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Minor - Dissertation

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Fracking and Sustainable Development.

A critical assessment of whether shale gas extraction (hydraulic fracturing) conforms with the underlying principles of sustainable development.

by

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Word Count: 24, 946

Submitted to **The University Of Cape Town**

in fulfilment of part of the dissertation requirements for Legal Masters Degree.

Date of submission:

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"The truth is: the natural world is changing. This world upon which we are dependent on. It provides our food, water and air. It is the most precious thing we have and we must defend it"

David Attenborough

Acknowledgements

I offer my sincerest gratitude to my supervisor, Jan Glazewski. He supported me during the entire dissertation process and provided me with the necessary direction and insight in the very interesting field of shale gas extraction, sustainable development and the application of environmental law thereto.

DECLARATION

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Abstract

It is estimated that the eighth largest resource of shale gas reserves in the world is in South Africa. The proposed extraction of shale gas using hydraulic fracturing requires great volumes of water and many hazardous chemicals which also risks water pollution. This can add to water stress because the Karoo is a semi-arid and drought prone region.

In this study I will, after taking into account that South Africa receives an average annual rainfall of almost half the international annual rainfall, answer the question on whether the fracking process is a risk worth taking by measuring the process to the underlying principle of sustainable development.

The world is faced with challenges in all three dimensions of sustainable development (economic, social and environmental). More than 1 billion people are still living in extreme poverty, and income inequality within and among many countries has been rising; at the same time, unsustainable consumption and production patterns have resulted in huge economic and social costs and may endanger life on the planet.

In this minor dissertation, sustainable development will be defined explained and examined, looking at environmental sustainability as well as an in depth look at the underlying principles of sustainable development, examining the advantages and disadvantages of each. However, because the first step in making sustainable development more concrete is the formulation of legal principles, I will analyse the South African legal framework governing fracking as a process. In this minor dissertation it is found that the disadvantages outweigh the advantages within the three spheres of sustainable development.

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Chapter 1

Background

During February 2014, the President of South Africa declared shale gas extraction as a 'game-changer for the Karoo region and the South African economy'.[1] It is estimated that South Africa has the eighth-largest shale-gas reserves in the world, following China, Argentina, Algeria, US, Canada, Mexico and Australia. Energy in South Africa is very coal dependent with 94% of electricity being generated from coal and this also results in high carbon emissions. Energy from shale gas is reported to be significantly less carbon emissions per unit energy compared to coal if the methane emissions are controlled. [2]

South Africa is experiencing an energy crisis due to an energy shortage. While new capacity is under construction more will be needed as South Africa's energy needs may double by 2030.5

According to Treasure Karoo Action group booklet (2015), shale gas mining (SGM), is presently banned or under some form of restriction or moratorium in more than a hundred countries or states around the world, including developed countries like France, Bulgaria and Germany. In the United States, New York State has recently extended their ban on fracking, citing public health concerns as one of the main reasons.

Not least of the potential benefits of shale gas extraction is the potential job creation and poverty alleviation. Although these factors make shale gas a very attractive resource to some proponents many landowners, environmentalists, lawyers are not convinced.[3]

Relevance of the study

As water insecurity is an ever-present danger, especially in the Karoo region, it is incumbent to revisit the notion of 'sustainable use' of water resources.

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[1] JG Zuma 'State of the Nation Address By His Excellency Jacob G Zuma, President of the Republic of South Africa on the occasion of the Joint Sitting of Parliament' State of the Nation Address, 13 February 2014, available on http://www.gov.za/speeches/view.php?sid=43620 accessed on 18 July 2015.

[2] A Burnham et al 'Life-Cycle Greenhouse Gas Emissions of Shale Gas, Natural Gas, Coal, and Petroleum' (2011) 46 Environ. Sci. Technol. 625.

[3] MJ de Wit 'The great shale debate in the Karoo' (2011) 107(7/8) S Afr J Sci. 791.

A study was conducted in the US regarding methane contamination of drinking water due to fracking.[4] During this study it was found that in aquifers overlying the Marcellus and Utica shale formations of northeastern Pennsylvania and upstate New York, documented systematic evidence for methane contamination of drinking water associated with shale gas extraction. It was found that, in active gas-extraction areas (one or more gas wells within 1 km), average and maximum methane concentrations in drinking-water wells increased with proximity to the nearest gas well and were 19.2 and 64 mg CH4 L−1 (n ¼ 26). This is extremely high and according to the authors, a potential explosion hazard.

The fact that South Africa is considering this method of natural gas extraction without nearly enough research, is disturbing to say the least.

Research question

Taking into account the economic opportunities as well as environmental risks, should SA take the environmental risk of conducting the fracking process in the Karoo and will this decision conform with the law relating to sustainable development? As will be emphasised in the chapters below, the possible water contamination issues and water usage issue highlights the need for an effective governance framework to be in place and requires every aspect of the process to be measured against the principles of sustainable development. This minor dissertation will conclude that the government must reconcile the much needed mining industry with Sustainable Development. This need to be done in order that Section 24 (b)(iii) of the Constitution of the Republic of South Africa[5] need not be divided in two. Should this happen then authorities will be obliged to either choose economic development or environmental protection. The reason being that Section 24 provides for both of these and it can be difficult to achieve both of these.

Rationale for study

One of the most serious current ongoing environmental debates is regarding the question of whether SA should take the environmental risk of conducting fracking in the Karoo. The fact that fracking is a risky process is no mystery and the possible negative impacts are advertised adversely. What is not as advertised is the economic positives that this process can provide to us as a country as well as certain

[4] S.G. Osborn et al. 'Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing' 2011
[5] Act 108, of 1996 (hereinafter referred to as 'the Constitution')

communities. This process does not only provide for an opportunity to strengthen our economy and provide for less expensive energy, it can provide communities in the Karoo with food security in the form of jobs created by this process. Most communities in the Karoo currently live under very poor conditions and food insecurity is not an unusual sighting. The reason being that, other than agriculture and small shops, there are very little job opportunities within this area. There is thus an ongoing contradictory choice for the government between the economic and environmental sphere of sustainable development, which includes 3 main dimensions or spheres. These three dimensions of sustainable development includes the economic, environmental and the political dimension and will be discussed in detail in this paper.

Climate policies and fuel reserves which are declining will drive substantial changes in energy policy in the coming decades. Shale gas development shares many science policy questions with other possible energy alternatives and, as a result, provides a good case study into the different actors at play and associated challenges. I believe that locally, nationally, and globally, costs and benefits of new energy options need to be assessed quickly.

In the South African context, S 24(*b*)(iii) of the Constitution contains the environmental clause in the Bill of Rights, which exhorts the passing of legislative and other measures that secure " ... ecologically sustainable development ...".[6] There is a clear need to discuss shale gas extraction from the perspective of sustainable development. This study will focus on these conflicting sustainable development dimensions (economical VS environmental).

Research methodology

This paper will be written as a desktop study.

Structure of the dissertation

This study is divided into five chapters. **Chapter two** explains and defines fracking as a process. Thereafter it will look at the consequences of the process, with human health and the environment as the main focus points. The disadvantages and the advantages will be weighed against each other in an attempt to establish the nature of the fracking process. **Chapter three** deals with fracking and

[6] J Glazewski *Environmental law in South Africa* (2005) Chapter 1.

sustainable development. Sustainable development will be defined and explained in both the legal framework of South Africa as well as in the international context. Sustainability and environmental sustainability will also be defined and explained in an attempt to see whether fracking amounts to sustainable practice. Thereafter an in-depth study will be conducted on the underlying principles of sustainable development.

In **chapter four** I looked at all the relevant laws within South Africa in an attempt to conclude whether the current law regime is satisfactory. This chapter started with the relevant Constitutional provisions. Thereafter an in-depth study is conducted on the Mineral and Petroleum Resource Development Act, which is the act that regulates fracking in South Africa. Other relevant legislation is also mentioned, as they relate to fracking.

Chapter five concluded this minor dissertation with a general conclusion and with some recommendations and safeguards which I believe is necessary for the fracking process to be in line with sustainable development and therefor, to protect the environment.

Chapter 2 - Fracking as a process

2. Introduction

While the engineering, scientific and technological processes applied in the fracking or shale gas mining enterprise are more or less the same worldwide, in South Africa there are some unique considerations. Firstly, from a bio-physical perspective, South Africa is generally considered a very water scarce country with an average rainfall of 450mm/y compared to an international average of 800mm/y. The Karoo region in particular is water stressed, with most of the area being dependent on groundwater.[7] According to the Water Research Commission (WRC), the total estimated volume of available, renewable groundwater in South Africa is a little over 10 000 million m3/a, or 7 500 million m3/a under drought conditions. South Africa is currently using between 2 000 and 4 000 million m3/a of this groundwater. According to the WRC there is the potential to considerably increase the use of this precious resource.[8] A second and related issue is that the Karoo has a unique geological structure in that the normal sandstone in which the shale gas resides is permeated by unusual dolerite dyke formations resulting in water unusually possibly being forced upward.[9] Therefore the unique Karoo region may need specific measures in order to affect groundwater protection. Thirdly, the Karoo is a landscape of unique biodiversity, particularly in the west which is considered one of the most diverse deserts in the world.[10] Towards the east, a range of distinct plant forms support an extensive wildlife ranching and pastoralism industry.

Because of the paucity of tertiary institutions in the region little research has been undertaken in the Karoo, and the likely impact of fracking on the region's biodiversity and ecosystem services is completely unknown. The heady ideal of sustainable development must however be seen against the backdrop of the growing divide between poor and rich nations as well as the increasing income disparities within countries, including South Africa, where the need to alleviate poverty and create employment are

[7] Steyl, G and GJ van Tonder, 'Hydrochemical and Hydrological Impact of Hydraulic Fracturing in the Karoo, South Africa', http://dx.doi.org/10.5772/56310 (As accessed on 10 December 2015).
[8] Maherry A. 'Planning for groundwater in South Africa' 2010 CSIR RESEARCH SPACE.
[9] Gerrit van Tonder, Fanie de Lange, Gideon Steyl and Danie Vermeulen 'Potential impacts of fracking on groundwater in the Karoo Basin of South Africa' Institute for Groundwater Studies, University of the Free State, Bloemfontein, Free State, South Africa http://gwd.org.za/sites/gwd.org.za/files/04_G%20vTonder_Potential%20%20Impacts%20of%20Fracking%20on%20Groundwater.pdf. (As accessed 10 December 2015)
[10] Myers N, Russell A. Mittermeier, CG; et al. 'Biodiversity hotspots for conservation priorities' Nature 2000 at 853-858.

acute.[11] South Africa's Gini co-efficient, a UN inequality index, increased from 0,66 to 0,7 in the period 1993–2008. The Organisation for Economic Co-operation and Development (OECD), reported that while total income poverty in South Africa has decreased slightly it persists at acute levels for certain racial groups'.[12]

As we are entering an age where energy is a necessary commodity, one must wonder where we are going to get it from. In the past, coal and oil have primarily been our source of energy. However, due to cost and environmental issues, there was a need to start looking into other sources. Among them have been solar power, windmills, and natural gas. While many of the ideas are clean and great sources of power, the first two are not feasible because of cost and they do not produce a sufficient amount of power to sustain all of our energy needs. In the past few years, natural gas has become very popular for energy production, especially in the U.S. While natural gas burns cleaner, the mining process may not be environmentally friendly. This has led to a great debate on whether the benefits of natural gas are worth the negative impacts it may have on the environment.

Achieving sustainable development will require global actions to deliver on the legitimate aspiration towards further economic and social progress, requiring growth and employment, and at the same time strengthening environmental protection. Sustainable development will need to be inclusive and take special care of the needs of the poorest and most vulnerable. Strategies need to be ambitious, action-oriented and collaborative, and to adapt to different levels of development. They will need to systemically change consumption and production patterns, and might entail, inter alia, significant price corrections; encourage the preservation of natural endowments; reduce inequality; and strengthen economic governance.

A particular challenge is the fact that sustainable exploitation in the case of minerals or shale gas extraction is literally not possible and the concept has to be nuanced, for example by differentiating between maintaining natural ecosystems and the extraction of physical mineral resources.

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[11] Skowno, A.L., Holness, S.D. and Desmet P.G 'Biodiversity Assessment of the Kannaland and Oudtshoorn Local Municipalities, and Eden District Management Area (Uniondale)'. DEADP Report LB07/2008a, 2010. http://bgis.sanbi.org/littlekaroo/LK_biodiversityassessment.pdf. (Accessed on 08 December 2015)

[12] Leibbrandt M, Woolard I, Finn A Et al., 'Trends in South African Income Distribution and Poverty since the Fall of Apartheid' OECD Social, Employment And Migration Working Papers No 101 (Directorate for Employment, Labour and Social Affairs) 2010.

2.1. What is fracking

In conventional natural gas reservoirs, a few vertical wells are usually drilled every 2.5 km² and are sufficient for the extraction of the existing natural gas. Tight natural gas formations are porous and have a permeability that is much lower than the conventional gas reservoirs. Tight gas does not diffuse easily in the low permeability formation rock and is often spread over a larger area. This then necessitates an approach where wells are drilled in different directions from a central location that penetrates the gas reservoir both vertically and horizontally. This would pose a limitation on the number of available drilling locations or wells pads on the surface.[13] On the other hand, in horizontal drilling, a large network of wells is generated, stretching underground for lengths of up to 2 kilometres or 1.2 miles. This increases the potential production to up to ten times more than is achieved through conventional methods. Mobile drilling units are moved between the well pads, avoiding the dismantling and reassembling of the drilling equipment for each pad.

The technique of hydraulic fracturing has been in use since the 1950s. However, in the last decade the development of the horizontal drilling technique has made hydraulic fracturing a useful technique. This allowed for the extraction of natural gas from shale rock deposits, which are usually around a mile in depth.[14]

Fracking is a process in which fractures in rocks below the earth's surface are opened and widened by injecting chemicals and liquids at high pressure for the purpose of extracting natural gas or oil. These fluids are being pumped under high pressure into a well whose casing has been perforated by projectiles shot from a specially designed gun to create fractures in the rock, thus increasing its permeability.[15] During this process, the sand keeps the cracks open after withdrawal of the fracturing fluid and allows the gas to flow into the perforated casing. This takes place deep underground below the shallow fresh water aquifers at high pressures, sufficient to create fractures in the host rock.[16]

The process of unconventional natural gas development (NGD) is typically divided into two phases: well development and production. Well development involves pad preparation, well drilling, and well completion. The well completion process has three primary stages: i) *Completion transitions* (concrete

[13] Magdi Ragheb, 'Tight Natural Gas as a Bridge Fuel toward Renewables,' 2011 Winter at 8-9
[14] B. Legarth et al 'Hydraulic fracturing in a sedimentary geothermal reservoir: Results and implications' 2005 IJRMMS 42 P1030
[15] Ragheb op cit note 3 at 11-12.
[16] Ibid at 11.

well plugs are installed in wells to separate fracturing stages and then drilled out to release gas for production); ii) *hydraulic fracturing* (the high pressure injection of water, chemicals, and propants into the drilled well to release the natural gas); and iii) *flowback*, the return of fracking and geologic fluids, liquid hydrocarbons (condensate) and natural gas to the surface. Once development is complete, the "salable" gas is collected, processed, and distributed. While methane is the primary constituent of natural gas, it contains many other chemicals, including alkanes, benzene, and other aromatic hydrocarbons.[17]

2.2. The impacts of fracking

2.2.1. Positive impacts:

2.2.1.1. Socio-economical

With regards to economics, the costs and benefits of fracking can be overwhelming and, as a result, it is, from the outset, hard to say which outweighs the other.

Although there are multiple benefits to allowing fracking, the economic benefits of an expanding gas industry, enhanced by shale gas production, will depend on the gas/inter-industry linkages with other domains in the economy. Most notably, an increase in employment, income, government revenue and economic growth are expected. Furthermore, consumers can benefit from using shale gas as a source of energy. This, in turn, can create a positive spill-over effect and as a result reduce the demand for more carbon intensive energy sources such as oil and coal.[18]

Also, the increase in value produced can increase the number of people employed directly in production and delivery activities. Another economic benefit that can arise from fracking is the royalties that are to be paid to landowners to conduct fracking on their land. An increased amount of fuel produced means lower fuel prices, and higher possible land prices near wells (although this might not be the case)[19]. It may also possibly include social benefits due to the fact that CO_2 emissions have declined due to the use of cleaner burning natural gas instead of coal.

