2020 at the eighth and last geo-thermal well in Kibiro parish as the drilling company planned to move to Panyimur in Pakwach district. According to a Ministry of Energy and Mineral Development (MEMD) report (2020), the blow-out resulted into uncontrolled discharge of gas, drilling fluids, geothermal fluids and sediments. The Ministry's report further indicated that small oil sheens were observed on sediments.

At the local level, the spill caused unrest among the residents of Kibiro fearing for their livelihoods and health, which triggered a site visit by an inter-ministerial task force headed by MEMD in which the task force concluded that (a) significant quantities of materials (natural gas, clay, water, drilling mud and limited traces of oil) were released into the environment; and that (b) the incident was benign because the ecology was not affected.

On 15th April 2020, the Ministry (MEMD) issued a press-statement that detailed a number of assurances and commitments[3] aimed at addressing negative impacts of the spill on people and the environment. Key among the Ministry's commitments included; (i) The commitment to continue informing, involving, and empowering the community and stakeholders regarding decisions about the spill and matters that may affect them; (ii) The decision to halt Temperature Gradient Holes (TGH) drilling activities in both Kibiro and Panyimur until a comprehensive Environmental and Social Impact Assessment (ESIA) is conducted; (ii) Undertaking environmental clean-up and remedial mitigation efforts

3 GoU (2020). Clarification on Oil Spill Incident at Kibiro Kigorobya sub-county, Hoima district. Press Release April 15, 2020. Ministry of Energy and Mineral Development (MEMD), Entebbe.

to restore the environment; (iv) MEMD to support a culture of effective stakeholder and community engagement as a way of enhancing decision-making processes and embedding the practice as an integral part of its operations.

The Ministry's press-statement was preceded by recommendations from Uganda's National Environment Management Authority (NEMA) advising the Ministry to conduct a detailed scientific study and to immediately embark on clean-up exercise. NEMA's recommendations were based on the fact that; (a) Kibiro Geothermal Project is in a sedimentary environment, implying that the likelihood of encountering oil and gas formations are high (the project is located between Waraga and Taitai Oil Discoveries); and that (b), a thin gas/oil bearing zone had been encountered during drilling of the last geo-thermal well in Kibiro implying that there is a likelihood that the spill contained elements of oil, gas and other hydrocarbons.

In May 2020, MEMD conducted the study which unfortunately did not test for presence of petroleum hydrocarbon contaminants in the spilled material. The Civil Society Coalition for Oil and Gas in Uganda (CSCO) sought to address this gap by conducting a comprehensive study that focused on the assessment of the level of concentration of petroleum hydrocarbons and heavy metals in the spilled material on the environment, as well as documenting community members' perspectives regarding impact of the spill on their socio-economic well-being.

1.3. Objectives of the study

The purpose of this study was to assess the environmental and socio-economic impacts of the blow-out and the resultant spillage in Kibiro Parish, Kigorobya Sub-county Hoima district. The specific objectives were.

i. To assess the level of compliance with national and international industry best practices for geothermal surveys, spill management, and pollution control.

ii. To determine the level of pollution caused by the spill by assessing concentration of petroleum hydrocarbons and heavy metal elements in water and soil resources at Kibiro spill area and surrounding communities.

iii. To assess the socio-economic impact of the spill on Kibiro community, Hoima district.

iv. To generate evidence-based recommendations for management of geothermal spills.

SECTION II: STUDY AREA, SCOPE, APPROACH AND METHODOLOGY

2.1 Study Area

The Kibiro geothermal area is located on the Eastern shores of Lake Albert with key structures being the Kachuru and Kitawe faults (NNE-SSE).[4] The faults intersect the Albert Rift in the Kachuru and Kibiro villages. The field is divided into two, having distinct geological features. To the East, it is dominated by crystalline volcanic rocks (granites and granitic gneisses). The west is dominated by thick (~5.5 km) sequences of sediments, with no volcanic rocks at the surface.[5] Surface manifestations are found in the western section on the shores of Lake Albert. They include hot and warm springs at Kibiro characterized by the presence of Hydrogen Sulphide, Fumarolic activity at Kachuru, Calcite and Sulphur deposits. These exhibit temperatures of up to 86.4 °C with flows of ~7 l/s (Bahati et al., 2010). The Geothermal Project where the spill/blowout occurred is located between two oil well discoveries, that is; Waraga and Taitai discoveries.[6]

In the floodplains of the area, is an eco-tourist site commonly known as 'Kibiro springs' (A community UNESCO site) and the shallow inshore belt of Lake Albert which is located a few meters from the spill area (approximately 80 meters). Kibiro community hosts a total of 8 geo-thermal wells drilled at the time of the study. The parish has 4 villages but of importance to this study, there were two villages, that is; Kachuru, and Kibiro villages. The two villages (at the time of the study) had 147 households with a total population of over 1,000 people most of whom were business people at the landing site in Kachuru village on the shores

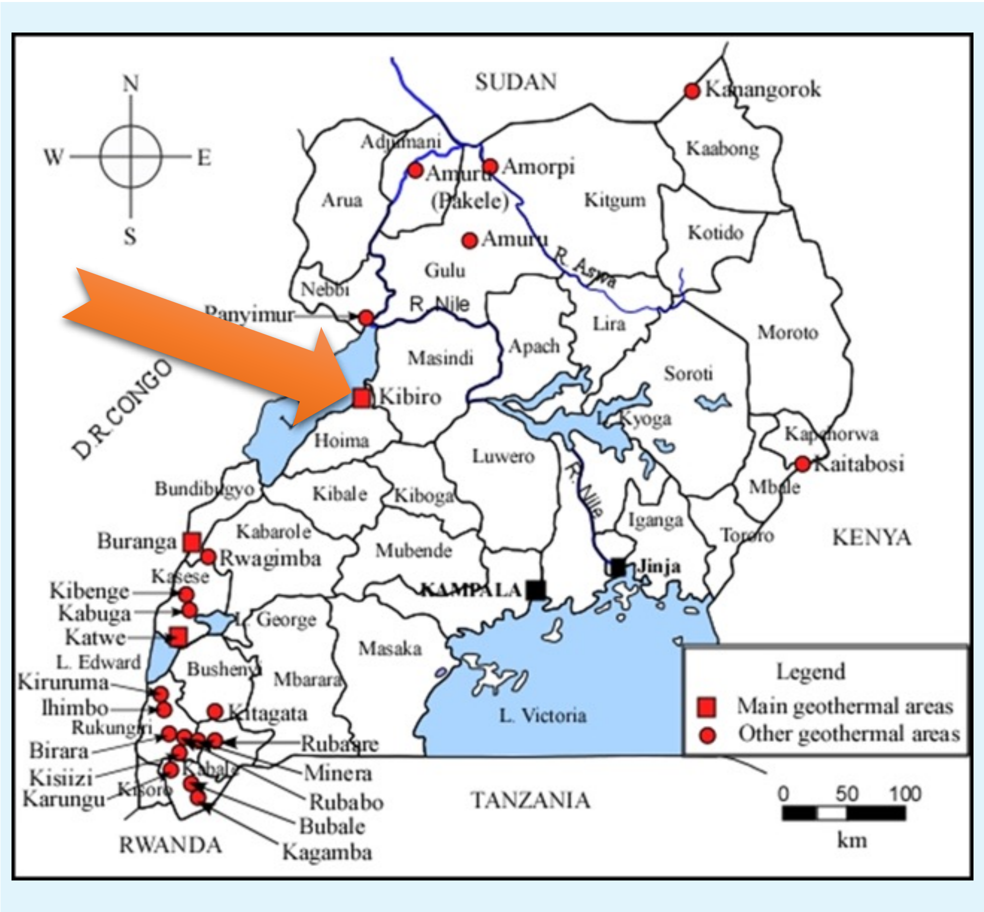
4 Mbanga (2020). New national policy targets geothermal energy usage. The Observer January 14, 2020

5 Bahati, G., Vincent, K. and Catherine, N., 2010. Geochemistry of Katwe-Kikorongo, Buranga and Kibiro Geothermal Areas, Uganda. In Proceedings of the World Geothermal Congress, Bali, Indonesia (pp. 25-29). https://www.geothermal-energy.org/pdf/IGAstandard/ARGeo/2010/Bahati.pdf

6 GoU (2020). Brief on the Geothermal Project Drilling Incident which occurred at Kachuru landing site on the shores of Lake Albert in Kibiro Parish, Kigorobya sub-county, Hoima district. National Environment Management Authority (NEMA), 3rd April 2020, Kampala.

of the lake (secondary receptor of run-off from the Kibiro spill).

Figure 1: Map of Uganda showing location of different geothermal energy resources (See Orange arrow pointing at Kibiro geothermal area)



2.2. Scope of the study

The study assessed the environmental and socio-economic impacts of the blow-out and the resultant spillage in Kibiro community. The study focused on determining concentrations of hydrocarbons and heavy metal elements in soil and water resources in relation to background elemental values, national thresholds, and 'world average limits". Geographically, the study was restricted to Kibiro Parish in the villages of Kachuru and Kibiro. The selection of these villages was based on their closeness to the spill area. For instance, Kibiro village is the host community of the geo-thermal well where the spill occurred while Kachuru village hosts the landing site which is located approximately 300 meters from the spill area.

The study commenced with document review in September 2020; followed by field visits in October and ended in November 2020 with data analysis, report presentation and validation meetings. Validation meetings were held with selected members of CSOs, CBOs, and networks working on Energy and the Extractives industry in Uganda.

