Take Stock of Fracking Risks and Count the Costs: Towards an Ecosystem Services Assessment in South Africa

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Abstract

Many citizens in countries now accept that there is a need to adapt to climate change and to invest in renewable resources. This paper contributes to the planning of energy development in South Africa. Currently, South Africa is faced with a crisis in energy security with 'load shedding' resulting in hours without power. Coal, a fossil fuel, is the main source for energy in South Africa with negative effects for the environment and human health. To provide security over the future supply of domestic energy, the technique of fracking on and offshore is being advanced as an alternative by government which has been granting exploratory fracking licences. A review of the literature at the nexus of fracking, the Sustainable Development Goals (SDGs) and ecosystem services was undertaken from a triple risk lens (Prpich & Coulon 2018). The findings indicate that fracking operations may create a short-lived economic boom but there is substantive scholarly evidence on the immense long- term risks for both the environment and human health. The impact of land use changes through fracking and the risks of fracking operations for ecosystems, climate change and achieving the SDGs of Agenda 2030 are evident and form a 'self-reinforcing loop'. We conclude that if fracking is predominantly being perceived from a prism of its economic benefits, then economic value needs to be attached to all the services that are provided by ecosystems. Thus, we recommend that an ecosystem services assessment must precede the granting of fracking licences to evaluate whether fracking is a viable option. It is also suggested

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that compensatory justice, be included as a policy measure for rehabilitation of the land where fracking has already commenced. In conclusion, we assert that healthy, environmentally sustainable living conditions need to be provided for all citizens and investment is needed to support adequate renewable energy infrastructure, a pre- requisite for government's Just Energy Transformation (JET).

Keywords: Fracking risks, Count the costs, ecosystem services, assessments

Introduction

Climate Politics has been normatively viewed from an international relations perspective (Colgan, Green & Hale 2021: 586) with country representatives converging and deciding on how to address common challenges. One of the easiest cited examples of this lies in the concept of Sustainable development, which became a buzzword since its first use in the 1987 Brundtland Report/ Our Common Future. The concept has gained momentum being cemented in the UN's sustainable development goals with country commitments to meet the set goals and targets. Some countries accept that there is a dire need to rethink development choices and make decisions based on sustainability therefore consumption patterns and waste management are revisited with mitigation and adaptation to climate change, a common challenge becoming a priority. In respect of energy, there has been a thrust to invest in renewable resources and Scandinavian countries (Sweden, Norway & Denmark) have topped the World Economic Forum's Energy Transition index (Kamal 2021) for their efforts. However, globally, statistics after the setting of goals for Agenda 2030, indicate that only 17.5% of total final energy comes from renewable sources (UN 2023).

This paper contributes to the planning of energy development in South Africa. Currently, South Africa is faced with a crisis in energy security with 'load shedding' resulting in hours without power, negatively affecting multiple facets of life. Countries in the global north pledged, at COP 26 in Scotland to assist SA and other developing countries to work towards achieving a just energy transition (Henning 2021). Coal, a fossil fuel, is the main source for energy in South Africa (SA) which has harmful effects for the environment and human health. To provide security over the future supply of domestic energy and to catalyse an economic boom, natural gas with the technique of fracking onshore and offshore is being advanced as one alternative by government (Henning 2021). This has resulted in the fast tracking and granting of exploratory fracking licences to foreign energy companies, but it has been met with environmental concerns, civil society protests and litigation (Jacklin 2021).

