

# Negotiating Natural Resources: A Case Study of Environmental Conflict Resolution

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## Abstract

In this study, we explored a complicated environmental conflict among four parties in Libya: the National Oil Corporation, Jakhira Municipality, the residents of Jakhira City, and the Farmer Association of Jakhira City regarding the operation of the As-Sarah oil field. Therefore, a negotiation model based on the four issues of air pollution, water quality and quantity, noise pollution, and sustainable development was developed to resolve the conflict and help in the development and operations of the oil field. The value of maximizing the product in the cooperative negotiation model was 139,500, and the contract options were 2 for air pollution, 2 for water quality and quantity, 3 for noise impact, and 1 for sustainable development and tax returns. FA, ROJ, JM, and NOC had contract values of 73, 68, 78, and 70, respectively. The value of maximizing the product in the cooperative model was improved to 643,125 by using the Nash solution. The contract options were as follows: 2 for air pollution, 1 for water quality and quantity, 1 for noise impact, and 3 for sustainable development and tax returns. FA, ROJ, JM, and NOC had contract values of 90, 90, 80, and 70, respectively.

**Keywords:** Environment, developing oilfield, conflict, Nash Solution, parties, and negotiation.

## 1. Introduction

The operations of petroleum exploration and production have a significant impact on the environment. The damage size and magnitude of impact are influenced by the nature and type of operations in the oil and gas companies. The main phases of upstream operations of oil and gas companies are described in (Table 1), and include aerial survey, seismic survey, exploration drilling, production and development, and decommissioning and abandonment (E&P Forum/UNEP, 1997 and Biltayib, Biltayib Misbah, 2006).

In the decommissioning and abandonment phase, improper removal and cleaning operations of the production facilities and infrastructure can result in soil and water

contamination, with several potential effects on human, socio-economic and cultural aspects, atmosphere, and aquatic and terrestrial life forms. (Table 1) provides an overview of the potential effects on the components of the environment of the source and operational activity under consideration (E&P Forum/UNEP, 1997 and Biltayib, Biltayib Misbah, 2006). Onshore oil and gas companies use seismic surveys to determine the location of underground oil and gas reserves. These surveys are typically conducted using large vehicles or helicopters for remote operations. The method involves sending seismic waves into the earth using an explosive charge or other energy wave-generating device. During exploration and appraisal operations, noise from surveying and

seismic vehicles may disrupt animal behavior and force them to abandon their natural habitats (E&P Forum/UNEP, 1997 and Biltayib, Biltayib Misbah, 2006).

Drilling and production operations cause physical land disturbances that arise from site preparation, facility and infrastructure construction, and utility access. Furthermore, noise and fugitive dust continue while the operation is ongoing. Additionally, discharging waste and toxic substances during drilling and production operations can pose a threat to the environment and nearby communities, as groundwater quality, wildlife, and residents are particularly sensitive to drilling and production of toxic waste material. The most significant source of water pollution during the drilling process is inappropriate disposal of formation water extracted with oil from the well, which

contains oil, high levels of chlorides, and heavy metals. The resulting contamination of ground- and surface water can have serious implications on local residents, animals, and vegetation (Ledec, George, 1990 and Wojtanowicz, A K, et. al, 1989).

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**Table 1.** Summary of the exploration and production processes

<b>Activity</b>	<b>Potential requirement on ground</b>
Aerial survey	Low-flying aircraft over study area
Seismic survey	Access to onshore sites and marine resource areas Possible onshore extension of marine seismic lines Onshore navigational beacons Onshore seismic lines
Exploration and appraisal	Access for drilling unit and supply units Storage facilities Waste disposal facilities Testing capabilities Additional drill site and waste disposal facilities Accommodation
Development and production	Improved access, storage and waste disposal facilities Wellheads Flow lines Separation/ treatment facilities Increased oil storage Facilities to export product Flares Gas production plant Transport equipment Accommodation, infrastructure
Decommissioning and Abandonment	Equipment to plug wells Equipment to demolish and remove installations Equipment to restore site

The most significant source of water pollution during the drilling process is inappropriate

disposal of formation water extracted with oil from the well, which contains oil, high levels of

chlorides, and heavy metals. The resulting contamination of ground- and surface water can have serious implications on local residents, animals, and vegetation (Ledec, George, 1990 and Wojtanowicz, A K, et. al, 1989).

### *1.2. Conflicts of Interest*

Conflicts of interest may be defined as “circumstances that expose professional judgments or actions regarding a primary interest to undue influences by a secondary interest” (Romain PL, 2015). The primary objective of the National Oil Corporation (NOC) is to maximize the profit from existing oil and gas fields. However, the oil and gas companies tend to achieve their objectives and preferences by maximizing oil production at low costs. Nonetheless, these objectives and preferences must be conducted ethically, and the companies must protect the rights of the residents living close to the oil production site. The principal concerns and interests of the residents usually include protecting the environment, sharing responsibilities for sustainable development of the city infrastructure, and providing financial support (Romain PL, 2015).

Addressing conflicts of interest has been increasingly acknowledged as a critical component of the systematic review process, with a range of strategies employed to manage these conflicts. Furthermore, documenting these conflicts is essential to ensure the transparency of the review process and the subsequent interpretation of the review findings (Romain PL, 2015).

Ethical issues may arise at several stages of the review, including the stage of decision-making, wherein the important aspects include deciding the topic of the review, the parties involved, and the interventions and outcomes to be included. Considering the ethical implications of every decision made throughout the review process is also important. Disclosure, open communication, and transparency of decision-making processes are paramount to the perceived integrity of the review process (Romain PL, 2015).