2.3. Approach and methodology

Given the nature of the study (involving assessment of socio-economic impacts, and laboratory analysis), a mixed research approach was applied where both qualitative and quantitative techniques were utilized. Thus, the study had two core components, that is; (a) the Sample collection component; and (b) the social appraisal. For the social appraisal, social research methods such as face-to-face individual interviews, Focus Group Discussions (FGDs), and self-administered questionnaires were utilized. For bio-chemical sample collection, soil and water samples were strategically collected and taken for laboratory analysis. Further still, to effectively apply both techniques in a study of this nature, the study area was divided into three distinct zones as follows.

Zone 1 which involved in-situ sampling units at the Kibiro spill area. In this study, zone one was assumed to be contaminated by the spill material.

Zone 2 involved the shoreline areas of Lake Albert located approximately 80 meters from the spill area. Thus, zone 2 encompassed the shallow inshore belt of Lake Albert (secondary receptors of run-off from the Kibiro spill). Zone two was meant to represent environmental conditions (water and soil quality conditions) after leachate from the spill area (zone 1). This zone had soil mixed with water sources (ponds and lake water). Thus, zone two was selected to gauge the extent of attenuation of pollution discharged from the spill area.

Zone 3 was the control area and included the human communities located before reaching Kibiro village. The areas considered in zone three were those at a distance of at least 1km-5km before the spill area.

The location of Zone three away from the spill area was meant to give the baseline environmental conditions (water and soil quality conditions) of the study area before the spill. Zone three was not suspected to be contaminated by leachate from the spill due to their location with respect to hydrologic and spatial influences. Thus, results from this zone were compared with those from zones one and two to assess the impact of the spill on water and soil quality.

2.4. Social survey

Qualitative data was collected through a household survey using questionnaires, focus group discussions (FGDs) and interview schedules. Sample size was determined using Slovin sampling formula n=N/1+N (e) 2 where 'n' is sample size, 'N' is total population and 'e' is the acceptable error tolerance i.e. allowed probability of committing an error in selecting a small representative population (Tejada and Punzalan, 2012). Error tolerance was determined by subtracting the desired confidence level from 1. In the current study, the confidence level selected was 95% hence 'e' was determined by 1-0.95 = 0.05. A 95% confidence level and 5% error tolerance were used in sample determination as recommended by Tejada and Punzalan (2012) when using Slovin formula to have a fairly representative sample. Slovin formula was selected because it is considered to be the most optimal option in situations of inadequate information on the study population (Byakagaba et al, 2018) and is one of the methods that blend well with FGDs. According to records from Kibiro Parish (LCII records) (2020), the study area had a total of 147 households; of these, a sample of 107 households was randomly selected using Slovin formular.

Thus, the following data collection methods and techniques were applied;

Review and Analysis of relevant literature (Desk Review of Documents)

Literature was reviewed to obtain background and secondary baseline information on all variables of the study. Literature review also aided in contextualizing the regulatory and institutional framework relevant to the control and management of spill incidents in Uganda. Key among the documents reviewed included; the National Environment Act (2019), The Petroleum (Exploration, Development and Production) Act (2013), UNBS (US) EAS portable water standards (2014), Alberta Tier 1 Soil and Groundwater Remediation Guidelines (2019), The World Health Organization (WHO) Guidelines for drinking water 4th Edition (2011); other documents included GoU reports and publications on Kibiro spill; and published scholarly material on spills, human rights and environmental protection.

Key Informant Interviews (KIIs)

A total of six (6) information-rich KIIs were identified and requested to provide data and they consented. Three KIIs were held with district Local Government leaders in Hoima (Natural Resources Officer, Production Officer, Senior Community Development Officer, and Deputy Chief Administrative Officer). One (1) KII was held with representative of the Bunyoro-Kitara Kingdom in charge of environmental matters, and one (KII) was held with the community leaders in Kibiro. The purpose of KIIs was to generate structured views from key stakeholders and for triangulation of data collected using other methods.

Plate 1: Interview session with Hoima district Local Government leaders

Household survey using questionnaires

Questionnaires were responded to by 107 spill-affected persons in Kibiro and Kachuru villages. The main aim of administering questionnaires was to collect useful information on community members' understanding of the spill, perceived level of impact on their livelihoods, and the proximity of households and social amenities to the spill area. The method also aided in generating community members' views on the awareness of the dangers of hydrocarbon spills in relation to commitments made by Uganda's Ministry of Energy and Mineral Development (MEMD) about the spill.

Focus Group Discussions (FGDs)

A total of 3 FGDs were conducted with opinion leaders (1 FGD), fishing groups (1 FGD), and persons whose properties (homesteads, fishing nets, businesses, and livestock) were directly affected by the spill both in-situ and surrounding areas. Special attention was paid to vulnerable and marginalized groups such as women, youth, persons with disabilities, and the elderly to determine whether there were any variations in social and economic impact of the spill among these groups.

Plate 2: FGD with members of the Banyakibiro Fishing Group

Validation meetings and workshops

Validation meetings and workshops were held with selected members of civil society organizations working on mining, and oil and gas related issues in Uganda. The purpose of validation meetings was to enable the research team generate more information and recommendations on the general management of spills in Uganda so as to further improve the draft report. Having conducted the study during COVD19 pandemic with strict Standard Operating Procedures (SOPs), both virtual and minimal physical meetings (of smaller numbers) were conducted.

2.5. Soil and Water sample collection and treatment

Sample collection procedure and quality control applied: During sample collection, composite sampling strategy was used as recommended by Biswas et al (2011) for spill and hazardous waste contamination. Surface soil samples were taken in a diagonal zig-zag pattern to obtain one composite sample using a soil auger and shovel. Soil samples (1 kg each) were collected from the top 5 cm layer from an area of one square meter (composite sample). For each of the composite samples, at least 4 sub-samples were collected and quartered in a basin, thoroughly mixed for homogeneity, and the remainder safely discarded. Samples were then put in plastic bags marked with information concerning sampling unit, location, other land-use activities observed in the area, geographical coordinates, and time of the day taken among other details (see appendix-ii for geographical coordinates of each of the samples).

Soil sampling and treatment: Onsite and offsite soil samples were collected from the Kibiro spill incident area and catchment areas. A total of 12 Soil samples were collected comprising 3 samples from the spill well-head area (n=3), 1 from the compound of the spill affected person (zone 1), 2 samples from the shores of L. Albert (n=2) (zone 2), and 3 samples from Kibiro geothermal gradient hole-7. From the control area, 3 soil samples were collected. The inorganic chemical pollutants determined in soil included Chromium (Cr), Iron (Fe), Lead (Pb), Manganese (Mn), and Nickel (Ni). These metal elements were considered over others because of their toxicological profiles and danger on environment and human health. Secondly, unlike other metal elements, Cr, Fe, Mn, and Ni are among metal elements which are not distributed in a similar manner between geothermal waters and other surface water sources (apart from hot springs),[7] thus, making selection of such elements relevant for this study. The organic elements included Total Petroleum Hydrocarbons (THC) – C10-C40. Soil samples were air dried, homogenized by grinding 5.00g of the sediment samples, weighed and digested in acid mixture of equal ratios (5m/HNO3, HClO4, and 5ml HF) for analysis.

Water sampling and treatment: A total of 6 water samples were collected out of which 5 samples were from Zone 1 (collected within a distance of 60m and 100m from the spill area). From the control area (1km distance before the spill area), 1 water sample was collected. Water samples were collected using sterilized plastic bottles. Samples were then filtered through 0.45µm Millipore filters to remove any debris particles and acidified using 2 mL of HNO3 (Nitric acid) to prevent sorption on containers before taking them for laboratory analysis. The inorganic chemical pollutants determined in water included; Aluminum (Al), Chromium (Cr), Iron (Fe), Lead (Pb), Manganese (Mn), and Nickel (Ni). The organic elements included; Total Petroleum Hydrocarbons (THC) – C10-C40.

Laboratory analysis: Water and soil samples were transported to EnviroServe Chemistry Laboratory (an internationally certified company to conduct laboratory analysis of hazardous oil and gas waste and other related hydrocarbon contaminants) located in Nyamasoga, Hoima district. Soil samples were sub-contracted by EnviroServe to a national laboratory in Entebbe[8] for heavy metal analysis. At both laboratories, heavy metals were determined with atomic absorption spectrophotometry, using a Perkin Elmer.

2.6. Data analysis

The collected data was analyzed quantitatively using MINITAB 14th Edition to generate descriptive statistics for concentrations of heavy metal elements (inorganic pollutants) and Total Petroleum Hydrocarbons (TPH) in water and soil samples. A two-sample t-test was conducted to determine differences between concentration of pollutants at

7 Birkle P. and Merkel B. (2000). Environmental impact by spill of geothermal fluids at the geothermal field of Los Azufres, Michoacán, Mexico. Article in Water Air and Soil Pollution, Technical University of Freiberg, Institute of Geology, Freiberg/ Saxony, Germany

8 Ministry of Water and Environment National Water Quality Reference Laboratory – Entebbe, Uganda

Kibiro spill incident area and at control area. Social Survey data from questionnaires and interview guides was assessed for precision before entering into MINITAB for descriptive statistics on community members' perspectives on issues regarding awareness of the dangers of the spill, economic impact caused by the incident, and perspectives on the impact of government's effort towards remediation (clean-up), and awareness efforts on the dangers of spills on peoples' livelihoods. Data on domestic water sources, soils and socio-economic impacts was analyzed basing on Pearson's correlation, to determine whether there was a linear association between location of spill area and perceived impact on homesteads and other livelihood activities. All statistical tests were conducted at a 5% significance level ($p < 0.05$).

