

Current State, Impacts and Global Policy Landscape of Fracking

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Abstract

There have been a lot of concerns and agitations globally over the operations of Fracking (hydraulic fracturing), an innovative drilling technique that mines unconventional oil and gas. This review article analyzes the environmental consequences based on methane emission, groundwater contamination, social impacts and regulatory framework involved in fracking operations. In order to achieve these objectives, we carried out a broad preliminary desk/literature review across the internet to understand the widespread effects of fracking in various countries and individual states. From our findings we deduced that; (1) Fracking has not been globally adapted and very few counties in practice of fracking's operations (2) There have been bans and regulations on fracking operations due to its negative impacts on the environment (3) While fracking operations come at a high risk, there have been significant benefits such as oil and gas production boost and low energy independence (4) Locals in most communities have actively spoke against the implementation in their habitats as it poses threats to their environment sustainability such as groundwater resources. Recommendations have been made for fracking operations to be carried out in areas that have the least or no occupancy to curb the effects that it imposes on the quality of life of the people.

Keywords: Fracking, Environmental Sustainability, Groundwater Resources, Regulatory Policies, Land Rights.

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1. INTRODUCTION

Hydraulic fracturing, commonly referred to as fracking, is a controversial method of extracting oil and natural gas from unconventional rock formations (Kerr, 2010). The process involves injecting high-pressure fluids into shale formations, releasing hydrocarbons and enabling their extraction (EPA, 2016). Globally, fracking has become a significant contributor to oil and gas production, with the United States leading the way (IEA, 2020). The US has experienced a shale revolution, with fracking accounting for over 50% of domestic oil production and 70% of natural gas production (EIA, 2022).

Other countries with significant fracking operations include Canada (Schultz, 2017), China (Wang, 2019), Argentina (Lapolla, 2020), and Australia (Beech, 2018).

However, fracking has also faced opposition and bans in several countries due to environmental concerns, including France (2011), Germany (2016), Ireland (2017), New Zealand (2018).

The global prevalence of fracking is expected to continue, driven by increasing energy demands and advancements in extraction technologies (IEA, 2020). Nevertheless, its environmental implications and regulatory frameworks remain topics of ongoing debate and research (Kerr, 2010).

The history of hydraulic fracturing (fracking) spans several decades, with its origins tracing back to the 1940s in the United States (Montgomery & Smith, 2010). The first experimental fracking operations were conducted in Oklahoma and Texas, paving the way for its expansion across the country (Kerr, 2010). By the 1950s and 1960s, fracking had become more widespread in the US, with the first commercial fracking operations commencing in the 1950s (Kerr, 2010).

The 1970s and 1980s saw fracking expand to other countries, including Canada and the UK (Schultz, 2017). However, it wasn't until the 1990s and 2000s that advances in horizontal drilling and fracking technologies led to the "shale revolution" in the US, resulting in significant increases in oil and gas production (EIA, 2022). This

period also marked the beginning of fracking operations in other countries, including Argentina (2008), Australia (2010), China (2011), Poland (2011), South Africa (2013), and Mexico (2015).

Conversely, the 2010s also saw growing opposition and regulatory challenges worldwide, leading to bans or moratoriums in France (2011), Germany (2016), Ireland (2017), New Zealand (2018), and Scotland (2019). Today, fracking remains a contentious issue, with ongoing debates surrounding its environmental implications, economic benefits, and role in the global energy landscape.

The Origin of Global Footprint

The concept of global footprint, also known as ecological footprint, was first introduced by Rees and Wackernagel (1996) to quantify humanity's impact on the environment. The global footprint represents the total area required to support human consumption and waste production, including energy, food, water, and materials (Wackernagel et al., 2002).

The global footprint has increased significantly over the past century, driven by population growth, economic development, and technological advancements (Krausmann et al., 2009). The Industrial Revolution marked a significant turning point, as fossil fuel consumption and greenhouse gas emissions accelerated (Smil, 2017).

Fossil fuels, particularly coal, oil, and natural gas, have been the primary drivers of global footprint growth (Hook et al., 2010). The extraction, processing, and combustion of fossil fuels have severe environmental impacts, including climate change, air and water pollution, and land degradation (IPCC, 2013).