In this paper, we examine relevant recent literature (via a google search) at the nexus of fracking, the SDGs and ecosystem services for application to the South African case of unconventional oil and gas (UOG) exploration via fracking, concentrating our focus on especially goal 6 (Clean Water and Sanitation) and 7 (Affordable and Clean Energy) which have relevance for climate change and sustainable development through harnessing clean[1] energy. We draw attention to the impact of land use changes through fracking and the risks of fracking operations for ecosystems, climate change and achieving the sustainable goals (SDGs) of Agenda 2030. We assert that if fracking is being perceived from a prism of economic benefits, then economic value needs to be attached to all the services that are provided by ecosystems for the areas where fracking is being targeted. We join a recent call made by Loos *et al.* (2023) to mainstream ecosystem services as an approach to sustainable development and we advance it in a specific context: that of unconventional oil and gas extraction in South Africa. As a country, it relies on coal for 90% of its electricity needs, but there is a movement to extract shale oil and gas as a potential alternative with the hope of a lower pollution footprint (Esterhuyse, Vermeulen & Glazewski 2022; McGranahan & Kirkman 2019; Willems *et al*. 2016). We take cognizance that this path of UOG, is strongly articulated by the Minister of Mineral resources and Energy, Gwede Mantashe, on 16 May 2023 (Makinana 2023) and it stands in opposition to renewable forms of energy (solar, wind, hydropower) which has been voiced by the Presidential Climate Commission (just weeks later) as sustainable energy choices for the country (Naidoo 2023). Below, in our discussion, we lean on the concepts of climate change, sustainable development and ecosystem services weaving in fracking research from a risks lens with an emphasis on its threats for the anthroposphere (Meng 2017; Prpich & Coulon 2018). These risks relate to contamination, exposure and disturbance (Prpich & Coulon 2018).

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[1] Minimal short and long term impacts comparatively to coal energy solutions.

Climate Change as a 'Wicked' Problem

Across the world, it can be asserted that we are living in a time of major global environmental changes and challenges which have become so profound that they have driven the Earth out of the Holocene epoch into an era that is complex (Steffen *et al.* 2018). Human activities exceed biogeophysical drivers in transforming the planet to the extent that this time in history warrants an epoch of its own, increasingly referred to as 'the Anthropocene' (Crutzen & Stoermer 2000; Crutzen 2002; Steffen *et al*. 2011). The planet's limited resources and the increasing population require a deeper understanding of sustainable solutions that are well informed of the geographic distribution of the planet's resources, flows, interconnected uses, resultant wastes and stressors, and environmental and social impacts. Understanding how our planet is affected by climate change is one of the most important scientific drivers of our time, with climate change being realised as a 'wicked problem' (Morgan 2006; Mitchell 2013) hence the need for country commitments to address this global challenge. The effects of climate change comprise among others of rising atmospheric and ocean temperatures, snow and glacial retreat, sea levels rising and increasing concentrations of greenhouse gases leading to a dangerous increase in global warming (IPCC 2022).

In many cases, the connection between environmental changes and health are very obvious, and we do acknowledge that they can sometimes be unclear (Bastin *et al*. 2019; Myers *et al*. 2013). It is understood that social and economic activities that are driven by humans lead to land and climate changes and these will have profound effects on local, regional, and global socio-ecosystems (Chiabai *et al*. 2018). Poorer societies that have usually contributed the least to environmental changes will unfortunately be the ones that will suffer disproportionately, the most from these negative effects. The changes that pose serious threats to human health today can usually be traced to a rising temperature, sea levels rising and growing concentrations of greenhouse gases and air pollution. Health risks include an increase in thermal stress and damage from floods, storms, the spread of vector-borne diseases and dangerous microbes. Air pollution causes increased cardiovascular ailments and diseases of the respiratory system. In addition, as a result of these changes, other secondary health effects occur from the loss of crops and livelihoods (Myers & Patz 2009; Myers *et al*. 2013). Currently, over-use of water is taking place in many places, which poses major risks to groundwater levels and it is argued that today we consume roughly half of the planet's accessible surface freshwater (Myers & Patz 2009). This makes it clear that if the dependence on ecosystems for human well-being becomes less visible, people will not even notice the possible ecosystems destruction (McMichael 2013). Hence as a current concept, sustainability is thus being pursued in numerous permutations: sustainable living practices and sustainable development- featuring through countries' efforts to meet the goals and targets contained in the UN's Sustainable Development Goals **(**SDGs).