Further still, qualitative content analysis using manifest approach of transcribed data was used to decipher key messages from focus group discussions (Halkier, 2010[9]; Stewart et al., 1990). This further enriched findings from the quantitative methods.

9 Halkier, B., 2010. Focus groups as social enactments: integrating interaction and content in the analysis of focus group data. Qual. Res. 10, 71–89.

SECTION III: FINDINGS

3.1. Compliance with national and international industry best practices and standards

This section presents a summary of international best practices and national policies and laws that govern geothermal surveys and environmental and social sustainability in Uganda. Based on these best practices, inference and reference is made upon which findings are presented with regard to observations made on how the Kibiro spill incident was handled and managed (before, during, and after).

International Best Practices in the geothermal industry in relation to blowouts, environment and social sustainability

'A best practice' is a method or technique that has been generally accepted as superior to any alternatives because it produces results that are superior to those achieved by other means or because it has become a standard way of doing things, e.g., a standard way of complying with legal or ethical requirements. Best practices may include management standards such as ISO 9000 and ISO 14001, IFC World Bank Standards, and the UN Sustainable principles among others. In this paper, literature is reviewed on best practices relating to environmental and social sustainability in the geothermal industry. Some of the best practice sources applied (in this paper) includes; (a) The International Geothermal Association (IGA) & IFC World Bank (2014) best practices guide for geothermal exploration; (b) GeoCom (2015) handbook of best practices of geothermal resources management; and (c) The USA Hawaii Geothermal Blowout Prevention Manual among others.

These best practices require geothermal explorers and host governments to; (i) conduct environmental and social impact assessments before implementation of activities; (ii) informing local communities of impacts of projects, both positive and negative; (iii) fencing of geothermal well sites and ensuring that gates are locked to limit access to grazing animals and community members given the fact that these sites are potentially contaminated with high levels of trace elements and heavy metals; (iv) putting in place blow-out/spill prevention plans and strategies; and (v) ensuring that contaminated sites are cleaned-up and restored near to their original condition, in a timely manner, in order to limit impacts associated with prolonged delays. See appendix I for details about specific requirements of these best practices as they apply to the geothermal industry in relation to environment and social sustainability.

Relevant policies and laws governing geothermal exploration in Uganda

Proper development of geothermal energy is challenging and more often than not requires a robust government policy (Zakkour et al., 2016). Although there is currently no substantive policy or clear legal framework governing geothermal operations in Uganda, the sub-sector is regulated through a number of other national laws and policies. Key among these includes; The Energy Policy 2002 (at the time of this study, government of Uganda through MEMD was in advanced stages of repealing and replacing the Energy Policy 2002 to specifically provide for the exploitation of the country's geothermal energy among other new and emerging issues in the energy sector), The Renewable Energy Policy 2007, The Mining Act 2003 (this law is always being reviewed), and the National Environment Act (NEA) 2019. These laws and policies provide for the institutional framework governing the energy sector in general, mandate of the different government MDAs (including MEMD, NEMA, Department of Renewable Energy, urban and district Local Government s among others).

In a nutshell, these policies and laws recognize the need for continued consultations, engagement, and delivery of information concerning renewable energy projects to affected communities and all other relevant stakeholders; the need to conduct ESIAs prior to exploration of geothermal energy (schedule 5(3)(b) of the NEA 2019). Particularly, Sections 79 and 80 of the National Environment Act 2019, place the responsibility of clean up and restoration of polluted environment to the person responsible for the pollution, and by extension, to pay compensation for the damage caused in accordance with the NEA Act and any other applicable law. See appendix I for further details concerning relevant policies and laws governing geothermal exploration in Uganda and mandate of the different MDAs in relation to geothermal energy.

3.1.1. Good practices observed

Timely Response: There was relatively quick response by the Multi-stakeholder committee spearheaded by Uganda's Ministry of Energy and Mineral Development (MEMD) and the National Environment Management Authority (NEMA). The research team observed that although the spill occurred during total lockdown of the country (due to the COVID 19 pandemic), MEMD was able to constitute a multi-stakeholder team which visited the site a few days (3-4 days) after the incident to establish the facts in respect to cause of the spill, impact, and possible post-incident interventions. A review of reports from various government agencies (such as that by MEMD, 2020; and NEMA, 2020) and information from key informant interviews indicated that the multi-stakeholder team involved all relevant government regulatory bodies among which included; the Directorate of Geological Surveys and Mines, Ministry of Water and Environment (MWE), NEMA, Petroleum Authority of Uganda (PAU), Environment Protection Police Unit, Health Safety and Environment Unit, MEMD, Hoima District Local Government and the Senior Presidential Advisor on Oil and Gas and Mining.

Reports concerning the spill were produced on time and shared with Local Leaders: It was established through document review and interviews that there was timely production and sharing of reports concerning the incident. For instance, the multi-stakeholder committee report was published two (2) weeks after the incident (The initial report was published in form of a press-statement by MEMD on the 15th of April, 2020). Similarly, the Ministry conducted a detailed scientific study whose findings were shared with other relevant government agencies including local leaders in Kibiro community. Although this is a commendable practice, it was established that the local leaders in Kibiro could not ably interpret the technical findings presented in these reports. As such, community members were not sure whether the pollution inflicted by the spill onto the local environment was within acceptable limits or not – for public health, and continued use and consumption of environmental resources (especially fish, water, and soil resources).

Community Consultation: There was general acknowledgement among community members that the Geo-Thermal Company (Ms Royal Techno Industries Ltd) and MEMD consulted them before implementation of the project in compliance with international best practices for geothermal energy development which require geothermal explorers to consult project affected communities throughout the process of geothermal energy operations. However, there was also general out-cry among community members that most of the commitments made by the company and MEMD were not met. The unmet promises cited by community members included compensation, express handling of grievances, and continued information and updates about the project. It was further established that even the promises made by MEMD after the spill (such as the commitment to undertake – with immediate effect – environmental clean-up and remedial mitigation efforts to restore the environment) had not yet been met at the time of this study (7 months after the incident).

3.1.2. Practices that require improvement

A number of issues relating to inadequate management of the Kibiro spill and other related environmental management matters were observed. Some of these were due to operational and institutional weaknesses while others were a result of gaps in the existing legislative frameworks. These are presented and discussed as follows.

Preparedness by district Local Governments to deal with spills: Interviews with Hoima Local Government leaders about the spill in Kibiro revealed that the district has very little responsive capacity – even to send staff to a spill location once an incident is reported. This situation is inappropriate in so far as sustainable mining and oil production are concerned. Moreover, Section 28(1) (f) of Uganda's National Environment Act (NEA), 2019 gives Local Governments (through the District Environment and Natural Resources Committees) the mandate to monitor all activities within their local jurisdiction to ensure that such activities do not have any significant impact on the environment; in addition, Section 29 of the same Act establishes Environment and Natural resources conditional grants to all districts, cities, municipalities, town councils and sub-counties partly aimed at empowering Local Governments deal with such environmental emergencies. However, in the last one and half (11/2) years since its establishment, very few resources if any have been allocated towards this purpose. As such, Local Governments (especially those in Uganda's Albertan Graben) have been left with no proactive capacity for spill detection, response, and monitoring. It was established during interviews with Local Government leaders in Hoima that the district relies on actions from the Central government and reports from drilling companies and civil society for information concerning environmental monitoring in the mining, and oil and gas sector.

The question of mandate in regard to cleaning-up a contaminated site: The existing Ugandan laws (NEA, 2019; Petroleum EDP, 2013; and the Mining Act, 2003) are non-committal when it comes to the question concerning which government agency is in charge of cleaning-up sites contaminated by spills of varying nature and magnitude. The National Environment Act places the mandate of coordination of lead agencies in their preparedness and response to environmental emergencies or disasters to NEMA; however, the NEA does not empower or assign responsibility of clean-up and remediation to any government agency. The sections of the NEA that come close are sections 80 and 130 which place strict liability to the polluter and provide for environmental restoration respectively, but still, none of these sections addresses the question of mandate or the required command and control structure in the event of a spill (such as Kibiro spill) or management, remediation and clean-up process of the same.

The Oil Spill Contingency Plan which is expected to address this gap, was still in its draft form at the time of this study, and is biased towards addressing oil and gas related spills. There is thus, no clear legislation addressing the issue of spills from other sectors such as Geo-thermal operations. In the absence of such clarification, and in extreme cases, government bodies such as NEMA and MEMD are likely to take differing approaches to interpreting the rules. It is not surprising therefore, that at the time of this study (7 months after the spill incident), no clean-up work had been commissioned and the heap of spill material was still present at one of the community member's homestead (Mr. Julius Kiiza) contrary to international industry best practices which require immediate effort to clean-up the affected area so as to minimize negative impacts associated with prolonged delays (Hawaii blowout prevention standards, 1994; IGA & IFC, 2014; and Helmy & Kardena, 2015).

Plate 3: Heap of spilled material (mixture of sand, clay, and cuttings) at the entrance of one of the affected community member's house

Non-compliance with Environmental and Social Impact Assessment (ESIA) requirements: It was established that Kibiro Geo-Thermal Project did not undergo the mandatory ESIA Process. Schedule 3(4) (d) of the repealed National Environment Act (NEA), 1995, as is the case with Schedule 5 of the NEA, 2019, require geothermal drilling projects to undergo mandatory ESIA process. In the same way, sources of international best practices such as GeoCom (2015) and IGA & IFC World Bank (2014) all encourage geothermal explorers to conduct environmental and social impact assessments before implementation of projects, especially in countries where this is a mandatory requirement. It was established through document review that at the time MEMD awarded a drilling contract to M/s Royal Techno Industries Limited to drill sixteen (16) Shallow Temperature Gradient wells in Kibiro and Panyimur areas (on 11th November 2019),[10] the new National Environment Act (which subjects such projects to the mandatory ESIA process) was already in place (7th March 2019) but was never complied-with.