[17] LM McKenzie 'Human health risk assessment of air emissions from development of unconventional natural gas resources' (2012) *Scitotenvironment* 1-2.
[18] T. C Kinnaman, 'The economic impact of shale gas extraction: a review of existing studies' 2011 Ecological Economics 70, 1243-1249.
[19] See 2.2.2.2. below.

2.2.1.2. Other

Other than the socio-economical benefits created by fracking, according to a 2011 paper by D.C. Holzman,[20] of most importance in meeting carbon reduction goals is that gas generates 50% fewer emissions than coal when burned, and 30% fewer emissions than oil. South Africa needs to transition from being entirely coal dependent for energy to renewable solutions: shale gas offers a 'bridging-fuel' and the time-gap needed to shift to a less carbon-intensive economy. Shale gas can improve energy security, lower the cost and price volatility of energy and reduce greenhouse gas emissions if burned instead of coal. Wang (et al),[21] while considering the higher power generation efficiency of shale gas, concluded that in the long run shale gas has a much lower carbon footprint than coal. The short run carbon footprint of shale gas can be reduced to a level similar to that of coal by using existing technology to minimise methane emissions.[22] The environmental impact could be reduced even further by storing the CO2 emissions in depleted shale gas reservoirs.[23]

Unconventional energy development has the potential to decrease emissions of some pollutants, particularly when natural gas replaces coal for the purpose of power generation.[24] As mentioned above, natural gas burned for electricity generates half the CO2 that coal does during combustion. If leaks of natural gas can be minimized, the green house gas benefits of this transformation would be substantial, in particul as a bridge to a renewables-based future. Approximately 1–3 kg NOx per MWh and 2–10 kg SO2 per MWh are emitted from coal powered power plants most likely to be replaced by natural gas.[25] Burning natural gas emits practically no SO2 or Hg and less NOx and particulates than burning coal does. Natural gas burning also does not result in billions of tons of toxic coal ash each year that cannot only impact water and air quality, but also human health. The air quality benefits from electricity generation when using natural gas are substantial compared with coal-fired power.

Natural gas also has a high specific energy when compared to existing fuel choices, only exceeded in the energy content per unit weight by nuclear fuel.[26]

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[20] D.C Holzman '*Methane Found in Well Water Near Fracking Sites' 2011 EHPJ*.
[21] J Wang et al. 'Reducing the greenhouse gas footprint of shale gas' 2011 Energy Policy, 39 (12), 8196-8199.
[22] Ibid.
[23] Ibid.
[24] J De Gouw et al. 'Reduced emissions of CO2, NOx and SO2 from U.S. power plants due to the switch from coal to natural gas with combined cycle technology' 2014 Earth's Future 2:75–82.
[25] A Venkatesh et al. 'Implications of near-term coal power plant retirement for SO2 and NOx and life cycle GHG emissions' 2012 EST 46:9838–45.
[26] Magdi Ragheb op cit note 3 at 21-29.

2.2.2. Negative impacts:

2.2.2.1. Socio-economical

Despite the significant claim that fracking will economically benefit the Karoo local community, I believe that, on the contrary, the benefits to the local economy of the planned development will be quite small and that the major beneficiaries will be the owners (e.g. Shell, Falcon Oil and Gas, Bundu, etc.) of the extraction activities who mostly reside outside the development area or even outside the country.

The initiation of drilling can have a profound impact on communities. Industrialization of bucolic rural areas will most probably have a significant negative impact on tourism, farming and property values. When industry workers move to town, rents can increase significantly. This can then lead to homelessness among low income community residents. All of which is present within the Karoo area and the communities within. The social fabric of communities is torn when self-interest pits neighbor against neighbor.[27] People who own mineral rights can become very rich overnight, whereas others see their quality of life deteriorate. Grassroots advocates find themselves involved in the time-consuming and intimidating process of going head-to-head with the highly paid public relations and legal counsel engaged by the oil and gas industry.[28] Many become environmental refugees and suffer all the stresses inherent in the upheaval of relocation.[29]

While it is true that fracking do in fact have its economic benefits, do they really outweigh the downfalls? When speaking of the local economies affected by oil and gas mining, one can refer to what is called the boom-bust cycle. This means that when these large companies come in, the economy booms and when they leave it busts. The local community has to build and supply more in order to keep up with the sudden demand; more roads, more schools, and more businesses. When the company is done and they leave, the community is left paying for upkeep of everything they built without the former revenue. In addition, because less housing is needed, home prices plummet and wreak havoc on the real estate market. Due to the loss of businesses, unemployment rises. Many instances of this can be seen within the global history. Ghost towns all over the world are proof of this cycle.

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[27] S.L Perry 'It's like we are losing our love. Documenting and evaluating social change in Bradford County PA during the Marcellus shale gas boon' 2011.

[28] A Lustgarten 'Hydrofracked? One man's mystery leads to a backlash against natural gas drilling 2011 ProPublica.

[29] M A Rafferty & Elena Limonik 'Is Shale Gas Drilling an Energy Solution or Public Health Crisis?' 2013 PHN Vol. 30 No. 5, pp. 454–462 P457-458

The above mentioned boom cycle, itself, causes socioeconomic problems. The rapid influx in population causes a shortage of housing which affects rent prices. This results in an increase in homelessness because renters can no longer afford their rent.[30] This population influx also causes problems because there is a growing demand for employees in law enforcement, emergency response, social services, medical services, and public works.[31] According to Barkdull et al.,[32] the substandard living conditions have induced an increase in child protection and foster care cases in the American state, North Dakota's boom towns as well as increases in those which involve family from out of state. They also mention that according to data, there is an increase in domestic abuse in these areas. Another problem that they mentioned facing was an increase in traffic problems whereby fatal accidents and reckless or dangerous driver citations had increased by between 72 and 102 percent in recent years. They attribute this to traffic and poor road quality. It is thus quite clear that the boom requires towns to build more, hire more, and spend more to accommodate the influx of population brought in by the oil and gas companies.

2.2.2.2. Property

Another socio-economic aspect which is rarely included in fracking studies is the impact that fracking has on property values. Boxall (et al) studied the impact of oil and gas drilling on residential property values in Alberta, Canada, and found a negative relationship.[33]

Studies show that home prices drop, in average, about 15 percent near fracking sites.[34] The money paid to landowners for leases have also resulted in problems. In 2011, a review of more than 111,000 leases by Ian Urbina and Jo Craven McGinty of The New York Times suggests that these leases do not protect the landowner. Their findings show that less than half of the leases require companies to compensate landowners for water contamination after the drilling has commenced and only about half require payment for damages to livestock or crops. It was found that most leases grant gas companies broad rights to decide where they can cut down trees, store chemicals, build roads, and drill. Companies are also permitted to operate generators and spotlights through the night near homes during drilling. In the

[30] B Weber, et al. 'Rural North Dakota's Oil Boom and Its Impact on Social Services.' 2014 National Association of Social Workers, 59(I), 62-71 at 67.
[31] Dickinson State University, Minot State University, and Great Plains Energy Corridor. 'Energy Impacts in North Dakota' 2011 at 4
[32] Weber op cit note 20 at 67.
[33] P. C Boxall, et al. 'The Impact of Oil and Natural Gas Facilities on Rural Residential Property Values: A Spatial Hedonic Analysis.' 2005 REE 27 (3): 248-269.
[34] T.R Simons, et al. 'A review of hydro "Fracking" and its potential effects on real estate' 2013 *JREL* 21(2), 205-232. Doi

leases, drilling companies rarely describe to landowners the potential environmental and other risks that the relevant laws require them to disclose.[35]

Muehlenbachs, Spiller, and Timmins[36] demonstrated that the risk of groundwater contamination from natural gas extraction will most probably lead to a large and significant reduction in house prices. They further found that these reductions offset any gains to the owners of groundwater-dependent properties from lease payments or improved local economic conditions, and may possibly even lead to a net drop in prices. This can even be to the extent that the net effect of drilling on groundwater-dependent houses might even be negative, and as a result we could see an increase in the likelihood of foreclosure in areas experiencing a rapid growth of hydraulic fracturing.[37]

On the other hand, recent reports indicate that obtaining insurance is likely to become increasingly difficult, if not impossible, for properties that may be impacted by fracking. This will then have a negative impact on property values, as residential mortgages require the property owner to carry homeowner's insurance.[38]

2.2.2.3. Public health costs

I believe that the potential public health costs should be reflected in a thorough economic assessment. Multiple researchers, as will be seen throughout this study, have discussed potential negative health impacts that may result from water and air contamination. Various chemicals used in hydraulic fracturing include carcinogens and endocrine disruptors, which are related to serious diseases and birth defects. All of these involves significant costs. With regards to humans, such costs can be estimated by measuring health services costs related to specific diseases and the loss of life and decreases in life expectancy. In the case of domestic and farm animals, values can be assigned based on market prices. All these health costs should be taken into account and can be estimated using probabilities based on the likelihood of contamination by the various pathways.[39]

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[35] Ibid

[36] L Muehlenbachs, E Spiller & C Timmins 'Shale Gas Development and the Costs of Groundwater Contamination Risk' RFF 2012 Discussion Paper.

[37] L. Muehlenbachs, et al. 'Shale Gas Development and Property Values: Differences across Drinking Water Sources' RFF 2012, Discussion Paper.

[38] The River Reporter 'Nationwide Insurance: No Fracking Way' July 11, 2012 Available at http://www.riverreporteronline.com/news/14/2012/07/11/nationwide-insurance-no-fracking-way accessed on July 12, 2012.

[39] J. M Barth 'The economic impact of shale gas development on state and local economies: benefits, cost and uncertainties' 2013 NEW SOLUTIONS Vol. 23(1) 85-101 at 95.

2.2.2.4. Landscape

The technology used to extract natural gas, known as hydraulic fracturing, has gained much attention because of its use of large amounts of fresh water, its use of proprietary fluids for the hydraulic-fracturing process, its potential to release contaminants into the environment, and its potential effect on water resources. Other than these very serious threats, Slonecker et al.[40] conducted a study of the Landscape Consequences of Natural Gas Extraction in Bradford and Washington Counties, Pennsylvania and they believe that this natural gas extraction method create potentially serious patterns of disturbance on the landscape.

In landscape analysis, disturbances are discrete events in space and time that disrupt ecosystem structure and function and change resource availability and the physical environment.[41] According to Slonecker et al., disturbance is a key concept in a landscape analysis approach and in ecology in general. They believe that gas development activities create a number of disturbances across a heterogeneous landscape.

It was also found that development of multiple sources of natural gas will result in increased traffic from construction, drilling operations (horizontal and vertical), hydraulic fracturing, extraction, transportation, and maintenance activities. The mere presence of humans, construction machinery, infrastructure (for example, well pads and pipelines), roads, and vehicles alone may substantially impact flora and fauna. Increased traffic, especially rapid increases on roads that have historically received little activity, can have detrimental impacts to populations.[42] Forest loss as a result of disturbance, fragmentation, and edge effects has been shown to negatively affect water quality and runoff (Wickham and others, 2008), to alter biosphere-atmosphere dynamics that could contribute to climate change,[43] and to affect even the long-term survival of the forest itself.[44]

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[40] Slonecker et al. 'Landscape Consequences of Natural Gas Extraction in Bradford and Washington Counties, Pennsylvania' 2004–2010 USGS.

[41] M.G Turner, et al. 'Landscape ecology in theory and practice: New York' Springer-Verlag at 401.

[42] JP Gibbs and WG Shriver 'Can road mortality limit populations of pool-breeding amphibians' 2005 WEM, v. 13, at 281–289.

[43] Bonan, G.B. 'Forest and climate change: forcings, feedbacks, and the climate benefits of trees' 2008 Science, v. 320 at 1,444–1,449.

[44] G Claude, et al. 'Receding forest edges and vanishing reserves' 2007 Science, v. 288, no. 5470, at 1,356–1,358.

The finding of the study was that natural gas resource development had the greatest impact on forest and agricultural land cover.

2.2.2.5. Other

Other possible negative impacts regarding the fracking operations relate primarily to the impact of surface infrastructure, large volumes of water use, ground- and surface-water contamination, health risks, air emissions, job creation, ability to rehabilitate and seismicity. Vehicular truck traffic operates day and night and are thus creating noise, pollution, seriously damaging the roads and causing motor vehicle accidents.[45] Communities report increases in crime and sexually transmitted diseases that may be attributed to transient workers from distant states.[46] Another concern is that a relatively clean energy source using proven technology is an 'easy out', and will remove focus from renewable sources of energy, such as solar and wind. The health and environmental impacts will be discussed in detail below.

2.3. Health impact assessment (HIA)

Toxicological data for the chemicals injected into wells (so-called frac-fluid) indicate that many (if not all) of them have known adverse effects on human and animal health.[47]

McKenzie's study of 'air emissions from development of unconventional natural gas resources' is a HIA of hydraulic fracturing conducted in the USA. This study calculated higher cancer risks for residents living nearer to wells as compared to residents residing further from wells. It revealed that benzene is the major contributor to lifetime excess cancer risk for both scenarios. It is also notable that these increased risk metrics are seen in an air shed that has elevated ambient levels of several measured air toxics, such as benzene. [48]

Sub-chronic health effects, such as headaches and throat and eye irritation reported by residents during well completion activities occurring in Garfield County, are consistent with known health effects of many

[45] R Witter 'Community impacts of natural gas development and human health' 2012 Paper presented at the Institute of Medicine Workshop on the Health Impact Assessment of New Energy Sources: Shale Gas Extraction, Washington, DC.
[46] Witter, R, et al. 'Potential exposure-related human's health effects of oil and gas development' 2008 Retrieved from www.ucdenver.edu
[47] S. Kovats, et al. 'The health implications of fracking' Department of Social and Environmental Health Research, London School of Hygiene and Tropical Medicine, London WC1E 7HT, UK (SK, AH, PW, NS); European Centre for the Environment and Human Health at 757 - 758.
[48] McKenzie op cit note 7 at 5.

of the hydrocarbons evaluated in this analysis. Inhalation of trimethylbenzenes and xylenes can irritate the respiratory system and mucous membranes with effects ranging from eye, nose, and throat irritation to difficulty in breathing and impaired lung function. Inhalation of trimethylbenzenes, xylenes, benzene, and alkanes can adversely affect the nervous system with effects ranging from dizziness, headaches, fatigue at lower exposures to numbness in the limbs, in-coordination, tremors, temporary limb paralysis, and unconsciousness at higher exposures.[49]

2.4. Environmental impact assessment

2.4.1. In general

Rapid development of shale formations due to horizontal drilling and fracking is redrawing the global energy picture but raising concerns about the environmental impacts of production. Environmental exposures includes outdoor air pollutants (ie, volatile organic compounds, tropospheric ozone, and diesel particulate matter) and pollutants (ie, benzene, hydrocarbons, endocrine-disrupting chemicals, and heavy metals) in both ground and surface water.[50] Most of which, as mentioned above, are concerns for both human and animal health.

At least 680 shale formations in 140 basins throughout the world are capable of producing natural gas.[51] By 2010, dry shale gas production in the United States had increased to 4.80 trillion cubic feet (tcf) from 0.39 tcf in 2000.[52] Exploration has also occurred in Austria, Australia, Canada, China, Poland, South Africa, the United Kingdom, and other countries. In all countries with shale resources, increased natural gas could provide national security, economic, and environmental benefits. However, environmental impacts are also arising from pollutants and activities which are associated with the production process, including greenhouse gas (GHG) emissions, chemicals used in the fracking process, and land clearance for the development of well sites.[53] The question of whether such large development should start in the arid region which is the Karoo, has started a heated debate and is in fact the essence of this study.