The Sustainable Development Goals (SDG)

In 2015, 193 Member States of the United Nations adopted the sustainable development goals (of the UN's Agenda 2030) for economic, social and environmental development (UN 2015). To achieve Agenda 2030´s vision, there is need for targeted climate action. Given the effects of climate change, food, water and energy security (Maupin & Ojoyi 2017) has come to the global fore as critical for continuing life on the planet with the need for greater access to food, water and energy. D'Alessandro and Zulu (2016) also report that the SDGs of major significance for Africa are connected to food security, energy, employment, and industrialization and this resonates for South Africa.

The SDGs are however not mutually exclusive goals and they do overlap with each other. Water (SDG6 - Clean water and sanitation), energy (SDG7- Affordable and Clean Energy), and food systems (SDG 2- zero hunger) are highly interconnected with each other (Maupin & Ojoyi 2017) and with other SDGs (UN 2023). The specific goals and indicators of SDG 6 and 7 (stated below) which need to be reached, will be compromised (we detail these below in further discussion) if fracking is allowed to unfold as per the exploratory fracking licenses granted.

Goal 6

By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

Goal 7

Energy is central to nearly every major challenge and opportunity the world faces today. Be it for jobs, security, climate change, food production or increasing incomes, access to energy for all is essential. Sustainable energy is opportunity – it transforms lives, economies and the planet.

Goal 6 includes aspects related to water treatment and the reuse of water and ecosystem health. But as stated above, both SDG 6 and 7 are linked to other SDGs (UN 2023). An example of this interconnection is shown in a study by Dawes (2022) in what he terms 'self-reinforcing loops' where goal 13 (Climate Action) reinforces progress on Goal 6, which in turn reinforces progress on Goal 7, which reinforces Goal 13 again. Indeed, climate change creates a new context of uncertainty and risk that further questions the successful implementation of the sustainable development goals at local level. SDG2 (Zero Hunger) and SDG3 (Good Health and Well-Being) cannot be achieved without access to sufficient good quantity and quality of food and clean water. Extrapolating from the work of Dawes (2022), an end to agricultural productivity in areas where there will be fracking will have a major influence on soil and water, land use and ecosystem health and functioning. Masipa (2017) drew attention to the importance of protecting food production in SA in the context of climate change and global warming. Climate change has wide-ranging impacts on health and food security through extreme weather (Verschuur *et al.* 2021) and a lack of climate action (SDG13) to reduce GHG emissions and conserve water in drought prone South Africa, will significantly constrain the achievement of SDG2 and SDG3 locally. Therefore, understanding the range of interactions between SDG 6 (which covers aspects including drinking water, sanitation and hygiene, treatment and reuse of wastewater and ecosystem health) with other goals and specially Goal 7, is of high importance.

Given the overlaps above, there is a concern which arises on whether SA is making the right energy choice by fracking in the context of climate change, attempting to achieve the SDGs and conserving crucial natural resources like water and soil which support life.

Energy Development, Fuzzy Thinking and Choices

The global energy landscape is undergoing a transformation, with new risks and new environmental threats. Fracking is linked to the extraction of shale gas (with the euphemism of 'natural gas') by the oil companies. Shale gas is a naturally occurring fossil fuel bound in small pores in the shale layers. The bedrock must be fractured in order to extract the gas. The most modern extraction technique to release the gas involves horizontal drilling and hydraulic fracturing (Oyaburen 2013; King 2012), the latter being termed 'fracking' for short. Large quantities of water mixed with sand and chemicals under high pressure are pumped into kilometer-deep boreholes.

