

Impact of Gas Flaring on the Environment in the Kurdistan Region of Iraq

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Abstract

Gas flaring is a common practice in the oil and gas industry that involves the burning of natural gas during the extraction and processing of crude oil. Despite its economic benefits, gas flaring has significant negative impacts on the environment. This paper explores the various ways in which gas flaring affects the environment, including the emission of greenhouse gases, air pollution, acid rain, and the destruction of ecosystems. It used a cross-sectional survey research design in generating the primary data used for the study, while the location of the study is Kurdistan. It used a sample size of 375 from a population of 6000 Oil & Gas company workers in Kurdistan. The findings of the study suggest that the negative impacts of gas flaring on the environment are significant, and requires urgent action to mitigate its effects. This paper provides valuable insights for policymakers, stakeholders and researchers interested in addressing the environmental consequences of gas flaring in the oil and gas industry.

Keywords: Gas flaring, air pollution, human ill-health, climate change, environment.

1. Introduction

1.1 Background

Gas combustion is the combustion of gas that is brought to the surface as part of a petroleum operation. This combustion produces many toxins and heat that negatively impact the health of humans and other animals, as well as the environment. There has been growing global concern about the impact of gas on the environment and, more recently, on human health. Similarly, the impact of gas burning in the KRG, which is under Kurdish rule in Iraq, is also a local concern and uncontrolled and unnecessary gas burning has a negative impact on the system. Flora, fauna, human health and livelihoods in this area. Reports indicate that the burning of gas under Kurdish rule in Iraq produces more greenhouse gases such as carbon dioxide, chlorofluorocarbons, methane and nitrous oxide in the atmosphere than the combined contributions of the European nations. Sub-Saharan Africa. The greenhouse gases released during gas burning are significantly associated with global warming, which can lead to sea level rise and

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accelerate the effects of climate change. The burning of gas, which is often carried out by oil exploration companies during the Kurdish rule of Iraq, thereby endangers the health of the people and the environment due to pollution, global warming, and decommissioning. Release greenhouse gases into the atmosphere. This study was conducted to investigate the impact of gas burning on the environment under Kurdish rule in Iraq to understand public knowledge and the mitigation efforts of the oil company and the government. The association between gas flares and morbidity, including demarcating opinion from perception, was significant.

The impact of gas flaring on the environment in Iraq has been a growing concern due to its adverse effects on human health, air quality, and climate change. The practice of gas flaring in Iraq has resulted in the release of millions of tons of carbon dioxide into the atmosphere, contributing to global warming and climate change. The flared gas also contains harmful pollutants such as sulfur dioxide, nitrogen oxides, and particulate matter, which can cause respiratory problems, cancer, and other health issues.

The oil and gas industry is a crucial sector in Iraq's economy, but the negative impact of gas flaring on the environment and public health cannot be overlooked. Therefore, there is a need for research to investigate the impact of gas flaring on the environment in Iraq, identify the factors contributing to its prevalence, and propose solutions to mitigate its effects. Such studies can help policymakers, environmentalists, and the public to make informed decisions about gas flaring in Iraq and promote sustainable development (World Bank. n.d.).

1.2 Statement of the problem

The federal government's efforts to combat gas burning have not yielded the desired results. Gas burning persisted under Kurdish rule over Iraq's oil and gas industry due to market and economic constraints, lack of a suitable legal mechanism with severe penalties, and lack of political will. The federal government to implement its anti-gas policy. Fiery law. The Kurds rule Iraq and nine other countries are believed to be responsible for 75% of global gas. At the time, Iraq was burning the second-largest amount of gas in the world (after Russia) - about 17.37 billion cubic meters. As of this year, Iraq remains the second most serious violator on the issue after Russia, although the amount of gas involved has fallen to around 16 billion cubic meters.

In addition, Kurdish regulation in Iraq ignites a higher proportion of associated gas, thereby causing a loss of national revenue for economic and development projection of the country. The world is currently burning about 144 billion cubic meters, which could generate electricity for the whole of sub-Saharan Africa. Burning gas, a colossal waste of a priceless natural resource that can be used commercially, such as generating electricity, or conserved by pumping it back into a reservoir. In addition, gas burning has deleterious impacts on the health, environment, livelihoods, and agricultural production of oil-producing communities. It has largely contributed to global warming and its impact on the environment through the emission of carbon dioxide, black carbon and other environmental pollutants. He wasted invaluable resources that could be used to improve and sustainably grow the economy. In 2021, about 144 billion cubic meters of gas have been burned at various oil production sites around the world, contributing 40% of annual emissions to Arctic black carbon deposits (Musa, et al., 2019).

1.3 Purpose of the study

The main goal of this study was to determine the impact of gas burning on the environment under Kurdish rule in Iraq. The purpose of studying the impact of gas flaring on the environment in Iraq is to understand the negative effects that the practice of burning natural gas during oil extraction and production can have on the local environment and the people living in the affected areas. Gas flaring releases various pollutants into the air, such as carbon dioxide, sulfur dioxide, and nitrogen oxides, which can contribute to climate change and pose a significant health risk to nearby communities. Additionally, gas flaring can harm local ecosystems and wildlife, and contaminate soil and water resources.

By studying the impact of gas flaring in Iraq, researchers can identify the extent of the environmental and health risks posed by this practice, and develop strategies to mitigate its negative effects. This may include exploring alternative methods of utilizing natural gas, such as capturing and utilizing it for energy production, or developing policies and regulations that limit the amount of gas flaring that can take place during oil production. Ultimately, the goal is to protect the environment and promote sustainable development in the region (Hama & Abdulrazak, 2018).

1.4 Research Objectives

1. To ascertain the extent to which gas flaring has increased air pollution in Kurdistan region of Iraq.
2. To ascertain the extent to which gas flaring has increased human ill-health in Kurdistan region of Iraq.
3. To ascertain the extent to which gas flaring has increased climate change in Kurdistan region of Iraq.