### *1.3. Conflicts between Oil Companies and Local Communities*

Economic engagement projects ensure an efficient corporate climate, as unrest is known to strike a crippling blow to energy enterprises within a community. For example, according to the Oil and Gas Journal, activities of the Shell Petroleum Production Company in the Niger Delta were halted for three years by community (Wells, John Bruce et. all, 2001). In 1998, there were more than 325 assaults on the assets of Shell Petroleum. Moreover, because of escalating conflict and instability, Elf Petroleum Nigeria Ltd. lost more than 15,899 cubic meter of production each day for several weeks (Wells, John Bruce et. al, 2001). However, the dispute in Ecuador, contradicting conventional negotiation theories, serves as a case study in multi-party negotiations between the strong multinational oil companies, a weak federal government, and disempowered indigenous communities. In such cases, an indigenous team is involved in internal negotiations, instead of serving as a unitary actor. This dispute is also an example of a particular form of environmental conflict in oil extraction in the developed world, suggesting that an in-depth study of the existing power dynamics and the ways in which the indigenous community can improve its negotiation power will provide insights into other communities dealing with common problems (Jamie Cerretti, 2006).

The “Snow White” oilfield was the first discovery in the Barents Sea, whose development began in 2007. The gas extracted from the oilfield was transported to Hammerfest using seabed pipelines, where it was refined into liquefied natural gas (LNG) at the Milk Island factory, situated 4 km away from the town center. Thus, Hammerfest provided an exceptional opportunity to analyze the effects of offshore oil discoveries in the Arctic on nearby communities, with oil exploration planning beginning at the nearby Goliath field in 2016. This study examined the local opinion on the influence of these two fields development, while exploring the perspectives of Hammerfest locals on the benefits of petroleum extraction for them and their expectations from the petroleum companies (Julia S.P. Loe and Ilan Kelman, 2016).

#### 1.4. Corporate Social Responsibility in the Oil and Gas Sector

Corporate social responsibility has emerged as an approach to manage the social and environmental impact of the operations of a company. Oil producers must make a positive contribution to the society —improvement in environmental sustainability, growth, and governance (White, S., 2002). The operations of oil and gas companies entail numerous possible adverse environmental consequences, especially during exploration and development stages, including habitat destruction, oil spills, and natural gas emissions, suggesting that the environment is continuously threatened by oil and gas production. Furthermore, oil and gas reserves are mostly located near regions with high biodiversity and ecological vulnerability, such as rainforests, mangroves, and protected national parks (Austin, D., 2002).

Nonetheless, oil companies often invest highly in economic welfare initiatives such as the development of hospitals, schools, and micro-credit schemes. Global investment of oil and gas producers on community development projects was estimated at more than \$500 million in 2001, but the contribution is much higher today. The four major oil producers — Shell, Exxon, BP, and Chevron — invested approximately \$500 million in such activities in 2006 (Jędrzej George Frynas, 2009).

#### 2. Case Study

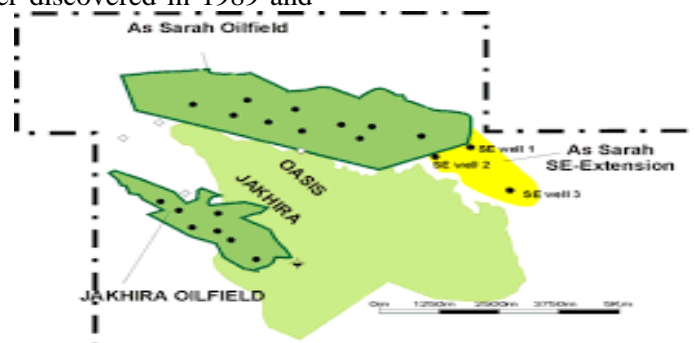
Jakhira is a small city in southeast Libya (Figure 1), with an estimated population of 10,000. The city is known for palm cultivation and contributes 5–10% to Libyan date production, with most of the residents relying on farming for their living expenses.



**Figure 1.** Libyan map showed the location of As Sarah oil field and Jakhira City.

The smaller Jakhira oilfield was discovered in 1969. It located in the southwest of the city. As-Sarah is a large onshore oilfield in the Sahara desert in eastern Libya, which is situated on the northern border of Jakhira City (Figure 2). As-Sarah oilfield was later discovered in 1989 and

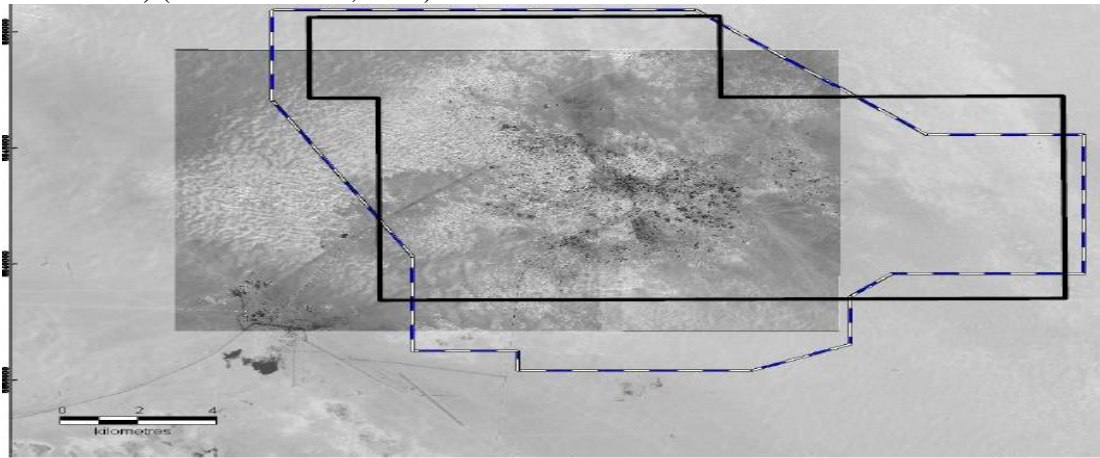
has since grown into a giant, with over 159 million cubic meter of original oil-in-place at a depth of 3,658 meter and producing more than 15,899 cubic meters per day (L. De Vincenzi, 2003).



