Proceedings, 7th African Rift Geothermal Conference
Kigali, Rwanda 31st October – 2nd November 2018

Environmental, Health and Safety Assessment of Geothermal Drilling Operation using the RIAM Method: The case of Assal-Fiale Geothermal Development Project

Abdek MAHAMOUD ABDI

Djiboutian Office for the Development of Geothermal Energy, ODDEG

Professional e-mail : abdekmoud.segrc@gmail.com

Keywords

Health and Environmental Security and Safety, Risk Management, Drilling Operation, Lake Assal Fiale field , RIAM Method.

ABSTRACT

The development of geothermal energy is the best way to get reliable, clean and affordable energy for the population, particularly for developing countries. Geothermal energy is also a solution to accelerate the transition of energy for African countries. Mainly, for the implementation of Geothermal Energy Project it is important to take in to consideration the different phases such as (i) the surface study phase (pre-feasibility phase), (ii) the drilling phase (the exploration phase), (iii) the power plant phase (production and power generation phase) (iv) and decommission phase (the closing-out of the power plant). Generally, most of the risks in geothermal development project occur during the drilling phase, due to the civil work, mobilization and drilling operations, cementing, testing and completion. The stated risks can cause financial, social, environmental, health, safety and security impacts. Those risks require to be assessed and monitored by the developer of the project, to reduce their potential impacts. Assessing the risk exclusively, clarifying the level of the risk occurring during the project execution; help to periodically evaluate their evolution and growth.

Therefore, Rapid Impact Assessment Method (RIAM) is a tool used in environmental impact assessment, to give a preliminary approach of risks in different environmental components like physical/chemical, biological/ecological, sociological/cultural and economic/operational. RIAM method can also be used to assess the sustainability of the risk management system. In this paper, the RIAM method will be used to assess the risk of Geothermal Drilling Operation in Lake Assal Fiale Caldera Geothermal Drilling Project, and evaluate the sustainability of the risk management system.

1. Introduction

The Republic of Djibouti has a long history of geothermal energy development. Exploration was begun by the French CNRS and the Italian CNR in the 70's. The main research focused on the East African Rift where the plan was to drill two geothermal wells., The first one was in Lake Assal (Assal 1 and Assal 2), operated by BRGM (Bureau Francais de Recherche Géologique et Miniére). Only Assal 1 was productive, with a temperature of 255 degree Celsius (BRGM, 1973; Coriea and al, 1985). The second drilling program was financed by the UNDP (United Nation Development Program) and OPEP occurred in Lake Assal in 80's, after

Ardoukoba Volcano eruption in 1977. At this site , Assal 3 , 4 , 5 and 6 were drilled., Consequently, Assal 3 (260 degree celcius) and Assal 6 (261 degree celsius) were productive, but Assal 4 (130 degree celcius) and Assal 5 (180 degree celcius) were not productive. Due to civil war of 90's, and the high salinity of the resource especially in Assal 3, the geothermal energy implementation was abandoned.

Currently, an exploration project was set up by the Electricity of Djibouti (EDD) in partnership approach with the World Bank, and other Development Institutions like AFDB, AFD, and OPEP, to prove the commercial viability of generating electricity from geothermal resources based in Lake Assal- Fiale Caldera site. The proposed first phase of the project is the drilling of four wells, after which a power plant will be constructed, for the generation of 50MW. The proposed four directional wells will be drilled by Island Drilling Company (IDC), with the supervision of Geologica Geothermal an International Consultant, and the Electricity of Djibouti (EDD) as the proponent.

Point	Drilling Duration	Depth (meter)	Temperature (degree Celsius)	Mass flow (Units)	Salinity (Units)
Assal 1	08/03/75 – 12/06/75	1146	260	135	120
Assal 2	01/07/75 – 10/09/75	1554	233	-	-
Assal 3	11/06/87 – 11/09/87	1316	264	350	130
Assal 4	15/09/87 – 21/12/87	2013	359	-	180
Assal 5	07/01/88 – 07/03/88	2105	359	-	-
Assal 6	08/04/88 – 10/07/88	1761	265	150	130

Table 1: Previously drilled well in Assal Lake area

Assal Lake is a protected area by the national law **n°45/AN/04/5th L** on the creation of protected areas. In compliance with this law, an environmental impact assessment study was carried out in 2014, financed by the World Bank. Further, an environmental and social management plan was done in 2016, financed by AFDB. This was done in accordance to the decree **n°2011-029/PR/MHUEAT** of 24th February 2011 on the national process of the environmental impact assessment, the World Bank IFC Guideline and the African Development Bank Environmental and Social Safeguards Policy.