Non-compliance with the requirement to fence-off geothermal drilling sites: Best Practices published by the International Geothermal

10 GoU (2020). Clarification on Oil Spill Incident at Kibiro Kigorobya sub-county, Hoima district. Press Release April 15, 2020. Ministry of Energy and Mineral Development (MEMD), Entebbe.

Association (IGA) & IFC World Bank (2014) as well as those contained in the Hawaii Handbook (1994) for geothermal explorers, require geothermal operators and host governments to ensure that geothermal drilling sites or production units are adequately fenced and gates locked to prevent grazing animals and community members from accessing geothermal drilling sites, given the fact that these sites are potentially contaminated with high levels of trace elements and heavy metals. This requirement was not observed in the Kibiro geothermal project, as none of the 8 drilling sites was fenced, as such, domestic animals were observed grazing at Kibiro geothermal gradient hole-4 where the spill occurred.

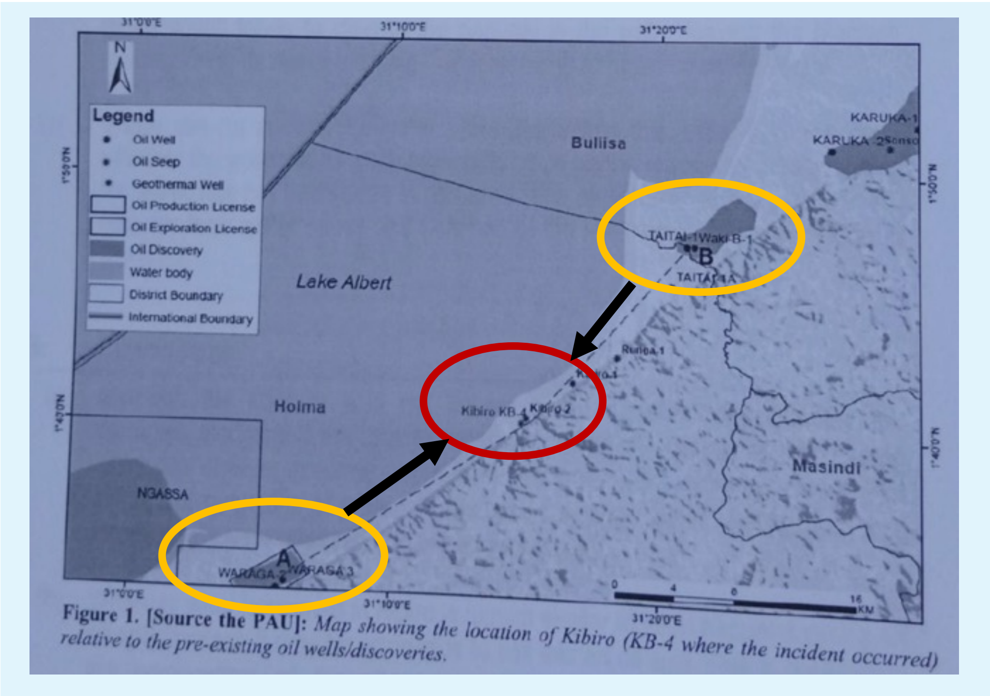
Plate 4: Domestic animals grazing from unfenced geothermal spill area at Kibiro Geothermal Gradient Hole-4

3.2. Concentration of petroleum hydrocarbons in soil and water resources

Regarding presence of hydrocarbons in the spilled material, results indicated that there were no petroleum hydrocarbons (C10-C40) in water and soil samples (including the original spill liquid) as all elements were below detection limit of the atomic absorption spectrophotometry (table 1).

It should be noted that the severity of the contamination by petroleum hydrocarbons depends on the type of oil involved. Lighter oil tends to seep through the topsoil and continue to move quickly through the layers of soil, while heavier oil does the opposite.[11]

Figure 2: Map showing location of the geo-thermal spill area (marked with red circle) relative to the pre-existing oil wells (marked with yellow circles)



11 Helmy Q., and Kardena E., (2015). Petroleum Oil and Gas Industry Waste Treatment; Common Practice in Indonesia. Journal of Pet Environ Bio-technology 2015, 6:5 http://dx.doi.org/10.4172/2157-7463.1000241

Table 1: Results for presence of petroleum hydrocarbons in water samples

Sampling Unit	Description	Element - TPH (C10-C40)
S1	Lake (middle of the affected area)	BDL
S2	Lake (Right side of the affected area)	BDL
S3	Lake (Left side of the affected area)	BDL
S4	Liquid from the original spill material	BDL
S5	Drinking water from home of the spill affected person	BDL
S6	Control area (1Km before the spill area)	BDL
S7	Control area (3km before the spill area)	BDL

BDL – Below Detection Limit

3.3. Concentration of heavy metals in soil and water resources

This section presents findings on concentrations of heavy metals in water and soil resources in the study area. The heavy metal elements considered for this study include Chromium (Cr), Iron (Fe), Lead (Pb), Manganese (Mn), Aluminum (Al), and Nickel (Ni).

3.3.1. Concentrations of heavy metals in water samples in the study area

Section 4.4 of this research paper shows that majority of people in Kibiro community depend on water from Lake Albert for drinking and other domestic purposes. In the current study, a total of 6 water samples were collected, wherein; 3 were collected from Lake Albert (approx. 80 meters from the spill area); one (1) from the homestead of the spill affected person (approx. 60 meters from the spill area); and one (1) sample from the original spill material that had been kept by one of the community members. The sixth sample was collected from the control area located approximately 1Km before the spill area. Samples from the control area were assumed not to be affected by the spill due to upslope location and distance from the spill area. Therefore, results of samples from the spill's area of influence (Lake Albert, homesteads, and liquid from the spilled material) were compared with those from the control area and with the Uganda National thresholds for drinking water so as to enable qualitative and quantitative assessment of the level of pollution. See table 2.

Table 2: Concentration of heavy metals in water samples

Sampling Unit	Description	Element in mg/kg					
		Aluminum (Al)	Chromium (Cr)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Nickel (Ni)
1	Lake (middle of the affected area)	0.4	0.0	0.8	0.0	0.1	0.0
2	Lake (Right side of the affected area)	0.1	0.0	0.3	0.0	0.0	0.0
3	Lake (Left side of the affected area)	0.7	0.0	2.4	0.0	0.4	0.0
4	Liquid from the original spill material	0.3	0.0	0.6	0.0	0.5	0.0
5	Drinking water from home of the spill affected person	0.2	0.0	1.0	0.0	0.2	0.0
6	Control Area (1km before the affected area)	0.1	0.0	0.9	0.0	0.8	0.0
National Standard*		**0.2**	**0.05**	**0.3**	**0.01**	**0.1**	**0.02**

*GoU (2014)[12]

Concentration of Aluminum (Al) at all the sampling units in the spill area of influence was higher than those at the control area and the Uganda National threshold for Al in drinking water. The table further reveals that although other elemental concentrations such as Iron (Fe) and Manganese (Mn) exceeded the national thresholds for drinking water, these were equally high at the control area. This suggests that except for Aluminum (Al) which exhibited concentration levels higher than the elemental background levels at the control area (> 1 km away), the high concentration of other heavy metals (Iron and Manganese) in water sources at Kibiro (study area) could be a result of both the known area's mineralogy and geology, and contamination from the Kibiro geo-

12 GoU (2014). UNBS (US) EAS Portable water standards, First Edition 2014-10-15. Uganda National Bureau of Standards (UNBS), Kampala

thermal spill.

3.3.2. Concentrations of heavy metals in soil samples in the study area

A total of 12 Soil samples were collected from two sites, that is, from Kibiro Geo-thermal Gradient Hole-4 (the publicized spill area), and from Kibiro Gradient Hole-7 (unpublicized spill area approx. 500m away from Gradient hole 4). Kibiro Gradient Hole-7 was considered for study due to community members' insistence that several spills had occurred from this Geo-thermal Gradient Hole (Kibiro Gradient Hole 7) before the publicized incident at Kibiro Gradient Hole-4. Thus, table 3 presents results of soil samples at Kibiro Gradient Hole-4 spill area while table 4 presents those at Kibiro Gradient Hole-7. Results were compared with elemental background concentrations at control area (> 1 km away) and with 'world average crustal values' for surface soils. The elements considered for analysis in soil included Chromium (Cr), Lead (Pb), Nickel (Ni), Iron (Fe), and Manganese (Mn).

3.3.4. Concentration of heavy metals in soil samples at Kibiro-4 spill area and downslope

Table 3 shows that concentrations of all metal elements considered for the study (Cr, Pb, Ni, Fe, and Mn) at all sampling units at Kibiro-4 spill area were several times higher than background values at the control area and 'world average crust values' for surface soils. For instance, at the well-head area, Chromium (Cr) was 240 times higher compared with elemental background concentrations for Cr at the control area (> 1km way) and 12 times higher than recommended world average for Cr in surface soils (64 mg/kg).