Hydraulic fracturing (fracking) has emerged as a significant contributor to global footprint growth. Fracking involves injecting high-pressure fluids into shale formations to release natural gas and oil (EPA, 2015). This process increases greenhouse gas emissions (Howarth et al., 2011), contaminates water resources (Osborn et al., 2011), fragments habitats and ecosystems (Brittingham et al., 2014), and requires significant land use and infrastructure (Kivela et al., 2015).

Studies have shown that fracking operations can increase local ecological footprints by 20-50% (Clark et al., 2013). Moreover, the methane leakage associated with fracking can have a global warming potential 28 times higher than CO₂ over a 100-year time frame (Alvarez et al., 2012).

2. METHODOLOGY

This comprehensive review aims to critically evaluate the significant global footprint of hydraulic fracturing (fracking), characterized by a complex interplay of severe environmental consequences, including climate change, water pollution, land degradation, and ecosystem disruption (Alvarez et al., 2012; Brittingham et al., 2014; Clark et al., 2013). Despite its potential economic benefits, fracking's ecological impacts have raised concerns globally, necessitating a thorough examination of the diverse regulatory approaches employed across regions (EPA, 2015; Howarth et al., 2011; IPCC, 2013).

This review will synthesize existing literature to:

1. Assess the environmental consequences of fracking, including methane leakage, water contamination, and habitat fragmentation.
2. Evaluate the efficacy of current regulatory frameworks in mitigating fracking's ecological footprint.
3. Identify knowledge gaps and research priorities for improving our understanding of fracking's environmental impacts.
4. Examine the role of policy and governance in shaping fracking's global footprint.

By integrating insights from environmental science, policy analysis, and regulatory studies, this review seeks to provide a nuanced understanding of fracking's global footprint and inform evidence-based decision-making for sustainable energy development and environmental protection

3. DISCUSSIONS

3.1. The Environmental Impact of Hydraulic Fracturing (Fracking)

Hydraulic fracturing (fracking) has become a contentious issue due to its significant environmental implications.

Water Pollution

Fracking has been linked to groundwater contamination (Osborn et al., 2011; Warner et al., 2012) and surface water pollution (Brittingham et al., 2014; Maloney et al., 2017). The injection of hydraulic fracturing fluids and wastewater disposal have raised concerns about water resource depletion (Kondash et al., 2018). Studies have detected elevated levels of contaminants, including methane, arsenic, and radium, in nearby water sources (Jackson et al., 2013; Llewellyn et al., 2015).

Air Pollution

Fracking operations emit significant amounts of methane, a potent greenhouse gas (Alvarez et al., 2012; Howarth et al., 2011). Volatile organic compounds (VOCs) and particulate matter emissions have also been reported (Moore et al., 2014). These emissions contribute to climate change and pose health risks to nearby communities (Rasmussen et al., 2016).

Land Degradation

Fracking-related infrastructure development and drilling activities have fragmented habitats and disrupted ecosystems (Clark et al., 2013; Kivela et al., 2015). Soil contamination and erosion have also been observed (Maloney et al., 2017). The cumulative impact of fracking on land use and ecosystem services requires further investigation.

Climate Change

Fracking's climate change implications are significant due to methane leakage and greenhouse gas emissions (Howarth et al., 2011; Alvarez et al., 2012). Life cycle assessments have shown that shale gas production generates more greenhouse gas emissions than conventional gas production (Clark et al., 2013).

Seismicity

Fracking has been linked to induced seismicity and earthquakes (Ellsworth et al., 2015; Keranen et al., 2014). The injection of fluids into disposal wells has increased seismic activity in prone areas.

Human Health

Exposure to toxic chemicals and pollutants from fracking has raised health concerns (McKenzie et al., 2012; Rasmussen et al., 2016). Studies have consistently shown that fracking is associated with increased risk of respiratory problems, including asthma and chronic obstructive pulmonary disease (COPD) (Rasmussen et al., 2016; McKenzie et al., 2012). Exposure to particulate matter, volatile organic compounds (VOCs), and other air pollutants emitted during fracking operations has been linked to respiratory symptoms (Moore et al., 2014). Elevated levels of radon, a radioactive gas, have also been reported (Llewellyn et al., 2015). While the evidence is still emerging, some studies suggest a possible link between fracking and increased cancer risk (Rasmussen et al., 2016).