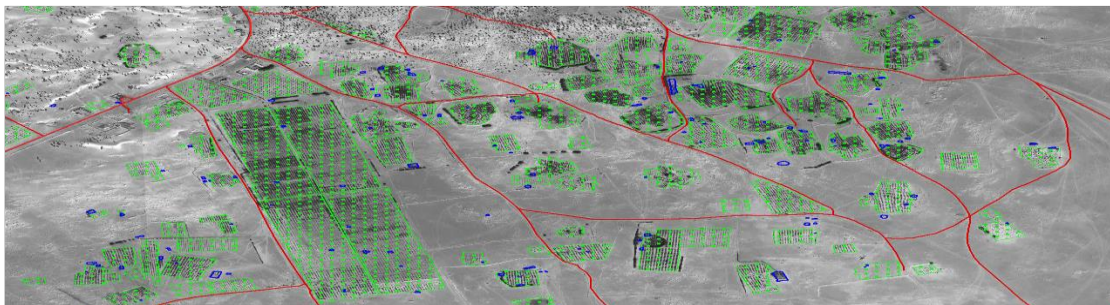
**Figure 2.** Location of As-Sarah and Jakhira Oilfields

The presence of Jakhira City at the center of concession C96, with its farms and palm trees, necessitated the compilation of a farm and landowner database to get access permission. Thus, in October 2001, satellite photographs (resolution: 1 meter) of concession C96 were acquired and deposited in a mapping software (**Figures. 3 and 4**) (L. De Vincenzi, 2003).

With a surface area of 185 square kilometer, concession C96 is located on the southeast of the Sirte Basin, 450 kilometer southwest of Benghazi in Libya. Wintershall-Libya is 100% interested in the concession, which encompasses two oilfields, namely As-Sarah and Jakhira (L. De Vincenzi, 2003).



**Figure 3.** The satellite photograph is showing the concession C96 and Jakhira City.



**Figure 4.** Satellite photograph is showing the farms and palm trees in Jakhira City.

The seismic survey was performed in real-time kinematic mode using the WGS84 ellipsoid, and construction started by the end of February 2002 in the northern part of the city. Vibrators and

recording crew began production operations on March 28, 2002 (**Figure 5**) (L. De Vincenzi, 2003).

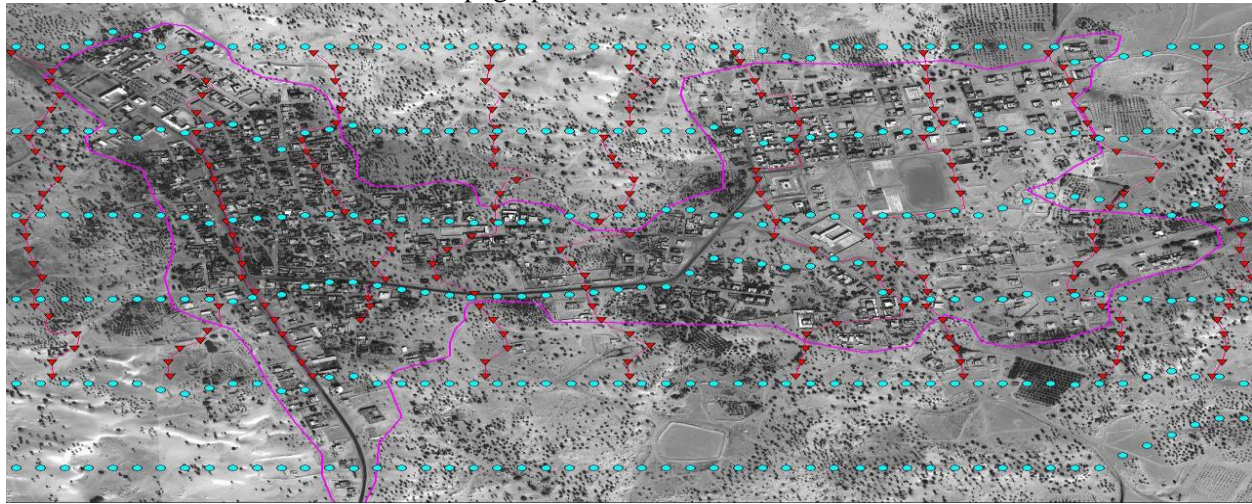


**Figure 5.** The seismic acquisition operation in Jakhira City uses seismic trucks.



The seismic acquisition map of Jakhira City center can be seen in **(Figure 6)**. Since the majority of the seismic survey was conducted either on farmland or urban Jakhira, topographic

difficulties in positioning the layout and employing seismic trucks delayed seismic acquisition (L. De Vincenzi, 2003).



**Figure 6.** Seismic acquisition map of downtown Jakhira (The blue circles indicate receiver lines, and red triangles indicate source lines).

### 2.1 *Opposing Interests*

The issue arose in 2017, when a German energy company named “Wintershall-Libya” failed to extract oil from the As-Sarah oilfield in the C96 license area located in Jakhira City. The Libyan government confirmed that the oilfield was closed illegally by the Jakhira Municipality, which complained that the NOC did not meet local demands. The tension between the Libyan NOC and the operating company, Wintershall-Libya, increased as the protests in Jakhira Halted oil production. The production of As-Sarah oil field has decreased by 7,949 cubic meters per day due to local protests in Jakhira City. The protestors accused the NOC of failing to fulfill its promises pertaining to local development projects and employment opportunities. The Libyan NOC confirmed that the closure resulted in a total loss of hundreds of thousands of barrels in production, with an estimated cost of \$281 million (Alison Williams, 2017 and Daniel J. Graeber, 2018).

The parties involved in this dispute, namely the NOC, Jakhira Municipality (JM), residents of Jakhira City (ROJ), and Farmer Association of Jakhira City (FA), were determined and specific of their interests. Their four primary issues were also identified and discussed in detail to help decision-makers find appropriate solutions for

each party. Subsequently, a negotiation model was proposed to resolve this conflict of interest and help in the development of the As-Sarah oilfield. The overall benefit of this negotiation model for conflict management in community-based natural resource projects is a win-win situation for all parties.

This study further discusses the issue of non-violent conflicts and disputes as a constraint to sustainable natural resource management at the community level.