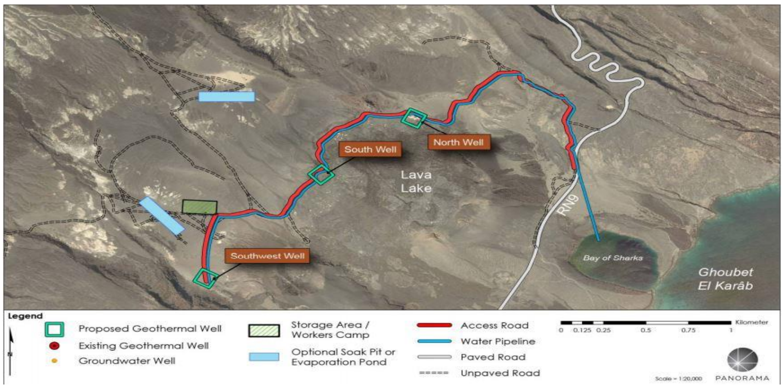


Figure 1: Project localisation map, ESMP , Panorama , 2016

2. Presentation of the Drilling Operation in Lake Assal Fiale

2.1. Civil works

- **Well pads and associated components**

The preparation of three well pads, measuring 6,000-10,000 square meters each (Fichtner, 2012), with cellar pits, mud and discharge ponds was conducted by a national company. Those components are commonly used in the drilling project.

Component	Issue
Well pads	They will be used to set up and lay the rig for the drilling operations, and to control the surface run-off. The wells pads can be only backfilled, concreted, or compacted according to the specification of the rig, in some case a rig mat is used to stabilize the rig but in this project, the wells pads was only backfilled.
Cellar pits	The cellar pit will be used to collect sumps for drilling fluids and to catch contaminated drilling fluids during casing and cementing. Four cellars pits will be constructed and designed according to the number and type of drilling wells.
Mud pit / discharge pit	Mud pit and discharge pit was combined into one pit. This pit will contain mud and geothermal fluids during the testing activities.

Table 2: Well pad components and their issues

2.1.2. Road Construction

The targeted zone is near the national road 9 (RN9). Some civil works was needed to construct an access road from the RN9 of the proposed drilling site (4.1 km from the RN9). The road is used to ferry all the drilling materials and the rig from the Port of Djibouti to the well pads. The road provide an access to all the drilling well pads, and will facilitate transportation of materials during the mobilization phase, between two well pads. It requires geotechnical data (as soil data, PSD, atterberg limit, plastic limit, compaction test, and CBR) before designing the road, to avoid possible failure during the drilling operations. Normally a failure can cause high cost of repair and loss of time. Soft rocks materials (clay or loam soil, organic soil, and lacustrine or soft sediments), can cause failure of the foundation (Terezie Vondrackova and al, 2015). Native rocks in the target area can be used because the basalt is a hard rock, but parameters should be tested like the porosity, and the alteration before the utilization of those materials. Sand and gravel require to be added if the quality of the basalt is not suitable, and compaction test conducted. In case a failure occurs, concrete reinforcement will be required.

2.1.3. Water Pipeline

A water pipeline was laid from the Goubet Bay to the drilling site to supply sea water at the well pads for the drilling operations. The sea water will be used only for the drilling and not for the material cleaning, washing, bathing or drinking. A supply rate of 2,000 litters per minute for the water will be needed (AU code of practice, 2016). Additionally, a storage water tank will be needed and installed, to address any water supply failure (pumping rate reduction, blocking materials in the pipeline, or pipeline break).

2.1.4. Camp site for workers

A camp site was set up near to the drilling site, where the drilling crew are accommodated. It consist of a restaurant, security and housekeeping facilities and services. Safety and health measures will be observed during the project, to protect the workers from possible sanitary risks.

2.2 Mobilization and Drilling

2.2.1. Rig Mobilization

The rig was mobilized from the Port of Djibouti to the drilling site, via the National Road 1 RN1 and the National Road 9, for the transportation. The RN1 is also used by the Ethiopian cars on transit, for the transportation of materials. Road traffic was reduced during the rig mobilization, to prevent any risk of collision or material losses. A crane or a forklift was used for loading the rig materials. Military escort was provided by the Government to prevent any risk of accident.