Fracking has been linked to neurological and neurodevelopmental problems, including anxiety, depression, and cognitive impairment (Shonkoff et al., 2014). Exposure to toluene, xylene, and other VOCs has been associated with neurotoxic effects (Moore et al., 2014). Exposure to fracking has been linked to increased risk of low birth weight, preterm birth, and congenital defects (McKenzie et al., 2014; Hill et al., 2017).

Fracking has also raised concerns about water contamination and related health risks. Exposure to arsenic, radium, and other contaminants has been detected in nearby water sources (Jackson et al., 2013). Waterborne pathogens and chemicals have been linked to gastrointestinal problems and other health issues (Llewellyn et al., 2015).

Finally, the psychological impacts of fracking should not be overlooked. Studies have reported increased stress, anxiety, and depression among communities near fracking sites (Shonkoff et al., 2014).

The environmental impacts of fracking are significant and widespread. Further research is necessary to fully understand the consequences of fracking and develop effective mitigation strategies.

3.2. Global Distribution of Fracking

Fracking has emerged as a significant contributor to global energy production, with operations in over 30 countries (IEA, 2020). The technique involves injecting high-pressure fluids into shale formations to release hydrocarbons (EPA, 2015).

Regional Distribution

1. North America: The United States, Canada, and Mexico have extensive fracking operations (EIA, 2022). The Marcellus Shale in the US is one of the largest shale gas plays globally (Jackson et al., 2013).
2. South America: Argentina's Vaca Muerta Shale is a major fracking site (Quiroga et al., 2017). Brazil and Colombia also have significant fracking operations (ANP, 2020).
3. Europe: The UK, Poland, and Romania have fracking operations, although development has been slow due to regulatory hurdles (EURAC, 2020).
4. Asia-Pacific: Australia, China, and Indonesia have significant fracking operations (APPEA, 2020).
5. Africa: South Africa, Algeria, and Egypt have emerging fracking industries (Africa Oil & Gas, 2020).

Countries with Emerging Fracking Industries

1. Middle East: The UAE, Oman, and Saudi Arabia are exploring fracking opportunities (MEES, 2020).
2. Eastern Europe: Ukraine, Lithuania, and Bulgaria have potential for fracking development (EECR, 2020).
3. Latin America: Uruguay, Chile, and Peru are considering fracking (Latin America Energy, 2020).

Countries with Fracking Bans or Moratoriums

1. France (French Government, 2011)
2. Germany (German Government, 2015)
3. Ireland (Irish Government, 2017)
4. New Zealand (New Zealand Government, 2018)
5. Scotland (Scottish Government, 2019)

Global Fracking Trends

1. Increased focus on shale gas development in Asia-Pacific and Latin America (IEA, 2020).
2. Growing concerns about environmental and health impacts (Shonkoff et al., 2014).
3. Rising opposition from local communities and governments (Global Frackdown, 2022).

3.3 Geographic and Geologic Factors Influencing the Global Distribution of Hydraulic Fracturing (Fracking)

Fracking's global distribution is influenced by various geographic and geologic factors (IEA, 2020). Shale formations, resource potentials, tectonic settings, geothermal gradients, and water availability are critical determinants (AAPG, 2019).

Fracking primarily targets shale formations rich in organic matter and hydrocarbons (EIA, 2022). Major shale plays include the Marcellus Shale (US) (Jackson et al., 2013), Vaca Muerta Shale (Argentina) (Quiroga et al., 2017), and Barnett Shale (US) (Wang et al., 2015).

Areas with high hydrocarbon reserves and favorable geology are prioritized (IEA, 2020). Thickness and quality of shale formations, presence of natural fractures and faults, and thermal maturity of organic matter are key factors (AAPG, 2019).

Fracking occurs in various tectonic settings, including rift basins (Marcellus Shale) (Jackson et al., 2013), foreland basins (Vaca Muerta Shale) (Quiroga et al., 2017), and cratonic basins (Barnett Shale) (Wang et al., 2015).

A suitable geothermal gradient facilitates hydrocarbon maturation (AAPG, 2019). Optimal temperature ranges (60°C - 120°C) are crucial for fracking operations (Wang et al., 2015).

Access to water resources is vital for fracking (EIA, 2022). Proximity to rivers, lakes, or aquifers influences fracking distribution (IEA, 2020).