### 3. **Methodology: Preparing the Negotiation Template**

Negotiation is a mechanism by which parties communicate or collaborate to reach an agreement. The philosophy of negotiation is multidisciplinary, drawing upon the disciplines of psychology, economics, history, political science, and the environment. A systematic analysis of the primary origins of negotiation grouped significant works in the field into a variety of approaches (Kemper, Robert E., and Daniele Renee Kemper, 1994). In the book “The Art and Science of Negotiation”, Howard Raiffa, focused on the game theory to examine the strategic choices in negotiation theories and argued that the success of negotiations depends on certain decisions. This suggests that the

historical roots of negotiation analysis lie in game theory (Raiffa, Howard, et. al, 2003). Another study revealed that negotiations during social conflicts outline the defective principles of the dominant normative negotiating paradigm; these conventional constructs presume that there are only two negotiating sides and that each side is organized to optimize self-interest (Dean G. Pruitt and Peter J. Carnevale, 1993). R. Lewicki et al. (1992) suggested a study of fundamental aspects of multi-party negotiations to verify that majority of the negotiation theory was built on the assumption that only two sides are communicating directly with each other (Lewicki, Roy J., et al., 1992).

The purpose of negotiation is not always reaching an agreement, as it is only a means to the end, which aims to satisfy interests of the parties. The purpose of negotiation is to explore whether one can satisfy their interests better through agreement than by pursuing the best alternative to a negotiated agreement (Raiffa, Howard, et. al, 2003).

The following steps have used in this paper to design the efficient contract for each party.

1- Determining the parties involved in the conflict: The following four parties were involved in this conflict: NOC, JM, ROJ, and FA.

2- Identifying the issues to be resolved: The four parties must decide on the issues that require resolution by the end of the negotiation.

3- Identifying possible resolutions of each issue: The four parties should identify the best possible resolutions of each issue.

3- Determining the preferences and value tradeoffs: Each party should state their preferences, in ordinal rank, for a different resolution of each issue. Moreover, each party must order the issues based on priority (Raiffa, Howard, et. al, 2003).

4- Additive scoring system: Each party should score their issue preferences, which must follow the order of decreasing importance. Alternatively, preferences can follow the order of improving choice (Raiffa, Howard, et. al, 2003).

5- Determining the reservation value: Each party should determine the minimum acceptable score

(reservation value) for their scoring of negotiation issues (Raiffa, Howard, et. al, 2003).

6- Designing efficient contracts: In this study, two approaches were used to design the most efficient contracts. Firstly, the four parties jointly negotiated contracts and selected the contract best suited for the four issues using full, open, truthful exchange (FOTE). Secondly, the Nash solution approach employs SOLVER to identify equitable contracts that would maximize the product of the excesses of the four parties (Raiffa, Howard, et. al, 2003).

#### **4. Interests of Each Negotiation Party**

##### *4.1. National Oil Corporation (NOC)*

The Libyan NOC was established in December 11, 1970, with the aim of organizing petroleum development plans and supervising the operations and investment activities of oil and gas projects. The NOC also regulates all exploration, production, and marketing activities of oil and gas reserves within and outside the country by subsidiaries (national companies) or by contracts with International companies (Saad Balhasan et. al., 2018). The NOC aims to raise Libyan oil production capacity to two million BPD using the following steps:

1. Directing attention towards unexplored areas such as Kufra basin, Cyrenaica platform, and basin margins.
2. Exploring deep targets within the Sirte basin.
3. Applying modern, state-of-the-art technology for exploration operations.
4. Opening new exploration areas within Sirte, Ghadames, and Murzuq.

##### *4.2. Jakhira Municipality (JM)*

The JM, representing the Libyan Government in the negotiation, is an authoritative body that is considered responsible for sustainable development in Jakhira City. The JM has advocated the quest to create and develop the infrastructure of the city, while taking responsibility of transportation, education, communication, and health services. The JM is an equal participant in the negotiation, but with a different perspective; the JM demands taxes (benefits) upon negotiation settlement and agreement. Furthermore, the JM was chosen to

host the negotiation and conduct the meeting. Thereafter, the JM was entrusted to submit the final report of the negotiation, including the final decision of all parties.

#### 4.3. Residents of Jakhira City (ROJ)

The commissioner of the ROJ represents approximately 10,000 individuals. As the city has limited economical means, resources, and services, the residents rely on government jobs and small businesses. The city is also among the top-ten cleanest cities in Libya, with a healthy environment and natural aesthetics. Residents are so wary of their quality of life that they believe that any oil company within or near the city will negatively affect their lives. They are particularly apprehensive about air pollution; damages to the city infrastructure, education, and health services; and the troublesome noise. Thus, the ROJ prefer that all oil and gas exploration and development operations must be performed away from the city.

#### 4.4. Farmer Association of Jakhira City (FA)

The FA represents approximately 1,000 farmers, who rely on groundwater for palm cultivation. The healthy environment of the city is the key determinant of its high-quality date production. Farmers draw good-quality water from a depth of approximately 30 meter. The main concern of the farmers is the unregulated use of shallow water aquifers for the operations of oil companies. Additionally, the operations will discharge pollutants, which will degrade water quality through leakage, well pits, and field pits. Undoubtedly, these concerns will adversely affect date production in the city.

### 5. Issue Information

#### 5.1. Air Pollution

Air pollution is defined as the presence of contaminants, materials, or substances, such as

dust, gases, odors, smoke, or saber, in the air in quantities that are harmful to humans, plants, animals, or property ( Xiaohong Xu and Yangfan Chen, 2016).

The sources of air pollution originating from oil and gas industries include:

1. Rigs, engines, generators, and compressors.
2. Dust from cement-related activities and mud.
3. Evaporation of crude oil from oil pits.
4. Flaring or discharge of natural gas directly into the atmosphere.
5. Burning of oil during production.

The air pollutants released from oil and gas production are as follows:

1. Sulfur dioxide
2. Carbon monoxide
3. Hydrogen sulfide
4. Volatile organic compounds
5. Natural gas
6. Nitrogen oxides
7. Dust

To control the release of air pollutants during oil and gas production, oil companies may implement the following strategies:

1. Optimizing oil and gas processing design.
2. Periodical maintenance.
3. Installing leak detection equipment along the pipeline, separation facilities, and on the wellheads.
4. Using the produced gas for gas injection to maintain reservoir pressure.
5. Enhancing oil recovery.