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[49] Ibid 6-7.
[50] Kovats op cit note 36 at 757.
[51] WEC 'Survey of Energy Resources: Focus on Shale Gas, London' 2010 UK: World Energy Council.
[52] U.S. Energy Information Administration (USEIA) 2011 World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States. Washington, DC: USEIA.
[53] E Branosky et al. 'Defining the shale gas life cycle: A framework for identifying and mitigating environmental impacts.' 2012 Working Paper (WRI) 1-2.

A study was conducted in the US regarding methane contamination of drinking water due to fracking.[54] During this study it was found that in aquifers overlying the Marcellus and Utica shale formations of northeastern Pennsylvania and upstate New York, documented systematic evidence for methane contamination of drinking water associated with shale gas extraction. It was found that, in active gas-extraction areas (one or more gas wells within 1 km), average and maximum methane concentrations in drinking-water wells increased with proximity to the nearest gas well and were 19.2 and 64 mg CH4 L−1 (n ¼ 26). This is extremely high and according to the authors, a potential explosion hazard.

The environmental impact of hydraulic fracturing also includes land use and water consumption, and risks for noise pollution, air emissions, water contamination, and health effects. While water and air pollution are the biggest risks to human health from fracking, noise from fracking and associated transport can affect residents and local wildlife.[55]

Shale gas development on a rather large scale may represent the start of several decades of production and the drilling of thousands of wells in South Africa. Such a development will have both local and dispersed land effects. The assessment of the adverse and serious effects of shale gas development cannot, therefore, focus on a single well or well pad, but must also consider cumulative effects of a most likely continuous process.[56]

In keeping up with the rush to produce more natural gas, technological advances have permitted the industry to drill deeper and expand wider, thus tapping into gas reserves with greater facility and profitability. While these advances may have allowed the mining of vast, newly discovered gas deposits, the new technology depends heavily on the use of undisclosed types and amounts of toxic chemicals.[57] These chemicals are used throughout operations to reach and release natural gas. Firstly, combinations of chemicals are added to the “muds” used to drill the bore hole. Chemicals are also added to increase the density and weight of the fluids in order to facilitate boring, to reduce friction, to facilitate the return of drilling detritus to the surface, to shorten drilling time, and to reduce accidents. After drilling, fracking is done to break up the zone in which the gas is trapped and make it easier for the gas to escape, increasing a well's productivity. In the U.S. West, approximately a million or more gallons of fluid containing toxic chemicals are injected underground during this operational stage. As with drilling,

[54] S.G. Osborn et al. 'Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing' 2011

[55] M Broomfield '*Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe'* 2012 European Commission DG Environment at iii.

[56] Council of Canadian Academies 'Environmental Impacts of Shale Gas' at XV.

[57] Theo Colborn, et al. 'Natural Gas Operations from a Public Health Perspective' 2011 IJHERA Volume 17, Issue 5.

chemicals are used in fracking fluids for many purposes (clay stabilisers, to allow the breakdown of gellants, to reduce friction, to achieve greater penetration, to reduce foaming, ect.) [58]

One well can be fracked 10 or more times and there can be up to 30 wells on one pad. An estimated 10% to 90% of the fracking fluid is returned to the surface during well completion and subsequent production.[59]

In addition to local health and environment threats created by fracking, an important consideration is the contribution of shale gas extraction to greenhouse-gas emissions and, thus, to climate change. Although there is conflicting evidence regarding the comparative contribution of lifecycle greenhouse gases of shale gas relative to coal, evidence from the USA indicates that instead of replacing coal, shale [60]gas has rapidly become an additional source of fossil fuel, leading to an increase in cumulative global greenhouse-gas emissions.[61]

With regards to animals, Two veterinarians who were researching fracking's effect on animals documented problems with human subjects in the same article. These research participants reported problems with the following bodily systems: gastrointestinal, neurological, urological, vascular, sensory, dermatological, and immunological.[62]

2.4.2 Wildlife

Sawyer et al.[63] conducted a study of the habitat selection of mule deer before and during development of a natural gas field. During this study it was found that, increased levels of natural gas exploration, development, and production across the Intermountain West have created a variety of concerns for mule deer (Odocoileus hemionus) populations, including direct habitat loss to road and well-pad construction as well as indirect habitat losses that may occur if deer use declines near roads or well pads. This study examined winter habitats election patterns of adult female mule deer before and during the first 3 years of development in a natural gas field in western Wyoming.

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[58] Ibid.
[59] BC Oil and Gas Commission 'Fracturing and disposal of fluids. Oil and gas commission fact sheet' 2010.

[61] Broderick J, Anderson K 'Has US shale gas reduced CO_2 emissions?' 2012 CCR University of Manchester.
[62] Bamberger, M., & Oswald, R. E. 'Impacts of gas drilling on human and animal health.' 2012 New Solutions 22, 51–77.
[63] Sawyer et al. 'Winter habitat selection of mule deer before and during development of a natural gas field' 2006 JWM Vol. 70, No. 2 pp. 396-403

They used global positioning system (GPS) locations collected from a sample of adult female mule deer to model relative frequency or probability of use as a function of habitat variables. Model co-efficients and predictive maps suggested mule deer were less likely to occupy areas in close proximity to well pads than those which were farther away. Changes in habitats election appeared to be immediate(i.e., within year 1 of development),and no evidence of well-pad acclimation occurred through the course of the study. On the contrary, mule deer selected areas farther from well pads as development progressed. Lower predicted probabilities of use within 2.7 to 3.7 km of well pads suggested indirect habitat losses maybe substantially larger than direct habitat losses. Additionally, some areas classified as high probability of use by mule deer before gas field development changed to areas of low use following development, and others originally classified as low probability of use were used more frequently as the field developed. Sawyer et al. concluded that, if areas with high probability of use before development were those preferred by the deer, observed shifts in their distribution as development progressed were toward less-preferred and presumably less-suitable habitats.[64]

2.4.3. South Africa (Karoo)

Within the South African context, the word 'karoo', a Khoisan word meaning 'place of thirst', describes the reality of the semi-arid Karoo region very well, not only from a geographical point of view, but also from a social perspective. The region receives an average annual rainfall of between 200 mm and 400 mm. One of many stark contrasts with regions in the USA where shale gas has been relatively feasible is that there are no significant permanent river systems in the Karoo and most water is obtained from underground water. Therefore the tangible impact, should water contamination occur, would be much more significant than in most regions of the USA. The region does not have adequate infrastructure to support a drilling industry. There are no existing gas pipelines, roads are generally not in a very good condition and maintenance of infrastructure, especially water and sewerage, is a challenge. The unemployed of the region are mostly unskilled, as many did not even complete school. Due to the lack of water, it would be expensive for companies to truck water from outside the region.

South Africa is a water-stressed country and surplus water is not a reality in most municipalities. The main economic drivers of the hundred or so towns in the Karoo region are agriculture, tourism and

[64] Op cit note 52 at 396-403.

supporting industries. About 30% of South Africa's meat is produced in the Karoo (venison, lamb and mutton; beef and ostrich), as well as 60% of the world's mohair(fiber made from the hair of the Angora goat). The natural beauty of the Karoo, coupled with game viewing, unique architecture, unique cultural heritage(rock paintings and fossils), the clear and magnificent night skies are all major tourists attractions that seek a break from the busy city life. The succulent Karoo biome is an internationally recognised biodiversity hotspot. The unique *koppies* (mountain/hill) are due to the prevalence of dolerite sills in the area. These dolerite intrusions are also of significance in the fracking debate, as dolerite could serve as a conduit for fluids to migrate to shallower depths and groundwater zones. In 1967, when Soekor (state-owned oil company) explored for oil in the eastern region of the Karoo, it experienced a total loss of drilling fluids and pressure at a depth of about 2,500 m. Six weeks later, 35 km further away, a farmer noticed a brown sediment in a spring on his farm and contacted Soekor. The drilling technician visited the farm and a water sample was taken. It was later confirmed that the fluid matched the drilling fluids used on the exploration well. The well was believed to have intersected dolerite.[65]

I believe that there is also a current lack of awareness and understanding of the fracking issue by the public, notably people that reside in the Karoo. This can be as a result of the poor public consultation process of 2011. Many Karoo communities are poor, marginalised and/or do not have access to media such as television and newspapers. Many of the families speak isiXhosa or Afrikaans as a home language, while the communication on shale gas has been done in English.

Shale gas development will most probably transform a previously quiet and calm natural region. This will be done by bringing increased industrialization to the region in the form of industrial contaminants, heavy truck traffic, and excessive noise. Due to concerns regarding potential contamination (water, air, and land), Barth believes that industries that have been vital to some of the communities in the shale region may decline. She believes that industries that are incompatible with high levels of industrialization and potential environmental degradation include agriculture, tourism, organic farming, hunting, fishing, outdoor recreation, etc.[66] All of which are practiced within the Karoo region.

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[65] Le Roux J 'Keeping 'place of thirst' safe' in Rodríguez SM *Global Resistance to Fracking - Communities rise up to fight climate crisis and democratic deficit* (2015) 74 - 76.

[66] J. M. Barth 'The economic impact of shale gas development on state and local economies: benefits, costs, and uncertainties' 2013 new solutions, vol. 23(1) 85-101.

2.5 Conclusion

South Africa faces numerous environmental challenges, ranging from current and proposed environmentally risky developments (such as fracking) to threats to natural resources as a result of over harvesting and poaching. These challenges cause one to examine the importance and responsibilities for sustainable management of natural resources.

It may be argued that sustainable development relates not only to the sustainable use and exploitation of natural resources, but could also include the enhancement of the quality of peoples' lives through inter alia constitutional governance. A massive responsibility is placed on South African courts when having to balance the predominant responsibilities of the South African constitutional state. Sustainable development is therefore pertinent to the South African constitutional experiment.[67]

I believe that in order to determine whether fracking conforms with the underlying principle of sustainable development, a holistic approach should be sought by addressing all three principles of sustainable development namely social, economic and environmental. Having outlined the fracking process and the arguments for and against fracking, the next chapter proceeds to put fracking in the context of sustainable development as contained in section 24 of the Constitution.

[67] LJ Kotze 'The Constitutional Court's contribution to sustainable development in South Africa' 2003 PER/PELJ (6)2.

Chapter 3 - Fracking and Sustainable development

3. Introduction

Section 24 of the Constitution gives effect to our Environmental right. In terms of Section 24 (b)(iii):

> "Everyone has the right to have their environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development."

In relation to Sustainable Development, the three principles of sustainable development involve aspects of society, environment and the economy.

3.1 What is Sustainable Development?

The most commonly used definition of SD is: *'Development that meets the needs of the present without compromising the ability of future generations to meet their own needs'.* This definition arose out of the Rio Earth Summit in 1992 and was used again at the World Summit on Sustainable Development (WSSD) in 2002 at which it was proposed that there are three dimensions of Sustainable Development, namely, Social; Environmental and Economic.

There are many more definitions in a similar vein which are quoted. However, the essential point here is that sustainable development became and remains what Dryzek has called, ''the dominant global discourse of ecological concern''[68]

Blowers Boersema and Martin believes that there are two linked concerns in most definitions. The one is the concern for maintaining, if not improving, the conditions for living. This is expressed in terms of meeting needs and aspirations, looking after the planet, providing a better quality of life and so on. The other is a concern for bequeathing an acceptable inheritance to future generations. This comes over in such terms as not compromising the future, handing on in good order, refraining from burdening future generations.[69]

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[68] Dryzek J.S. *The Politics of the Earth* (1997) Oxford University Press P123.

[69] Blowers A., Boersema J. and Martin A 'Is sustainable development sustainable?' 2012 JES Vol. 9, No. 1 at 1–8.

3.2 International recognition

Sustainable development (SD) is a term that has gained much momentum and it has earned international recognition.

According to Glazewski,[70] the contemporary international norm which underpins environmental law generally is the notion of sustainable development. The pioneering World Commission on Environment and Development (also known as the Brundtland Commission), convened by the United Nations General Assembly in 1983 (which was a response to global environmental concerns), defined sustainable development as:

> '. . . development that meets the needs of the present without compromising the ability of future generations to meet their own needs.'

Glazewski believes that it contains within it two key concepts. The concept of 'needs', in particular the needs of the poor, which should be prioritised; and the idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs.[71] He believes that while much have been written on sustainable development in essence, the notion attempts to integrate three facets: environmental protection; economic development, and social upliftment. These are what I am going to refer as the pillars of sustainable development throughout this writing. It should be noted that the enthusiasm of legal academics vary with regards to this notion. Brownlie[72] describes sustainable development as a "protean concept" while Birnie *et al*[73] break down the notion into a number of substantive elements. Namely: integration of environmental protection and economic development; the right to development; sustainable utilisation and conservation of natural resources; intergenerational equity; intra-generational equity; procedural elements of sustainable development.

Birnie *et al* distinguish the above substantive elements of sustainable development from its procedural elements, namely environmental assessment, access to information, and public participation in decision-making.[74]

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[70] Op cit note 3 at chapter 1.
[71] World Commission on Environment and Development *Our Common Future* (1987) at 43. (Hereinafter referred to as the Brundtland Report).
[72] Brownlie I. *Principles of Public International Law* (2003) 6th ed at 276.
[73] Birnie P, Boyle A and Redgwell C *International Law and the Environment* (2009) 3rd ed at 116–123.
[74] Ibid.

Sands adopts a similar approach, outlining the following four elements which comprises the legal elements of the concept of the notion of sustainable development, these are: the preservation of natural systems for the benefit of future generations; the exploitation of natural resources in a manner which is "sustainable", "prudent", "rational", "wise" or "appropriate"; the need to ensure that environmental considerations are incorporated into economic and other development plans, programmes, and projects (the principle of integration); and the equitable use of natural resources (the principle of equitable use or intra-generational equity).[75]

In the international case of *Gabcikovo Dam*[76] Justice Weeramantry, the then Vice President of the International Court of Justice, held the following:

> 'Throughout the ages, mankind has for economic and other reasons, constantly interfered with nature. In the past, this was often done without consideration of the effect upon the environment. Owing to new scientific insights and to growing awareness of the risks for mankind – for present and future generations – of pursuit of such interventions at an unconsidered and unabated pace, new norms and standards have been developed, set forth in a great number of instruments during the last two decades. Such new norms have to be taken into consideration, and such new standards given proper weight, not only when states contemplate new activities, but also when continuing with activities begun in the past. This need to reconcile economic development with protection of the environment is aptly expressed in the concept of sustainable development. [77]

Weeramantry continued referring to sustainable development and held that sustainable development, is "... likely to play a major role in determining important environmental disputes of the future", and described the notion as "an integral part of modern international law" in balancing the competing demands of development and environmental protection.[78]

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[75] Sands P, *Principles of International Environmental Law* (2003) 2nd ed at 253.
[76] Referred to in the *Case Concerning the Construction of the Gabcikovo Nagymaros Project* (Hungary/Slovakia) (1998) 37 *ILM* 162.
[77] Op cit note 62 at 2.3.
[78] Ibid at 201, para 140.

3.3 The South African context

The relevant constitutional and legislative provisions relating to sustainable development will be mentioned in detail in Chapter 4.

3.4 What is sustainability

There are several definitions of the term "sustainability". While sometimes sustainability is defined in relation to the ability of man to preserve the available natural resources and not overuse the resources in a way that it will be deficient in the future; others have defined it in relation to policy making.[79] However the definition given by the UN Commission on Economic Development in its 1987 Brundtland report seems to be generally acceptable. In its report titled Our Common Future, sustainability is defined as that which "meets the needs of the present without compromising the ability of the future generations to meet their own goals" (United Nations, 1987). Although, some writers have found this definition to be problematic,[80] yet, most believe that it meets most aspects of sustainability in its wide applications. [81]

Taylor,[82] in his critic of the UN definition; is of the opinion that it is often difficult to determine the future needs of people in the next generation which may be much different from the current needs of people today. He further said that the way the developed countries view the concept of needs, is entirely different from the views of that of the developing countries towards the concept of needs. However, even though the UN definition of sustainability may have raised some controversies, it still covers the two fundamental issues. These two issues are: firstly the pressing problem of environmental degradation that results from economic growth, and secondly, the need for such growth to lighten poverty in the society. Barton[83] and Du Plessis[84] present this as three interconnected sectors in a conceptual model to describe the term "sustainable development". These interconnected sectors represent the Society, the Economy and the Environment.[85] Barton and Du Plessis maintain that, there

[79] Adams W.M. 'Green Development: environment and sustainability in the Third World.' 2001 London: Routledge.
[80] Taylor J. 'Sustainable Development: A dubious solution in search of a problem.' 2002 Policy Analysis, No. 449, p.1-49
[81] Op cit note 67.
[82] Op cit note 68.
[83] Barton, H. *Conflicting perceptions of neighborhood: In Sustainable Communities.* (2000) Barton H (ed.), London: Earthscan.
[84] Du Plessis C. *Cities and sustainability: sustaining our cultural heritage. In Cities and Sustainability: Sustaining Our Cultural Heritage, Conference Proceedings.* (2000) Brandon P, Lombardi P, Perera S (eds.). Sri Lanka: Kandalama
[85] Three spheres of SD

must be a reasonable level of balance of interactions amongst these sectors for the world to achieve sustainable development.