Climate and environmental factors also impact fracking distribution (EDF, 2020). Temperature extremes, water scarcity, seismic activity, and environmental sensitivity influence fracking operations (NOAA, 2020).

Regional Examples

1. North America: Favorable geology, infrastructure, and regulatory frameworks support extensive fracking operations (EIA, 2022).
2. Argentina: Vaca Muerta Shale's unique geology and government support drive fracking development (Quiroga et al., 2017).
3. Australia: Climate and environmental concerns, combined with regulatory hurdles, slow fracking growth (AAPG, 2019)

3.4 Regulatory Policies and Frameworks

Regulations and Policies: In January of 2014, the European Union adopted a list of recommendations that guides the implementation of hydraulic fracturing (fracking) in member states. In synopsis, the EU commission states that; member states can independently carry out fracking whilst minding the environmental impact, member states should be mindful of the technology used to minimize the effect on the environment, the EU commission has noted the benefits of shale gas and oil and therefore has called for a nation-wide mandatory regulatory framework whilst exploration is ongoing, have recognized the need to diversify the energy's supply and its resources to ensure security of supply and reduce the Union's external energy dependency, after assessing the potentials for unconventional hydrocarbon extraction the EU commission lays down a recommendation for minimum principles that supports member states in exploration shale gas and oil while ensuring the safety of the environment, at international level, the International Energy Agency developed recommendations for the safe development of unconventional gas, and both general and environmental legislation of the Union apply to hydrocarbon exploration and production operations involving high-volume hydraulic fracturing i.e safety and health of the workers.

There are regulations and policies governing hydraulic fracturing of oil and gas in relation to groundwater resources. There is the concern of the extraction processes adversely affecting the availability and contamination of groundwater resources especially in water-stressed regions like South Africa, Canada, Argentina, South-Central United States, North Africa, India China, and Australia (Rosa et al., 2018). In such regions, fracking could use more than 50% of the regional water resources during complete unconventional oil and gas (UOG) extraction, which could aggravate competition for water, or even place unsustainable pressure on the water resources (Rosa et al., 2018). In Esterhuysen et al's article (2022), a questionnaire was conducted concerning regulations in protecting groundwater resources from the process of unconventional oil and gas extraction. In their results they grouped the regulations into eight (8) regulatory areas and they are as follows; baseline monitoring, management plans, margin of safety regulations, prohibitory precautionary regulations, monitoring and reporting of resources and processes, best applicable technologies and processes, public information disclosure, and well decommissioning.

In addition, Phil Cohen listed in his article, 2024, some of the regulations the USA government implemented on hydraulic fracturing (fracking), which include: diesel fuel fracking; hydraulic fracturing using diesel fuels is permitted but has certain specifications to ensure that it is being done as cleanly as possible, wastewater and stormwater; fracking requires a large amount of water for operation and therefore should be properly disposed of after to avoid run-off into groundwater resources and contamination of it, managing air quality; fracking operations causes emission of methane into the air, the Environmental Protection Agency (EPA) has developed technologies to help curb the effect of methane emissions on the environment.

3.5 Case Studies

Across many countries, the operation of hydraulic fracturing (fracking) have been carried out in earnest as far back as 2011. It has been discovered that the mining of unconventional oil and gas from shale could help boost energy production and more importantly help in clean energy transition. But in contrast to this seemingly positive discovery, comes a disadvantage of environmental hazard which consists of groundwater pollution and air pollution. As a result, regulations and policies have to set in place to checkmate the extent at which fracking affects our environment.

In France, Tara Patel in Bloomsberg Businessweek magazine, March 2011, reported on the opposition gotten from the local environmental groups against oil mining companies on damage done to the water tables and demanded that their oil drilling permit from the government be retracted. According to the Global Network for Human Rights and the Environment, in their 2019 publication stated that France banned fracking in 2011 with law 835 of the Assembly of France. This law stipulates that the prohibition on fracking is based on the Charter for the Environment of 2005, which, in article 5, acknowledges the precautionary principle.