The air quality standards have been classified into three categories (**Table 2**) (V Ehsani, 2017 and Yasser F Nassar et. al., 2018). The three categories are listed as under:

1. Category A: Covers industrial areas.
2. Category B: Covers residential areas.
3. Category C: Covers forests and parks.

**Table 2.** Air quality standards

Category	Concentration in micrograms per cubic meter			
	Suspended Particulate Matter (SPM)	Sulfuric Dioxide	Nitrogen Oxides	Carbon Monoxide
Industrial Areas	500	120	120	2000
Residential Areas	150	80	80	1000



Air pollution can result in the following:

1. Death (human and animal)
2. Sickness (human and animal)
3. Damage to crops and plants.

The issues resulting in air pollution can be mitigated using the following measures:

1. Using horizontal drilling technology to avert effects on residential and green areas.
2. Pre-burning oil or gas before discharging into the atmosphere.
3. Using air regulation control system.
4. Installing vapor recovery system.
5. Using absorbers.
6. Ensuring a good process design.

The following options were included for mitigating air pollution:

#### Option 1

- Measure and regulate air quality in the categories 1 and 2.
- Install protection equipment with the vapor recovery system.
- Use pre-burning treatment technology.
- Establish a compensation fund of \$5 million for residents and farmers.
- Horizontal drilling at a depth of 6 kilometer from the reference line.

#### Option 2

- Measure and regulate air quality in the categories 1 and 2.
- Install protection equipment with the vapor recovery system.
- Use pre-burning treatment technology.
- Establish a compensation fund of \$10 million for residents and farmers.
- Horizontal drilling at a depth of 4 kilometer from the reference line.

#### Option 3

- Measure and regulate air quality in the categories 1 and 2.
- Install protection equipment with the vapor recovery system.
- Use pre-burning treatment technology.
- Establish a compensation fund of \$15 million for residents and farmers.
- Horizontal drilling at a depth of 2 kilometer from the reference line.

### 5.2. Water Quality and Quantity

Because the city solely relies on shallow water aquifers for irrigation and resident requirements,

the quality and quantity of water comprise an important issue for ROJ and FA.

In Jakhira City, oil drilling and production operations resulted in water pollution. Water quality was affected by toxic chemicals released from hydraulic fracturing, which moved into the water supply of the city. Additionally, the wastewater from the drilling and production operations contaminated groundwater. Furthermore, every oil well required a pit, which was used to store all the liquid and solid wastes associated with oil production, maintenance operations, and borehole cleaning. This waste caused the following issues:

- Contamination of groundwater.
- Contamination of soil and vegetation.

The oil companies must use alternatives to mitigate this issue, such as closed containment systems for oil and gas wells and closed-loop drilling system for drilling operations (Ledec, George, 1990 and Wojtanowicz, A K, et.al, 1989).

Most of the oil and gas producing companies use water as an injection fluid to improve production performance. Since hundreds of millions of water barrels are used throughout the life of the oilfield, drawing water from shallow aquifers will reduce groundwater level, increase well depth, and consequently the cost of drilling water wells. Moreover, the productivity of most palm trees, which are naturally irrigated, is affected by the reduction in groundwater levels. Thus, oil and gas companies must identify alternatives of injected water. ROJ suggested that these companies must use deep water aquifers or water delivered from distant resources through pipelines.

The following are the options to regulate water quality and quantity:

#### Option 1

- Use a closed containment system (tanks).
- Use pretreatment alternatives to alter the characteristics of wastewater and make subsequent treatment and disposal more sustainable.
- Use thermal technologies to remove hydrocarbons from waste products.
- Water injection wells must set up at a depth of 1,829 meter or more.

- Create an annual \$2-million trust fund for individual farmers if the groundwater level reduces or the quality worsens.
  - Create a \$2-million trust fund to support the FA by providing the required technologies to monitor water level and quality.
- Option 2
- Use a closed containment system (tanks).
  - Use pretreatment alternatives to alter the characteristics of wastewater and make subsequent treatment and disposal more sustainable.
  - Use thermal technologies to remove hydrocarbons from waste products.
  - Water injection wells must set up at a depth of 1524 meter or more.
  - Create an annual \$3-million trust fund for individual farmers if the groundwater level reduces or the quality worsens.
  - Create a \$3-million trust fund to support the FA by providing the required technologies to monitor water level and quality.

#### Option 3

- Use a closed containment system (tanks).
- Use the pretreatment alternatives to change the characteristics of wastewater and make subsequent treatment and disposal more sustainable.
- Use thermal technologies to remove hydrocarbons from waste products.
- Water injection wells must set up at a depth of 1,219 meter or more.
- Create an annual \$4 million trust fund for individual farmers if the groundwater level reduces or the quality worsens.
- Create a \$4-million trust fund to support the FA by providing the required technologies to monitor water level and quality.

### 5.3. Impact of Noise on the Quality of Life

The quality of life of the ROJ was affected by the exploration, drilling, and production operations of the oil and gas companies. Noise was the most important issue for homeowners living close to oil and gas wells, gathering stations, and the main campus. During production operations, oil wells require periodic maintenance and moving the rigs and heavy

trucks in the operation region. Moreover, operating the production line in oil and gas wells requires putting on the well pit first to burn the discharges and eliminate fluid and contaminated crude products. This creates noise similar to that of a jet engine for at least 30 minute. Furthermore, this operation occurred several times during each year of production. The homeowners require the oil and gas companies to meet the permissible residential noise levels of 30 decibels (dB) in the residential area (Berglund Birgitta, 2019).

The following are the options to reduce the impact of noise:

#### Option 1

- Maintenance operation from 9:00 am to 4:00 pm every weekday.
- Set limits of 30 dB in the residential area, and 45 dB around other boundaries.
- Use noise reduction technology for all equipment.
- Create a \$2-million trust fund for monitoring noise.
- Truck movement must be restricted to 7:00 am–5:00 pm.

#### Option 2

- Maintenance operation from 8:00 am to 5:00 pm every weekday.
- Set limits of 30 dB in the residential area, and 45 dB around other boundaries.
- Use noise reduction technology for all equipment.
- Create a \$3-million trust fund for monitoring noise.
- Truck movement must be restricted to 7:00 am–5:00 pm.