Much can be learned about the risks of fracking from international case studies. The USA's extraction of UOG is instructive given that it pioneered this field decades ago (Murtazashvili and Piano 2019). In addition, Canada had initially extended UOG extraction but it is being forced to curtail development in British Colombia (Parfitt 2017). In the US and Canada, hydraulic fracturing has been used extensively since the 1950s but in the early 2000s, numerous other countries around the world started to deliberate on fracking to provide additional security over the future supply of domestic energy (Goodman *et al*. 2016; Esterhuyse *et al*. 2016). There is a body of literature which reports that the so-called shale gas revolution (fracking) that occurred in many countries resulted in lower energy prices and local economic development (Hughes 2015; Cotton & Charnley Parry 2018). Other potential benefits that have been described by Davis and Fisk (2017) for the US is that fracking offers access to an abundant source of domestic energy that reduced the U.S. dependence on imported oil. It is thus flagged as creating an economic boom with new infrastructure, well-paid jobs, revenues, and taxes for affected local governments. However, there is a substantial body of scholarship which outlines the costs to health and the environment which was a high price to pay as a result of fracking (Parfitt 2017; Zacher 2023).

Fracking was and at times is still is being articulated as a clean energy option because it is natural gas that emits lower carbon dioxide per unit of energy when produced and with lower CO_2 emissions than coal, it can be seen to be contributing to the bigger decarbonization goal. Burning natural gas also releases lower amounts of nitrogen oxides, sulphur dioxide, particulates and mercury when compared to coal and oil (SLR Project No: 720.18034.00016). However, we are reminded that Howarth *et al*[2] (2011)

[2] Whilst there is some debate about the exact degree of risk, his findings have not been refuted

had long ago pointed out that tapping into unconventional oil and gas (UOG) comes with risk: it is actually not a 'clean' energy option as methane gas, a far worse GHG is emitted and leaked with long term effects. Over a longer time period (more than 20 years), natural gas has a larger GHG footprint, than does coal or oil. However, UOG continues for more than a decade to be discursively positioned by countries, such as the United Kingdom (Brock 2020) and South Africa, as a justifiable transition energy choice enroute to renewables.

Today fracking is either banned (e.g. Scotland, Germany, France) or restricted in many countries as well as in several states and about a hundred cities in the USA given the numerous risks to fracking. Collectively, the fracking operation consists of many different steps and in each there is the potential for threats to the environment. At the beginning of the operation, it is necessary to drill wells and for each well, the following phases are needed:

1. construction and drilling – representing the arrival of drilling equipment;
drill casings and drilling water at the well pad, and the removal
of bored material and drilling water from site;
2. hydraulic fracturing – encompassing the delivery of water, proppant materials and chemicals to the well;
3. flowback treatment – representing the removal of wastewater from the well. The flowback phase is linked directly to the fracturing phase, so that a certain percentage of wastewater needs to be removed from the well; and
4. miscellaneous – encompassing all other operations and activities associated with the well, such as routine movements of site staff (Goodman *et al*. 2016).

Other Risks Associated with Fracking

There are well-documented groundwater and earthquakes risks (McGranahan & Kirkman 2019). As it is necessary to destabilize and fracture the bedrock itself in order to release the trapped fossil gas, fracking can also cause noticeable earthquakes (Goodman *et al*. 2016; McGranahan & Kirkman 2019; Davis & Fisk 2017). A shocking 192 earthquakes in 182 days between 2018 and 2019 occurred near Blackpool, United Kingdom due to fracking. This forced politicians to a parliamentary debate with the Labour party calling fracking 'unsafe' and questioning why renewable forms of energy were not being prioritised (Horton 2022). An earthquake in Canada (Parfitt 2017) was also linked to excessive water consumption.

Groundwater is at risk at multiple levels: contamination and consumption. Ground water is at risk of being contaminated through the extensive use of chemicals, and methane gas release with carcinogenic benzene, uranium, radon and health-damaging heavy metals also being released and rising to the groundwater level, from the shale deposits. An example by Hughes (2015) reporting on Canada's fracking industry demonstrated the drain on natural resources and drew attention to consumption, with water-use data showing that in a 2year period since 2012, water consumption more than doubled the amount of water which was contained in 2 nearby basins. Hughes (2015) commented on the extent of water consumption and impact on infrastructure from water use stating that atleast 2,300 truckloads of water had to be pumped underground and on completion, tankers would make 700 trips to remove the contaminated wastewater. Another example by Parfitt (2017) of fracking near Port St John in Canada has relevance here: Oil and Gas company, Energy, exceeded their limit and pumped more than 8 times the amount of water used typically for fracking in the USA and this destabilised the rock strata leading to a 4.6 earthquake. Studies reflect that water consumption in fracking is frequently underestimated or not declared (Parfitt 2017). Hughes (2015; 06) also reported that in British Colombia, 'trucks deliver thousands of tons of sand and chemicals to each well site for use in the fracking process. Repeated again and again, the cumulative effect of all such activities constitutes a formidable assault on water and land resources across the landscape'.