2.2.2. Rigging up

The Rigging up phase is the phase at which the rig equipment and auxiliaries will be set up. Cranes and forklifts was mobilized for the transportation of heavy materials, generators and electrical connection; circulation system, hoisting and BOP systems was checked and installed. The workers was exposed to high health and safety risks during this phase. The rigging up phase and the rigging down phase have the same activities and risks. The use of personal protective equipment requires to be enforced. Short training on safety measures (fire safety, first aid training, emergency plan, H_2S training, site security and signage), needs to be provided for the new workers.

2.2.3. Drilling phase

The Drilling phase is the most important phase in the project operation. Four directional wells of 2,500 meters each will be drilled in Assal Fiale Geothermal Project. The proposed drilling points are located near to the previous geothermal well Assal 5 in the caldera of Fiale. The geothermal consulting company, Geologica Geothermal, had designed the drilling target wells and did the conceptual model. Before and during the drilling phase, some records are required, as well as the well design documentation, the drilling program, the daily drilling activity records, the hole measurements, the casing specification, the casing string depth, cementing records, the wellhead assembly, the lost circulation, the cores and cuttings, the operating range, the consumable used, the drilling fluids’ quantities, drilling parameters (WOB, ROP, pumping rate) , tool and drilling string diameters (AU code of practice ,2016) .

During directional drilling, electronic materials of the drilling tools will be exposed to high underground temperature (360 degree Celsius is expected according to the well Assal 5 temperature).This exposure to high temperature can cause failure of the electronic components of the directional tools. Hence, a suitable cooling system will be used to cool the mud, and reduce the exposure of those materials to the high temperature.

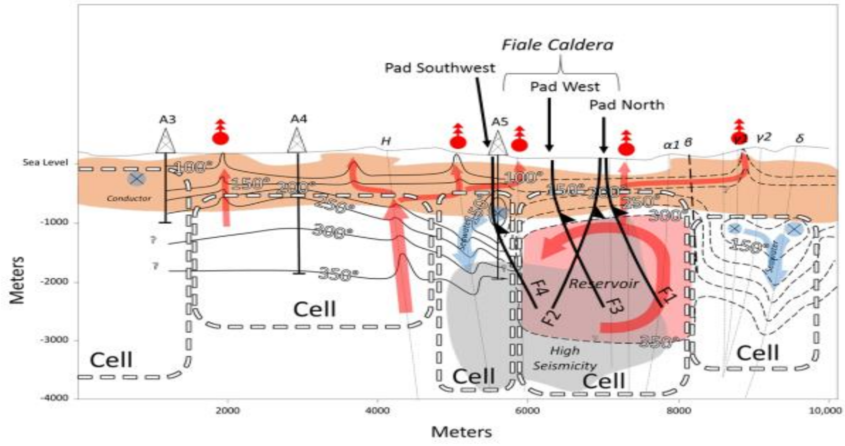


Figure 2: Assal Fiale Conceptual model, Geologica , 2016

2.3 Cementing

The cementation is the pumping of cement slurry (cement, water, and other chemical elements), into the well, displaced to a predefined point with a plug. The different types of cementating are: (i) Primary cementing (casing cementating) and (ii) Secondary cementing (plug cementing, squeeze cementing). Cementating is used to protect the casing from corrosion, to reduce fluid loss, to seal off problematic zones, to plug back depleted zone, for the directional drilling and for the side tracking. The pumping equipment require to be checked before the cementing operation, to avoid any failure of the drill string. Cementing materials need be stored and used appropriately, and the quality of the cement monitored.

3.4 Testing and Completion

Well completion test phase is the phase that transforms a drilled well into a production well. Hence, down hole condition need to be checked and some parameters must be known, such as, the down hole pressure/ temperature, the formation integrity, the flow rate, the rank and the intensity of the hydrothermal alteration. Thus, some activities that will be conducted as the leak off test include, the flow testing, the well logging, the go-devil running, and the fluid sampling (AU code of practice, 2016). If the Assal Fiale geothermal wells are productive (suitable temperature, and reservoir), testing and completion operation will be done. In addition, protective equipment (BOP, RAM… etc), will be tested to avoid any blowout risk. Further, discharge pit will be monitored avoid the risk of failure, noise generation, gases emission (CO_2, H_2S, NOx … etc.) and geothermal fluids analysed to avoid any risk of pollution.