But despite all these critiques, it is a globally known fact that the rate of environmental degradation is increasing at a very fast rate. The rate of transformation of the earth is very rapid and this is true especially in the developing countries that are currently undergoing industrialization. The significance and scale of the global human footprint is not in doubt. Consumption of living resources as raw material and sinks for waste materials is high and growing.[86] The realization of sustainable development and the need to maintain a balance between the environment, economy and man has become the pressing goal that is facing the communities, enterprise organizations, government and the world at large. Developing and developed nations are interacting in a bid to work towards a sustainable environment.

3.5 Environmental sustainability

Sands, *Principles of International Environmental Law* 1995 describes the recurring legal elements of "ecological sustainable development" as follows: (i) the need to preserve natural systems for the benefit of future generations; (ii) the aim of exploiting natural resources in a manner which is "sustainable" or "prudent" or "rational" or "wise" or "appropriate" (the principle of sustainable use); (iii) the equitable use of natural resources (the principle of equitable use); and (iv) the need to ensure that environmental considerations are incorporated into economic and other development plans, programmes, and projects (the principle of integration).[87]

I believe that environmental sustainability involves the making of decisions and the taking of action which are in the interests of protecting the natural world. This needs to be done with specific emphasis on the preservation of the capability of the environment to support humans. It is an important topic in our current time, as some people are wise enough to start realising the full impact that businesses and individuals can possibly have on the environment.

Environmental sustainability is all about making responsible decisions which will reduce your business' negative impact on the environment. It is not merely about reducing the amount of waste you produce

[86] Wackernagel M. and Rees W.E. 'Our Ecological Footprint: Reducing Human Impact on the Earth.' 1996 NSP Gabriola Island, BC.
[87] Cheadle, Davis and Haysom *South African Constitutional Law: the Bill of Rights* (2002) at p 424.

or using less energy, but it is also concerned with developing processes that will lead to businesses becoming entirely sustainable in the future.

Currently, environmental sustainability is a topical issue that receives plenty of attention from the media and from different governmental departments. This is a result of the amount of research that is currently going into the assessment of the impact that human activity can have on the environment. Even though the long term implications of this very serious issue are not yet fully understood, it is generally agreed that the risk is of such a nature in order to merit an immediate response. Businesses are expected to lead in the area of environmental sustainability as they are considered to be the biggest contributors and are also in a position where they can make a significant difference.

For much of the past, most businesses have acted with little regard or concern for the negative impact they have on the environment. This is true even today regarding some big corporations. Many large and small organisations are guilty of significantly polluting the environment and engaging in practices that are simply not sustainable. This is because of the fact that they are only interested in how much they can make and it does not matter who or what gets hurt or damaged in the process. However, there are now an increasing number of businesses that are committed to reducing their damaging impact and even working towards having a positive influence on environmental sustainability.

Environmental sustainability forces businesses to look beyond making short term gains and look at the long term impact they are having on the natural world. You need to consider the long term implications and not only the immediate impact your actions has on the environment. For example, when manufacturing a product, you need to look at the environmental impact of the products entire lifecycle, from development to disposal before finalising your designs. The same can be true regarding fracking. The long term consequences are, in my opinion, no point of concern for these big corporations who are only considered about their pockets.

3.6 Underlying principles of sustainable development

3.6.1 Introduction and in general

In the UK, in 1999 the Department of Environment, Transport and Regions (DETR) defined sustainability as social progress which recognises the needs of everyone while providing effective protection of the environment by prudent use of natural recourses ensuring maintenance of high and stable levels of economic growth and employment.[88] I believe that this definition includes all three principles of sustainable development. I will now briefly name and define these so called principles[89] and then follow by explaining their role in more detail.

In relation to Sustainable Development, the three principles of sustainable development involves aspects of society, environment and the economy.
Society involves an understanding of social institutions and their role in change and development, as well as the democratic and participatory systems which give opportunity for the expression of opinion, the selection of governments, the forging of consensus and the resolution of differences. Environment on the other hand provides for an awareness of the resources and fragility of the physical environment and the effects on it of human activity and decisions, with a commitment to factoring environmental concerns into social and economic policy development. Lastly, the economic aspect referrers to skills to earn a living as well as a sensitivity to the limits and potential of economic growth and its impact on society and on the environment, with a commitment to assess personal and societal levels of consumption out of concern for the environment and for social justice.[90]

The world is faced with challenges in all three dimensions of sustainable development. More than 1 billion people are still living in extreme poverty and income inequality within and among many countries have been rising; at the same time, unsustainable consumption and production patterns have resulted in huge economic and social costs and may endanger life on the planet. Achieving sustainable development will require global actions to deliver on the legitimate aspiration towards further economic and social progress, requiring growth and employment, and at the same time strengthening environmental protection. [91]

[88] Mawhinney, M. *Sustainable Development–Understanding the Debates* (2002) Blackwell Publishing, Oxford.
[89] Also referred to as the three 'pillars', 'dimensions', or 'spheres' of sustainable development throughout this study.
[90] Arima A, et al. *UN Decade of Education for Sustainable Development 2005-2014 International* Implementation (2005) Scheme January.
[91] World Economic and Social Survey. *Sustainable Development Challenges* (2013).

The World Bank sees green growth as "the pathway to sustainable development" and "a vital tool for achieving sustainable development" (World Bank, 2012b, p. xi). It proposes a green growth strategy that rests on three pillars:

(a) Maximizing local and immediate economic or social benefits and avoidance of the lock-in of economies in fossil fuel technologies for several decades (this pillar seeks to prevent irreversibility in the adoption of energy systems and reduce inertia);

(b) Providing incentives to engage in smart decision-making. Examples of the measures covered in this pillar are green accounting (see box II.2), getting prices right so as to overcome behavioural biases, providing incentives and regulations to engage firms in green growth, and using regulations, innovation strategies and industrial policies;

(c) Addressing the problem of financing green growth through the adoption of innovative financing tools designed to tackle high upfront financing needs. The overall strategy allocates different priorities to developed and developing countries (World Bank, 2012b, pp.15-22; see also World Bank, 2012c).[92]

Agenda 21 (United Nations, 1993) emphasized the interconnectedness among the three dimensions of sustainable development. Its actual implementation, however, arguably did not occur in the integrated manner envisaged. While the Millennium Development Goals focused attention on selected social and human development priorities, the world today witnesses emerging new challenges, aggravated by multiple financial, economic, food and energy crises , which have threatened the ability of all countries to achieve sustainable development. For this reason the United Nations Conference on Sustainable Development reaffirmed the political commitments of the international community to pursue sustainable development, under the principles of Agenda 21, including the principle of common but differentiated responsibilities. [93]

3.6.2 Distinguishing the principles

The Organisation for Economic Co-operation and Development held that fostering development and protecting the environment are 'linked but separate' imperatives, thereby flatly contradicting the Brundtland Commission's insistence that they were "impossible to separate". Furthermore, he asserts that in the absence of strong synergies between environmental and social issues, the inclusion of the

[92] Ibid
[93] Op cit note 79.

latter agenda tends to swamp the former. In other words, having an infinite tradability between the three pillars suggests there are no environmental bottom lines that cannot be crossed. [94]

This sort of conclusion is only true if all three dimensions are regarded as being similar in substance, elements of which are capable of being substituted one for another with the absence of any real limits. Interestingly however, that is not the flavour of the Rio Declaration itself. That was the product of a conference on environment and development. And the conference didn't suddenly generate three pillars. Rather, it was focussed on meeting the developmental and environmental needs of present and future generations. Significantly, Agenda 21 is laid out in two sections: the social and economic dimensions; and the conservation and management of resources for development. In other words, there is the human sphere, which encompasses economic and social questions, and the biophysical sphere.

The very first Rio principle affirms the anthropocentric nature of our interest in sustainability. "Human beings," it states, "are at the centre of concerns for sustainable development." As such, any use we make of resources will involve trade-offs that have as their object the enhancement of human welfare. But there is no suggestion that welfare can be raised infinitely at the expense of those biophysical systems that make life on earth possible. [95]

The organisation for Economic Co-operation and Development[96] believes that the division of labour, for analytical purposes, between the human sphere and the biophysical sphere is a sensible one. To the extent that the former is constrained by the latter, it is not unreasonable to contend that the so-called 'environmental pillar' is materially different from the social and economic ones. There are no limits to the ingenuity and efficiency with which natural resources can be transformed. However, there is a widely held intuition, and now some scientific evidence, that there are boundary conditions for the stability of the linked biological, chemical and physical systems that form the global life-support system on which human life ultimately depends. Many social outcomes, on the other hand, depend on ethical choices made concerning the distribution of income. There is, therefore, a substantive difference between the social and environmental dimensions of sustainable development. [97]

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[94] Organisation for Economic Co-operation and Development Sustainable Development *Round Table On Sustainable Development* - MEASURING WHAT? (2001).
[95] Op cit note 88.
[96] Ibid
[97] Ibid

Protecting natural resources like water or the protection of the ozone layer from degradation caused by pollutants is susceptible to a wholly different range of policy responses and measurement from those applying, for instance, to ensuring the incomes of retired people. Not only is access to income within an economic and taxpaying community an ethical judgement that defies any definitive 'answer'; it's relative importance is highly variable depending on the economic development and level of wealth in each country. By contrast, the maintenance of natural systems on which people rely, as the examples which I mentioned, is universal in its significance and amenable to quantitative monitoring and analysis without recourse to ethical theories.[98]

Harris[99] believes that an economically sustainable system must be able to produce goods and services on a continuing basis. He believes that it also supposed to maintain manageable levels of government and external debt, and to avoid extreme sectorial imbalances which damage agricultural or industrial production. While an environmentally sustainable system must maintain a stable resource base, avoiding over-exploitation of renewable resource systems or environmental sink functions, and depleting non-renewable resources only to the extent that investment is made in adequate substitutes. This includes maintenance of biodiversity, atmospheric stability, and other ecosystem functions not ordinarily classed as economic resources. Also, a socially sustainable system must achieve distributional equity, adequate provision of social services including health and education, gender equity, and political accountability and participation.

Clearly, these three elements of sustainability introduce many potential complications to the original simple definition. The goals expressed or implied are multidimensional, raising the issue of how to balance objectives and how to judge success or failure. For example, what if provision of adequate food and water supplies appears to require changes in land use which will decrease biodiversity? What if non-polluting energy sources are more expensive, thus increasing the burden on the poor, for whom they represent a larger proportion of daily expenditure? Also, as is the case with fracking, what if water and food security is being risked in order to provide for energy and economic growth? Which goal will take precedence?

[98] Ibid.
[99] Harris M.J 'International Society for Ecological Economics' - Internet Encyclopaedia of Ecological Economics - Sustainability and Sustainable Development 2003.

Harris says that in the real world, we can rarely avoid trade-offs, and as Richard Norgaard points out, we can "maximize" only one objective at a time. Norgaard concluded that "it is impossible to define sustainable development in an operational manner in the detail and with the level of control presumed in the logic of modernity."[100] The strongly normative nature of the sustainable development concept makes it difficult to pin down analytically. However, does this render these respective principles useless in some sense? I believe not.

Harris is of the opinion that the three principles outlined above do have resonance at a commonsense level. They satisfy the criterion set forth earlier for a powerful, easily grasped concept which can have wide applicability. Surely if we could move closer to achieving this tripartite goal, the world would be a better place, and equally surely we frequently fall short in all three respects. It may be easier to identify unsustainability than sustainability – and the identification of unsustainability can motivate us to take necessary policy action.[101]

3.6.3 Break down of the principles

As mentioned above, there are three dimensions of sustainable development (economic, environmental and the political). Each of the three principles of sustainable development is commonly referred to as a system: economic systems, environmental systems and social systems, each having their own logic. As mentioned above, it is an impossible task to analyze all these systems at once. Therefore we must start by considering each of them separately, as suggested by the Balaton Group's report on sustainability indicators:

> 'The total system of which human society is a part, and on which it depends for support, is made up of a large number of component systems. The whole cannot function properly and is not viable and sustainable if individual component systems cannot function properly. . .sustainable development is possible only if component systems as well as the total system are viable.'[102]

Despite the uncertainty of the direction of sustainable development, I believe it is necessary to identify the essential component systems or spheres and to define indicators that can provide essential and

[100] Norgaard, Richard B. Development Betrayed: The End of Progress and a Co-evolutionary Re-visioning of the Future, New York and London: Routledge. 1994 at 22.
[101] Op cit note 99.
[102] Ibid.

reliable information about the viability of each and of the total system.

3.6.3.1 The Economic Perspective

In light of the economical dimension, the focus of economic policy is fixated on the notion of ‘‘growth’’. However, growth is not the same as ‘‘development’’. Development is a qualitative concept incorporating ideas of improvement and progress, including cultural as well as economic dimensions. With development, the focus should be just as much on the future than on the present, and I am of the opinion that the current political and legislative emphasis is on maintaining growth in order to satisfy the consumer's demand for the present and the immediate future. I believe that the focus is on sustainable growth and not on sustainable development, as I believe it should be. Giddens[103] supports my belief by saying: [104]

> ‘People find it hard to give the same level of reality to the future as they do to the present. Thus a small reward offered now will normally be taken in preference to a much larger one offered at some remove’.

From the point of view of neoclassical economic theory, sustainability can be defined in terms of the maximization of welfare[105] over time. Most economists simplify further by identifying the maximization of welfare with the maximization of utility derived from consumption. Although this may be criticized as an oversimplification, it certainly includes many important elements of human welfare (food, clothing, housing, transportation, health and education services, etc.) and it has the analytical advantage of reducing the problem to a measurable single-dimensional indicator.[106]

The question can now be raised of whether sustainability has any validity as an economic concept. Harris believes that, according to standard economic theory, efficient resource allocation should have the effect of maximizing utility from consumption. If we accept the use of time discounting as a method of comparing the economic values of consumption in different time periods, then sustainability appears to mean nothing more than efficient resource allocation, a concept already well established in economics.

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[103] Giddens *The Politics of Climate Change* 2009, pp. 2–3.
[104] Ibid
[105] Under this heading 'welfare' will mean human welfare, I will introduce certain claims of the non-human welfare world when I am considering the ecological perspective under the next heading.
[106] Op cit note 99.

One of the current criticism of this reductionist approach to sustainability, according to Harris, centers on the use of discounting. For argument sake, at a discount rate of 10%, the value of R1 million one hundred years from now is the same as a mere R72 today. Thus it would seem to be justifiable to impose costs of up to $1 million on people in the year 2100 in order to enjoy R72 worth of consumption today. By this logic, a large number of resource depletion and environmental damage could be considered acceptable, and even optimal, according to a criterion of economic efficiency.[107]

The problem is that when we accept the use of a discount rate, we have implicitly imposed a specific choice regarding the relative welfare of present and future generations. Howarth and Norgaard have shown that the choice of a discount rate is equivalent to a choice of allocations among generations.[108] The use of a current market discount rate gives, in my opinion, way too much weight to the preferences of our current consumers generation. When we consider issues such as soil erosion, irreversible water pollution(for example ground water pollution) or the atmospheric build-up of greenhouse gases, where the most damaging impacts are felt over decades or generations, this creates a strong bias against sustainability. Thus in order to achieve intergenerational equity, we must either impose a low discount rate[109] or some kind of sustainability rule regarding resource use and their environmental impacts.