Thus, when environmental and health costs are not factored in, these are borne by the immediate community who bear the brunt of a loss of ecosystem services and regulations not being followed. From an ethics perspective, in terms of environmental justice, there are implications for the community underpinned by distributional justice, however there is a need for 'compensatory justice' in the aftermath of earthquakes, that is some form of compensation would be necessary to right the wrongs for the impacts on ecosystem services. A follow up would comprise an assessment of rehabilitation costs which can inform the compensation amount. These international findings signal impending problems for SA which is already a water stressed country prior to fracking and will now face additional threats with fracking.

It should also be noted that close to 5 years ago, Mc Clung and Moran (2018: 24) advanced that 'Unconventional oil and gas development is predicted to intensify across the globe' extending into regions where conservation should be retained and valuable ecosystem services protected 'such as temperate forests in China's Yangtze Platform region and temperate grasslands in Argentina's Parana Basin'. They also reported on three biodiverse regions adversely affected by fracking in the US. There are fragile areas that need to be protected which will be affected by fracking in SA. Exploration right 350 was granted to Rhino Oil and Gas and it extends from northern Kwa-Zulu Natal into the Free State. The company has stated that they will avoid the Drakensberg, a UNESCO World heritage site but no specific map displays the exact extent of their operations (personal communication with Groundwork 2022). Interestingly, Groundwork's (2021) Jacklin also commented on the need for 'provision for any compensation to be claimed by communities'.

Given the above, it is necessary to unpack the findings of selected studies already undertaken in SA on the risks of fracking with some commentary on ethics.

What the Research on Fracking in South Africa Reveals

Due to many families in the sub-Saharan African region lacking in access to basic municipal services such as water, housing, sanitation, and electricity, the critical role is to provide socially, economically, and environmentally sustainable conditions for all (Ingwani & Gumbo 2016). There have been some studies on policy, the envisaged impacts of fracking and suggestions for implementing fracking in South Africa. In summary, these studies show that there is a rather poor knowledge of the impacts of fracking, thus insufficient information on the potential health risks associated with fracking for communities. Atkinson (2018), reveals that most municipalities in South Africa seem to have no awareness at all that shale gas extraction will have negative social impacts at municipal level. In the study by Willems *et al*. (2016), they showed that 40% of the participants do not know what fracking is or the potential risks and benefits thereof. In another study in four towns in eastern South Africa, the participants were pessimistic about the potential benefits of fracking for South Africa's domestic energy supply, and they did not agree that fracking would reduce the negative impacts of coal mining nor did they believe that it would create jobs (McGranahan and Kirkman 2019). From a study by Esterhuyse, Vermeulen and Glazewski (2022) where the focus was to study the regulations to protect groundwater during fracking, all respondents answered that it is important to have management plans that act as command-and-control regulatory tools to obtain data on the fracking process. The participants also considered it important to have plans in place for waste management, well decommissioning, and specification of water sources for fracking before proceeding with fracking.

Bringing Ecosystem Services into Focus for Fracking

Mc Clung and Moran 2018: 24) draw attention to how energy development extensively alters land use: 'Well pads, access roads, and other supporting infrastructure completely convert natural landscapes into artificial structures. Pipelines typically alter landscapes from natural cover into degraded or modified habitats'. They highlight the biodiversity and ecological impacts for terrestrial and aquatic resources stressing that with time ecosystem services will suffer with ripple economic, social, and environmental costs.