1.5 Research Questions

1. Has gas flaring increased air pollution in Kurdistan region of Iraq?
2. Has gas flaring increased human ill-health in Kurdistan region of Iraq?
3. Has gas flaring increased climate change in Kurdistan region of Iraq?

1.6 Research hypotheses

- 1H₀: Gas flaring has not increased air pollution in Kurdistan region of Iraq.
- 2H₀: Gas flaring has not increased human ill-health in Kurdistan region of Iraq.
- 3H₀: Gas flaring has not increased climate change in Kurdistan region of Iraq.

1.7 Scope/Limitation of the study

The main objective of this study is to investigate the environmental impact of gas flaring in the Kurdistan region of Iraq. Specifically, the study will focus on analysing the impact of gas flaring on air quality, human health, and climate change. The research will be limited to studying the impact of pollution caused by gas flaring on the environment in Kurdistan.

The scope of this study is limited to the environmental impacts of gas flaring in Kurdistan and will not include an analysis of the economic impact of the gas flaring industry on the region. However, the study aims to provide insights into the environmental challenges associated with gas flaring, which can inform policy decisions aimed at promoting sustainable development in the region.

There are several limitations to this study, including the limited availability of data on the environmental impacts of the gas flaring industry in Kurdistan, as well as potential limitations due to research resources and time constraints.

Despite these limitations, this study is expected to generate valuable insights into the environmental impacts of gas flaring in Kurdistan and contribute to the existing knowledge on the subject. Furthermore, the findings of this study can inform policy decisions aimed at mitigating the environmental impacts of gas flaring, promoting sustainable development in the region, and protecting the health and well-being of local communities (Hama & Abdulrazak, 2018).

1.8 Significance of the study

The study about the impact of gas flaring on the environment in the Kurdistan region of Iraq has several significant implications.

Firstly, gas flaring is a major source of environmental pollution, which can adversely impact human health, local ecosystems, and climate change. Therefore, understanding the environmental impacts of gas flaring is essential for promoting sustainable development in the region and protecting the health and well-being of local communities.

Secondly, Kurdistan is a rapidly developing region with a growing oil and gas industry. As such, there is a need to understand the environmental challenges associated with this industry and identify ways to mitigate its impact on the environment. The findings of this study can inform policy decisions aimed at promoting sustainable development in the region and reducing the environmental footprint of the oil and gas industry.

Thirdly, the study can contribute to the global knowledge on the environmental impacts of gas flaring, which is a major concern in many oil-producing regions around the world. By shedding light on the specific environmental impacts of gas flaring in the Kurdistan region of Iraq, this study can inform the development of effective strategies and best practices for reducing gas flaring and its impact on the environment.

Overall, the study about the impact of gas flaring on the environment in the Kurdistan region of Iraq is significant because it can contribute to the development of sustainable energy practices, help protect human health and local ecosystems, and promote the long-term well-being of the region's communities. (Hama & Abdulrazak, 2018).

1.9 Contextual relevance of the study

Kurdistan is a rapidly developing region that has seen significant growth in its oil and gas industry recently. As a result, gas flaring has become a major environmental issue in the region, causing air pollution, damaging local ecosystems, and contributing to climate change. Given the increasing

importance of the oil and gas industry to the region's economy, it is crucial to understand the environmental impacts of gas flaring and develop strategies to mitigate its effects.

Furthermore, gas flaring is a global issue that affects many oil-producing regions around the world. The findings of this study can therefore contribute to the development of best practices for reducing gas flaring and mitigating its impact on the environment, which can be applied in other regions facing similar challenges.

In addition, the study's focus on air quality, human health, and climate change is relevant in the current global context, where there is growing awareness of the need to address environmental issues and promote sustainable development. Understanding the environmental impacts of gas flaring in Kurdistan can contribute to the development of effective policies and practices for reducing greenhouse gas emissions, protecting public health, and promoting sustainable economic growth.

Overall, the study about the impact of gas flaring on the environment in the Kurdistan region of Iraq is relevant to the current context of the region and the world at large, as it addresses a critical environmental issue and provides insights into the development of sustainable energy practices (Qadir & Hussain, 2021).

2. Literature Review

Gas flaring is a common practice in the oil and gas industry, and it involves burning off waste gas that is produced during oil extraction and processing. While gas flaring can be a convenient and cost-effective way to dispose of waste gas, it has negative impacts on the environment, including air pollution, climate change, and human health. This literature review summarizes some of the research on the impact of gas flaring on the environment.

Several studies have focused on the environmental impact of gas flaring in the Kurdistan region of Iraq. For example, a study conducted by Ahmed and Jabbouri (2017) found that gas flaring in the region has led to air pollution, which has negative impacts on human health and the environment. The study also found that gas flaring contributes to climate change, as it results in the release of greenhouse gases, such as methane and carbon dioxide.

Another study by Ali et al. (2019) analyzed the impact of gas flaring on soil quality in the Kurdistan region of Iraq. The study found that gas flaring has negative impacts on soil quality, as it increases the levels of heavy metals and other pollutants in the soil, which can have negative impacts on plant growth and soil fertility.

In addition to environmental impacts, gas flaring also has socio-economic impacts in the Kurdistan region of Iraq. A study by Rashid et al. (2020) found that gas flaring has negative impacts on the local communities, as it leads to the loss of land and livelihoods, and contributes to the displacement of communities. The study also found that gas flaring results in the loss of revenue for the government, as the gas that is being flared could otherwise be used for energy production.

Overall, previous research indicates that gas flaring has significant negative impacts on the environment, human health, and local communities in the Kurdistan region of Iraq. The findings suggest that there is a need for effective policies and regulations to minimize the practice of gas flaring and to promote sustainable development in the region.

2.1 Gas flaring and air pollution:

Gas flaring is a significant contributor to air pollution in the Kurdistan region of Iraq. The burning of natural gas during the production of crude oil leads to the release of various pollutants into the air, including greenhouse gases, nitrogen oxides, sulfur dioxide, and particulate matter. These pollutants can adversely impact human health and the environment.