3. Evaluation of the operation with RIAM data

3.1 Presentation of the Method

The Rapid Impact Assessment Matrix is a method used to assess risks. This method can provide a permanent record of information for evaluation process (Pastakia and al,1998). The project impact is evaluated against environmental components, and for each component, there is a measurement that will give an assessment of risks (Hossein Yousefi and al , 2010) .

1. ES (environmental score) = (A1 x A2) x (B1+B2+B3) , (Pastakia and al 1998)

❖ To evaluate the sustainability of the risk management system , (E) and (HN1) has to be calculated (Zayre Gonzalez and al , 2015)

2. S (sustainability rate) = E – HN1
3. E= (∑ PC + ∑BE) / (PC max + BE max)

4. $HN1= ((SC\ max - \sum SC)+(EO\ max- \sum E\ddot{O}))/(SCmax + EO\ max)$

Group	Category	Scale	Description
A	A1 Importance of condition	4	International importance
		3	National importance
		2	Outside of local condition
		1	Local condition
		0	Not Important
	A2 Magnitude of change-effect	+3	Major positive benefit
		+2	Significant improvement
		+1	Improvement in "status quo"
		0	No change / "status quo"
		-1	Negative change to "status quo"
		-2	Significant negative effect
		-3	Major negative effect
B	B1 Permanence	1	No change / not applicable
		2	Temporary
		3	Permanent
	B2 Reversibility	1	No change / not applicable
		2	Reversible
		3	Irreversible
	B3 Cumulative	1	No change / not applicable
		2	Non – cumulative /single
		3	Cumulative / synergistic

Table 3: Assessment criteria, RIAM Method, Pastalkia, 1998

Environmental score (ES)	Range value (Alphabetic)	Range value (Numeric)	Description
72 to 108	E	5	Impact / major positive change
36 to 71	D	4	Impact / significant positive change
19 to 35	C	3	Impact / moderate positive change
10 to 18	B	2	Impact / positive change
1 to 9	A	1	Impact / slight positive change
0	N	0	No change / status quo / not applicable
-1 to - 9	-A	-1	Impact / slight negative change
-10 to -18	-B	-2	Impact / negative change
-19 to -35	-C	-3	Impact / moderate negative change
-36 to -71	-D	-4	Impact / significant negative change
-72 to -108	-E	-5	Impact / major negative change

Table 4: Assessment Range, RIAM Method, Pastalkia , 1998

3.2 Physical and Chemical

3.2.1. Gaseous emissions

During the drilling operations, some non-condensable gases can be emitted, such as hydrogen sulphide, and carbon dioxide. (CO_2, H_2S), like during the testing of Assal 3 (Aquater, 1988). Nevertheless, these gases were not released during the drilling of Assal 5. Due to the release of hydrogen sulphide gas, some measures that will be taken include installing H_2S detectors near the drilling rig and shale shakers, monitoring of the gas emissions, training on emergency plan for the workers, and a periodic monitoring of the concentration during the drilling and testing.

3.2.2. Lost Circulation

The lost circulation is defined as a total or a partial loss of drilling fluids, during the drilling, cementing, or circulating operations. Lost circulation occurs if the hydrostatic pressure exceeds the formation pressure, or if the fracture is larger than the biggest particle in the mud. Lost circulation can occur in unconsolidated formation, in cavernous formations, in fractured formations or in induced formations. There are different type of lost circulation: seeping loss: 0.2-2.0 m3/hr, partial loss: 2.0 – 8.0 m3/hr, complete loss: 60-150 m deep of mud loss, Severe loss: 150 – 300 m deep of mud loss, and a partial or complete loss to deep induced fractures

Lost circulation can cause several problems, such as loss of costly drilling materials, loss of time, plugging of potentially productive zones, blow out resulting from decrease in hydrostatic pressure, excessive inflow and loss of water. This can be addressed by using bridging materials against lost zones, reducing hydrostatic pressure of the mud (to be equal to the formation pressure), by using cement, bentonite or diesel like plugs, or by operating blind drilling (this option will need a large amount of water for drilling).