A somewhat related issue concerns the concept of natural capital. Water, soils and atmospheric functions are aspects of natural capital, which consists of all the natural resources and environmental services of the planet. Herman Daly has suggested that sustainable development can be operationalized in terms of the conservation of natural capital.[110] This policy goal leads to two decision rules. Firstly, one for renewable and secondly, the other for non-renewable resources. For renewables, the rule is to limit the consumption of resources to sustainable yield levels. Then for non-renewables the rule is to re-invest the proceeds from non-renewable resource exploitation into investment in renewable natural capital. Following these two rules will maintain a constant stock of natural capital. However, in order to maintain a constant per capita stock of natural capital, a stable level of human population is also required, a factor which Daly has also emphasized.[111]

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[107] Ibid

[108] Howarth, Richard B. and Richard B. Norgaard. 'Intergenerational Transfers and the Social Discount Rate.' Environmental and Resource Economics 1993 at 337-58

[109] William Cline has suggested the use of a discount rate of 1.5% for balancing long-term costs and benefits of global climate change abatement.

[110] Daly, H E. *Operationalizing Sustainable Development by Investing in Natural Capital* in Ann-Mari Jansson et al. eds., Investing in Natural Capital: The Ecological Economics Approach to Sustainability. Washington, D.C.: Island Press. (1994).

[111] Daly, H E. *Steady State Economics* (2nd ed.), Chapters 2 and 9. Washington, D.C.: Island Press. (1991).

The above suggestion of a specific sustainability decision rule for natural capital is quite different from the standard neo-classical approach. In this view, there is no separate reason to conserve natural capital. A well-known principle derived from work by Solow and Hartwick (the "Hartwick rule") states in it that consumption may remain constant, or increase, with declining non-renewable resources provided that the rents from these resources are reinvested in reproducible capital.[112] Unlike Daly's reinvestment rule, this does not require maintenance of any specific stock of natural capital.

The essential assumption involved in the Solow/Hartwick approach is that of substitutability of the two types of capital. If, for example, we cut down forests but build an industrial plant, we are better off provided the economic value of the new industrial plant exceeds the economic value of the lost forests. Daly's view is based on the direct opposite assumption in the sense that "man-made and natural capital are fundamentally complements and only marginally substitutes."[113] If natural capital has a special and unique importance, then neo-classical economic efficiency will not suffice for sustainability.

Michael Toman has suggested that the issue may be resolved by recognizing that some issues can be appropriately dealt with through neo-classical market efficiency, while others require the protection and application of a "safe minimum standard" approach in order to preserve essential resources and environmental functions.[114] He suggested that the criteria of possible severity and irreversibility of ecological damages should be used to decide which theoretical framework is more appropriate. He believed that:

> 'The concept of a safe minimum standard can be applied to concerns about intergenerational fairness, resource constraints, and human impact. The safe minimum standard posits a socially determined, albeit "fuzzy," dividing line between moral imperatives to preserve and enhance natural resource systems and the free play of resource trade-offs. . . Following a safe minimum standard, society would rule out actions that could result in natural impacts beyond a certain threshold of cost and irreversibility. Central to the safe minimum standards approach are the role of public decision making and the formation of societal values. The safe minimum standard

[112] Common M. and Perrings C, "Towards an Ecological Economics of Sustainability" (1992) Ecological Economics 6 pp. 7-34
[113] Op cit note 110 at 25
[114] The "safe minimum standard" approach was originally proposed with reference to endangered species by Ciriancy-Wantrup. See Ciriancy Wantrup, S.V. (1952), Resource Conservation. Berkeley: University of California Press.

> will be defined differently by ecologists and economists, depending on moral judgement about moral imperatives and the value of discounting.'[115]

The adoption of this reasonable suggestion would have far-reaching implications for economic theory and policy. I believe that it is important to note the essential role of "moral imperatives," "public decision making," and "the formation of social values" in the decision framework which Toman suggested. None of these can be seen in the neo-classical economic model, where markets are presumed to be the best resource allocators, and the occasional correction of a "market imperfection" the only appropriate role for government. Which are, in my opinion, very much like our current South African government. I am of the same view as Harris in the sense that Toman is in effect asserting the importance of sustainability as a concept independent of standard neo-classical economic analysis, one which requires an explicitly normative and socially determined process of decision-making.

This represents a very big shift in the economic paradigm. Almost as the Keynesian revolution validated the concept of government intervention to achieve macroeconomic stability, the acceptance of sustainability as a valid social goal places a new complexion on all policy issues concerning the relationship between human economic activity and the environment. [116] Markets might be valuable and an essential means, but it cannot determine the ends, which must be arrived at by a social decision process informed by different disciplinary viewpoints. This will require an unprecedented humility on the part of economists, and a willingness to work together with other social and natural scientists. As Toman suggests:

> There is great scope for interdisciplinary work to address some key issues related to sustainability, including defining objectives, identifying constraints, and resolving the relevant disagreements. Economists could make greater use of ecological information and the implications of physical resource limits in an analysis of resource values. Social scientists can contribute to an understanding of how future generations might value different attributes of natural environments. Ecologists should provide ecological information in a manner that can be used in economic valuation. They should also take into account the role of economic incentives in ecological impact analysis.[117]

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[115] Toman, M A. "The Difficulty in Defining Sustainability" (1992), 106 pp.3-6

[116] International Society for Ecological Economics - Internet Encyclopaedia of Ecological Economics -+ Sustainability and Sustainable Development Jonathan M. Harris February 2003

[117] Toman, op. cit. note 115 at 90.

In order to explore further the implications of this approach, I will be examining the ecological and social dimensions of the issue. Only then will it be possible to return to the question of whether a new paradigm for development policy has truly emerged from the multidisciplinary discussion on the nature of sustainability.

3.6.3.2 The Environmental Perspective

Not like economists, whose models provide for no upper bound on economic growth, ecologists and physical scientists are accustomed to the idea of limits. Natural systems must exist subject to the unyielding laws of thermodynamics, and the science of population ecology has explored the implications of these laws for living organisms. As ecologist C.S. Holling[118] puts it:

> 'Two of the fundamental axioms of ecological and evolutionary biology are that organisms are exuberantly over-productive, and that limits set by time, space, and energy are inevitably encountered. The foundations for all modern ecology and evolutionary biology rest in part upon the consequences of these two axioms.'

In the ecological dimension, then, sustainability needs to involve limits on population and levels of consumption. These limits apply to all biological systems. While humans may think they are busy evading them for a time, they must ultimately accept the boundaries of a finite planet. Ecologist Paul Ehrlich and colleagues have estimated that humans are currently "consuming, co-opting, or eliminating some 40% of the basic energy supply for all terrestrial animals."[119] Clearly, a doubling of this demand, as might well be implied by a 33% growth in population (to 8 billion) and a 50% growth in per capita consumption by 2050, would not leave much room for any other species on this planet.[120]

However, the above basic assertion of limits does not capture the contribution of ecologists to the discussion of sustainability fully. What C.S. Holling identifies as a third axiom of ecology has even more

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[118] Holling, C.S. (1994). "An Ecologist View of the Malthusian Conflict," in Kerstin LindahlKiessling and Hans Landberg eds., Population, Economic Development, and the Environment, p. 84. New York and Oxford: Oxford University Press.

[119] Ehrlich, Paul R. "Ecological Economics and the Carrying Capacity of the Earth," in AnnMari Jansson et al eds., Investing in Natural Capital: The Ecological Economics Approach to Sustainability. Washington, D.C.: Island Press. Original research in Vitousek, P.M., P.R. Ehrlich , A.H. Ehrlich, and P.A. Matson, "Human Appropriation of the Products of Photosynthesis" (1986). BioScience 36 (6): 368-73.

[120] Op cit note 99.

significant implications. The third axiom "concerns processes that generate variability and novelty"[121] – the generation of genetic diversity and the resultant processes of evolution and change in species and ecosystems.

Genetic diversity provides for the resilience in ecosystems. Resilience is a "bounce-back" capacity which enables ecosystem to respond to disturbances or damage. For example, a forest ecosystem may recover from a pest infestation through an increase in the population of predators which control the pest, an expansion of species unaffected by the pest, and possibly a development of pest resistance in affected species. The patterns of response will be widely variable, but the essential integrity of the ecosystem will be preserved. The key to resilience is the existence of a wide variety of species, interacting with each other and providing a reservoir of genetic forms which provide the potential to adapt to changing conditions.[122] Should you ask anyone who have been in the Karoo for more than a day; he will tell you that resilience is much needed there as conditions are not always ideal there.

I believe that, for the ecologist, then, sustainability should be defined in terms of the maintenance of the resilience of ecosystems. This view of sustainability is clearly different from the human-centered conceptions put forward by the World Commission on Environment and Development and the consumption-based principles proposed by economic theorists such as the above mentioned.[123] This contrast has been explored by Common and Perrings,[124] who distinguished between "Solow-sustainability", derived from the economic model of stable or increasing consumption, and "Holling-sustainability", based on ecosystem resilience. Their finding was that "the concepts of Solow-sustainability and Holling-sustainability are largely disjoint, implying that there may be no close relationship between economic efficiency and ecological sustainability."

The importance of the ecological perspective becomes increasingly evident, as more of the critical problems facing humanity arise from failures of ecological resilience. The resurgence of diseases due to the development of antibiotic resistance, the disruption of ecosystems by the increase of introduced species, the formation of "dead zones" in coastal waters, and the multiple ecological threats related to

[121] Holling, op cit note 118.
[122] Op cit note 99.
[123] Ibid.
[124] Op cit note 112 at 7-34.

climate change and increased climate volatility, are all testaments to the impacts of expanding human economic activity. As Holling puts it:

> Increasing human populations in the South, and the planetary expansion of their influence, combined with exploitative management in both North and South, reduces functional diversity and increases spatial homogeneity not only in regions but on the whole planet. Functional diversity of the structuring processes and spatial heterogeneity are the two most critical determinants of ecological robustness and resilience, the attributes that provide the reserve of ecological services and of time that have allowed people to adapt and learn in the past. And now these critical attributes are being compromised at the level of the planet.[125]

The terrible impact of AIDS, specifically on the African continent, is perhaps the worst example to date of the feedback effects of human destruction of ecosystem resilience. Harris stated that AIDS probably originated in rain-forest primates, and spread to humans through human intrusion into the forest. Rather than remaining isolated in small communities. This then spread worldwide through global commerce and travel, like many other destructive viruses and pests. Population checks by means of such drastic ecological backlash are, of course, familiar to ecologists. But they are generally far from the thoughts of the economists and policymakers who up until now have shaped our conceptions of development.

Sustainability, would then seem to be more than limits on population or restraint in consumption, even though these are important. It means that in our choice of goods and technologies we must be oriented to the requirements of ecosystem integrity and species diversity. This also implies that the so called independence of economics from biophysical science is a luxury we can no longer afford. Common and Perrings suggest that:

> 'An ecological economic approach requires that resources be allocated in such a fashion that they threaten neither the system as a whole nor the key components of the system. For the system to be sustainable it must serve consumption and production objectives that are themselves sustainable. If existing preferences and technologies, as perpetuated and sanctified in the concept of consumer sovereignty, are not sustainable, then the system as a whole will be unstable. The appropriate policy instruments to address these concerns are varied and complex.

[125] Holling, op. cit. note 118 at 93.

> ...What is important is that an ecological economics of sustainability privileges the needs of the system over those of individuals.'[126]

It seems clear that an integration of economics and ecology is required. However, I believe that this can only be achieved by means of the assistance of the third sphere of sustainable development, the social perspective. Harris believes that, if we cannot rely on unregulated markets to solve our problems, we must turn to conscious social action. But social action by whom, and at what level? And how do the environmental issues relate to the other great failure of development to date – the persistence of inequality? It is in the social area that we must seek the key to the formulation of policies for sustainable development. [127]

3.6.3.3 Social perspective

Advocates of sustainable development, as mentioned above, recognize the social sphere of sustainable development as an important part of the new paradigm. A 'human development' approach which emphasises issues of basic needs and equity is well grounded in the history of the economic theory. Anand, Sudhir and Sen[128] pointed out that concerns for these dimensions of economic development start with the earliest economic theorists, and contrast the human development approach to the wealth maximization approach that has dominated modern economics.

Equity and basic needs in development have been the focus point of the United Nations Development Programme's (UNDP) series of Human Development Reports. Other than calculating the Human Development Index, which are offering a different measure of development success from per capita GNP or GDP, the Human Development Reports focus each year on a different aspect of social and economic development, such as democratic governance (1993), gender inequity and equality in general (2014), and multidimensional poverty (2014). In the 2014 report, South Africa was listed at 114th with regards to human development., which is far below average considering the number of countries mentioned in the report (around 180).

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[126] Common and Perrings, op. cit. p.112.
[127] Op cit note 99.
[128] Anand, Sudhir and Amartya K. Sen (1996), Sustainable Human Development: Concepts and Priorities, United Nations Development Programme, Office of Development Studies Discussion Paper Series.

While the HDI does not usually include any environmental measures, some reports (including the 1994 and 2013 report) have discussed the relationship between equity and sustainability, arguing that 'the concept of sustainable development raises the issue of whether present life-styles are acceptable and whether there is any reason to pass them on to the next generation. Because intergenerational equity must go hand in hand with intra-generational equity, a major restructuring of the world's income and consumption patterns may be a necessary precondition for any viable strategy of sustainable development'.[129]

The issue of environmental sustainability is inter-connected with that of poverty and inequity. This relationship runs both ways, in the sense that increased poverty and loss of rural livelihoods increases and/or accelerates environmental degradation as displaced people put more and more pressure on forests, fisheries, and marginal lands. Lipton[130] and Scherr[131] emphasized the relationship between social conditions, population growth and resource degradation. Reed[132] noted that the social component of sustainability includes issues of distributional equity, provision of social services, gender equity, population stabilization, and political accountability and participation.

The relationship of the human development paradigm to sustainability is discussed by Haq (1995) and Chambers (1992). Interrelationships between development, population growth, and environmental sustainability are prominent in the exposition of human development concepts by Sen (2000). [133]

In Canada, shale gas development is occurring mostly in the traditional territories of Aboriginal peoples who depend on the local environment for food and water for their survival and whose culture may be particularly affected. For this reason Nelson[134] wrote that specific monitoring of impacts on Aboriginal peoples' physical and mental health, social well-being, quality of life, and ecological systems on which they depend, is therefore essential. This includes not only impacts of shale gas development directly on their health, communities, and cultures, but also indirect and long-term impacts of intrusion into

[129]UNDP, 1994.
[130] Lipton, M '*Accelerated Resource Degradation by Agriculture in Developing Countries? The Role of Population Change and Responses to It*', in Stephen A. Vosti and Thomas Reardon eds., Sustainability, Growth and Poverty Alleviation: A Policy and Agro-ecological Perspective, Baltimore: Johns Hopkins University Press. (1997).
[131] Scherr, Sara J. 'People and Environment: What is the Relationship between Exploitation of Natural Resources and Population Growth in the South?' Forum for Development Studies(1), 33-58 1997.
[132] Reed, David ed. *Structural Adjustment, the Environment and Sustainable Development*, London: Earthscan Publications. 1997
[133] Op cit note 99.
[134] Joyce Nelson 'Why provinces and First Nations are wise to put a hold on unconventional gas' (2014) - CCPA Canadian Centre for Policy Alternatives

traditional territories and economic and social activities. To my mind not enough emphasise was and is currently being put in the same for the Karoo people. Because at the end of the day the Karoo people are in a sense the same as these aboriginal people. They all rely directly on the environment for their survival. Whether it be in the form of a farmer whose livelihood depends solely on the environmental elements; farm workers who rely on the success of the farm to earn a salary; someone buying his food from small farm shops because the nearest town is to far; entire communities relying on a single borehole to supply them with their daily drinking water; and the list goes on.