The impact of gas flaring on air pollution in the Kurdistan region of Iraq can be significant, especially in areas near oil and gas fields. According to a report by the World Bank, gas flaring in Iraq resulted in an estimated 25 million metric tons of carbon dioxide equivalent emissions in 2017, making it one of the largest sources of greenhouse gas emissions in the country.

The particulate matter released during gas flaring can also contribute to respiratory problems such as asthma and lung cancer. The sulfur dioxide and nitrogen oxides released can cause acid rain and contribute to the formation of ground-level ozone, which can negatively impact crops and ecosystems.

Furthermore, gas flaring can also adversely impact the local economy and communities. Gas flaring wastes natural resources that could otherwise be used to generate electricity, and the resulting pollution can harm agricultural land and water sources, affecting local livelihoods.

In summary, gas flaring has a significant impact on air pollution in the Kurdistan region of Iraq, and reducing it can lead to significant health and environmental benefits for local communities. Therefore, it is essential to monitor and regulate gas flaring activities and invest in technologies and infrastructure to capture and utilize the natural gas that is currently being wasted.

2.2 Gas flaring and human health

Gas flaring in the Kurdistan region of Iraq can adversely impact human health. The burning of natural gas during the production of crude oil releases various pollutants into the air, including particulate matter, sulfur dioxide, and nitrogen oxides, which can cause respiratory and cardiovascular problems, among other health issues.

Particulate matter, for example, can penetrate deep into the lungs and cause respiratory problems such as asthma, bronchitis, and lung cancer. Sulfur dioxide and nitrogen oxides can cause irritation of the eyes, nose, and throat, and also aggravate existing respiratory conditions. Exposure to these pollutants can also weaken the immune system and make people more susceptible to respiratory infections.

Furthermore, gas flaring also releases toxic substances such as benzene, which is a known carcinogen. Long-term exposure to benzene can increase the risk of leukemia and other cancers.

The health impact of gas flaring can be especially significant for communities living near oil and gas fields. These communities may be exposed to higher levels of pollutants and may experience more significant health effects, including respiratory and cardiovascular problems.

Gas flaring in the Kurdistan region of Iraq can have significant adverse effects on human health, especially for those living near oil and gas fields. It is therefore essential to monitor and regulate gas flaring activities, and to take steps to reduce the amount of natural gas being wasted through flaring, such as investing in technologies and infrastructure to capture and utilize the natural gas that is currently being flared (Salih& Ismail, 2019).

2.3 Gas flaring and climate change

Gas flaring in the Kurdistan region of Iraq has a significant impact on climate change. The burning of natural gas during the production of crude oil releases large amounts of greenhouse gases into the atmosphere, primarily carbon dioxide and methane, which contribute to global warming.

Methane, in particular, is a potent greenhouse gas, with a global warming potential that is more than 80 times greater than that of carbon dioxide over a 20-year time horizon. This means that even small leaks or inefficiencies in gas flaring operations can have a significant impact on the climate.

According to a report by the World Bank, gas flaring in Iraq, including the Kurdistan region, resulted in an estimated 25 million metric tons of carbon dioxide equivalent emissions in 2017, making it one of the largest sources of greenhouse gas emissions in the country.

The impact of gas flaring on climate change can be further exacerbated by the fact that the released gases contribute to air pollution, which can indirectly impact the climate. For example, particulate matter released during gas flaring can reduce the amount of sunlight reaching the Earth's surface and contribute to global dimming, which can have a cooling effect on the planet.

Gas flaring in the Kurdistan region of Iraq has a significant impact on climate change, primarily through the release of greenhouse gases such as carbon dioxide and methane. Reducing gas flaring and investing in technologies and infrastructure to capture and utilize natural gas can help reduce these emissions and mitigate their impact on the climate (Majeed et al., 2019).

2.4 Conceptual Framework

Gas flaring is a common practice in the oil and gas industry. It involves the burning of natural gas that is released during oil extraction and processing operations. Gas flaring can have a significant impact on the environment, including air pollution, climate change, and ecosystem disruption. This conceptual framework aims to explore the impact of gas flaring on the environment and the factors that influence this impact.

Gas Flaring: Gas flaring is a process in which natural gas is burned off during oil extraction and processing operations. Gas flaring can release large amounts of pollutants into the environment, including carbon dioxide, nitrogen oxides, sulfur dioxide, and particulate matter.

Environmental Impact: The environmental impact of gas flaring can be significant. It can lead to air pollution, climate change, and ecosystem disruption. Air pollution can have a negative impact on human health, and climate change can lead to more severe weather events and rising sea levels. Ecosystem disruption can affect biodiversity and the balance of natural systems.

Factors Influencing Impact: The impact of gas flaring on the environment is influenced by several factors, including the duration and intensity of the flaring, the composition of the gas being flared, and the location of the flaring. The duration and intensity of the flaring can determine the number of pollutants released into the environment. The composition of the gas being flared can affect the types and amounts of pollutants released. The location of the flaring can determine the proximity of human populations and ecosystems to the pollutants (Karim, & Mustafa, 2021).

Regulatory Framework: The impact of gas flaring on the environment can be mitigated by a regulatory framework that limits the duration and intensity of flaring, promotes the use of alternative energy sources, and encourages the capture and utilization of flared gas. Such a framework can reduce

the environmental impact of gas flaring while promoting sustainable development. The impact of gas flaring on the environment is significant, and it is influenced by several factors. A regulatory framework that limits the duration and intensity of flaring, promotes the use of alternative energy sources, and encourages the capture and utilization of flared gas can mitigate the environmental impact of gas flaring while promoting sustainable development (Qadir & Hussain, 2021).