Table 5: Water measurement, Assal 5 drilling well, Aquater, 1988

Date	Hour	Bottom hole Depth (Units)	Last Casing shoe (m RKB)	Level	Remarks
22.1.88	8:44	416	204	184	7 hour from water pumping
1.2.88	3.10	835	572	13	Not stabilized
2.2.88	8:30	835	572	203	21 hours after circulation stop
5.2.88	1:30	1019	572	214	4-5 hours after circulation stop
8.2.88	8:00	1207	572	170	4-5 hours after circulation stop (2-3 m3/h)
15.2.88	1.30	1566	572	143	4-5 hours after circulation stop
23.2.88	4:15	1800	572	152	
24.2.88	1:00	1800	572	146	Cement plug at 614m, probably leaking
5.3.88	8:30	2105	1258	51	After pumping testing
6.3.88	1:40	2015	1258	268	After Air lift
18.3.88	11:00	2105	1258	200	13 Days after air lift

In Assal 5 geothermal well near the Fiale Geothermal target wells, several circulation losses occurred during drilling but the fluids losses were low (2-4 m3/ hr) as mentioned in the table.

<u>3.2.3. Water utilization</u>

Sea water will be pumped from the Shark Bay (Goubet Bay) to the drilling site, via a water supply pipeline. Several pumps will be needed to pump the salty water from the sea. A storage tank is required to supply water when a total loss occurs. Fresh water that will be used for cleaning materials, washing and bathing, will be supplied by trucks from PK51 to the drilling site, about 20 km by road. The requirement for fresh water is estimated at 10 cubic meter per day, 1000 litters for a maximum of 100 workers. Salty water was also used for drilling Assal 5 geothermal well.

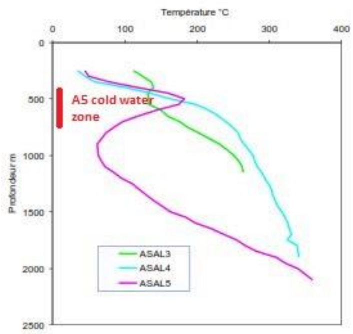
Table 6: Drilling fluid temperature, Assal 5 drilling well, Aquater, 1988

Depth (m)	Fluid Type	Temperature In (Degrees Celcius)	Temperature Out (Degrees Celcius)	DT (Degrees Celcius)
200	Foam	/	46	/
350	Foam	/	60	/
Water entries in the 200-300 m interval				
500	Foam	-	65	/
1200	Sea Water	42	46	4
1400	Sea Water	46	50	4
1500	Sea Water	47	52	5
1650	Sea Water	47	53	6

1750	Sea Water	50	56	6
1850	Sea Water	48	55	7
1950	Sea Water	49	55	6
2030	Sea Water	50	58	8
2100	Sea Water	51	60	9

3.2.4. Groundwater

There is no well-known fresh groundwater near the proposed drilling site, Fiale Caldera. However, it was proven that there is sea water flow from Goubet Bay to Lake Assal through the North West – South East faulting system of the Assal Rift. Assal 5 shows two phases of cold groundwater circulation at 200 and 400-600 meter depth, respectively. Therefore, drilling fluids can move through those zones and contaminate the Assal Lake. The drilling company must be careful about the design of the drilling fluids in those zone.



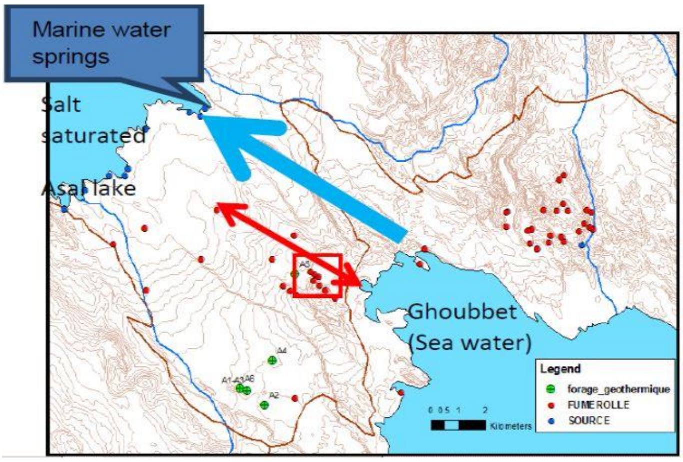


Figure 3: A5 cold water zone, Abdou et al , 2012 , Figure 3 : Seawater circulation , Geologica, 2016

3.2.5. Stuck pipes

This is a common phenomenon during drilling activities, when the drill string cannot be pulled out of the well, at a force equal to the tensile strength of the drill pipe. It can be caused by a thick filter cake, pressure difference, balling the bit (tool joint, and drill collar) by shale sloughing, accumulation of cuttings in the annular space, and the carelessness of personnel. . Fishing tools are used to pull out the drill string. Stuck pipes can cause time loss. There is no record of stuck pipes in Assal 5 Geothermal Drilling.