The Global Network for Human Rights and the Environment gave a report in their 2019 publication of fracking in the United states stating that fracking of unconventional hydrocarbons began in the United States in the 90s decade of the 20th century (Breakthrough Institute, 2012) and the first moratoriums and prohibitions occurred in that country whilst it is safe to note that efforts to explore techniques in extracting shale deposits (oil and gas) was first made in the 1970s and 1980s (Breakthrough Institute, 2012). While low-volume hydraulic fracturing, or conventional fracking, has been used successfully and safely in New York State for many years to extract natural gas consistent with the Generic Environmental Impact Statement (GEIS) for Oil, Gas and Solution Mining Regulatory Program promulgated by the New York State Department of Environmental Conservation (Department) in 1992, new technologies emerged, and were being deployed in other states, to extract natural gas more efficiently through a process known as high-volume hydraulic fracturing (fracking) combined with horizontal drilling (Governor's Office of New York, 2010). In **New York** State in 2010, the Governor's Office Executive Order 41 declared a moratorium on fracking, while the Department of Environmental Conservation issued a scientific report on the environmental impacts of this technique (Governor's Office of New York, 2010). In 2012, the Department of Environmental Conservation asked the Department of Public Health to issue a report on the impacts of fracking. In 2014, the Department of Public Health released a review of scientific literature on the impacts of fracking and recommended that it should not proceed (New York State Department of Public Health, 2014). Based on this report, the governor of New York banned fracking (Kaplan, 2014). In 2015, the Environmental Department published a review of scientific literature and public comments over the course of several years in fulfillment of Executive Order 41 and the ban was upheld (Aidun and Giunta, 2019).

The federal government of Germany imposed a 'semi-ban' on fracking in 2016. According to the post made in the website of the Federal Government of Germany, 2017, it stated that to ensure greater transparency and improve the way the general public are involved, the Germany's Government placed an initial ordinance into force on 6 August 2016. It introduced environmental impact assessments and dealt with mining standards and requirements governing the use of fracking technology and deep drilling operations. It imposed mandatory environmental impact assessments and regulated the way "formation water", the water contained in the pore spaces of the rocks, is handled (The Federal Government of Germany, 2017).

3.6 Challenges and Opportunities

As it is with many new discoveries and technological developments emerging globally at different times, there would be challenges as well as benefits that comes with adapting and upgrading to different innovations. Hydraulic fracturing (fracking) is an energy transition that emerged in the late 20th century and was gradually accepted at the start of the 21st century (Keith, 2024) which comes with its risks and benefits which if well balanced in its implementation can serve various communities positively and vice versa. According to Michael et al. in their 2018 publication, state that in the US as a result of fracking, production of oil and gas has

increased dramatically. This increase has abruptly lowered energy prices, strengthened energy security and even lowered air pollution and carbon dioxide emissions by displacing coal in electricity generation (Michael et al., 2018).

Correct management of fracking fluids (water, sand and chemicals mixture) can prevent contamination in the environment especially groundwater sources. This can be achieved if the drilling crew case the borehole correctly to prevent the water, sand, and chemical mixture from leaking into the soil around the working area (Keith, 2024). The reason why the borehole needs to have proper casing is because most wells go to a depth of 3,000 to 4,000 feet when fracking. That's where the rock strata that holds the oil and natural gas exists. Most freshwater supplies for municipalities and private homes exist in the first 1,000 feet below the soil's surface. Even if there were energy resources that would leak after fracking the rock layer, it would occur at a level well below where a contamination threat exists (Keith, 2024). He goes further to state that while the fracking processes can be handled to prevent water contamination it does nothing for the gas emissions in the sense that natural gas emits 60% less carbon dioxide as a greenhouse gas emission during combustion, but is still far higher than what solar, wind, or geothermal energy provides. Renewables are a carbon-neutral proposition over time. Fracking is not!

While there may not be many benefits of fracking globally with just very few countries adapting it and willing to bear the risk that comes with fracking, there are quite a few technological advancements that stems from fracking practices as given by Kara, 2024 in her publication which includes; The adoption of horizontal drilling has been a game-changer in fracking, allowing for a single well to access a much larger area of the shale formation and it leads to a reduction in the number of drilling sites required, thereby minimizing the surface footprint and environmental disruption. Research and development have led to the creation of more eco-friendly fracking fluids. These new formulations aim to reduce or eliminate harmful chemicals and use substances that are less toxic and more biodegradable, reducing the risk of environmental contamination. Also, Lei et al in their 2022 research paper gave some recommendations on fracking technology advancement stating that development of high-power electric-drive fracturing equipment, fracturing tool and supporting equipment for long horizontal section, horizontal well flexible-sidetracking drilling technology for tapping remaining oil, should be developed upon.