The heap of spill material at the compound/home of the affected person exhibited concentrations of Cr (633.4 mg/kg) 7 times higher than recommended world average thresholds, Lead (Pb) was 11 times higher, Nickel (Ni) 19 times higher, and Iron (Fe) was 1065 times higher than the world average threshold for Iron (Fe) in soils. The extraneously high levels of heavy metal concentrations observed in soils at the spill area (zone 1) and surrounding areas/downslope (zone 2) suggest that the health of people and animals could be at high risk. It should be noted that long term exposure to even small quantities of heavy metals such as Lead (Pb), Copper (Cu), Nickel (Ni), Chromium (Cr), and Manganese (Mn) among others, all of which are present in the Kibiro spill, can lead to long term serious health problems and have exhibited a propensity to accumulate in the human body, causing irreversible damage,[13] [14] and death. Mere breathing in of dust or even skin contact with contaminated soil may also affect human health and that of domestic animals (see Chapman and Reiss 1995[15]; Mackey et al. 1996[16]).

Plate 5: Domestic animals feeding on the abandoned spill material in the compound of Mr. Julius Kiiza (the affected person)

13 Adeniyi, A. A. (1996). Determination of cadmium, copper, iron, lead, manganese and zinc in water leaf (Talinum triangulate) in dumpsites. Environmental International, 22, 259–269.

14 Key among the documented health effects associated with ingesting soil, food, or water contaminated with heavy metals includes kidney failure, tumors in some organisms, loss of memory, birth defects, joint and muscle pains, visual impairment, and intestinal problems among other fatal dangers (see Davies 1997 ; Amadi and Nma 1996). Children exposed to Lead (Pb) are at risk for impaired development, shortened attention span, hyperactivity, and mental deterioration, with children under the age of six being at a more substantial risk.

15 Chapman, J. L., & Reiss, M. J. (1995). Ecology principles and applications (pp. 95–108). Cambridge: Cambridge University Press.

16 Mackey, E. A., Becker, R., Demiralaph, R., Greenberg, P. R., Koster, B. J. & Wise, S. A. (1996). Bio-accumulation of vanadium and other trace elements in livers of Alaskan cetaceans and pinnipeds. Archives of Environmental Contamination and Toxicology, 30, 503–514.

Table 3: Total concentration of heavy metal elements in soil at the spill area (Kibiro Gradient Hole 4) and surrounding areas

Sampling Unit	Description	Element in mg/kg				
		Chromium (Cr)	Lead (Pb)	Nickel (Ni)	Iron (Fe)	Manganese (Mn)
1	At the well head (8meters from the well-head)	1049.9	198.4	560.8	278049.1	8359.5
2	50m East of the well head	587.2	157.7	281.2	198209.4	5524.1
3	At the home of the affected	633.4	169.9	369.5	212926.3	5215.2
4	60m from the well-head/downslope	790.0	199.5	417.4	250468.9	8002.3
5	50 meters East of the Lake	1062.6	245.3	391.6	283465.9	5885.5
6	50 meters west of the Lake	727.3	300.0	338.6	218224.0	5532.7
7	Control Area (background soils, 1km away)	4.4	0.0	0.0	2422.2	50.3
'World average' in surface soils (mg/kg)		**64[b]**	**15[a]**	**45[b]**	**200[a]**	**350-2000[a]**

[a]Kabata-Pendias (2011); [b]Alberta Environment and Parks (AEP) Guidelines. 2019

3.3.5. Concentration of heavy metal elements in soil at Kibiro-7 and surrounding areas

At Kibiro-7 and surrounding areas, all heavy metals of concern at all sampling units exhibited concentration levels higher than those at control area (> 1km away/before the site) and several times greater than the recommended 'world average' thresholds for Chromium, Lead, Nickel, Iron, and Manganese in surface soils. For instance, concentration of Nickel (789.5 mg/kg) at Kibiro-7 well head area was three times higher compared with background values at the control area (252.4 mg/kg), and 40 times higher than the recommended 'world average' limit of 45 mg/kg for Ni in surface soils. Lead (Pb) was two times higher compared with elemental background values at the control area and was seventeen times greater than the recommended 'world average' threshold for Pb (15 mg/kg) in surface soils (see table 4). This finding indicates that the spill did not only occur at Kibiro geo-thermal gradient hole-4 (as was reported by the MEMD multi-stakeholder committee) but may have also occurred at Kibiro-7 (as was reported by community members in Kibiro). Therefore, clean-up and remediation actions should be extended to both sites including their areas of influence and surrounding communities.

Table 4: Total concentration of heavy metal elements in soil at Kibiro Gradient Hole-7 and surrounding areas

Sampling Unit	Description	Element in mg/kg				
		Chromium (Cr)	Lead (Pb)	Nickel (Ni)	Iron (Fe)	Manganese (Mn)
1	At the well head area (10 meters from the well-head)	1668.6	255.4	789.5	365373.7	9220.5
2	50m south of the well head	1054.5	159.9	538.0	254313.6	6558.7
3	60m south west of the well-head (close to the nearest homestead)	1214.0	218.9	619.7	295269.1	8135.0
4	Control Area (Av. background soils, > 800m upstream)	586.3	144.4	252.4	162096.7	4410.5
'World average' in surface soils (mg/kg)		**64[b]**	**15[a]**	**45[b]**	**200[a]**	**350-2000[a]**

[a]Kabata-Pendias (2011); [b]Alberta Environment and Parks (AEP) Guidelines. 2019

3.4. Potential Impact of the Spill on Community Livelihoods

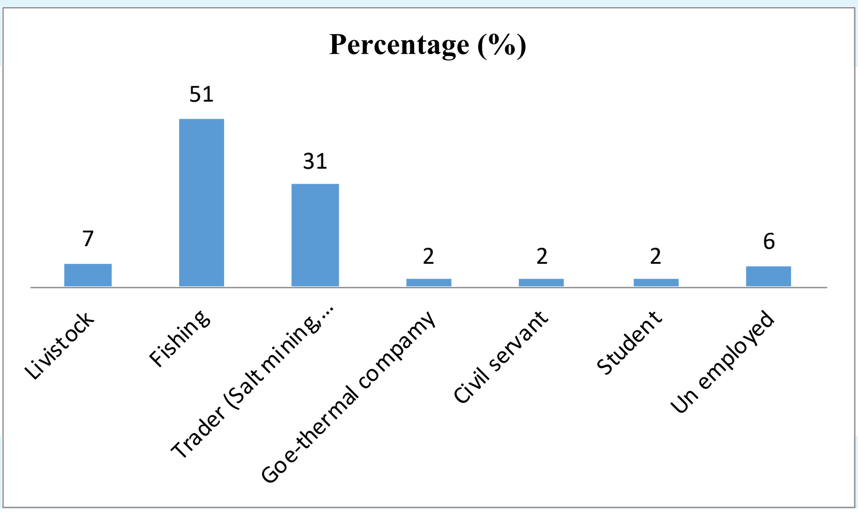
A social survey was conducted using questionnaires, focus group discussions (FGDs), and interviews with affected persons and key informants (see details in section 2.2). The survey collected information on the major economic activities in the study area; sources of domestic water; possible causes of the spill, geographical extent of the spill, and the socio-economic impact of the spill on Kibiro community.

3.4.1. Major economic activities in Kibiro community

Community members in the study area were asked about their main economic activities. In response, majority of them (51%) revealed that fishing is their main source of income followed by trading in items such as foodstuffs, merchandise, and salt-mining (31%) (See fig.3). It was established through FGDs that women were mostly engaged in salt-mining while men and the youths were into fishing. There was strong association between community members' perceived impact of the spill on fishing ($p = 0.952$) than on any other economic activity in the area. What this suggests, is that anything that negatively impacts Lake Albert, would impact the livelihoods of the people in Kibiro and Kachuru villages, as one of the fishing groups in the area (Banyakibiro Fishing Group) put it.

> "Our mother and father is the Lake (refereeing to L. Albert). It fed our forefathers and it is now feeding us and our families, we don't want anything that would jeopardize the quality of the lake. Already, there are three geothermal well-heads submerged by the rising water levels. Should our boats accidentally collide with the submerged well-heads, we fear this could trigger off another spill." (FGD Group)

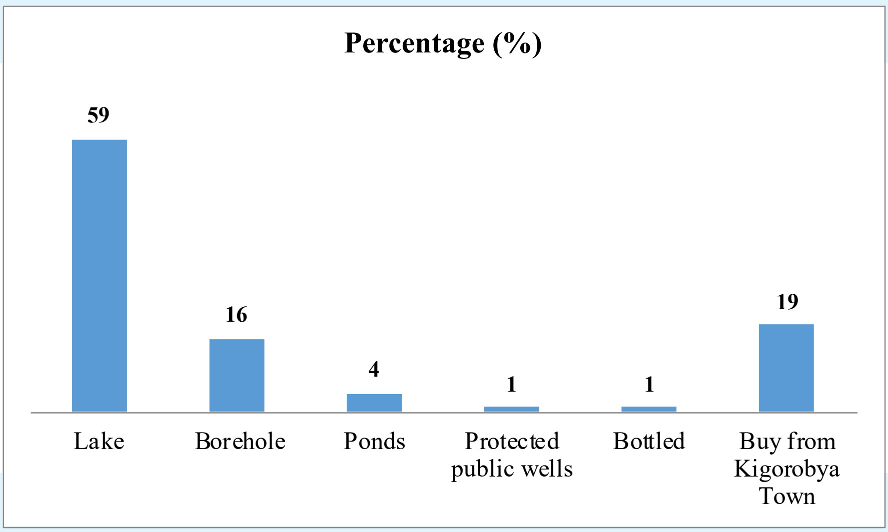
Figure 3: Graphic presentation of responses on economic activities in Kibiro community



3.4.2. Sources of domestic water

Understanding sources of domestic water is one of the key denominators in evaluating the impact of spills and pollution on a community's livelihoods.[17] In the study area, majority of the respondents (59%) revealed that Lake Albert is their main source of water followed by those who buy it from Kigorobya town (located about 12km from the study area) (19%), and those who fetch from boreholes (16%). It was established through interviews with local leaders in Kibiro community, that being a salty lake, water from Lake Albert is used for other domestic purposes other than drinking (it is only those who cannot afford to buy that rely on the lake for drinking water). Drinking water – especially – for those who can afford, buy it from Kigorobya town at UGX 2,000 (USD 0.54) per Jerry-can (a Jerry-can is equivalent to 20 liters). Others (4%) depend on rainwater that collects in ponds. This finding suggests that although Lake Albert is located a few meters from households in Kibiro community, portable water is still inaccessible and therefore, the community is water-stressed and any negative impact on existing water sources adversely affects the people of Kibiro and neighboring communities. The result is presented in fig. 4.