3.2.6 Noise

Drilling operations can generate high levels of noise, exceeding 85 dBA, from the generators, compressors, boosters and pumps. This noise has to be monitored, to reduce the negative impact to the population living near the drilling site, especially the Daba le Gahar village, and to the fauna at the shark bay. The noise during the testing will be reduced by using silencers.

3.2.7. Blowout and kicks

A kick is the infiltration of water or gas into the wellbore and a blowout is the outflow of uncontrolled water or gas from the wellbore. It is important to know that if a kick is not controlled, a blowout may occur. The signs of kicks; are, for example, increase of ROP ,increase in rotary torque, drag, gas content, in flow line temperature, in sloughing shale and decreasing in shale density . A kick can be controlled by the hydrostatic pressure of un-weighted drilling fluid, or by shutting the well to kill its operation. A blowout and kick can cause loss of time and materials.

3.2.8. Waste

The camp site for workers and the rig site will produce waste. The waste needs to be handled appropriately by a qualified person. Domestic waste, drilling operation waste (steel, metal, plastic), liquid waste (motor oil, lubricants) and sanitary waste (toilet waste) must be segregated at source and collected separately, to avoid any risk of pollution.

3.2.9. Geothermal fluids

Only one discharge pit was constructed, for both the geothermal fluids and the drilling fluids. Both fluids can contain chemical components like heavy metals, e.g. chrome that is present in the chrome-lignosulfonate, lead , cadmium in grease, ammonium salt used as foam, citric acid, caustic soda, … etc . The composition of the drilling fluids must be checked carefully, the discharged geothermal fluids controlled, and the integrity of the discharge pit monitored periodically, to avert potential failure.

3.3 Biological and Ecological

3.3.1. Flora

The proposed drilling area is not inhabited by abundant flora. However, some flora species were found in Lake Assal, e.g. ***Acacia Mellifera***, ***Acacia Tortilis***, and ***Acacia Asak***, the ***Dracaenae Ombe***t, ***Pulicaria Somalensis***, and ***Calotropis Procera***. Those species can be found the wadis zones, but not in the Caldera of Fiale.

3.3.2. Fauna

There is no abundant fauna in Assal Lake. There is only one kind of fish, *the* ***Cyprinodon sp*** that inhabit Lake Assal, near the wadis feeding zones. Nevertheless, in Goubet Bay, especially in the Shark Bay, 27 species of shark (with the wale shark), four species of turtle, 13 species of seabirds, dugongs and dolphins are also present. There are also 77 families of Actinopterygians and 7 families of Chondrichthyan (National Monography , 2000).

3.3.3 Habitat loss

The project will neither cause habitat loss to fauna and the population, nor degradation of animal habitat, and disruption of migratory pathway. This is because the drilling area is in a desert zone. Resettlement action plan will not be necessary.

3.4 Sociological and Cultural

3.4.1. Settlement and population

The people living near the proposed project zone, in Daba le Gahar village, are about 8 km away. The population of Daba le Gahar is 76 households. The sedentary population living near the proposed project site, Laita and Ardoukoba villageis 298 households. An estimated population of 248 semi-nomads lives nearby. The population of Daba le Gahar is mainly male-dominated, because of salt exploitation work at the Salt Investment Company and the Port of Goubet. The semi-nomads practice transhumance. Financial support will be provided for initiating several activities for women, by UNFD (National Union of the Djiboutian Woman) and ADDS (Djiboutian Social Development Agency). Awareness creation on the sexually transmitted diseases will be done by the UNFD and the ADDS for the workers, as well as for the local community members living in those village. Grievance handling mechanism was implemented by the drilling company, to receive complaints from the population.