3.7 Conclusion

The world is faced with challenges in all three dimensions of sustainable development—economic, social and environmental. More than 1 billion people worldwide are still living in extreme poverty. Also, income inequality within and among many countries has been rising and at the same time, unsustainable consumption and production patterns have resulted in huge economic and social costs and may endanger life (not only human) on the planet. Achieving sustainable development will require global actions to deliver on the legitimate aspiration towards further economic and social progress, requiring growth and employment, and at the same time strengthening environmental protection.

Sustainable development will need to be inclusive and take special care of the needs of the poorest and most vulnerable. Strategies need to be ambitious, action-oriented and collaborative, and to adapt to different levels of development. They will need to systemically change consumption and production patterns, and might entail, inter alia, significant price corrections; encourage the preservation of natural endowments; reduce inequality; and strengthen economic governance. [135]

South Africa faces numerous environmental challenges, ranging from current and proposed environmentally risky developments, such as fracking, to threats to natural resources as a result of over harvesting and poaching. These challenges cause one to examine the responsibilities for sustainable management of natural resources. It also causes one to ask the question who is ultimately responsible for natural resources.

[135] World Economic and Social Survey 2013 Sustainable Development Challenges

If the state is the custodian of these natural resources, I believe that it is important to determine how they protect these resources and how they implement this protection. In South Africa there is a large number of relevant legislative provisions which seek to preserve and protect these resources. Our court are also increasingly giving effect to these provisions by enforcing them strictly. However, at the end of the day, the success of sustainable development will lie in the manner in which the three spheres of sustainable development is implemented into law and policy.

As can be seen from the above discussion, it is proposed that the three dimensions of sustainable development are inter-dependent. Whilst the one cannot exist without the other it may be construed from the above that social, environmental and economic sustainable development have to be present in order to constitute a sound understanding of sustainable development per se. The concept of sustainable development is frequently used in the provisions of environmental framework legislation. This can be seen by the inclusion in the preamble of the NEMA which states that sustainable development requires the integration of social, economic and environmental factors in planning, implementation and evaluation of decisions to ensure that development serves present and future generations. A discussion of the entire legal regime relating to sustainable development will follow in the next chapter.

Chapter 4 - Relevant law

4. Introduction

Fracking is a relatively new process that is being introduced in South Africa. There are some relevant legislative sections and principles which are applicable to this process, including the Constitution of South Africa, the National Environmental Management Act (NEMA) and the Mineral and Petroleum Resources Development Act[136]. In particular, Chapter 6 - 10 of the MPRDA, deals specifically with and regulates fracking as a process. Thus, while we do have a legislative framework that governs the exploitation of petroleum resources, there is concern regarding whether the existing law is adequate and whether it will be applied.

A leading authority (Verschuuren), in a South African journal,[137] argues that the idea of sustainable development is a fuzzy and indeterminate goal that society aims at, to reach perfection. It can be seen as a goal of high moral standard that the entire world community has embraced. He suggests that the first step to make the ideal more concrete is the formulation of legal principles, and that, in order to apply these principles, more concrete rules be developed. He also held that principles are a necessary medium for ideals to find their way into concrete rules. They can be used to bridge the gap between the morality of duty (incumbent upon present generations and current populations) to promote the goal of sustainable development and the morality of aspiration.[138]

4.1 Relevant Constitutional provisions

The Constitution of the Republic of South Africa is the supreme law of the country. It provides the legal foundation for the existence of the Republic, sets out the rights and duties of the citizens, and defines the structure of the government. All laws are subject to the Constitution and would only apply in so far as it is not inconsistent with the Constitution.

Section 24 of the Constitution gives effect to our Environmental right. In terms of Section 24 (b)(iii) Everyone has the right to have their environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological

[136] Act No. 28 of 2002 (Hereinafter referred to as the MPRDA).
[137] Sustainable development and the nature of environmental legal principles, 9(1) 209-261 (220 – 222) POTCHEFSTROOM ELECTRONIC LAW JOURNAL (2006).
[138] Supra 220 -221.

degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

Section 27 of the Constitution provides for health care, food, water and social security and Section 27(1) provides that everyone has the right to have access to (a) health care services, including reproductive health care; (b) sufficient food and water. Section 27 (2) then provides that the state must take reasonable legislative and other measures, within its available resources, to achieve the progressive realisation of each of these rights.

4.2 Legislative framework

In South Africa, exploration for, and production of, oil and gas is regulated by the following key legislative instruments a) Mineral and Petroleum Resources Development Act; b) National Environmental Management Act, 1998; [139] c) National Water Act, 1998 [140] d) Waste/waste water Management

4.2.1 Mineral and Petroleum Resources Development Act

The central legislation which is currently regulating virtually all aspects of mining and petroleum resources in South Africa is the Mineral and Petroleum Resources Development Act. This act came into force in May 2004. Glazewski[141] states that the MPRDA reflects post-1994 democratic values and is embedded within the spirit of the new South Africa. A distinguishing feature of the MPRDA is the emphasis which it places on sustainable development and environmental protection. While most of the chapters apply to both minerals and petroleum, it is worth noting that Chapter 4, which is headed "Mineral and Environmental Regulation" applies only to minerals, while on the other hand petroleum is dealt with separately in Chapter 6.

Section 3(3) of the MPRDA confirms Glazewski (as mentioned above) by providing that the Minister must ensure the sustainable development of South Africa's mineral and petroleum resources within a framework of national environmental policy, norms and standards while promoting economic and social

[139] Act No. 107 of 1998) (Hereinafter referred to as the NEMA)
[140] Act No. 36 of 1998) (Hereinafter referred to as the NWA)
[141] Op cit note 3 at Chapter 17.

development. This was further confirmed in case law. In the Agri South Africa case[142] the court held that according to its long title, the MPRDA was enacted to facilitate equitable access to and sustainable development of the nation's mineral and petroleum resources. This objective finds support from the Preamble which sets out a list of commitments which lie at the heart of the MPRDA. They are, among others, the eradication of all forms of discriminatory practices in the mining sector. Also included is the undertaking to take measures to address the effects of the skewed distribution of economic benefits which took place during the apartheid era and the creation of a mining regime that is internationally competitive and efficient. Also, Section 39 of the MPRDA provides that any person who applies for an exploration or production right must conduct an environmental impact assessment and/or submit an environmental management programme. Such a right becomes valid only on approval of the associated environmental management programme.

In June 2015, the Department of Mineral Resources gazetted *an* amendment to include four further chapters (chapters 6 to 10) to deal with land operations. As mentioned above, it relates particularly to fracking.[143] Chapter 6 commences by setting out their purpose, namely "to augment" the regulations and "prescribe standards and practices that must ensure the safe exploration and production of petroleum."[144]

The "petroleum" chapter, as Glazewski calls it (chapter 6), of the MPRDA operates in a similar manner to the mining provisions of chapter 4. Section 69(2) specifically states that many of the provisions in the "mineral and environmental regulation" (chapter 4) also apply to petroleum. Section 5 specifies the legal nature of exploration and production rights, namely that they are limited real rights while section 5A, prohibits technical co-operation operations, reconnaissance operations, exploration or production of petroleum or work incidental thereto from taking place without an environmental authorisation. It should be noted that this section also applies to prospecting and mining operations. Thereafter, chapter 6 sets out the rules and deal with the procedures for applying for and obtaining "reconnaissance permits", "exploration rights", "technical co-operation agreement permits" and "production rights" for petroleum resources. Similarly to the mining right, the granting of these rights and permits also requires the issuance of environmental authorisations and that the of issuing permits or production rights will

[142] Agri South Africa v Minister for Minerals and Energy 2013 (4) SA 1 (CC) [PAR 26].
[143] Department of Mineral Resources, *Regulations for Petroleum Exploration and Production*, R 466 *Government Gazette* No. 38855 OF 3 June 2015. Regulation 85 specifies that they deal with on-shore operations.
[144] Op cit note 3 at chapter 17.

not result in unacceptable pollution, ecological degradation or damage to the environment and that the environmental authorisation is issued. The chapter also sets out and include the rights and obligations of exploration and production right holders in Ss 82 and 86 respectively.[145]

Chapter 8, in particular regulations 94 to 107, contains specific and itemised regulations for the design and construction of wells, namely identifying and assessing the risk of sinking the well; well design; well construction standards which adopt the standards laid down by the American Petroleum Institute (API). Glazewski believes that it is unclear whether these standards are appropriate for South African conditions, particularly as the rock formations in the Karoo are unique and no testing has taken place to ensure the suitability of the API standards. The regulations continue with further construction requirements, namely: casings requirements: conductor, surface, intermediate and production casings, the centralisation of casings, cement requirements, which are also subject to API standards; blowout prevention equipment which is also required to meet API standards. Various technical well testing measures are prescribed including compressive tests for cement, casing strings pressure integrity and pressure testing of blowout prevention equipment (in accordance with API standards). Lastly, the chapter also requires the right holder to submit a well examination plan to the designated authority prior to beginning fracking which must at a minimum cover: (*a*) groundwater and aquifer isolation; (*b*) fracture containment; (*c*) related seismicity risks; (*d*) fracturing and flow-back or testing programmes and operations; and (*e*) independent well examination.[146]

Chapter 9, in particular regulations 108 to 129, deals with both the management of fracking as well as environmental management, namely that of water, waste and air quality, all issues that are environmental issues and thus, fall within the remits of the Minister of Water Affairs and Sanitation and the Minister of Environmental Affairs to regulate and not the Minister of Mineral Resources.[147]

Chapter 9 includes a number of provisions regarding operations including requirements relating to well engineer design and fracking programmes and procedures. Thereafter, the chapter details the management of fracking activities. It regulates the fracking equipment and mechanical integrity which includes monitoring and testing; the fracking fluid which includes: disclosure; fracture and fracking fluid

[145] Ibid.
[146] Ibid.
[147] Ibid.

containment; fluid management; management of flow-back and produced fluids, fluid transportation and storage. Significantly, regulation 112(10) requires that fracking be

> "immediately suspended if an anomalous pressure or flow condition or other anticipated pressure or flow condition is occurring in a way that indicates that the mechanical integrity of the well has been compromised and that continued operations pose a risk to the environment".

It is then also the responsibility of the right holder to notify the relevant authority responsible for water affairs of this situation within one hour and must immediately undertake remedial action. Operations may only proceed once the authority responsible for water affairs is satisfied with the remedial action and the designated authority has given written consent for operations to recommence, having consulted with the relevant water affairs authority.[148]

Furthermore, with regard to disclosure, regulation 113 makes reference to Schedule I which contains a list of close to 50 different chemicals that may not be used in fracking fluid and include substances such as formaldehyde, methanol, benzene, and sulphuric acid. The listed substances are all noted in the schedule as carcinogens, chemicals regulated under the US Safe Drinking Water Act and hazardous air pollutants. Glazewski held however that, while the list is to be welcomed, there are other hazardous chemicals used in fracking fluid.[149]

Regulation 114 requires that fracking fluid be confined only to the target zone. However, should the monitoring programme give an indication that either the fracking fluid or the flow-back is migrating outside of that zone, the right holder is obligated to immediately suspend fracking operations until such time as the necessary remedial action has been taken to prevent such migration. The right holder must also notify the designated authority as well as the Department of Water and Sanitation and need to acquire approval from the designated authority before resuming fracking operations. [150]

The regulations then address the actual fracking operations and the post fracking reporting. Regulation 119 confirms that the right holder must have the necessary approvals before commencing with fracking operations and that the authority responsible for water affairs be notified at least 5 days prior to

[148] Ibid.
[149] Ibid.
[150] Ibid.

fracking operations commencing. In addition, the right holder must comply with numerous further requirements stipulated in regulation 119(3)(*a*) to (*g*).

It is provided further that the right holder must conduct a risk assessments that address the elimination or reduction of the release of dangerous substances and the impact of that release on the environment. The holder should also propose measures for the control and mitigation of risk, which must form part of the submission for an environmental authorisation. Lastly, the right holder must ensure that the approved control and mitigation measures are implemented. As soon as fracking operations are completed, the right holder is obliged to submit a detailed report to the designated authority and the authority responsible for water affairs in conformity with regulation 120. In addition to the report, the right holder must also submit an audit report about post fracking operations for the completed well pad as provided for by regulation 120(2). [151]

The regulations then prescribe standards for water waste and air quality management in regulations 121 to 123. These regulations contain a general provision describing the different types of waste that may be generated and how they should be disposed in regulation 124. Importantly, these regulations stipulate that disposal of waste underground, including the re-injection of disposal well is prohibited as is the discharge of fracking fluids, flow-back and produced water into surface watercourses. It is further provided that, if the spillage of harmful substances enters a watercourse, then the regulations specify that the spill must be handled in accordance with the provisions of the National Water Act 1998 and the NEMA. [152]

Finally, Chapter 10, specifically in regulations 130 to 133, deals with well suspension, decommissioning and closure. A right holder may only suspend a well with the approval of the designated authority and the suspension may only be for the period specified by that authority. Once a well is suspended, the well integrity must be managed. The procedure and standards for this must be determined prior to the development of the well and must be done in a manner that the well can be re-entered safely and securely without jeopardising the future final abandonment of the well. [153]

[151] Ibid.
[152] Ibid.
[153] Ibid.

4.2.2 National Environmental Management Act[154]

The NEMA, which was enacted to give effect to s 24 of the Constitution, embraces the concept of sustainable development. The NEMA bases the all-important environmental management principles which underpin this Act on the general provision that "development must be socially, environmentally and economically sustainable".[155] NEMA establishes a general framework for environmental law by, *inter alia*, prescribing national environmental management principles that must be applied by state institutions when making decisions that may have a significant impact on the environment. S 1(1)(xxix) of NEMA defines sustainable development as "the integration of social, economic and environmental factors into planning, implementation, and decision making so as to ensure that development serves present and future generations"

NEMA defined sustainable development in section 1 thereof. This was the very first attempt to provide a formal definition of sustainable development within the South African environmental law. This definition describes sustainable development as the integration of social, economic and environmental factors into planning, implementation and decision-making so as to ensure that development serves present and future generations. This definition clearly includes all 3 spheres of sustainable development which I mention throughout and forms part of this study. Other than the fact that development should be socially, environmentally and economically sustainable, section 2(1)(4)(a) establishes a number of relevant principles that should be considered by relevant authorities during the initiation and implementation of development. These principles include: that the disturbance of ecosystems and loss of biological diversity be avoided or minimized and remedied; that environmental pollution and degradation should be avoided or minimized and remedied; that the disturbance of landscapes and sites that constitutes cultural heritage be avoided or minimized and remedied; that waste should be avoided or minimized, reused or recycled in a responsible manner; that the use and exploitation of non-renewable and renewable resources should be responsible and equitable; that a risk averse and cautious approach should be applied during the environmental management process and that negative impacts on the environment and on peoples' environmental rights be anticipated and prevented.[156] Also, Section 2(1) of NEMA provides that the principles set out in Section 2 apply throughout the Republic to the actions of all organs of State that may significantly affect the environment.[157]

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[154] Act No. 107 of 1998 (hereinafter referred to as 'NEMA')
[155] S 2(3) of the NEMA.
[156] S 4(*a*) of the NEMA.
[157] Op cit note 67 at 6(2).

Kotze believes that it is evident from a literal interpretation of these principles, that all of the national environmental management principles contained in section 2 of the NEMA, does in fact find their root in the concept of sustainable development. The definition and description of sustainable development provided by the NEMA is furthermore much more comprehensive than the definition as contained in section 24 of the 1996 Constitution. As mentioned above, the NEMA definition aims to integrate social, environmental and economic concerns into planning, development and decision-making. By providing a number of factors that should be considered when having to facilitate sustainable development, the NEMA provisions greatly enhances the understanding of what is meant by the concept of sustainable development. Kotze proposes that the Constitutional Court should consider the NEMA definition of sustainable development during the adjudication of environmental matters before the Court. This proposition of Kotze is based on the fact that by heeding these comprehensive provisions, the Constitutional Court will be enabled to create balanced precedents based on the notion that sustainable development should further the interests of present and future generations in a country where justifiable, sustainable development and environmental protection is of the essence. [158]

S 2(4)(a)(vii) of the National Environmental Management Act (NEMA) relates to sustainable development and requires that a risk-averse and cautious approach must be applied which takes into account the limits of current knowledge about the consequences of decisions and actions. This Section in effect makes provision for the application of the precautionary principle. This can be seen by the use of the words "risk-adverse" and "cautious". In terms of S 2(4)(a)(vii) of NEMA the negative impacts on the environment and on people's environmental rights must be anticipated and prevented. In the case where these impacts cannot be prevented, they are to be minimised and remedied.