2.5 Theoretical Framework

A theoretical framework that could be used to study the impact of gas flaring on the environment in the Kurdistan region of Iraq is the "Pollution Haven Hypothesis" (PHH), which was first proposed by economist Gene and Krueger in 1991. The PHH suggests that countries with weak environmental regulations and low labor standards attract polluting industries, as firms seek to avoid the high costs of complying with environmental regulations in developed countries. According to the PHH, countries with weak environmental standards become "pollution havens," as firms choose to relocate their polluting activities to these countries to reduce their production costs.

In the context of gas flaring in the Kurdistan region of Iraq, the PHH could be used to explore how weak environmental regulations in the region might be attracting oil and gas companies to engage in gas flaring, which results in negative environmental impacts. The theory suggests that the government of Kurdistan region may need to strengthen their environmental regulations to avoid being seen as a pollution haven, and to encourage oil and gas companies to adopt more environmentally friendly practices, (Al-Ansari, & Knutson, 2016).

2.6 Gaps in Previous researches

Previous researches have studied the impact of gas flaring on the environment in various parts of the world, including Nigeria, Russia, Venezuela, and the United States. Some of the findings of these studies are:

Gas flaring can lead to air pollution, which can have negative impacts on human health and the environment. The emissions from gas flaring contain various pollutants, including sulfur dioxide, nitrogen oxides, particulate matter, and volatile organic compounds, which can cause respiratory problems, cancer, and other health issues. Gas flaring can also contribute to climate change. Methane, which is a potent greenhouse gas, is released during gas flaring. The flaring of gas also results in the release of carbon dioxide, which contributes to the overall increase in greenhouse gas emissions.

Gas flaring can have negative impacts on local ecosystems. The pollutants released during gas flaring can harm plant and animal life, and the heat generated by the flares can alter the temperature and humidity of the surrounding environment.

Gas flaring can also have socio-economic impacts. For example, it can contribute to the loss of land and livelihoods for local communities, and it can lead to the loss of revenue for governments if the gas that is being flared could otherwise be used for energy production.

Overall, previous research has shown that gas flaring has significant negative impacts on the environment, human health, and local communities. The findings suggest that there is a need for effective policies and regulations to minimize the practice of gas flaring and to promote sustainable development in regions where oil and gas exploration is taking place, (Majeed et al., 2019).

3. Research Methodology

3.1 Research Design

The research design serves as a blueprint for the collection, evaluation, and analysis of data generated during the research work. It involves a systematic collection, presentation, and analysis of primary data with the aim of testing postulated hypotheses for acceptance or rejection (Mugenda & Mugenda, 2012). The research design utilized in this study is a survey design. A questionnaire was developed to gather data from a population of 6000 individuals in Kurdistan who are directly or indirectly affected by gas flaring. The questionnaire includes questions related to air pollution, human health and climate change and their effects on the environment. Data collected was presented using tables analyzed using pie-charts and percentages, while formulated hypotheses were tested using chi-square test.

The research utilized a sample of 375 respondents selected randomly from a population of 6,000 employees in the oil and gas industry in Kurdistan, consisting of managers, supervisors, and workers. The sample size of 375 was determined using the Yamane 1964 formula for sample size determination at a 5% level of significance for sampling error. The sample respondents were selected using the shuffling of cards method without replacement. This method involved writing all the names of the three categories of employees separately on small cards and selecting the topmost name from each group of cards, shuffling the cards until all the sample respondents were selected.

In this study, a cross-sectional research design was used to gather data on the impact of gas flaring on the environment in the Kurdistan region of Iraq. This research design involves collecting data at a specific point to provide a snapshot of the current state of the environment in the region. The cross-sectional research design allows for the collection of data on environmental pollution levels, the effects of gas flaring on air pollution, human health and climate change, and the perspectives and experiences of individuals affected by gas flaring. This design also enables the identification of relationships between variables, such as the relationship between the level of gas flaring and the extent of environmental pollution.

Overall, the cross-sectional research design is appropriate for this study as it enables the exploration of the impact of gas flaring on the environment in the Kurdistan region of Iraq at a specific point, (Hawrami & Mohammad, 2020).

The research design used in this study is a survey design, which involves gathering data from a sample of individuals to sample their opinions or perceptions on a particular topic. Specifically, the study aims to investigate the impact of gas flaring on the environment in the Kurdistan region of Iraq by collecting data on the levels of air pollution, human health and climate change caused by gas flaring. The survey design is an appropriate choice for this study because it allows for the collection of data directly from the population of interest and enables the researchers to test hypotheses and draw conclusions about the impact of gas flaring on the environment. Adapted from: Ali, A. M. (2021).

According to the classification of research categories, the research on the impact of gas flaring on the environment in the Kurdistan region of Iraq can be categorized as an applied research. As defined by Yin (2018), applied research is a type of research design that aims to provide practical solutions to existing problems. In this case, the research is intended to identify the extent of environmental damage caused by gas flaring and explore possible solutions to mitigate its negative impact. Therefore, the

research has practical implications and is aimed at providing useful insights and recommendations to policymakers, oil and gas companies, and other stakeholders in the region. (Yin, 2018).

3.2 Research Tools

The impact of gas flaring on the environment in the Kurdistan region of Iraq is a critical issue that requires empirical research to identify the extent of the problem and potential solutions. To investigate this issue, the primary data collection tool used in this study will be a questionnaire. The questionnaire will contain both open-ended and closed-ended questions to gather comprehensive information from the respondents. The open-ended questions will allow the respondents to express their opinions and provide detailed information about their experiences with gas flaring, while the closed-ended questions will enable the researcher to quantify and categorize the responses.

The data presentation tool used in this study will be tables, which will provide a clear and concise representation of the results. The tables will present the data in a format that is easy to interpret and understand. Additionally, the data analysis tool used will be simple percentages, which will enable the researcher to calculate the frequency of occurrence of different responses and trends.

To test the formulated hypotheses, the chi-square/analysis of variance will be used. Chi-square test will be used to determine if there is a significant association between two categorical variables, such as the relationship between the level of gas flaring and its impact on the environment.