3.4.2. Transhumance zone

The proposed project area is within the transhumance zone of semi-nomads. Hence, a transhumance corridor is planned to facilitate the movement of semi-nomads.

3.4.3. Living facility

There is no supply of electricity in the nearby villages and hospitals. Fresh water is supplied by Salt Investment with water tanks. The implementation of a desalinization unit for Daba le Gahar village has been planned in the project finance as a corporate social responsibility project. Fresh water is supplied to the population, during the drilling operation by the operator.

3.4.4. Migration

Migration is a complex phenomenon due to economic, social and environmental issues (Clark and al, 2007). Immigrant in Djibouti are mainly from Ethiopia, especially from Oromia and Amhara region of Ethiopia, Yemen and India. Djibouti became a transit place for immigrants since 2000's (Amina Said Chiré and al, 2016). There are no exact statistics of immigrants coming from Ethiopia to Djibouti. This is because they walk from Ethiopian border in Galafi, Dikhil District, to Obock city, Obock District, from where they can sail to Arabic Peninsula or Yemen . They pass by Tadjourah region, especially the proposed project area by walking, because the transport of immigrants is banned in Djibouti. This makes them extremely vulnerable to heat, 40-45 degrees Celsius in the hotter seasons, and to diseases, especially cholera. Walking or dead immigrants can be observed in the proposed project zone. Water will be given to immigrant passing near to the project area.

3.5 Economical and Operational

3.5.1. Jobs for local communities

As stated above, local communities live near the proposed project zone, 8km away from the project area. The people are living in hardship, since there is no other occupation apart from salt exploitation operations and pastoralism. Therefore, drilling operations can create job opportunities, educate them to work on specialized jobs like welding, cleaning, electrical and mechanical works.

3.5.2. Tourism

The caldera of Fiale, especially the lava lake, is a major tourist attraction site. Drilling activities will not disturb the tourism activities. An information board was erected near the drilling site, to inform visitors about the activities being conducted in the proposed project area.

3.5.3. Drilling materials

Supply of materials is an important phase in the drilling operation. Drilling materials was stored appropriately, to avoid wasting of time. The material must be checked and tested accordingly to the API standards. Drilling consumables must be supplied in sufficient quantities. This is because there are no drilling materials companies in Djibouti that can supply drilling materials to the operator on a short notice.

3.5.4 Climate risk

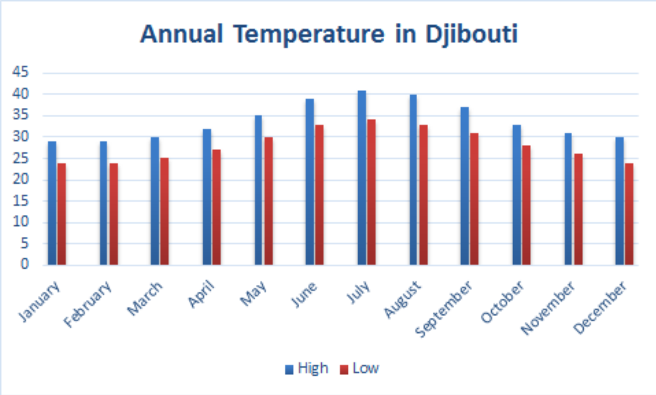


Figure 4: Annual temperature in Djibouti by NOAA

The temperature in Djibouti is always high, even in the proposed project area. The drilling activities has begun in July – August, in the hot season. During this period, the "Khamsin" the hot and violent wind from the West of Ethiopia Region, blows to the interior of the country, increasing the temperature level . Lake Assal is also a high wind velocity region average of 9 m / s (ODDEG AWS, 2018). The Ministry of Energy also plans to develop wind energy in this region. The climate condition can reduce the efficiency of the drilling operations. Hence, medical assistance need to be provided in the drilling area, protective measures taken to protect workers from the heat, wearing personal protective equipment, more activities in the night shift, and reducing exposure to the sun. Further, all the materials have to be stabilized on the ground, to reduce the risk of being swept away by the strong winds. An automatic weather station (AWS) was put by ODDEG near to the project site to collect weather data especially the wind parameter.

3.6 Results and Interpretation

3.6.1. RIAM analysis results

The RIAM analysis table was done according to the assessment criteria (table 3) and the assessment range (table 4) .