NEMA defines ecological sustainable development as, firstly, recognising that the maintenance of healthy ecosystems and natural resources are preconditions for human wellbeing. Secondly, it recognises that there are limits to the goods and services that can be provided. In other words, ecological sustainability acknowledges that human beings are part of nature and not a separate entity.

Section 23 of NEMA can, in my opinion be directly applied to fracking and provides for the general objectives of integrated environmental management. Section 23 (2)(a)-(e) provides that the general objective of integrated environmental management is to: a.) promote the integration of the principles of

[158] Ibid.

environ-mental management set out in section 2 into the making of all decisions which may have a significant effect on the environment; b.) identify, predict and evaluate the actual and potential impact on the environment, socio-economic conditions and cultural heritage; the risks and consequences and alternatives and options for mitigation of activities, with a view to minimizing negative impacts. maximizing benefits. and promoting compliance with the principles of environmental management set out in section 2; c.) ensure that the effects of activities on the environment receive adequate consideration before actions are taken in connection with them; d.) ensure adequate and appropriate opportunity for public participation in decisions that may affect the environment; e.) ensure the consideration of environmental attributes in management and decision-making which may have a significant effect on the environment.

4.2.3 Other Legislation

The notion of sustainable development underpins the above mentioned environmental management principles. However, Glazewski believes that it is also alluded to in other sectoral legislation, including the MLRA (In the objective and principles), the Water Act, and the MPRDA, which includes a definition of sustainable development in the mining context as defined in s 1.

The Biodiversity Act defines "sustainable" in relation to the use of a biological resource as the use of the resource in such a way and at a rate that: (*a*) would not lead to its long term decline; (*b*) would not disrupt the ecological integrity of the ecosystem in which it occurs; and (*c*) would ensure its continued use to meet the needs and aspirations of present and future generations of people".[159]

The Waste Act is similarly underpinned by the concept, stating in section 1 that sustainable development "has the meaning assigned to it in section 1 of the National Environmental Management Act". With the exception of nuclear and mining waste (residue deposits and stockpiles), waste management in South Africa is generally regulated by the National Environmental Management: Waste Act, 2008 which is administered by the Department of Water and Environmental Affairs (DWEA). This statute provides norms and standards for regulating the management of waste by all spheres of government, licensing and control of waste management activities, remediation of contaminated land, compliance and enforcement measures, etc. Waste management activities associated with hydraulic fracturing that may require a waste management licence include, but are not limited to, the following: a)

[159] S 1 of the Biodiversity Act, "Definitions" ("sustainable").

Storage, including the temporary storage of general and hazardous waste; b) Re-use, recycling and recovery of general and hazardous waste; c) Treatment of general and hazardous waste including effluent, waste water or sewage; and d) Construction of facilities and associated structures and infrastructure.[160]

The Local Government: Municipal Systems Act 32 of 2000, refers to "environmentally sustainable" which it defines in relation to the provision of a municipal service to mean the provision of a municipal service in a manner aimed at ensuring that –(*a*) the risk of harm to the environment and human health is minimised to the extent reasonably possible under the circumstances; (*b*) the potential benefits to the environment and to human health and to safety are maximized to the extent reasonably possible under the circumstances; (*c*)legislation intended to protect the environment and human health and safety is complied with.

The purpose of the National Water Act is to 'ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled' taking into account, *inter alia,* the basic human needs of present and future generations, equitable access to water, social and economic development, the public interest, the growing demand for water, ecosystems and biological diversity and international obligations.

4.2.4 Case Law

4.2.4.1 BP Case

"Sustainable development" has been considered in a number of cases: In BP Southern Africa (Pty) Ltd v MEC for Agriculture, Conservation and Land Affairs[161], it was stated that:

Sustainable development constitutes an important part of modern international law and it balances the competing demands of development and environmental protection. The concept of "sustainable development" is the fundamental building block around which environmental legal norms have been fashioned, both internationally and in South Africa. It was also held that pure economic principles will no longer determine, in an unbridled fashion, whether a development is acceptable. Development, which may be regarded as economically and financially sound, will, in future, be balanced by its environmental impact, taking coherent cognisance of the principle of intergenerational equity and sustainable use of

[160] Treasure Karoo Action Group 'Report On Investigation Of Hydraulic Fracturing In The Karoo Basin Of South Africa' 2015.
[161] 2004 (5) SA. 124 (w).

resources in order to arrive at an integrated management of the environment, sustainable development and socio-economic concerns.

4.2.4.2 Fuel Retailers Case[162]

Glazewski says that the leading case on the notion of sustainable development is Fuel Retailers Association of Southern Africa v Director-General: Environmental Management, Department of Agriculture, Conservation and Environment, Mpumalanga Province, and Others.[163] The case of Fuel Retailers involved an elaborate discussion on SD and involved an application for a filling station in White River, Mpumalanga. Inama Trust applied to the Mpumalanga environmental authorities for authorisation to construct a filling station in White River. Fuel Retailers Association, an organisation representing the interests of fuel retailers, objected to the construction of the filling station on various grounds, including the construction of the filling station will have an adverse impact on the environment. The applicant insisted that the environmental authorities reconsider whether the proposed filling station would in fact be socially, environmentally and economically sustainable as required by the laws governing the protection of the environment. Nonetheless, authorisation to the Inama Trust to construct the filling station was still granted and an internal appeal by Fuel Retailers Association was unsuccessful. The applicant thereafter approached the Pretoria High Court and thereafter the SCA, all of which were unsuccessful. They were eventually successful at the Constitutional Court when Ngcobo J granted the application for leave to appeal and upheld the appeal.

In this case the Constitutional Court considered the nature and extend of the application of sustainable development in some detail. In delivering the majority judgment, Ncgobo J firstly placed sustainable development in the context of international law. He observed that the concept has received approval of the International Court of Justice and citing with approval the previously quoted words of Weeramantry in the *Gabcikovo Dam* case,[164] namely,

> "Throughout the ages, mankind has for economic and other reasons, constantly interfered with nature. In the past, this was often done without consideration of the effect upon the environment. Owing to new scientific insights and to growing awareness of the risks for mankind, for present and future generations, of pursuit of such interventions at an

[162] See Glazewski J *Environmental law in South Africa* (2005 LexisNexis Durban).
[163] 2007 (6) SA 4 (CC) , 2007 (10) BCLR 1059 (CC) (hereinafter referred to as the *Fuel Retailers* case).
[164] Op cit note 73 at 116–123.

> unconsidered and unabated pace, new norms and standards have been developed, set forth in a great number of instruments during the last two decades. Such new norms have to be taken into consideration, and such new standards given proper weight, not only when states contemplate new activities, but also when continuing with activities begun in the past. This need to reconcile economic development with protection of the environment is aptly expressed in the concept of sustainable development".[165]

Ngcobo J then went on to place "sustainable development" in the context of the Constitution, stating that the Constitution recognises the interrelationship between development and the environment; indeed it recognises the need for the protection of the environment while at the same time it recognises the need for social and economic development. It contemplates the integration of environmental protection and socio-economic development. He further held that it envisages that environmental considerations will be balanced with socio-economic considerations through the ideal of sustainable development. This is apparent from section 24(*b*)(iii) which provides that the environment will be protected by securing 'ecologically sustainable development and use of natural resources while promoting justifiable economic and social development'. Sustainable development and sustainable use and exploitation of natural resources are at the core of the protection of the environment.[166]

In the legislative context, Ngcobo J noted that NEMA, which was enacted to give effect to s 24 of the Constitution, embraces the concept of sustainable development. As mentioned in the beginning of this chapter, sustainable development is defined to mean 'the integration of social, economic and environmental factors into planning, implementation and decision-making for the benefit of present and future generations'. Glazewski believes that this broad definition of sustainable development incorporates two of the internationally recognised elements of the concept of sustainable development, namely, the principle of integration of environmental protection and socio-economic development, and the principle of inter-generational and intra-generational equity.

Ngcobo J further reasoned that unsustainable developments are in themselves detrimental to the environment if a development such as a filling station may have a substantial impact on the environment. However, he emphasised that the objective of considering the impact of a proposed

[165] At 201, para 140.
[166] The *Fuel Retailers* case (fn 103) para 45 at 22B–22D.

development on existing ones is not to stamp out competition. It should rather be to ensure the economic, social and environmental sustainability of all developments. The filling station infrastructure that lies in the ground may have an adverse impact on the environment. He held that the authorities misconstrued the nature of their obligations and failed to comply with a compulsory and material condition prescribed by the law for granting authorisation to establish a filling station.

In a separate judgment Sachs J associated himself in all aspects with the Ngcobo J judgment except for the materiality of the failure by the environmental decision-makers. In his view, this failure was innocuous as far as the environment was concerned, and had formal rather than substantive significance. Holding that the purpose of environmental law was to protect the environment and not the profits of incumbent petrol stations, he would support the findings of the High Court and the Supreme Court of Appeal, and dismiss the appeal.

4.2.4.3 Kyalami Ridge Case

Another recent case that came before the Constitutional Court for the adjudication of environmental matters that pertains to section 24 of the 1996 Constitution, is Minister of Public Works v Kyalami Ridge.[167] In this case the applicants, a concerned environmental association, took the government to court, arguing that the realization of some of the socio-economic rights of desperate and poor people infringed on the property and environmental rights of property owners in the disputed area.

This case is severely criticised because the court did not have due regard to the literal interpretation of the principles that unquestionably supports sustainable development

4.2.5 International law (precautionary principle)

As mentioned above, S 2(4)(a)(vii) of the National Environmental Management Act (NEMA) relates to sustainable development and requires that a risk-averse and cautious approach must be applied which takes into account the limits of current knowledge about the consequences of decisions and actions. This Section in effect makes provision for the application of the precautionary principle. This can be seen by the use of the words "risk-adverse" and "cautious".

[167] 2001 (7) BCLR 652 (*CC*).

Article 3 of the United Nations Framework Convention on Climate Change (UNFCCC) endorses and details the principles of intra- and inter-generational equity, the precautionary principle, the principle of sustainable development and the principle of common but differentiated responsibility. In his article, Roberto Andorno defines the nature of the precautionary principle as of a flexible nature.[168] He also states that, because of this flexible nature, it is important to specify the conditions that must be met for the adoption of precautionary measures. From the analysis of the international legal instruments and policy documents that refer to it, the following conditions can be drawn: i). Uncertainty of risk; ii). Scientific assessment of risk; iii). Serious or irreversible damage; iv). Proportionality of measures; v). A shifting burden of proof.

It must also be borne in mind that in the 'Guidelines for Applying the Precautionary Principle to Biodiversity Conservation and Natural Resource Management' as approved by the 67th meeting of the IUCN Council it was concluded that the precautionary principle is generally only relevant where the following elements are present:

First, in situations where there is uncertainty. Where the threat is relatively certain (i.e. a causal link between an action and environmental damage can be established, the probability of occurrence can be calculated, and the damage insured against), measures may also need to be taken. However, these should be seen as preventive, not precautionary measures;
Second, where there is a threat of environmental damage. Where there is no indication of a threat of environmental harm, the principle will not apply; and
Third, where the threatened harm is of a serious or irreversible nature. If, for example, the threatened damage is easily reversible, the principle will not be applicable.[169]

It is my opinion and I feel confident to say that all of these above mentioned sets of conditions and elements for the application of the precautionary principle have been met in the case of fracking in the Karoo. The precautionary principle or precautionary approach has been incorporated into and applied in several international environmental agreements, and I believe that it is now recognized as a general principle of international environmental law.

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[168] Andorno R "The Precautionary Principle: A New Legal Standard for a Technological Age" 2004 JIBL Volume 01.
[169] IUCN Council *Guidelines for applying the precautionary principle to biodiversity conservation and natural resource management.* http://cmsdata.iucn.org/downloads/ln250507_ppguidelines.pdf (Accessed 2015-04-14).

4.3 Conclusion

Concern has been raised that the existing regulatory framework may not be adequate to deal with all the implications of the fracking process. An initial analysis has been carried out and gaps identified. The existing regulatory framework of the upstream petroleum industry in South Africa operates at a high level and relies to a large extent on, firstly, the principle that administrative decisions should err on the side of caution and secondly, reference to other Acts (National Environmental Management Act, Mine Health and Safety Act, National Water Act, Astronomy Geographic Advantage Act) administered by other Departments as well as the right of the regulator to require submission of documents not otherwise specified in regulation. Regulation can be divided into several areas, the most obvious being concerned with environmental protection. However, regulation does not function in isolation; rather it is closely linked to operators' practices. Regulation may stipulate requirements in respect of workers' health and safety, well planning and construction and the optimal extraction of hydrocarbons.

Several jurisdictions with mature regulatory systems governing the upstream oil and gas industry have had no difficulty embracing hydraulic fracturing in shale gas exploration and production mainly because these practices are not revolutionary, but rather have evolved from established procedures. In order to address public anxiety regarding pollution risks, rules requiring disclosure of the composition and volume of fracturing fluid are being introduced. There are several jurisdictions with mature regulatory systems governing (onshore) oil and gas operations which may be adapted for application in South Africa. (Colorado, Louisiana, Texas, Pennsylvania in the USA, Alberta in Canada, and possibly Queensland in Australia). This will have the dual benefit of providing assurance to the public and predictability for investors.

It is suggested that a comprehensive review of the adequacy of the existing regulatory environment as it applies to oil and gas exploration and production generally, and hydraulic fracturing specifically, be undertaken. Based on our understanding of the regulatory system in Texas, for example, it is recommended that a more detailed and specific system of regulation be put in place together with mechanisms for co-ordination between the various interested Departments to ensure integrated and consistent enforcement.

Any plan to augment the regulation of the subject activities must include provision to augment capacity for enforcement within the relevant agencies, as regulation without capacity for enforcement serves only to undermine the credibility of regulatory systems in general.[170]

In conclusion it seems clear that sustainable development is a well recognised term within our law and that the courts and legislatures are attempting to give effect to this principle. However it is a very broad principle and its scope is quite difficult to determine.

The judgment of the Court in the Kyalami case did in many respects not further the cause of sustainable development in South Africa. I agree with Kotze when he proposed that the Constitutional Court should in future engage in a holistic, purposive and contextual approach in constitutional interpretation when having to deal with the concept of sustainable development in South Africa.[171] The reason being that such an approach might just establish a law of precedent upon which a certain practice may evolve which will protect the fundamental rights of all South Africans while it also guarantees the 'greening' of a country that is well known for its natural beauty.

[170] Op cit note 160.
[171] Op cit note 67.

Chapter 5 - General Conclusion

The world is faced with challenges in all three dimensions of sustainable development. More than 1 billion people are still living in extreme poverty and income inequality within and among many countries have been rising; at the same time, unsustainable consumption and production patterns have resulted in huge economic and social costs and may endanger life on the planet. Achieving sustainable development will require global actions to deliver on the legitimate aspiration towards further economic and social progress, requiring growth and employment, and at the same time strengthening environmental protection. [172]

Sustainable development will need to be inclusive and take special care of the needs of not only the poorest and most vulnerable people, but also the poorest and most vulnerable areas. Strategies need to be ambitious, action-oriented and collaborative, and to adapt to different levels of development. They will need to systemically change consumption and production patterns, and might entail, inter alia, significant price corrections; encourage the preservation of natural endowments; reduce inequality; and strengthen economic governance. [173]

However, adopting a mere 'copy and paste' is also not the answer. Because contemporary fracking is a relatively new mining technique, South Africa is but one of many jurisdictions where this legislative issue exists of whether SA should adopt a separate fracking-specific legal framework. Even in the USA, which has the most fracking experience, there is a move to introduce fracking-specific legislation to areas that possess shale gas resources, with the exception of course of those areas where the technology has already been banned. For the South African government a swift solution does not exist. Arguably, filling South Africa's legislative problem by simply adopting a foreign regulatory regime is not an appropriate solution. It is common cause that the potentially negative consequences of fracking vary depending on the specific features of the location in which fracking is proposed.