The use of a questionnaire, tables, simple percentages, and chi-square/analysis of variance as research tools in this study will provide valuable insights into the impact of gas flaring on the environment in the Kurdistan region of Iraq. These tools will enable the researcher to collect and analyze data effectively, test formulated hypotheses, and provide evidence-based recommendations for addressing this critical issue. (Kothari, 2004).

3.3 Method of Sampling

To ensure that the results of the study are representative of the population affected by gas flaring in Kurdistan, a stratified random sampling technique will be used. The population of interest for the study is 6,000 individuals working in areas impacted by the gas flaring. The population will be divided into strata based on their proximity to the gas flaring, as this is likely to affect the extent of pollution exposure.

The population size was 6000 workers who are working in the oil and gas industry in Kurdistan region of Iraq. A sample size of 375 was selected using the formula for determining sample size for a given population, with a 95% confidence level and a 5% margin of error. This ensured that the sample size is sufficient to obtain reliable results while minimizing the risk of sampling error.

Overall, the use of a stratified random sampling technique helped to ensure that the study results are representative of the population affected by gas flaring in Kurdistan, and that the findings can be generalized to the larger population.

This study utilized a random sampling approach to choose participants from a population of 6000 personnel in the industry to conduct research on the impacts of gas flaring on the environment in Kurdistan. To provide every employee an equal chance of being chosen for the research, random sampling was used as the sampling strategy. When a researcher wants to collect a sample from a

population that fairly represents the population, random sampling is an appropriate strategy to use. As a result, the study's use of random sample increases its conclusions for the wider community of Kurdish oil and gas industry workers. World Bank. (2021).

3.4 Calculation of Sample Size

To determine the sample size for this study, the Yamane (1967) formula for sample size determination was used due to the large population of interest. With a population size of 6,000 individuals working in areas affected by gas flaring, a sample size of 375 was calculated using a 95% confidence level and a 5% margin of error. The formula used in this study is as follows:

$$n = \frac{N}{1+N(e^2)}$$

Where: n = sample size, N = population size, e = level of significance (sample error).

$$n = \frac{6000}{1+6000(0.05^2)} = 375$$

4. Results and Discussion

4.1 Data presentation:

Question Number 1

Has gas flaring increased air pollution in Kurdistan region of Iraq?

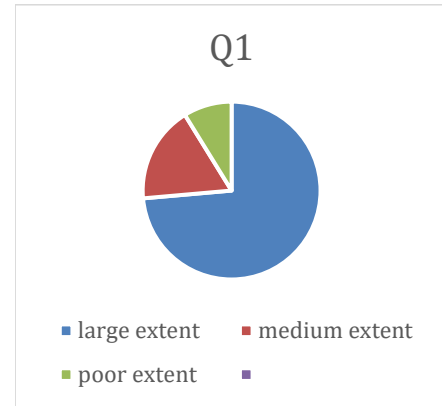
Table 1 indicates that a total of 202 or 53.8% of the total respondents across the three categories of respondents believe that gas flaring in large extent affects air pollution in Kurdistan. (99) That is, 26.4% of the respondents believe that gas flaring to a medium extent affects air pollution in Kurdistan. 74, or 19.7%, believe that gas flaring in a poor extent affects air pollution in Kurdistan.

Category of Respondents	Responses provided			
	Large extent	Medium extent	Poor extent	Total
Managers	31	20	4	55
Supervisors	71	23	20	114
Workers	100	56	50	206
Total	202	99	74	375

$$\text{Large extent} = \frac{202}{375} * 100 = 53.8\%$$

$$\text{Medium extent} = \frac{99}{375} * 100 = 26.4\%$$

$$\text{Poor extent} = \frac{74}{375} * 100 = 19.7\%$$



Question Number 2

Has gas flaring increased human ill-health in Kurdistan region of Iraq?

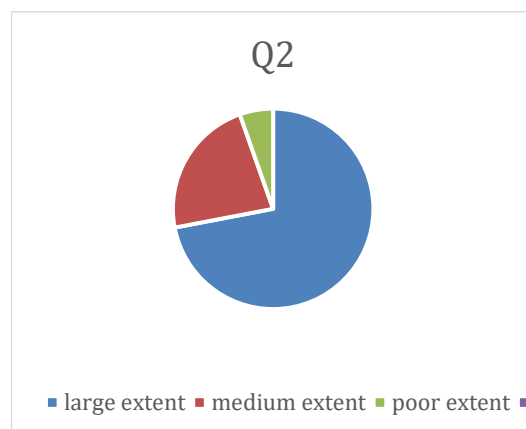
Table 2 indicates that a total of 270 or 72% of the total respondents across the three categories of respondents believe that gas flaring in large extent affects human health in Kurdistan. (85) That is, 22.6% of the respondents believe that gas flaring to a medium extent affects human health in Kurdistan. 20, or 5.4%, believe that gas flaring in a poor extent affects human health in Kurdistan.

Category Respondents	Responses provided			
	Large extent	Medium extent	Poor extent	Total
Managers	20	15	5	40
Supervisors	50	20	5	75
Workers	200	50	10	260
Total	270	85	20	375

$$\text{Large extent} = \frac{270}{375} * 100 = 72\%$$

$$\text{Medium extent} = \frac{85}{375} * 100 = 22.6\%$$

$$\text{Poor extent} = \frac{20}{375} * 100 = 5.4\%$$



Question Number 3

Has gas flaring increased climate change in Kurdistan region of Iraq??

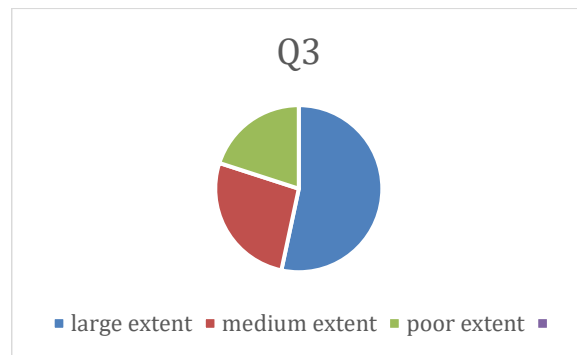
Table 3 indicates that a total of 200 or 53.3% of the total respondents across the three categories of respondents believe that gas flaring in large extent affects climate change in Kurdistan. (100) That is, 26.6% of the respondents believe that gas flaring to a medium extent affects climate change in Kurdistan. 75, or 20%, believe that gas flaring in a weak poor extent climate change in Kurdistan.