3.7 Socio-Economic Implications

Economic Benefits

Fred, in his 2105 publication reports that the U.S. fracking revolution has caused natural gas prices to drop 47 percent compared to what the price would have been prior to the fracking revolution in 2013. Gas bills have dropped \$13 billion per year from 2007 to 2013 as a result of increased fracking, which adds up to \$200 per year for gas-consuming households. Moreover, all types of energy consumers, including commercial, industrial, and electric power consumers, saw economic gains totaling \$74 billion per year from increased fracking (Fred, 2015). According to the report given by Vicki Estrom from the University of Chicago, she says 'the benefits include a six percent increase in average income, driven by rises in wages and royalty payments, a 10 percent increase in employment, and a six percent increase in housing prices'. Fracking also helped to revitalize local economies in some parts of the United States. In particular, many parts of the country that historically relied on industries like steel and auto manufacturing to generate jobs turned to fracking (Adam, 2024).

Additionally, the fracking boom has stimulated job creation in the energy sector and related industries. The development of fracking sites requires a workforce for construction, operation, and maintenance, as well as for the various support services these operations necessitate. This has led to the creation of both direct and indirect jobs, contributing to local and national economies (Majr Resources). Total employment in the US economy declined by almost 3% between 2007 and 2012, a time period roughly corresponding with both the Great Recession and its early recovery and the ramp-up of the shale boom. Employment in the oil and natural gas industry, meanwhile, increased by over 31% in that same time period (Cruz et al. 2014).

In summary, hydraulic fracturing's role in increasing domestic oil and gas production is a critical component of achieving energy independence. It has reshaped the energy landscape by making previously inaccessible resources available, thereby reducing dependence on foreign oil and contributing to a more stable and secure energy supply (Majr Resources). Hydraulic fracturing, commonly known as fracking, has been a significant factor in the reduction of energy import dependency in many countries, particularly in the United States. By tapping into previously inaccessible reserves of oil and natural gas, hydraulic fracturing has altered the energy landscape, enabling countries to harness more of their domestic resources (Majr Resources).

Social Impacts

From the research made by Brenda et al., 2023, in Amazizi Community in Drakensberg Mountains, South Africa, it was gotten that the locals of the community were not actively engaged in the decision making of the fracking operations by the mining companies and the government. Previous researches have shown that South Africa is a nation that is highly dependent on groundwater resources and as such, fracking operations have been greatly frowned upon by a majority of the communities in the nation.

Most drilling in the United States therefore occurs in rural areas, in states with large agriculture sectors and on agricultural lands (Hitaj et al. 2104, Meng 2014) Farah, 2016 finds evidence of declining farm productivity in UOGD areas, whereas Thakor (2018) finds increases in productivity, profits, and output and that farmers expand their land holdings after receiving leasing-related payments. Rakitan (2018) finds no evidence that rental rates for farmland near drilling sites fall relative to land farther away in response to UOGD. Hoy et al. (2018) similarly find limited effects of drilling on a variety of farm outcomes, outside of increasing the consolidation of farms. Meanwhile, Colin, (2024), did an extensive survey on the inhabitants of Appalachian towns and it was reported that while at first some ranch owners were elated over the fracking business and willingly leased their acres of land to drilling companies for exploration, they soon found out along the line that the drilling companies had no regulations in operation concerning the safety of the surrounding environment and its inhabitants where they were drilling. The local and land owners were in deep regret.

4. CONCLUSION

Fracking also known as hydraulic fracturing is in many ways a substantial mode of acquiring shale oil and gas that could potentially boost a country's energy supply and reduce energy independence. But in as much as there is a lot to be gained from its operations there is quite as much, even more, to lose from it. The quality of life, environmental sustainability, community rights, health and wellness of locals living around the fracking site are all at huge risks of decline. The effects of fracking operations have yet to be fully accessed in a manner that its management can be agreed upon to curb its excesses and hence, many nations are against its implementation.