Figure 4: Sources of domestic water in Kibiro Community



17 Bamberger M., & Oswal R.E (2012). Impacts of gas drilling on human and animal health. Scientific Solutions. New Solutions, Vol. 22(1) 51-77, 2012

3.4.3. Proximity of homesteads & water sources to the spill area

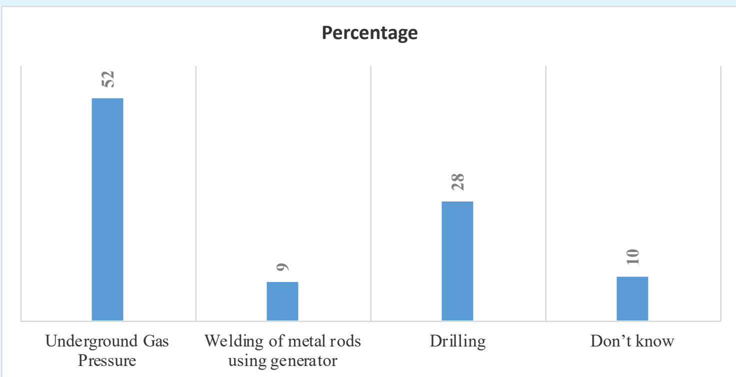
It was observed that the geo-thermal drilling operations were too close to homesteads and important water sources such as Lake Albert, consequently, the spill that occurred was approximately 60 meters from the nearest homestead (downslope); about 80 meters from the shores of Lake Albert; and approx. 2km from Kachuru landing site in Kibiro parish, Hoima district. The Uganda National Environment (Wetlands, Riverbanks and Lake Shores Management) Regulations, 2000 require developers to observe buffer distance from important ecological resources. The regulations require a distance of at least 200m away from lakeshore. Although clearance may have been obtained by the Geo-Thermal drilling company (Ms. Royal Techno Ltd) from Uganda's Ministry of Energy and Mineral Development (MEMD) to conduct business within the 200m distance, such clearance should have been based on scientific studies such as the Environmental and Social Impact Assessments (ESIA) which in the case of Geo-Thermal drilling activities in Kibiro were not adhered to.

Plate 6: Notice how close the spill area is from the nearest homestead and the shoreline of L. Albert

3.5. Possible cause of the Kibiro Spill

Globally, geothermal spills and blowouts are attributed mainly to deep drilling, increase in temperature, and human error.[18] In the current study, it appears the spill was caused due to human error and drilling past a tolerable depth (300m deep) which is not feasible given the sedimentary nature of the area. This observation agrees with community members' views majority of whom attributed the cause of the spill to underground gas pressure (n = 56; 52%) followed by those who believed the cause of the spill was due to drilling past a tolerable depth (n = 30; 28%). The finding is also in conformity with NEMA's observation that the Kibiro spill may have been due to gas pressure and drilling close to 300m deep which is not feasible given the areas geological structure and history. Studies conducted on causes of geothermal spills in other countries (Kruszewski & Volker, 2018; Elders et al. 2014; and Bischoff et al. 1984) show that once critical pressure of the Geothermal reservoir is reached, especially those in the rift valley zones or reservoirs with low or non-existent vertical permeability, expulsion of fluids at temperatures exceeding 400 °C without boiling conditions occurring is inevitable. For instance, in Italy, Croatia, Mexico, and USA, such extreme reservoir conditions and blowouts caused damage to the external environment, casing material, cement sheaths, surface equipment, and led to serious well failures and in many cases to well abandonment and a loss of public confidence in geothermal energy projects (Kruszewski & Volker, 2018).

Figure 5 Peoples' perceptions on the cause of the spill



18 The major cause of most blowouts is human error; either none of the crew or the Operator's advisors recognizes an existing well control problem, or steps to control the situation are not performed soon enough (Patterson & Associates, 1994).

3.6. Level of impact of the spill (geographical extent of the impact)

It was established that although the spill affected Kibiro community economically, environmentally, and socially, the level of impact was not uniform. There was a very strong inverse relationship (-956) between the level of impact of the spill and distance of homesteads from the spill area (Table.6). What this means is that the higher the distance, the lower the impact and vice versa. In essence, people living closer to the spill area felt the impact of the spill more than those living far away. As indicated in table 5, the average distance of those who were mostly affected by the spill was 2.5km from the spill area. This means that the physical impact of the spill did not spread very far.

Table 5. Descriptive Statistics indicating level of impact in relation to distance of the affected homestead and businesses

	Mean	Standard Deviation	N
Distance of homestead from the spill area	2.50	1.291	4
Level of impact on the community	19.00	20.248	4

Data presented in table 5, shows that the mean value for the level of impact is very high at 19 and the average distance between the respondents' households or businesses and the spill area is relatively short at 2.5km.

Table 6. Correlation between level of impact of the spill and the distance from the spill area

		Distance	Impact
Distance of homestead from the spill area	Pearson Correlation	1	-.956*
	Sig. (2-tailed)		.044
	N	4	4
Perceived level of impact on the community	Pearson Correlation	-.956*	1
	Sig. (2-tailed)	.044	
	N	4	4

*. Correlation is significant at the 0.05 level (2-tailed).

3.7. Real Socio-economic impact of the spill

Loss of property

It was established through interviews and focus group discussions with the affected persons that the spill destroyed peoples' property, especially the property of those within a 1 km distance from the spill area. Among key properties lost includes 10 fishing nets belonging to 6 different fishermen, 2 domestic animals, and 3 graves which were covered in the spill material (clay, sand, and drilling waste). The graves that were covered in the spill material belonged to Mr. Julius Kiiza whose homestead is located a few meters (approximately 60 meters) from the spill area. As already indicated in the previous sections of this report, the affected persons had not yet been compensated for the loss occasioned to them by the spill (at the time of the study). Similarly, the drying mixture of clay, sand, and drilling waste that spilled from the geo-thermal gradient hole was still present at the compound of Mr. Julius Kiiza (7 months after the spill incident) despite the fact that NEMA had recommended quick removal and clean-up of the affected person's homestead.

Plate 7: One of the fishermen in Kibiro community showing some of his nets destroyed by the spill

Disruption of fishing activities

Although findings in section 3.2 of this report revealed that there was no pollution related to petroleum hydrocarbons (C10-C40) in water samples taken from the shoreline of L. Albert, community members claimed that fish was heavily contaminated by elements of petroleum hydrocarbons from the spill, especially during the first 2weeks after the spill incident. They claimed that contamination of fish was exhibited in form of paraffin-like smell which made it hard for them to consume fish during that period. Fishermen from Kachuru landing site added that during this period they made business losses as consumers from both local markets and outside Kibiro community were not buying from them with a belief that fish from Kachuru landing site had been contaminated by the spill material. Findings from focus group discussions with Banyakibiro fishing association (a fishing group in Kibiro community) revealed that the effect of this disruption lasted for at least 2 months after the Kibiro geothermal spill incident.

Tension and unrest among community members

There was tension and unrest among community members fearing that the spill could re-occur. This was due to the fact that, at the time of the study, at least 3 of the 8 geothermal gradient holes in Kibiro had been submerged in water due to rising water levels of the lake (Lake Albert). Fishermen expressed fear that their boats might accidentally collide with the submerged geothermal rigs hence triggering-off another spill. The foregoing notwithstanding, community members expressed fear that their health could be at risk citing examples of the delayed remediation works which had not commenced 7 months after the spill incident. They further attributed the cause of their fear to a lack of feedback from Uganda's Ministry of Energy and Mineral Development (MEMD) from whom they expected answers regarding; (a) level of pollution associated with the spill and its impact on environment and public health; and (b) safety measures they needed to take in order to protect themselves from the negative and cumulative health impacts of the spill. During one of the focus group discussions about the effects of the spill and how community members had so far responded to the negative impacts, this is what they had to say;

> "We think our lives are at stake, ever since the spill occurred, no one has come back to tell us whether we are safe or not. We saw a group of government officials a few days after the spill but they have never come back to talk to

> us, so we don't know what to do. Some of us even fear consuming anything from that lake (referring to L. Albert) but we have nothing to do. We are told that they came (referring to government representatives) and gave a written report to our chairman, but we don't even know what is in that report as they never engaged us to interpret for us what's in the report".

The foregoing statement implies that Ministry of Energy and Mineral development (MEMD) did not heed to the commitment made in the press statement of 15th April 2020 wherein the Ministry committed to continue informing, involving, and empowering community members of Kibiro and other stakeholders regarding decisions about the spill and matters that may affect them.