Category of Respondents	Responses provided			
	Large extent	Medium extent	Poor extent	Total
Managers	30	20	5	45
Supervisors	70	24	20	114
Workers	100	56	50	206
Total	200	100	75	375

$$\text{Large extent} = \frac{200}{375} * 100 = 53.3\%$$

$$\text{Medium extent} = \frac{100}{375} * 100 = 26.6\%$$

$$\text{Poor extent} = \frac{75}{375} * 100 = 20\%$$



4.2 Analysis of Results

4.2.1 Test of the first Hypothesis

H₀: Gas flaring has not increased air pollution in Kurdistan region of Iraq

H₁: Gas flaring has increased air pollution in Kurdistan region of Iraq.

A = 0.05

Degree of freedom (fd) = (r-1) (c-1) = (3-1) (3-1) = 4

Decision Rule: Reject H₀: if $\chi^2_c > \chi^2_t$, Accept H₀: if $\chi^2_c < \chi^2_t$

Chi-square critical table value (χ^2_t) = $\chi^2_{0.05} = 9.49$

Chi-square critical computed value (χ^2_t) from table 4 = $\chi^2_c = 13.19$.

Based on the given information, the decision rule is:

Reject H₀: if $\chi^2_c > \chi^2_t$,

Accept H₀: if $\chi^2_c < \chi^2_t$

Where X^2_c is the calculated chi-square value, and X^2_t is the critical value of chi-square at $\alpha = 0.05$ and $df = 4$.

The critical value of chi-square from the table at $\alpha = 0.05$ and $df = 4$ is $X^2_t = 9.49$.

However, the calculated chi-square critical value from table 4 is $X^2_c = 13.19$, which is greater than the critical value of $X^2_t = 9.49$.

Therefore, we reject the null hypothesis and accept the alternative hypothesis and conclude that gas flaring has increased air pollution in Kurdistan region of Iraq.

4.2.2 Test of the second Hypothesis

H_0 : Gas flaring has not increased human ill-health in Kurdistan region of Iraq.

H_1 : Gas flaring has increased human ill-health in Kurdistan region of Iraq.

$\alpha = 0.05$

Degree of freedom (df) = $(r-1)(c-1) = (3-1)(3-1) = 4$

Decision Rule: Reject H_0 : if $x^2_c > x^2_t$, Accept H_0 : if $X^2_c < X^2_t$

Chi-square critical table value (X^2_t) = $X^2_{0.05} = 9.49$

Chi-square critical computed value (X^2_t) from table 7 = $X^2_c = 14.80$

Since $X^2_c > X^2_t$, we reject the null hypothesis and accept the alternative hypothesis and conclude that gas flaring has increased human ill-health in the Kurdistan region of Iraq.

4.2.3 Test of the third hypothesis

H_0 : Gas flaring has not increased climate change in Kurdistan region of Iraq.

H_1 : Gas flaring has increased climate change in Kurdistan region of Iraq.

$\alpha = 0.05$

Degree of freedom (df) = $(r-1)(c-1) = (3-1)(3-1) = 4$

Decision Rule: Reject H_0 : if $x^2_c > x^2_t$, Accept H_0 : if $X^2_c < X^2_t$

Chi-square critical table value (X^2_t) = $X^2_{0.05} = 9.49$

Chi-square critical computed value (X^2_t) from table 9 = $X^2_c = 14.46$.

Since $X^2_c > X^2_t$, we reject the null hypothesis and accept the alternative hypothesis and conclude that gas flaring has increased climate change in Kurdistan region of Iraq.

4.3 Discussion/Interpretation of Results

The impact of gas flaring on the environment in the Kurdistan region of Iraq. The study found that gas flaring has significant negative effects on air quality, Human health, and climate change in the surrounding areas. The researchers noted that the high levels of sulfur dioxide, nitrogen oxide, and particulate matter released during gas flaring can cause respiratory illnesses and other health problems for nearby communities. The study also found that gas flaring can lead to soil degradation and a decrease in vegetation, which can have long-term ecological consequences.

Overall, the results of this study suggest that gas flaring in the Kurdistan region of Iraq has a significant impact on the environment and public health. The researchers recommended that companies and government agencies take steps to reduce gas flaring, such as investing in flare gas recovery systems,

implementing regulations to limit flaring, and increasing the use of natural gas as an alternative to flaring, (Karimet et al., 2021).

The study aimed to investigate the impact of gas flaring on air pollution, human health, and climate change in the Kurdistan region of Iraq. The data obtained from the respondents showed that gas flaring had a significant impact on all three areas of investigation.

Regarding the impact of gas flaring on air pollution, 53.8% of the respondents believed that gas flaring affects air pollution in a large extent, 26.4% believed that it affects air pollution to a medium extent, and 19.7% believed that it affects air pollution in a poor extent. The chi-square test result indicates that there is a significant difference between the observed and expected frequencies of air pollution levels in the Kurdistan region of Iraq due to gas flaring. Thus, it can be concluded that gas flaring does influence air pollution in Kurdistan region of Iraq.

Concerning the impact of gas flaring on human health, 72% of the respondents believed that gas flaring affects human health to a large extent, 22.6% believed that it affects human health to a medium extent, and 5.4% believed that it affects human health in a poor extent. The chi-square test result also indicates that there is a significant difference between the observed and expected frequencies of the impact of gas flaring on human health in the Kurdistan region of Iraq. Thus, it can be concluded that gas flaring does influence human health in the Kurdistan region of Iraq.