The concept of ecosystem services encompasses the range of human benefits derived from ecosystem functions generated by nature and it forms the basis for a functional economy; today it is applied in both regional and national planning to manage, and sustain biodiversity and ecosystem services in many countries (Costanza *et al*. 2021). Many international agreements abound between countries: to reduce the emissions of greenhouse gases and ensure effective conservation and management of at least 30% of the world's lands, inland waters, coastal areas and oceans, with an emphasis on areas of particular importance for biodiversity and ecosystems functioning and services (CBD 2022; MEA 2005). The Millennium Ecosystem Assessment (MEA 2005) points out the importance that the variety of ecosystems provide in terms of a range of services that are of fundamental value to human well-being, health, livelihoods, and survival (MEA 2005). According to the MEA (2005) and Allen and Palmer (2011), ecosystem services are divided into:

Provisioning services – for example wild foods, crops, fresh water and plant-derived medicines;

Regulating services – for example filtration of pollutants by wetlands, climate regulation through carbon storage and water cycling, pollination and protection from disasters;

Cultural services – for example recreation, spiritual and aesthetic values, education;

Supporting services – for example soil formation, photosynthesis and nutrient cycling

Our argument for an ecosystem services assessment is a timely choice. There is a difference in our approach to an ecosystem services assessment because we do not only suggest it as a mitigation approach to climate change but more importantly as a measure for the current SA government to take stock and count the costs of its energy development trajectory for the future: whether the short- term benefits of choosing UOG extraction for man's immediate consumption needs outweighs the long- term environmental destruction and health impacts for SA citizens. Governments, including SA are advancing (apart from domestic energy security) multiple economic reasons for fracking which underscore the high financial gains yet there are ecological and livelihood impacts that are not being quantified in monetary terms. There is an increased understanding of the risks of fracking and how they are linked to negative effects on ecosystem services from numerous studies that must be factored into decision-making. Our argument for an ecosystem services assessment also comes off the back of several international studies which have quantified (or drawn attention to) the ecosystem services losses. One study undertaken in the United States of America by McClung and Moran (2018:19) reports that vast tracts of land have experienced land use changes since energy development, as fracking was expanded in the USA. This destruction of the land resulted in 'hundreds of millions of dollars of annual ecosystem services costs, including negative effects on agricultural production, plant and wildlife populations, animal migrations, and human well-being'. Interestingly the United Kingdom lifted a ban on fracking in September 2022 as gas prices rose due to the Russian invasion of Ukraine affecting pricing. Whilst the UK was able to state the gas cost of subsidizing homes and business is $110.4 billion due to the price increase in gas. However, there were no estimated costs on the loss of ecosystem services that will result from fracking. It is of significance that conservationists have highlighted that the UK has already lost half of its biodiversity since the industrial revolution (McKie 2021) and with fracking land use will alter.

Elsewhere globally, the MEA framework has been adopted in Sweden at the national level with the aim that ecosystem services should be generally known and it has been implemented in societal decision-making and planning processes since 2018 (Schubert *et al*. 2017). The benefit of the ecosystem services as a conceptual planning tool for municipalities have also been carried out in several large cities in China, USA and many European countries being perceived as a useful tool for strategic planning and management (Sang *et al*. 2021). An assessment of ecosystem services can today be perceived as a promising strategy for decision-making authorities when planning urban and rural environments, are in favor of healthy living conditions and when seeking to improve quality of life (Sen & Guchhait 2021), which is linked to the attainment of many of the sustainable development goals (SDGs). Ecosystem services as an approach, is argued to be crucial to the conservation of biodiversity, it includes air purification, water and climate regulation, storage of coal and regulation of stormwater. Costanza (2014) considers that the most important contribution of ecosystem services is that it reframes the relationship between humans and the rest of nature weaving in Nature's Contributions to People (NCP). In 2007, the framework: Millennium Ecosystem Assessment (MEA 2005) was adopted by The Economics of Ecosystems and Biodiversity (TEEB), a global initiative focused on capturing the value of nature and its integration into decision-making.