A good example of this is Chapter 8 of the MPRDA which contains specific and itemised regulations for the design and construction of wells which adopt the standards laid down by the American Petroleum Institute (API). I believe that these standards cannot be assumed to be appropriate for South African conditions, particularly as the rock formations in the Karoo are unique and no testing has taken place to ensure the suitability of the API standards.

[172] World Economic and Social Survey 2013 Sustainable Development Challenges.
[173] Ibid.

As a result this study focussed to a great extent on the advantages and disadvantages which fracking provides to the Karoo region and communities as a whole. Looking back at the entire study, and after immense research, the possible positives that can be produced by fracking seem a bit worrying. The benefits of fracking are: benefits from using shale gas as a source of energy; an increase in, income, government revenue and economic growth are expected; CO_2 emissions have declined and thus a much lower carbon footprint than with coal.

On the other hand, the disadvantages were immense, which was even more worrying to me. Some of the disadvantages which were discovered throughout this study includes: homelessness among low income community residents; a significant negative impact on tourism, farming and property values; the community is left paying for upkeep of everything they built without the former revenue when the company is done and they leave; because of loss of businesses, unemployment rises; chemicals used in hydraulic fracturing include carcinogens and endocrine disruptors, which are related to serious diseases and birth defects; serious patterns of disturbance on the landscape; large volumes of water use; ground- and surface-water contamination; other health risks; air emissions; increase in crime and sexually transmitted diseases which may be attributed to transient workers from distant states; and it remove the focus from renewable sources of energy, such as solar and wind.

All of these disadvantages are relevant for the Karoo region and some actually arose because of the nature of the Karoo area and the communities within. Also, fracking, is presently banned or under some form of restriction or moratorium in more than a hundred countries or states around the world, including developed countries like France, Bulgaria and Germany. In the United States, New York State has recently extended their ban on fracking, citing public health concerns as one of the main reasons. Surely these are based on some reason for concern. I fail to believe that so many countries will ban such a profitable activity if there is no reason for concern.

I also conclude in this study that the benefits to the local economy of the planned development will be quite small and that the major beneficiaries will be the owners (e.g. Shell, Falcon Oil and Gas, Bundu, etc.) of the extraction activities who mostly reside outside the development area or even outside the country.

In conclusion, I believe the Karoo region to be one of South Africa's poorest areas and surely exposing its drinking water and other scarce natural resources does not, in my opinion, amount to sustainable development in any sense other than for the economical sphere of sustainable development. I believe that our government should remove their "dollar goggles" and start looking at a picture much bigger than what they are observing. Also, the precautionary principle should be used in order to safeguard human health until there is more research.[174]

The Karoo has a unique geological structure in that the normal sandstone in which the shale gas resides is permeated by unusual dolerite dyke formations resulting in water unusually possibly being forced upward. Therefore the unique Karoo region needs specific measures in order to affect groundwater protection. Until thorough research has been conducted with regards to the Karoo in particular, fracking should not be conducted as the precautionary principle would not allow this. A mere copy and paste approach is not the answer, especially not with regards to a unique region such as the succulent Karoo.

[174] Finkel, M., & Law, A. 'The rush to drill for natural gas: A public health cautionary tale.' American Journal of Public Health, 101(5), 784 –785. 2011.

Bibliography

Articles

A

Adams W.M. 'Green Development: environment and sustainability in the Third World.' 2001 London: Routledge.

B

Bamberger, M., & Oswald, R. E. 'Impacts of gas drilling on human and animal health.' 2012 New Solutions 22, 51–77.

Barth J. M 'The economic impact of shale gas development on state and local economies: benefits, costs, and uncertainties' 2013 new solutions, vol. 23(1) 85-101.

Blowers A., Boersema J. and Martin A 'Is sustainable development sustainable?' Journal of Integrative Environmental Sciences Vol. 9, No. 1, March 2012, 1–8

Bonan, G.B. 'Forest and climate change: forcings, feedbacks, and the climate benefits of trees' 2008 Science, v. 320

P. C. Boxall, W. H. Chan, and M. L. McMillan, 'The Impact of Oil and Natural Gas Facilities on Rural Residential Property Values: A Spatial Hedonic Analysis' Resource and Energy Economics 27 (3) (2005).

Branosky E, Stevens A & Forbes S 'Defining the shale gas life cycle: A framework for identifying and mitigating environmental impacts.' 2012 Working Paper (WRI).

Broderick J, Anderson K 'Has US shale gas reduced CO_2 emissions?' 2012 CCR University of Manchester.

M Broomfield '*Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe*' 2012 European Commission DG Environment.

C

G Claude, GB Williamson, GAB da Fonseca, Receding forest edges and vanishing reserves: 2007 Science, v. 288, no. 5470

T Colborn, et al. 'Natural Gas Operations from a Public Health Perspective' 2011 Human and Ecological Risk Assessment: An International Journal Volume 17, Issue 5.

Common M. and Perrings C, "Towards an Ecological Economics of Sustainability" (1992) Ecological Economics 6 pp. 7-34

Council of Canadian Academies 'Environmental Impacts of Shale Gas' at XV.

D

De Gouw J, Parrish DD, Frost GJ, Trainer M. 2014. Reduced emissions of CO2, NOx and SO2 from U.S. power plants due to the switch from coal to natural gas with combined cycle technology. Earth's Future.

Dickinson State University, Minot State University, and Great Plains Energy Corridor '*Energy Impacts in North Dakota' 2011 at 4.* Retrieved from: http:/www.ag.ndsu.edu/ccv/documents/energyimpacts

Dryzek J.S. *The Politics of the Earth* (1997) Oxford: Oxford University Press.

F

Finkel, M., & Law, A. 'The rush to drill for natural gas: A public health cautionary tale.' American Journal of Public Health, 101(5), 784 –785. 2011.

G

JP Gibbs and WG Shriver 'Can road mortality limit populations of pool-breeding amphibians' 2005 Wetlands Ecology and Management, v. 13.

H

Harris M.J 'International Society for Ecological Economics' - Internet Encyclopaedia of Ecological Economics - Sustainability and Sustainable Development 2003.

Holzman D.C, *Methane Found in Well Water Near Fracking Sites,* Environmental Health Perspectives Journal (EHP), 2011.

Howarth, Richard B. and Richard B. Norgaard. 'Intergenerational Transfers and the Social Discount Rate.' Environmental and Resource Economics 1993 at 337-58

J

Joyce Nelson ‘Why provinces and First Nations are wise to put a hold on unconventional gas’ (2014) - CCPA Canadian Centre for Policy Alternatives

K

Kotze L.J. ‘The Constitutional Court’s contribution to sustainable development in South Africa’ 2003 PER/PELJ (6)2.

Kovats S. et al. 'The health implications of fracking' Department of Social and Environmental Health Research, London School of Hygiene and Tropical Medicine, London WC1E 7HT, UK (SK, AH, PW, NS); European Centre for the Environment and Human Health.

L

B. Legarth et al Hydraulic fracturing in a sedimentary geothermal reservoir: Results and implications, International Journal of Rock Mechanics & Mining Sciences 2005 at 42.

Leibbrandt M, Woolard I, Finn A Et al., ‘Trends in South African Income Distribution and Poverty since the Fall of Apartheid’ OECD Social, Employment And Migration Working Papers No 101 (Directorate for Employment, Labour and Social Affairs) 2010.

M

Maherry A. ‘Planning for groundwater in South Africa’ 2010 CSIR RESEARCH SPACE.

McKenzie LM 'Human health risk assessment of air emissions from development of unconventional natural gas resources' (2012) *Scitotenvironment.*

L. Muehlenbachs, E. Spiller, and C. Timmins, Shale Gas Development and Property Values: Differences across Drinking Water Sources , Discussion Paper, Resources for the Future, July 2012.

Myers N, Russell A. Mittermeier, CG; et al. ‘Biodiversity hotspots for conservation priorities’ Nature 2000 at 853-858.

N

Norgaard, R B. Development Betrayed: The End of Progress and a Co-evolutionary Re-visioning of the Future, New York and London: Routledge. 1994

O

S.G. Osborn et al. 'Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing' 2011

P

Perry, S. L. (2011). It's like we are losing our love. Documenting and evaluating social change in Bradford County PA during the Marcellus shale gas boon (2009–2011). Paper presented at the 2nd Annual Conference Health Effects of Shale Gas Extraction, University of Pittsburgh. Video retrieved from: http://mediasite.cidde.pitt.edu/mediasite/SilverlightPlayer/Default.aspx?peid=689293c50f404f12b8c628b8f2285780

R

M A Rafferty & Elena Limonik 'Is Shale Gas Drilling an Energy Solution or Public Health Crisis?' 2013 Public Health Nursing Vol. 30 No. 5

Magdi Ragheb, "Tight Natural Gas as a Bridge Fuel toward Renewables," 2011 Winter.

S

Sawyer et al. 'Winter habitat selection of mule deer before and during development of a natural gas field' 2006 JWM Vol. 70, No. 2 pp. 396-403

Scherr, Sara J. 'People and Environment: What is the Relationship between Exploitation of Natural Resources and Population Growth in the South?' Forum for Development Studies(1), 33-58 1997.

Simons R & Mao X 'A review of hydro "Fracking" and its potential effects on real estate' (2013) *Journal of Real Estate Literature,* 21(2), 205-232. Doi

Slonecker et al. 'Landscape Consequences of Natural Gas Extraction in Bradford and Washington Counties, Pennsylvania' 2004–2010 USGS

T

Taylor J. 'Sustainable Development: A dubious solution in search of a problem.' 2002 Policy Analysis, No. 449

Turner, M.G., Gardner, R. H., and O'Neill, R.V., 2001, Landscape ecology in theory and practice: New York, Springer-Verlag, 401 p.

U

U.S. Energy Information Administration (USEIA) 2011 World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States. Washington, DC: USEIA.

V

Venkatesh A, Jaramillo P, Griffin WM, Matthews HS. 2012. Implications of near-term coal power plant retirement for SO2 and NOx and life cycle GHG emissions. Environ. Sci. Technol. 46:9838–45

W

Wackernagel M. and Rees W.E. 'Our Ecological Footprint: Reducing Human Impact on the Earth.' Gabriola Island, BC: New Society Publishers.

Wang, J., Ryan, D. and Anthony, E.J., 2011. Reducing the greenhouse gas footprint of shale gas. Energy Policy, 39 (12), 8196-8199.

B Weber, Geigle, J., & Barkdull, C. (2014). Rural North Dakota's Oil Boom and Its Impact on Social Services. *National Association of Social Workers,* 59(I).

WEC 'Survey of Energy Resources: Focus on Shale Gas, London' 2010 UK: World Energy Council.

R Witter 'Community impacts of natural gas development and human health' 2012 Paper presented at the Institute of Medicine Workshop on the Health Impact Assessment of New Energy Sources: Shale Gas Extraction, Washington, DC.

Witter, R., Stinson, K., Sackett, H., Putter, S., Kinney, G., Teitelbaum, D. 'Potential exposure-related human's health effects of oil and gas development' 2008 Retrieved from www.ucdenver.edu

Books

A

Arima A, et al. *UN Decade of Education for Sustainable Development 2005-2014 International* Implementation (2005) Scheme January.

B

Barton, H. *Conflicting perceptions of neighborhood: In Sustainable Communities.* (2000) Barton H (ed.), London: Earthscan.

Binedell M and Brownlie S *Limits of acceptable change – how much is too much?* Chapter 6 in CSIR 2007. ENHANCING THE EFFECTIVENESS OF SEA IN SOUTH AFRICA. pp55-74.

Birnie P, Boyle A and Redgwell C *International Law and the Environment* (2009) 3rd ed at 116–123.

Broomfield M *Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe* (2012) European Commission DG Environment.

Brownlie I. *Principles of Public International Law* (2003) 6th ed at 276.

C

Cheadle, Davis and Haysom *South African Constitutional Law: the Bill of Rights* (2002) at p 424.

D

Daly, H E. *Operationalizing Sustainable Development by Investing in Natural Capital* in Ann-Mari Jansson et al. eds., Investing in Natural Capital: The Ecological Economics Approach to Sustainability. Washington, D.C.: Island Press. (1994).

Daly, H E. *Steady State Economics* (2nd ed.), Chapters 2 and 9. Washington, D.C.: Island Press. (1991).

Davies DP *Sustainable Development*.
Intergenerational Democracy: Rethinking Sustainable Development Paperback –2011

Du Plessis C. *Cities and sustainability: sustaining our cultural heritage. In Cities and Sustainability: Sustaining Our Cultural Heritage, Conference Proceedings.* (2000) Brandon P, Lombardi P, Perera S (eds.). Sri Lanka: Kandalama

G

Giddens A *The Politics of Climate Change* 2009.

J Glazewski *Environmental law in South Africa* (2005 LexisNexis Durban)

L

Le Roux J 'Keeping 'place of thirst' safe' in Rodríguez SM *Global Resistance to Fracking - Communities rise up to fight climate crisis and democratic deficit* (2015) Ecologistas en Acción.

Lipton, M '*Accelerated Resource Degradation by Agriculture in Developing Countries? The Role of Population Change and Responses to It*', in Stephen A. Vosti and Thomas Reardon eds., Sustainability, Growth and Poverty Alleviation: A Policy and Agro-ecological Perspective, Baltimore: Johns Hopkins University Press. (1997).

M

Mawhinney, M. *Sustainable Development–Understanding the Debates* (2002) Blackwell Publishing, Oxford.

O

Organisation for Economic Co-operation and Development Sustainable Development *Round Table On Sustainable Development* - MEASURING WHAT? (2001).

R

Reed, David ed. *Structural Adjustment, the Environment and Sustainable Development*, London: Earthscan Publications. 1997

S

Sands P, *Principles of International Environmental Law* (2003) 2nd ed at 253

Case law

Agri South Africa v Minister for Minerals and Energy 2013 (4) SA 1 (CC)

BP SOUTHERN AFRICA (PTY) LTD v MEC FOR AGRICULTURE, CONSERVATION, ENVIRONMENT AND LAND AFFAIRS 2004 (5) SA 124 (W)

Fuel Retailers Association v DG, Environmental Management, Mpumalanga [2006] SCA 109 RSA.

Gabcikovo Nagymaros Project (Hungary/Slovakia) (1998) 37 *ILM* 162.

Internet resources

R

The River Reporter 'Nationwide Insurance: No Fracking Way' July 11, 2012 Available at http://www.riverreporteronline.com/news/14/2012/07/11/nationwide-insurance-no-fracking-way accessed on July 12, 2012.

S

Skowno, A.L., Holness, S.D. and Desmet P.G 'Biodiversity Assessment of the Kannaland and Oudtshoorn Local Municipalities, and Eden District Management Area (Uniondale)'. DEADP Report LB07/2008a, 2010. http://bgis.sanbi.org/littlekaroo/LK_biodiversityassessment.pdf. (Accessed on 08 December 2015)

Steyl, G and GJ van Tonder, 'Hydrochemical and Hydrological Impact of Hydraulic Fracturing in the Karoo, South Africa', http://dx.doi.org/10.5772/56310 (As accessed on 10 December 2015).

V

Van Tonder G, De Lange F, Steyl G and Vermeulen D'Potential impacts of fracking on groundwater in the Karoo Basin of South Africa' Institute for Groundwater Studies, University of the Free State, Bloemfontein, Free State, South Africa. http://gwd.org.za/sites/gwd.org.za/files/04_G%20vTonder_Potential%20%20Impacts%20of%20Fracking%20on%20Groundwater.pdf. (As accessed 10 December 2015)

Legislation (full act citation in footnotes)

Constitution of the Republic of South Africa, 1996

Mineral and Petroleum Resources Development Act

National Environmental Management Act

National Water Act