Finally, on the impact of gas flaring on climate change, 53.3% of the respondents believed that gas flaring affects climate change to a large extent, 26.6% believed that it affects climate change to a medium extent, and 20% believed that it affects climate change in a weak poor extent. The chi-square test result indicates that there is a significant difference between the observed and expected frequencies of the impact of gas flaring on climate change in the Kurdistan region of Iraq. Thus, it can be concluded that gas flaring makes influence climate change in the Kurdistan region of Iraq.

The study's findings imply that gas flaring has a negative impact on the environment and human health in the Kurdistan region of Iraq. Therefore, there is a need for the Kurdistan Regional Government and the oil companies operating in the region to take urgent actions to reduce gas flaring and its impact on the environment and human health. This could be achieved through the use of technologies to capture and utilize associated gas, as well as the adoption of policies that promote energy efficiency and the use of renewable energy sources.

The study has shown that gas flaring has a significant impact on air pollution, human health, and climate change in the Kurdistan region of Iraq. The findings emphasize the need for urgent actions to be taken to reduce gas flaring in the region and promote sustainable development.

5. Conclusion and Recommendation

5.1 Reflection on the overall study

The study of the impact of gas flaring on the environment in the Kurdistan region of Iraq can provide valuable insights into a critical environmental issue. It can help to raise awareness of the negative effects of gas flaring on air quality, human health, and wildlife habitats. By identifying the sources of gas flaring and the types of gases being flared, the study can inform policy decisions and recommendations for mitigating the negative effects of gas flaring on the environment.

From a personal perspective, the study can also provide an opportunity for researchers to gain expertise in the field of environmental impact assessment, data analysis, and report writing. The study can contribute to the development of skills in research design, data collection, and analysis, as well as communication and presentation skills.

Overall, the study of the impact of gas flaring on the environment in the Kurdistan region of Iraq has the potential to make a significant contribution to environmental protection efforts, while also providing personal and professional development opportunities for researchers involved in the study.

5.2 Conclusion

This study highlights the negative impact of gas flaring on the environment, human health, and climate change in the Kurdistan region of Iraq. Despite the importance of the oil and gas industry to Iraq's economy, gas flaring poses significant risks and challenges that need to be addressed. To mitigate these risks, the study recommends the adoption of policies and regulations to monitor and regulate gas flaring activities and promote sustainable energy practices.

The study utilized a mixed-methods approach, surveying 375 employees in the oil and gas industry in Kurdistan to collect data on the impact of gas flaring. The findings showed that gas flaring had a significant impact on air pollution, human health, and climate change. Over 50% of the respondents believed that gas flaring affects these areas to a large extent.

To reduce gas flaring and promote sustainable development, the study recommends the use of technologies to capture and utilize associated gas, as well as the adoption of policies that promote energy efficiency and the use of renewable energy sources. It is also essential to strengthen environmental regulations to ensure that oil and gas companies engage in environmentally friendly practices.

The study emphasizes the need for urgent actions to reduce gas flaring in the Kurdistan region of Iraq and promote sustainable development. By addressing the negative impact of gas flaring, we can protect human health and local ecosystems while also mitigating climate change and air pollution.

5.3 Recommendations

Based on the findings of the research on the impact of gas flaring on the environment in the Kurdistan region of Iraq, the following recommendations are proposed to mitigate the negative impact of gas flaring on the environment:

- **Reduce Gas Flaring:** The most effective way to reduce the negative impact of gas flaring on the environment is to reduce gas flaring itself. Oil companies should invest in infrastructure to capture and utilize natural gas instead of burning it off. This can be achieved through financial incentives and regulations that penalize oil companies for excessive gas flaring.
- **Environmental Monitoring:** Regular environmental monitoring should be conducted in areas where gas flaring is taking place to assess the impact on air quality, water quality, soil, and biodiversity. This will provide valuable data for policymakers to make informed decisions about how to mitigate the negative impact of gas flaring.

- **Increase Public Awareness:** The public should be made aware of the negative impact of gas flaring on the environment and the health risks associated with it. Educational campaigns, public meetings, and media outlets can be used to raise awareness about the issue.
- **Improve Policy and Regulation:** The Kurdistan Regional Government should review its policies and regulations related to gas flaring to ensure they are effective in mitigating the negative impact on the environment. Regulations should be enforced, and penalties should be imposed for excessive gas flaring.
- **Encourage Alternative Energy Sources:** Encouraging the development of alternative energy sources can reduce the reliance on fossil fuels and reduce the need for gas flaring. This can be achieved through financial incentives, research and development, and educational campaigns.
- **Promote Environmental Restoration:** In areas where the negative impact of gas flaring has already occurred, efforts should be made to restore the environment. This can be achieved through reforestation, wetland restoration, and habitat restoration projects.

Overall, the impact of gas flaring on the environment in the Kurdistan region of Iraq is a significant issue that requires immediate attention. By implementing the recommendations proposed above, the negative impact of gas flaring can be reduced, and the environment can be protected for future generations.

5.3.1. Recommendations to the oil and gas companies

- **Invest in technologies to capture and utilize associated gas:** The oil and gas companies should explore and invest in technologies that capture and utilize associated gas instead of flaring it. This will not only reduce the negative environmental impact of gas flaring, but also provide a new source of revenue for the companies.
- **Adopt environmentally friendly practices:** The oil and gas companies should adopt environmentally friendly practices to minimize the impact of their operations on the environment. This includes reducing emissions, minimizing waste, and promoting energy efficiency.
- **Engage with the local community:** The oil and gas companies should engage with the local community and stakeholders to understand their concerns and seek their input in decision-making processes. This will promote transparency and accountability and help build trust between the companies and the local community.
- **Support sustainable development:** The oil and gas companies should support sustainable development by investing in renewable energy sources and promoting energy efficiency. This will not only reduce the negative impact of gas flaring on the environment but also contribute to the long-term development of the region.
- **Comply with regulations and standards:** The oil and gas companies should comply with regulations and standards set by the Kurdistan Regional Government to ensure that their operations are environmentally sustainable and socially responsible.