Table 7: RIAM analysis table

Component	A1	A2	B1	B2	B3	ES	RV	Description
PC: Physical and Chemical								
PC1 : Gases emission	2	-2	2	3	3	-32	-C	Moderate negative
PC2: Loss Circulation	2	-1	2	3	3	-16	-B	Negative
PC3: Water Utilization	3	-2	2	2	3	-35	-C	Moderate negative
PC4: Groundwater	3	-1	3	3	3	-27	-C	Moderate negative
PC5: Sticking pipe	2	-1	2	2	2	-12	-B	Negative
PC6: Noise	2	-2	2	2	3	-28	-C	Moderate negative
PC7: Blowout and Kicks	3	-3	2	3	3	-72	-E	Major negative
PC8: Waste	1	-2	3	2	3	-16	-B	Negative
PC9: Geothermal fluids	3	-3	3	3	3	-81	-E	Major negative
BE: Biological and Ecological								
BE1: Fauna	2	-2	2	3	2	-28	-C	Moderate negative
BE2: Flora	2	-2	1	3	2	-20	-C	Moderate negative
BE3: Habitat losses	1	0	1	1	1	3	A	Slight positive
SC: Sociological and Cultural								
SC1: Settlement and Population	1	1	3	2	2	7	A	Slight positive
SC2: Transhumance zone	1	-1	2	2	2	-6	-A	Slight negative
SC3: Living Facility	3	3	3	3	2	72	E	Major positive
SC4: Migration	4	1	2	2	2	24	C	Moderate positive
EO: Economical and Operational								
EO1: Jobs for locals	3	3	2	2	3	64	D	Significant positive
EO2: Tourism	3	0	1	2	2	15	B	Positive
EO3: Drilling materials	2	-2	2	2	2	-24	-C	Moderate negative

EO4: Climate	2	-2	2	2	2	-24	-C	Moderate negative

3.6.2. Sustainability rating

S= E - HN1; E= (∑ PC + ∑BE) / (PC max + BE max) = (-319-45) / (-81-28) = 3,34

HN1= ((SC max -∑SC)+(EO max- ∑ EÖ)) / (SC max + EO max) = ((72 – 97)+(64-31)) / (72+64)) = 0,06

S= 3,34-0,06=**3, 28** ; S>0 : **The system is sustainable** .

4. Conclusion

According to the RIAM analysis table, it shows that the environmental, social, health and safety risk management system of the project is sustainable. This sustainability is due to the environmental and social policies operated by the Work Bank, which guide the investment of the project. But the risk assessment is an iterative process, and it has to be monitored periodically because of the changing conditions. Monitoring of the environmental and social impact of drilling activities can be done jointly by the project proponent and the drilling company, to avoid any risks during the project.

REFERENCES

Abdou Mohamed Houmed , Abdourahman Omar Haga , Saida Abdillahi , and Jacques Varet , The Asal Geothermal Site , Djibouti Republic (Model update , 2012) , *ARGEO*, 2012

African Union, African Union Code of Practice for Geothermal Drilling, 2016

Dr Amina Said Chiré and Bezunesh Tamru, Coming Back of migrant in the Horn of Africa, *Open Edition Journals* 2016

Aquater, Drilling Documents of Assal Geothermal Wells, 1988

Clark X., Hatton J., Williamson J., 2007. Explaining us immigration, 1971-1998. *Review of Economics and Statistics, vol. 2,* 1989, p. 359-373

Fichtner, Projet d'évaluation géothermique d'Assal, *Etude cadre d'impact environnemental et social ,* 2012

Geologica Geothermal , Assal Fiale Geothermal Project Planning Testing, *Conceptual Model of the geothermal system for well Targeting*, 2016

Hossein Yousefi, Sachio Ehara, Amin Yousefi, and Fariba Seiedi , Rapid Environmental Impact Assessment of Sabalan Geothermal Power Plant, NW Iran , *World Geothermal Congress* , 2010

Panorama Environmental, Projet d'exploration géothermique de la caldera de Fiale, *Plan de gestion environmental et social*, 2016

Terezie Vondrackova , Josef Musilek , and Ladislav Kais , The Issue of Soft Rocks causing problems in foundation engineering , *Procedia Earth and Planetary Science 15 , 54-59* , 2015

Zayre González, Disraely González and Thomas Kretzschmar , First Approach of Environmental Impact Assessment of Cerro Prieto Geothermal Power Plant, *World Geothermal Congress* , 2015