Mistrust and suspicion among community members

The study established that there is mistrust and suspicion among community members due to unmet promises related to delayed compensation of land taken for the development of geothermal energy fields in Kibiro, delayed compensation for the property lost due to the spill, and failure to handle grievances emanating from the spill. For instance, while 100% of the respondents appreciated government of Uganda and the geothermal exploration company for having consulted them during project development, 82% of these respondents (n = 98) were dissatisfied with the way government and geothermal company had handled affected persons' grievances related to damage caused by the spill. They cited the case of Mr. Julius Kiiza whose house, fishing nets, grave yard, compound, and toilet had been affected by the spill but government and the Geo-thermal company had not yet compensated him at the time of the study. Some community members placed blame on their local leaders (LC Leaders) whom they accused of conniving with the geothermal company to deprive them of any compensation related to the project and the spill that occurred in their community. Experiences from other countries show that negative impacts of geothermal energy projects such as failure to respond to project affected community members' grievances and continued environmental pollution tend to breed mistrust and suspicion among community members in the affected areas leading to a loss of confidence from the public and financial sectors to invest in geothermal energy industry (Mladen et al, 2019; GeoCom, 2015; and IGA & IFC, 2014).

SECTION IV: CONCLUSION AND RECOMMENDATIONS

This section presents the conclusion, and recommendations aimed at improving the process of handling spills in Uganda. The conclusion and recommendations presented in this section are informed by study findings.

4.1. Conclusion

While the spill occurred in March 2019, seven months later, the contaminated sites had not yet been cleaned by the responsible parties (MEMD and the Geo-thermal company in Kibiro). Natural attenuation processes had also not yet reduced pollution levels of some heavy metals such as Aluminum (Al), Chromium (Cr), Lead (Pb), Nickel (Ni), Iron (Fe), and Manganese (Mn) to acceptable levels (especially in soil resources). Findings indicated that the Geo-thermal project at Kibiro did not undergo Environmental and Social Impact Study. As such, there were a number of social and economic injustices caused by the project without any formal impact management plan or system. The affected community members raised a number of issues including but not limited to empty promises by the Geo-thermal company relating to compensation, inadequate handling of community grievances emanating from the project and the spill, and lack of clear feedback from government agencies – particularly MEMD on impact of the spill on peoples' livelihoods, health and environment, all of which could be attributed to absence of formal management tools such as ESIA, and spill contingency plan among other tools.

To address these concerns, and other related issues pointed out in this report, all relevant stakeholders including but not limited to MEMD, NEMA, the Kibiro spill multi-stakeholder committee, District Local Government leaders, Community leaders in Kibiro, CSOs and CBOs among others should pay attention to recommendations pointed out in this research paper.

4.2. Recommendations

Based on gaps identified by the study on impact of the Kibiro spill on environment and socio-economic well-being of people, this section presents some actionable mitigation measures and recommendations that may further guide clean-up exercise, and the implementation of drilling projects in Uganda. The recommendations are categorized according to stakeholder groups such as relevant government MDAs, and Civil Society Organizations (CSOs) and CBOs.

4.2.1. Recommendations for government Authorities (MEMD & NEMA)

Subject all Geo-thermal and exploration projects in Uganda to Environmental and Social Impact Assessments (ESIAs)

Ensure that all Geo-thermal and exploration projects in Uganda are subjected to Environmental and Social Impact Assessments (ESIAs) before implementation, in accordance with Schedule 5 of the National Environment Act, 2019.

Encourage public participation in the ongoing ESIA for Geo-thermal exploration and drilling projects in Uganda

The Ministry of Energy and Mineral Development (MEMD) and Uganda's National Environment Management Authority (NEMA) should ensure that there is wide consultation of all concerned stakeholders including but not limited to the affected community members, local leaders, CSOs and CBOs among others for informed decision making, meaningful input, and public buy-in, into the ongoing ESIA studies for Geo-thermal exploration and drilling projects in Kigorobya, Panyimur, and Kasese.

Government should fast track the clean-up exercise of the affected area

Findings showed extraneously high levels of soil contamination with heavy metals at the spill area and downslope, therefore, there is urgent need for MEMD to fast track the clean-up exercise of the affected community in order to restore the environment near to its original condition in accordance with Sections 57, 79, 91, and 130 of Uganda's National Environment Act (2019) and best practices for remediation of spill contaminated sites. In pursuance of this recommendation, govern met should,

- As a matter of urgency, in addition to clean-up of Kibiro spill Gradient Hole-4, MEMD should pay attention to Kibiro Geo-thermal Gradient Hole-7 and its surrounding areas which showed extremely high levels of contamination of soil resources with heavy metal elements compared with those at control area and word average thresholds.
- Prior to site clean-up, detailed site plan should be prepared for (a) clean-up of the contaminated soil; (b) risk reduction at the site; and (c) risk reduction in the community. This is because, if not well planned and managed, clean-up exercises tend to result into new forms of contamination and aggravated pollution levels that further threaten public health.
- MEMD together with the Geo-Thermal Drilling Company in Kibiro should remove the pile of drilling waste at the home of Mr. Kiiza Julius with some compensation.

Assess the loss and compensate spill victims

There is urgent need to compensate all those who were directly affected by the spill. Some community members lost their fishing nets while others lost domestic animals. Thus, MEMD should work out a procedure of identifying those who were affected and compensate them for the loss occasioned to them by the spill. MEMD and the Multi-stakeholder committee on Kibiro spill should ensure that all commitments made in the Press Release of 15th April 2020 are implemented. Among the unfulfilled commitments at the time of this study included; engaging community members on the impact of the spill on their livelihoods, compensation to the affected persons, and cleaning-up of the affected area.

Government should fast track the National Oil Spill Contingency Plan

There is need for MEMD and Office of the Prime Minister (OPM) to fast track the process of establishing the National Oil Spill Contingence Plan. At the same time, government authorities should equally consider expanding the scope of the draft oil spill contingence plan to cover spills from other sub-sectors.

Fencing and controlling access to Drilling Sites

There is need for MEMD to ensure that geothermal drilling sites in Kibiro community and those in other areas of the country are adequately fenced so as to limit grazing animals and community members from accessing the sites, in accordance with international best practices for geothermal drilling and production.

4.2.2. Recommendations to Civil Society Organizations (CSOs) and CBOs

Advocate for establishment of soil quality standards

Civil Society organizations should advocate for establishment of soil quality standards that are relevant to all development sectors (with both organic and inorganic standards and guidelines). This is because the scope of the current national soil quality standards (2000) focuses only on the organic pollutants in the agricultural sector but neglects heavy metals from mining, oil and gas, and other related industries.

Dissemination of the study findings and recommendations

Ensure that results of the study are disseminated to the affected communities in order to restore community members' confidence about their livelihoods, environmental integrity, and create awareness about dangers of spills on public health.

Follow-up on the commitments made by the MEMD and the Multi-stakeholder committee in addressing impacts of the spill

There is urgent need for CSOs on behalf of community members in Kibiro to make a follow-up on the commitments made by the MEMD and the Multi-stakeholder committee in addressing impacts of the spill on community livelihoods and the environment.

Conduct scientific baseline studies

Civil Society Organizations need to conduct similar scientific studies in areas where oil and gas operations are taking place in order to establish the level of pollution before the sector metamorphoses into production phase. Such studies may help inform oil companies and government in the sustainable management of the environment the more sensitive production phase.

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APPENDICES

APPENDIX – I: International best practices, and national legislative framework governing geothermal exploration

International Best Practices in the geothermal industry in relation to environment and social sustainability

'A best practice' is a method or technique that has been generally accepted as superior to any alternatives because it produces results that are superior to those achieved by other means or because it has become a standard way of doing things, e.g., a standard way of complying with legal or ethical requirements. Best practices may include management standards such as ISO 9000 and ISO 14001, IFC World Bank Standards, and the UN Sustainable principles among others. In this paper, literature is reviewed on best practices relating to environmental and social sustainability in the geothermal industry. Some of the best practice sources applied (in this paper) includes; (a) The International Geothermal Association (IGA) & IFC World Bank (2014) best practices guide for geothermal exploration; (b) GeoCom (2015) handbook of best practices of geothermal resources management; and (c) The USA Hawaii Geothermal Blowout Prevention Manual among others. The specific requirements of these best practices as they apply to the geothermal industry in relation to environment and social sustainability include the following;

Social sustainability best practices

a. Sec.3.2 of the IGA & IFC World Bank (2014) best practices guidelines requires geothermal companies and host governments to ensure that local communities are made aware of the impacts, both positive and negative, of any geothermal development; the same section further provides that;

b. Having good communications with local communities is essential from the outset of any program, and that public meetings and surveys should be undertaken to determine preexisting public attitudes towards development and to provide information in response.

c. Operators are required to fence each individual exploration/production unit and its production well and evaporation pond with locked gates to prevent people and grazing animals from accessing geothermal drilling units and ponds. This is because if left unfenced, geothermal sites can be accessed by community members and grazing animals hence posing health risk from the high trace elements and heavy metal content of the brines through ingestion, breathing, skin contact with contaminated soil, or through bio-accumulation in the animal bodies and subsequently enter into the human food chain.