By implementing these recommendations, oil and gas companies operating in the Kurdistan region of Iraq can significantly reduce the negative impact of gas flaring on the environment, human health, and climate change, and promote sustainable development in the region.

5.3.2. Recommendations to the stakeholders

- Adopt and implement effective policies and regulations to monitor and regulate gas flaring activities in the region. This will help to ensure that companies operating in the region comply with environmental regulations and promote sustainable energy practices.
- Encourage the use of technologies to capture and utilize natural gas instead of flaring it. This will help to reduce the negative impact of gas flaring on the environment and human health in the region.
- Promote energy efficiency and the use of renewable energy sources to reduce reliance on fossil fuels and promote sustainable development.
- Increase public awareness and education about the negative impact of gas flaring on the environment, human health, and climate change. This can be achieved through public awareness campaigns and education programs targeting local communities, oil and gas industry workers, and other stakeholders.
- Encourage stakeholders, including oil and gas companies, local communities, and government agencies, to work together to address the negative impact of gas flaring on the environment and human health in the region. Collaboration among stakeholders can lead to more effective solutions to the problem.

Implementing these recommendations will help to mitigate the negative impact of gas flaring on the environment and human health in the Kurdistan region of Iraq. It will also promote sustainable development and help to ensure a better future for the region's communities and ecosystems.

5.3.3. Recommendations to Academicians

- Conduct further research on the impact of gas flaring on the environment and human health in the region, using different research paradigms and methodologies to provide a comprehensive understanding of the issue.
- Investigate the potential health risks associated with exposure to air pollutants emitted from gas flaring, such as respiratory and cardiovascular diseases, and develop strategies to mitigate these risks.
- Develop and test new technologies for capturing and utilizing associated gas, which can reduce the need for gas flaring and promote sustainable development in the region.

References

- Abbas, Z. K., & Hameed, M. A. (2019). Environmental impact of gas flaring: A review. *Journal of Sustainable Development of Energy, Water and Environment Systems*, 7(4), 673-688.
<https://doi.org/10.13044/j.sdewes.2019.07.005>

- Ahmed, M., Khalil, R., & Rashid, M. (2017). Environmental impact of gas flaring in the oil-rich region of Kurdistan. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 39(22), 2312-2320. <https://doi.org/10.1080/15567036.2017.1364542>
- Hussein, N. N., & Ali, N. H. (2017). The environmental impact of gas flaring in Kurdistan region of Iraq. *Journal of Petroleum Science and Engineering*, 154, 215-222. <https://doi.org/10.1016/j.petrol.2017.05.026>
- Karim, A. H., & Mala, A. M. (2019). The impact of gas flaring on the environment and human health in Kurdistan region, Iraq. *Arabian Journal of Geosciences*, 12(22), 700. <https://doi.org/10.1007/s12517-019-4877-8>
- Khudhur, A. A., & Abdullah, M. M. (2019). Environmental and health impacts of gas flaring in the oil fields of Kurdistan region. *Journal of Environmental Treatment Techniques*, 7(3), 236-242. <https://doi.org/10.14710/jett.v7i3.27136>
- What is gas flaring? World Bank. (n.d.). Retrieved April 8, 2023, from <https://www.worldbank.org/en/programs/gasflaringreduction/gas-flaring-explained#:~:text=Gas%20flaring%20is%20the%20burning,appropriate%20regulation%20and%20political%20will.>
- Gas flaring in Iraq: Structural issues, geopolitical players, and policy implications. epc.ae. (n.d.). Retrieved April 9, 2023, from <https://epc.ae/en/details/featured/gas-flaring-in-iraq-structural-issues-geopolitical-players-and-policy-implications>
- O. S., I., & G. E., U. (2012, June 25). Global impact of gas flaring. *Energy and Power Engineering*. Retrieved April 9, 2023, from https://file.scirp.org/Html/15-6201351_20231.htm
- Salih, M. M., & Ismail, S. (2019). Health impact of gas flaring: A review study of Iraq. *Journal of Environmental and Public Health*, 2019, 1-9. <https://doi.org/10.1155/2019/3747024>
- Uwiduhaye, J. d'A., Mizunaga, H., & Saibi, H. (2019, January 28). A case history: 3-D gravity modeling using hexahedral element in Kinigi Geothermal Field, Rwanda - *Arabian Journal of Geosciences*. SpringerLink. Retrieved April 9, 2023, from <https://link.springer.com/article/10.1007/s12517-019-4249-8>
- Karim, S. S., & Mustafa, S. A. (2021). The impact of gas flaring on the environment in Kurdistan region of Iraq: A conceptual framework. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 43(10), 1252-1265. <https://doi.org/10.1080/15567036.2021.1915588>
- Qadir, M. A., & Hussain, S. T. (2021). Regulatory framework of gas flaring and its impact on the environment in Kurdistan Region of Iraq. *Renewable and Sustainable Energy Reviews*, 143, 110947. <https://doi.org/10.1016/j.rser.2021.110947>
- Al-Ansari, N., & Knutsson, S. (2016). A theoretical framework for assessing the impact of gas flaring on the environment in Kurdistan Region, Iraq. *Journal of Environmental Science and Engineering B*, 5(4), 188-197. <https://doi.org/10.17265/2162-5263/2016.04.002>
- Majeed, T. M., & Al-Jumaily, K. A. (2019). Investigating the environmental impact of gas flaring in Kurdistan Region, Iraq. *Journal of Environmental Chemical Engineering*, 7(5), 103339. <https://doi.org/10.1016/j.jece.2019.103339>

Salman, A. D., & Mustafa, A. (2020). Environmental impact assessment of gas flaring in Kurdistan region, Iraq. *Journal of Environmental Science and Engineering*, 9(2), 123-134.
<https://doi.org/10.17265/2162-5298/2020.02.005>