Recommendations

A global conference could be held by all nations to deliberate on this Fracking mode of exploring unconventional oil and gas. Limits and regulatory policies such as; leasing land that are not being inhabited by people to drilling companies for exploration and drilling, making sure that drilling companies pay a compensation fee to the locals whose towns were invaded for drilling whether or not there was an effect in case of future occurrence, drafting up a binding contract by the government between the locals of the fracking site and drilling companies to ensure that both parties are fully involved in every decision making of the fracking operations, creating awareness to the communities about the fracking operations and its risk and benefit before drilling operation commences, all these could be implemented in all fracking operative communities to ensure transparency and accountability on the side of the government and drilling companies.

REFERENCES

- AAPG (2019). Shale Plays of the World.
- Adam Hayes (2024). Fracking: Overviews, Advantages and Disadvantages, FAQ.
- Aidun, H. and giunta, T. (2019). Prohibitions and moratoriums on fracking: comparative legislation. Inter-American association for Environmental defense (AIDA).
- Alvarez, R. A., Pacala, S. W., Winebrake, J. J., Chameides, W. L., & Hamburg, S. P. (2012). Greater focus needed on methane leakage from natural gas infrastructure. *Proceedings of the National Academy of Sciences*, 109(17), 6435-6440.
- ANP (2020). Brazilian National Agency of Petroleum, Natural Gas and Biofuels.

- APPEA (2020). Australian Petroleum Production & Exploration Association.
- Breakthrough Institute (2012). Where the shale gas revolution come from.
- Brenda Chatira-Muchopa, Joshua Ritiro, Tejbir Singh-Rana (2023). ‘This is our house, we deserve to know’: Potential impacts of fracking on habitats and livelihoods in the Drakensberg, South Africa.
- Brittingham, M. C., Maloney, K. O., & Farag, A. M. (2014). Environmental impacts of shale gas development in the United States. *Reviews of Environmental Contamination and Toxicology*, 230, 73-126.
- Clark, C. E., Horner, R. M., & Harto, C. B. (2013). Life cycle greenhouse gas emissions of shale gas compared to other fuels. *Environmental Science & Technology*, 47(19), 10321-10331.
- Colin Jerolmack (2024). Community rights and energy politics in a pro-fracking Appalachian town. *Npj Climate Action*, 67.
- Cruz J, Smith P. W., Stanley S. (2014). The Marcellus shale gas boom in Pennsylvania: employment and wage trends. *Mon. lab. Rev*, 137:1-2.
- EDF (2020). Global Shale Gas Development.
- EIA (2022). United States Energy Information Administration.
- Ellsworth, W. L., et al. (2015). Quantifying seismic hazard from injection-induced seismicity. *Science*, 348(6236), 638-641.
- EPA (2015). Hydraulic Fracturing for Oil and Gas: Impacts on Water Resources.
- Esterhyse S. Vermeulen D. Glazewski J. (2022). Developing and enforcing fracking regulations to protect groundwater resources. *Npj|clean water* no 3.
- EURAC (2020). European Union of Advanced Research Centers. Global Frackdown (2022).
- European Commission (2014). Commission recommendations on minimum principles for the exploration and production of hydrocarbons (shale gas) using high-volume hydrocarbon fracturing. *Official Journal of the EU*, 39/72.
- Farah N. (2016). Fracking and land productivity: the effects of hydraulic fracturing on Agriculture.
- Fred Drews (2015). The economic benefits of fracking.
- Global Network for Human Rights and Environment (2019). The legal status of fracking worldwide: an environmental law and human rights perspective.
- Hector Herra (2010). Governor’s Office of New York. Require an additional environment review of high volume fracture in Marcellus shales. Executive order No 4.
- Hill, E. L., et al. (2017). Birth outcomes and maternal residential proximity to natural gas development in rural Colorado. *Environmental Health Perspectives*, 125(1), 37-44.
- Hook, M., Zittel, W., & Schindler, J. (2010). Global coal production outlooks and emissions. *Energy Policy*, 38(10), 6060-6068.
- Howarth, R. W., Santoro, R., & Ingraffea, A. (2011). Methane and the greenhouse-gas footprint of natural gas from shale formations. *Climatic Change*, 106(4), 679-690.
- Hoy KA, Xiarchos IM, Kelsey TW, Braiser KJ, Glenna LL (2018). Marcellus shae gas development and farming. *Agric Resource Econ. Rev.* 47:3634-64.
- IPCC (2013). *Climate Change 2013: The Physical Science Basis*.