#### Option 3

- Maintenance operation from 7:00 am to 5:00 pm on Saturday through Thursday.
- Set limits of 30 dB in the residential area, and 45 dB around other boundaries.
- Use noise reduction technology for all equipment.
- Create a \$4-million trust fund for monitoring noise.
- Truck movement must be restricted to 7:00 am–5:00 pm.

### 5.4. Sustainable Development

The annual budget of the city is very limited, barely covering essential services such as healthcare, education, communication, and public transportation. Sharing these services with oil and gas companies would reduce the quality of city services and the quality of life of the residents. The shortage of essential services would increase pressure on the General Committee, who may not receive enough support from the residents during the next elections. The General Committee would request the oil and gas companies to deliver their responsibility of sharing the expenses of these services.

The following options are suggested to ensure sustainable development:

#### Option 1

- Transportation infrastructure share of oil companies should be \$5 million per year.
- Services sector share (health, education, and communication) should be \$5 million per year.
- Entertainment support share (culture activities and sports clubs) should be \$3 million per year.
- Employment responsibility share should be 10% of the total field task force.
- The tax rate should be 3% of the annual production.

#### Option 2

- Transportation infrastructure share of oil companies should be \$6 million per year.
- Services sector share should be \$6 million per year.

- Entertainment support share should be \$4 million per year.
- Employment responsibility share should be 15% of the total field task force.
- The tax rate should be 2% of the annual production.

#### Option 3

- Transportation infrastructure share of oil companies should be \$8 million per year.
- Services sector share should be \$8 million per year.
- Entertainment support share should be \$5 million per year.
- Employment responsibility share should be 20% of the total field task force.
- The tax rate should be 1% of the annual production.

## 6. Position of Parties on Dominant Issues and Their Priorities

### 6.1. National Oil Corporation (NOC)

#### 1. Issue of air pollution

This is a high-priority issue, as it affects development strategy and costs. The costs of horizontal wells are a function of their diameter (**Table 3**), with wells closer to the city incurring fewer development costs (M. Enamul Hossain, 2015). In this case, only option 3 is desirable, whereas option 2 is less desirable and option 1 is unacceptable.

**Table 3.** Development cost of each well and the total cost of 10 wells

Horizontal Well Length	2000 meter	3000 meter	4000 meter
Cost per foot	\$ 300	\$ 300	\$ 300
Cost per well	\$ 1,968,000	\$ 2,952,000	\$ 3,936,000
Total Cost for 10 Wells	\$ 19,680,000	\$ 29,520,000	\$ 39,360,000

#### 2. Issue of sustainable development

Sustainable development and tax returns are also high-priority issues. Since tax is a function of the production rate, high production rates will increase tax returns of the General Committee. The NOC expects that the production in the new explored field will reach up to 7947 cubic meter

per day (CM/D). Nonetheless, the NOC will minimize the tax rate as much as possible (**Table 4**). The first choice of NOC in such cases is option 3. Options 2 and 1 are less desirable and unacceptable, respectively.

**Table 4.** Annual taxable income for the General Committee of Jakhira City

Oil rate, CM/D	Oil rate, CM/yr	Oil price, \$/0.164 CM	income, \$	Tax rate, %	Tax, \$/yr
7,947	2,901,518	80	1,415,374,634	3	42,461,239
7,947	2,901,518	80	1,415,374,634	2	28,307,493
7,947	2,901,518	80	1,415,374,634	1	14,153,746

3. Issue of water quality and quantity  
This is a moderate-priority issue for the NOC. The only acceptable constraint is the depth of the water injection wells; the deeper the well, the more the cost. In this case, option 3 is desirable, option 2 is less desirable, and option 1 is the least desirable.

4. Issue of the impact of noise  
This is another moderate-priority issue for the NOC. The unacceptable restriction is the maintenance operation time, wherein option 2 is desirable, and options 3 and 1 are less desirable.

#### 6.2. Jakhira Municipality (JM)

1. Issue of sustainable development  
This is a high-priority issue for the JM, as support for the infrastructure is more valuable to the general community. Moreover, increased tax returns will fulfill requirements of the city. The order of choice in this case is option 1, followed by options 2 and 3.

2. Issue of water quality and quantity  
The only concern for the JM is water scarcity. Sharing water resources with oil and gas companies will deteriorate the quantity and the quality of water, which will, in turn, increase the cost of finding a suitable alternative. Under such circumstances, option 1 is the first choice, followed by option 2, and option 3 is the least desirable.

3. Issue of air pollution  
This is a moderate-priority issue for the JM. Setting up wells 2–6 km away from the city will protect the infrastructure of the city and increase its durability compared to when there will be no restrictions. In this case, the order of choices is options 1, 2, and 3, which is the least desirable.

4. Issue of the impact of noise  
This is a low-priority issue for the JM, with option 1 as the most desirable choice, followed by options 2 and 3.

#### 6.3. Farmer Association of Jakhira City (FA)

Farmers are highly concerned about negotiations. They aim for more guarantees to exercise their rights from any agreement reached with the NOC.

1. Issue of air pollution  
This is a high-priority issue for the farmers. Air pollution affects the productivity of dates and vegetable cultivation. Thus, option 1 is the most desirable choice, with options 2 and 3 being desirable and less desirable, respectively.

2. Issue of water quantity and quality  
This is another high-priority issue for the farmers. Water levels are fundamental to their farms; therefore, option 1 is desirable, followed by options 2 and 3.

3. Issue of the impact of noise  
Since farms are closest to oil and gas wells and the main campus, farmers suffer much more from the noise of production operations. Nonetheless, this is a moderate-priority issue for the farmers, with option 1 being the most desirable. Options 2 and 3 are less and least desirable, respectively.

4. Issue of sustainable development  
This is a low-priority issue for the farmers, as the present situation of the city is satisfactory to meet their requirements. Therefore, the first choice is option 3, followed by options 2 and 1.

#### 6.4. Residents of Jakhira City (ROJ)

The aim of the residents of this remote area is to prevent any calamity and improve the quality of their lives if any oil and gas company is established within or around their city. They consider air pollution, decreasing water quality and quantity, and noise pollution as the main issues.