Environmental sustainability best practices

a. The International Geothermal Association and IFC World Bank guidelines on best practices for geothermal exploration (2014) stipulate that;

b. Although geothermal development is frequently viewed as an environmentally friendly option for power generation, the fact that any development impacts the environment, environmental protection regulation and requirements such as the conduct of Environmental and Social Impact Assessment (ESIA) must be appreciated and followed before the operation phase of geothermal projects, especially in countries where this is a requirement.

c. Best practice guidelines further stipulate that even when geothermal development is permitted, an environmental and social impact statement (ESIS) may be a prerequisite to embarking on a survey or exploration program.

d. Where different exploration methods are used, the environmental impact of each exploration method itself should be considered; this is because application of some exploration methods may have unique impacts on environment, nature reserves or water protection zones.

e. The Hawaii handbook on blowout prevention requires geothermal explorers and Regulators to put in place a blowout prevention plan as an integral element of geothermal well plans so as to ensure safety of facility workers and that of local communities.

f. The Hawaii standards require geothermal operators to frequently conduct blowout prevention equipment (BOP)[19] testing and drills in order to prevent or minimize occurrence of blowouts and spills at geothermal exploration and drilling sites. The same standard guides that the BOP closing system should be checked on each trip in or out of the hole

g. Best practices (IGA & IFC World Bank, 2014; and Hawaii, 1994) require geothermal operators to carryout BOP drills at least once a week for each crew. The standard practices further guide that every member of the crew should be familiar with all aspects of the operation of the BOP equipment, along with all of the accessories and monitoring devices

19 The term blowout prevention equipment (BOP) here means the entire array of equipment installed at the well to control kicks and prevent blowouts. It includes the BOP stack, its activating system, kill and choke lines and manifolds, kelly cocks, safety valves and all auxiliary equipment and monitoring devices.

that aid in detection of a blowout or spill incident.

h. Best practices on spills and blowouts (Helmy and Kardena, 2015)[20] require operators and host governments to act fast by way of remediation and clean-up of contaminated sites in order to limit negative impacts on the affected area and surrounding communities.

Relevant policies and laws governing geothermal exploration in Uganda

Proper development of geothermal energy is challenging and more often than not requires a robust government policy for effective exploitation (Zakkour et al., 2016). Although there is currently no substantive policy or clear legal framework governing geothermal operations in Uganda, the sector is regulated through a number of other national laws and policies, key among which includes;

The Energy Policy 2002 and the new Draft Energy Policy 2019: The broad objectives of the Energy Policy for Uganda (2002) are to: establish the availability, potential and demand of various energy resources; increase access to modern affordable and reliable energy services; improve energy governance and administration; stimulate economic development; and manage energy-related environmental impacts.

However, it's worth noting that since 2012, Uganda has developed and become a party to new national and international guiding frameworks such as Vision 2040, the UN SDGs (2015) and Paris Agreement (2016) among others, all of which call for utilization and promotion of clean energy mechanisms, development of green economy strategies, and enhancement of environmental sustainability. Aware of this, and with increased desire to promote and utilize the country's clean energy resources (such as geothermal energy,) the Government of Uganda through the Ministry of Energy and Mineral Development (MEMD) embarked on plans to develop a new energy policy aimed at addressing new and emerging issues in the sector. At the time of this study, a draft national energy policy was out and accessible through MEMD's website www.energyandminerals.go.ug. Among others, the Draft Policy commits to establishing and strengthening a robust institutional, legislative and regulatory framework for the geothermal industry which is currently inadequate. The draft policy further makes commitments to establishing a Geothermal Communication Strategy aimed at raising public awareness and meaningful engagement

20 Helmy Q., and Kardena E., (2015). Petroleum Oil and Gas Industry Waste Treatment; Common Practice in Indonesia. Journal of Pet Environ Bio-technology 2015, 6:5 http://dx.doi.org/10.4172/2157-7463.1000241

of communities affected by geothermal developments in Uganda.

The Renewable Energy Policy 2007: One of this Policy's strategic objectives is to develop the country's geothermal energy to complement hydro and other sources of power to meet the energy demand of rural areas in sound environment. The Policy (under principle 10) recognizes that while it is generally accepted that renewable energy is environmentally friendly, its production must conform to acceptable environmental standards. Under this Policy, Ministry of Energy and Mineral Development (MEMD) has the overall responsibility of issuing licenses and permits to renewable energy project proponents. Section 5.1 of the policy creates a Renewable Energy Department within the ministry whose mandate is to specifically focus on the promotion of Renewable Energy and Renewable Energy Technologies. The Policy also establishes a National Energy Committee to provide strategic policy guidance to the subsector.

The National Environment Act (NEA) 2019: The National Environment Act 2019 repealed, replaced and reformed the law relating to environmental management in Uganda; The Act provides for the management of the environment for sustainable development; and gives NEMA the mandate to coordinate, monitor, regulate and supervise all activities relating to environment. Under section 26 of the Act, urban and district councils are responsible for the management of the environment and natural resources within their jurisdiction. The Act establishes District Environment and Natural Resources Committees whose mandate is to among others, monitor all activities within their local jurisdiction to ensure that such activities do not have any significant impact on the environment; promote the dissemination of information about the environment; and to coordinate with the Authority (NEMA) on all issues relating to the management of the environment.

Regarding requirements to conduct environmental and social impact assessments, schedule 5(3)(b) of the NEA makes it mandatory for all geothermal exploration and generation of geothermal resources in Uganda to undertake detailed Environmental and Social Impact Assessment (ESIA) before such projects or activities are implemented. In the event of pollution of the environment, the same Act under sections 79 and 80 places responsibility of clean up and restoration of polluted environment to the person responsible for the pollution, and by extension, to pay compensation for the damage caused in accordance with the NEA Act and any other applicable law.

APPENDIX II: Mean Concentration and Standard deviations of heavy metals in soil samples

Element		Soils (zones 1&2; n=6)	Control Soils (Zone 3; n=3)	P - value	World Average a
Chromium, Cr	Range	587.2-1062.6	4.4-1098	0.569	64[b]
	Mean ± SD	0.2 ± 0.3	586 ± 550		
Lead, Pb	Range	157.7-300.0	0.0-280.5	0.506	15[a]
	Mean ± SD	211.8 ± 52.8	144.4 ± 140.4		
Nickel, Ni	Range	281.2-560.8	0-409	0.401	45[b]
	Mean ± SD	393.2 ± 94.6	252 ± 221		
Iron, Fe	Range	198209-283466	2422-250509	0.438	200[a]
	Mean ± SD	240224 ± 35777	162097± 138548		
Manganese, Mn	Range	5215-8360	50.3-6980	0.468	350-2000[a]
	Mean ± SD	6420 ± 1385	4410 ± 3796		

[a]Kabata-Pendias (2011). [b]Alberta Environment and Parks (AEP) Guidelines. 2019

Mean concentration of heavy metal elements in soil at Kibiro spill area (zones 1&2) and Control area (zone 3). Units = $mgkg^{-1}$.

APPENDIX – III: Correlations

Correlation for Kibiro-4				
	Chromium (Cr)	Lead (Pb)	Nickel (Ni)	Iron (Fe)
Lead, Pb	0.327			
	0.527			
Nickel, Ni	0.754	-0.014		
	0.084	0.978		
Iron, Fe	0.978	0.243	0.772	
	0.001	0.643	0.072	
Manganese, Mn	0.553	-0.117	0.826	0.632
	0.255	0.826	0.043	0.179
Cell Contents: Pearson correlation P-Value				

Correlations for Kibiro-7				
	Chromium (Cr)	Lead (Pb)	Nickel (Ni)	Iron (Fe)
Lead, Pb	0.919			
	0.258			
Nickel, Ni	0.997	0.944		
	0.045	0.213		
Iron, Fe	0.993	0.959	0.999	
	0.077	0.182	0.031	
Manganese, Mn	0.930	1.000	0.954	0.967
	0.240	0.019	0.195	0.163
Cell Contents: Pearson correlation P-Value				

APPENDIX – IV: Coordinates for soil and water samples

SOIL SAMPLE COORDINATES	
Sample Number	Coordinates
K1	36N0305121 E0184679
K2	N0305105 E0184708
K3-H	N0305069 E0184752
K4	N0305049 E0184781
K5-S	N0305106 E0184808
K6-S	N0305000 E0184779
KB1-7	N0304818 E0184467
KB2-7	N0304784 E0184487
KB3-7	N0304764 E0184424
C1	N0304554 E0185146
C2	N0305595 E0185169
C3	N0305563 E0185217
C4	N0305431 E0185214

WATER SAMPLE COORDINATES	
Sample Number	Coordinates
K1	N0305049 E0184786
K2	N0305106 E0184808
K3	N0305011 E0184785
C1	N0305563 E0185217

WATER SAMPLE COORDINATES	
Sample Number	Coordinates
C2	N0305431 E0185214
C3-R	N0304633 E0184124

ABOUT CSCO

The Civil Society Coalition on Oil and Gas (CSCO) is a loose network comprised of 63 member organizations which aim at enhancing sustainable governance of Uganda's oil and gas resources for the benefit of all Ugandans. CSCO was founded in 2008 and is hosted by the Advocates Coalition on Development and Environment (ACODE).

CSCO envisions a well-managed oil and gas sector for the benefit of all Ugandans. Its mission is to foster an effective civil society coalition that promotes good governance of the oil and gas sector through networking, research, information exchange and advocacy for socio-economic transformation of Uganda.

CSCO works through four thematic groups: Revenue Tracking and Management; Oil Justice, Human Rights, Gender and Local Content; Environment, Land and other Natural Resources; and Policy and Legal Affairs. Currently, CSCO is constituted of strong members comprised of community organisations, sub-regional and international organisations. CSCO engages government Ministries, Departments and Agencies at national and sub-national levels, policy makers at all levels, extractive companies, private sector, citizen groups, civil society and development partners.

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