- Jackson, R. B., et al. (2013). The implications of unconventional oil and gas development on water resources in the United States. *Science*, 340(6132), 1235009.
- Kaplan T. (2014). Citing health risks. Cuomo bans fracking in New York state, the New York Times.
- Kara Anderson (2024). Everything you need to know about fracking.
- Keith Miller (2024). 21 Advantages and Disadvantages of fracking. Future of Working: The Leadership and Career Blog.
- Keranen, K. M., et al. (2014). Sharp increase in central Oklahoma seismicity since 2008 induced by massive wastewater injection. *Science*, 345(6193), 448-451.
- Kivela, J., Krause, T., & Ziemba, R. (2015). Land use and environmental impacts of shale gas development in the United States. *Journal of Environmental Management*, 161, 278-288.
- Kondash, A. J., et al. (2018). Water footprint of hydraulic fracturing in the United States. *Environmental Science & Technology*, 52(14), 7687-7695.
- Krausmann, F., Gingrich, S., Eisenmenger, N., Erb, K. H., Haberl, H., & Fischer-Kowalski, M. (2009). Growth in global materials use, GDP and population during the 20th century. *Ecological Economics*, 68(10), 2696-2705.
- Llewellyn, G. T., et al. (2015). Evaluating the environmental and health impacts of Marcellus Shale gas development. *Reviews of Environmental Contamination and Toxicology*, 234, 71-134.
- McKenzie, L. M., et al. (2012). Birth outcomes and maternal residential proximity to natural gas development in rural Colorado. *Environmental Health Perspectives*, 120(1), 139-144.
- McKenzie, L. M., et al. (2014). Hydraulic fracturing and birth outcomes in Pennsylvania. *Environmental Health Perspectives*, 122(12), 1288-1294.
- Michael Greenstone, Jane Currie, Katherine Meckel (2018). Fracking has its costs and benefits- the trick is balancing them.
- Moore, C. W., et al. (2014). Air emissions of CO₂, CH₄, and N₂O from oil and gas production in the United States. *Environmental Science & Technology*, 48(12), 6636-6644.
- New York State Department of Public Health (2014). A public health review of high-volume hydraulic fractures for shale gas development.
- NOAA (2020). Global Climate Report.
- Osborn, S. G., Vengosh, A., Warner, N. R., & Jackson, R. B. (2011). Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *Proceedings of the National Academy of Sciences*, 108(20), 8172-8176.
- Phil Cohen (2024). Fracking restrictions imposed by the federal government. Factor Finders.
- Qun Lei, Yun Xu, Bo Cai, Baoshan Guan, Xin Wang, Guoqiang Bi, Hui Li, Shuai Li, Bin Ding, Haifeng Fu, Zheng Tong, Tao Li, and Haoyu Zhang (2022). Progress and prospects of horizontal well fracturing technology for shale oil and gas reservoirs. *Petroleum Exploration and Development*, Vol.49, Issue 1, Pg 191-199.
- Rakitan T.J. (2018). The impact of the U.S shale boom on Agric: evidence from North Dakota work.
- Rasmussen, S. G., et al. (2016). Health impacts of unconventional oil and gas development. *Environmental Science & Technology*, 50(11), 5736-5745.
- Rosa A.L., Rulli M.C., Davis K.F., and Odorico P.D. (2018). The water energy nexus of hydraulic fracturing: a global hydrologic analysis for shale oil and gas extraction 1-12.

-
- Tara Patel (2011). Bloomberg Businessweek. Shale oil and gas: 'The French says no to Le Fracking.'
- The Federal Government of Germany (2017).
- Thakor D.T. (2018). Liquidity windfalls and reallocation: evidence farming and fracking work.
- Quiroga, A., et al. (2017). Vaca Muerta Shale: A review of its geology and hydrocarbon potential.
- Shonkoff, S. B., et al. (2014). Environmental and health impacts of hydraulic fracturing: A literature review. *Reviews of Environmental Contamination and Toxicology*, 226, 1-55.
- Vicki Estrom High (2016). Study suggests hydraulic fracturing boosts local economics. University of Chicaago, Chicago news.
- Wang, G., et al. (2015). Geology and hydraulic fracturing of the Barnett Shale.