1. Issue of air pollution  
This is a high-priority issue for the residents. Air pollution adversely affects human health.

Therefore, residents want to ensure that the levels of air pollutants are within the permissible range specified in the country standards. Thus, option 1 is desirable; with options 2 and 3 are less desirable.

2. Issue of water quantity and quality  
This is also a high-priority issue for the residents, as water is one of the basic necessities of life. In this case, option 1 is highly desirable, followed by options 2 and 3.

3. Issue of the impact of noise  
Residents are concerned about the noise issue, as the noise generated by the operations of oil and gas companies will affect the quality of their lives, making it another high-priority issue.

Thus, option 1 is desirable, whereas options 2 and 3 are less desirable.

4. Issue of sustainable development  
This is a less important issue for the residents. However, they consider active participation of oil and gas companies in sustainable development as the most important goal. Therefore, option 3 is the first choice, followed by option 2 and 1, which is the less desirable.

## 7. Analysis of the Templates Provided by the Negotiating Parties

### 7.1. National Oil Corporation (NOC)

The generated options, scores, negotiation score of each issue, and the reservation value of the interest deal of the NOC are shown in (Table 5).

**Table 5.** Template Score Analysis of the NOC

Pr. Ranking	Issue	Pos. Resolution	D. Value	Score	Neg. Score
1	Develop. Sustainability & Tax	Option 1	10	30	10
		Option 2	20		
		Option 3	30		
2	Air Pollution	Option 1	10	30	20
		Option 2	20		
		Option 3	30		
3	Water Quality & Quantity	Option 1	10	20	15
		Option 2	15		
		Option 3	20		
4	Noise Impacts	Option 1	10	20	20
		Option 2	15		
		Option 3	20		
			Total	100	65
<b>Reservation Value = 45</b>					

### 7.2. Jakhira Municipality (JM)

The generated options, scores, negotiation score of each issue, and the reservation value of the interest deal of the JM are shown in (Table 6).

**Table 6.** Template Score Analysis of the General Committee of Jakhira City

Pr. Ranking	Issue	Pos. Resolution	D. Value	Score	Neg. Score
1	Develop. Sustainability & Tax	Option 1	30	30	30
		Option 2	20		
		Option 3	10		
2	Water Quality & Quantity	Option 1	30	30	20
		Option 2	20		
		Option 3	10		
3	Air Pollution	Option 1	30	30	20
		Option 2	20		
		Option 3	10		



4	Noise Impacts	Option 1	10	10	6
		Option 2	8		
		Option 3	6		
			Total	100	76
<b>Reservation Value = 45</b>					

### 7.3. Farmers Association of Jakhira City (FA)

The generated options, scores, negotiation score of each issue, and the reservation value of the interest deal of the FA are shown in (Table 7).

**Table 7.** Template Score Analysis of the Farmers Association

Pr. Ranking	Issue	Pos. Resolution	D. Value	Score	Neg. Score
1	Air Pollution	Option 1	30	30	20
		Option 2	20		
		Option 3	15		
2	Water Quality & Quantity	Option 1	30	30	20
		Option 2	20		
		Option 3	15		
3	Noise Impacts	Option 1	20	20	10
		Option 2	15		
		Option 3	10		
4	Develop. Sustainability & Tax	Option 1	20	20	20
		Option 2	15		
		Option 3	10		
			Total	100	70
<b>Reservation Value = 55</b>					

### 7.4. Residents of Jakhira City (ROJ)

The generated options, scores, negotiation score of each issue, and the reservation value of the interest deal of the ROJ are shown in (Table 8).

**Table 8.** Template Score Analysis of the Residents of Jakhira City

Pr. Ranking	Issue	Pos. Resolution	D. Value	Score	Neg. Score
1	Air Pollution	Option 1	30	30	20
		Option 2	20		
		Option 3	10		
2	Water Quality & Quantity	Option 1	30	30	20
		Option 2	20		
		Option 3	10		
3	Noise Impacts	Option 1	20	20	10
		Option 2	15		
		Option 3	10		
4	Develop. Sustainability & Tax	Option 1	20	20	20
		Option 2	15		
		Option 3	10		
			Total	100	70
<b>Reservation Value = 55</b>					

## 8

**. Result of Negotiation**

The results of the cooperative negotiation model are summarized in **(Table 9)**. The negotiation was settled at reservation values of 55, 55, 45,

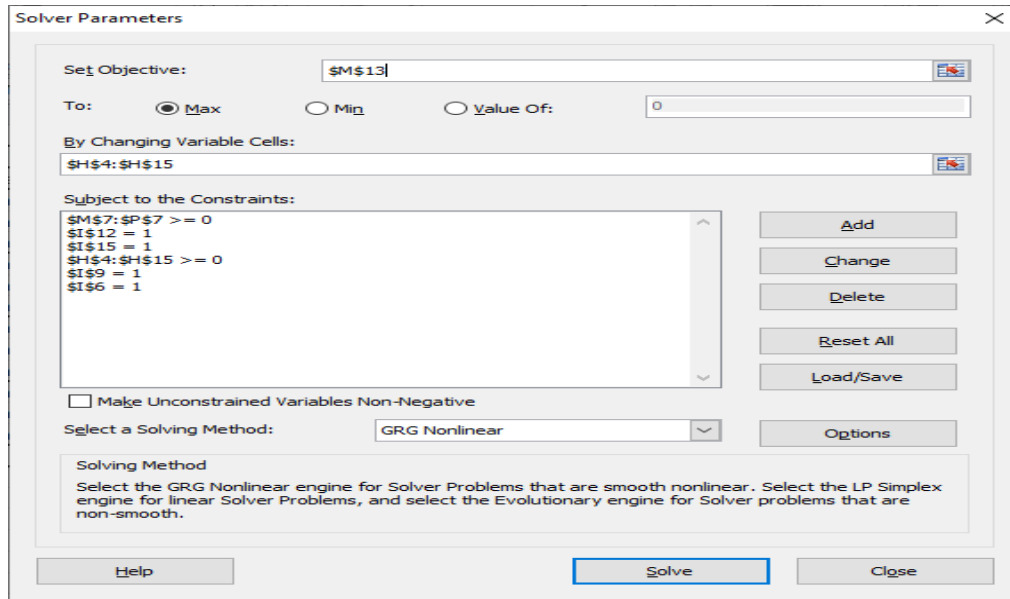
and 45 for FA, ROJ, JM, and NOC, respectively. The minimum POP was 0.353 and the sum-product of excesses was 139,500.

**Table 9.** A four-party negotiation template without optimization

Negotiation Template							
Issue	Resolution	FA	ROJ	JM	NO C	Contracts	Sum
Air Pollution	Option 1	30	30	30	10	0	
	Option 2	20	20	20	20	1	
	Option 3	15	10	10	30	0	1
Water Quality & Quantity	Option 1	30	30	30	10	0	
	Option 2	20	20	20	15	1	
	Option 3	15	10	10	20	0	1
Noise Impacts	Option 1	20	20	10	10	0	
	Option 2	15	15	8	15	0	
	Option 3	10	10	6	20	1	1
Develop. Sustainability & Tax	Option 1	20	20	30	10	1	
	Option 2	15	15	20	20	0	
	Option 3	10	10	10	30	0	1
Value		70	70	76	65		
		FA	ROJ	JM	NOC		
Value		70	70	76	65		
RV		55	55	45	45		
Excess		15	15	31	20		
Max F		97.5	97.5	98	92.5		
Potential		42.5	42.5	53	47.5		
POP		0.353	0.353	0.585	0.421		
Sum of the negotiation values		281					
Sum-product of excesses		139,500					
MinPOP		0.353					

Nash added a potential solution value to the optimization problem, because it considered fair solution for the negotiators. In the Nash solution, the contract scores of the four parties are maximized by maximizing the minimum of the product of excesses. The negotiation score output of the four parties from the Nash solution is summarized in **(Table 10)**. This output has been determined with the help of SOLVER. The SOLVER engine is a special mathematical program that works within Excel. The SOLVER dialogue box that appears in **(Figure 7)** is shown

maximizing the objective of the product of the excess of the contract of the four parties. The solver runs to maximize the set objective, which is the product of the excess by changing variable cells (contracts in table 9). The value of maximizing the product of excesses was estimated at 643,125, and the contract options were 1 for air pollution, 1 for water quality and quantity, 1 for the impact of noise, and 3 for sustainable development and tax returns. The contract values were 90, 90, 80, and 60 for FA, ROJ, JM, and NOC, respectively **(Tables 10)**.



**Figure 7.** The SOLVER dialogue box showed maximizing the objective of the product of the excess of the contract of the four parties using the Nash solution.

**Table 10.** A negotiation template of the four parties without optimization

Negotiation Template							
Issue	Resolution	FA	ROJ	JM	NO C	Contracts	Sum
Air Pollution	Option 1	30	30	30	10	1	
	Option 2	20	20	20	20	0	
	Option 3	15	10	10	30	0	1
Water Quality & Quantity	Option 1	30	30	30	10	1	
	Option 2	20	20	20	15	0	
	Option 3	15	10	10	20	0	1
Noise Impacts	Option 1	20	20	10	10	1	
	Option 2	15	15	8	15	0	
	Option 3	10	10	6	20	0	1
Develop. Sustainability & Tax	Option 1	20	20	30	10	0	
	Option 2	15	15	20	20	0	
	Option 3	10	10	10	30	3	1
Value		90	90	80	60		
		FA	ROJ	JM	NOC		
Value		90	90	80	60		
RV		55	55	45	45		
Excess		35	35	35	15		
Max F		97.5	97.5	98	92.5		
Potential		42.5	42.5	53	47.5		
POP		0.824	0.824	0.660	0.316		
Sum of the negotiation values		320					
Sum-product of excesses		643,125					
MinPOP		0.316					

Nash Solution provided the best contract for the FA, ROJ, and JM by giving them the top contract options, which are the best options in

the air, water, and noise, which is life quality. The NOC will pay a tax of just 1% of the annual oil production (**Table 11**).

**Table 11.** Summarizes the difference between cooperative negotiation and the Nash Solution

Approach	Contracts' Options				Solution Values					
	Air	Water	Noise	Develp. S.	F A	ROJ	JM	NO C	Product	MinPOP
Co. Negotiation	2	2	3	1	73	68	78	70	139,500	0.353
Nash Solution	1	1	1	3	90	90	80	60	643,125	0.316

## 9. Conclusions

The study explores a highly complicated conflict of interest among four parties in Libya — the NOC, JM, ROJ, and FA. The conflict was raised in 2017 by the JM, who complained that the NOC did not meet local demands of reducing carbon footprint, improving labor policies, participating in fair trade, charity, volunteering in the community, and corporate policies that benefitted the environment. The study proposes a model of negotiation to solve this conflict. The negotiation template was designed based on four primary issues, namely air pollution, water quality and quantity, impact of noise on the quality of life, and sustainable development and tax returns, which were highly concerning for the NOC, JM, ROJ, and FA. The model was scored based on the priorities of each party. The Nash solution by maximizing the product of excesses was used to find the best negotiation contract for each party.

The negotiation contracts were obtained using the collaborative model and Nash solution approach. In the collaborative model, the value of maximizing the product was 139,500, and the contract options were 2 for air pollution, 2 for water quality and quantity, 3 for the impact of noise, and 1 for sustainable development and tax returns. The contract values were 73, 68, 78, and 70 for FA, ROJ, JM, and NOC, respectively.

In the Nash solution, the value of maximizing the product of excesses was improved at 643,000, and the contract options were 1 for air pollution, 1 for water quality and quantity, 1 for the impact of noise, and 3 for sustainable development and tax returns. The contract values were 90, 90, 80, and 60 for FA, ROJ, JM, and NOC, respectively.

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## Funding:

This research is not supported or funded by any institutions.

## Institutional Review Board Statement:

Not applicable.

## Informed Consent Statement:

Not applicable.

## Data Availability Statement:

Not applicable.

## Conflicts of Interest:

The authors declare no conflict of interest nor personal circumstances or interest that may be perceived as inappropriately influencing the representation or interpretation of reported research results.

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