Frequently ecology is pitted against economics in the climate change and fracking discourses and as such an ecosystem services lens will attribute a value in terms of losses to a specific location in SA, targeted for fracking. Thus, for example, exploration right 350 covers the Drakensberg in Northern Natal and extends into the Free State province. An ecosystems services assessment will be useful to evaluate the land that will be lost and to maintain ecosystems that deliver ecosystem services (Elbasit *et al*. 2021).

In contrast to the advantages of fracking there are several reports and studies that show that commercial extraction of more fossil energy delays all attempts for a rapid and efficient global energy transition. An increased level of fracking leads to increased climate destruction and less room for investment in renewable energy. Esterhuyse *et al*. (2016) in the context of South

Africa, determined that it is of great importance that the negative social impacts resulting from fracking need to be well understood and avoided where possible. This will also include the impacts on water resources, habitat fragmentation and losses for communities. An example connected to the shortage of water in South Africa emanates from the drought stress that occurred in the Cape Province which lasted for more than a year from March 2017 to June 2018. That drought led to a disaster being declared in the affected areas with accumulated losses of about $1.2 million (Orimoloye *et al*. 2021). The same study showed that the framework ecosystem services could be used in order to quantify drought disaster risk adaptation (Orimoloye *et al*. 2021). The water needs for society and human well-being make wetlands even more important as it is one of the most valuable ecosystems on our planet, which provide ecosystems services such as water supply, waste treatment, local climate regulation, and flood control (Assefa *et al*. 202). This is but one caveat that needs to included in the ecosystem services assessment. Meng (2017: 953) indicates that fracking dramatically changes the anthroposphere, which in turn significantly affects the atmosphere, hydrosphere, lithosphere, and biosphere through the significant input or output of water, air, liquid or solid waste disposals, and the complex chemical components in fracking fluid. Thus, an ecosystem services assessment will need to be detailed in considering the costs.

Conclusions and Recommendations

It is evident that the effects of climate change have a major influence on land use, ecosystem services, human well-being and health (Steffen *et al*. 2011; McMichael 2013). Our findings disclose the numerous threats to ecosystem services, should fracking be firmly entrenched as one of the chosen routes to energy security in SA. The scholarship is replete with evidence that indicate that fracking operations may create a short lived economic boom but it is accompanied by immense long term risks for both the environment and human health. Indeed, it is a frequent contention that 'ecosystems and humans are inexorably linked as ecosystem services are essential for human welfare' (Paudel, Cobb, Boughton, Spiegal, Boughton, Silveira, Swain, Reuter, Goodman & Steiner 2021: 1). Hence, we agree that it is necessary to integrate ecosystem services, human well-being and sustainable development in order to solve questions of sustainable living (Fu 2020). Global examples are instructive on why an ecosystem services assessment can be beneficial locally.

In South Africa there is an ongoing debate and discussion how municipalities should respond and act regarding proposals for shale gas mining. Some organizations in South Africa reflected a positive outcome of fracking in respect of energy security, job creation and economic development (MacGranahan & Kirkman 2019). In order to prevent bad regional and local planning in relation to the exploration of oil and gas via fracking, it is necessary to ensure a proper legal and regulatory framework and an effective regulation of this activity in order to ensure the protection of humans and the environment (Esterhuyse *et al*. 2016). As South Africa is a water-scarce, groundwater-dependent country there is need for specific extraction regulations to protect groundwater resources (Esterhuyse *et al*. 2022). A possible way could be to undertake an assessment of ecosystem services in environmental planning for municipalities, which will help to sustain the functions of water resources (Orimoloye *et al*. 2021). In connection to ecosystems-based management there should be an increased communication by the municipalities with the public that stresses the complicated interactions between fracking and the environment (Meng 2017). There is complexity in evaluating the ecosystem services and assessing the possible trade-offs in trying to manage sustainable pathways into the future. Also, it is of high importance to analyze, track and update the environmental impacts of fracking on ecosystems (to include wetlands: rivers, aquifers and lakes etc. and the services they provide) (SDG, Goal 6.6). Added to the many direct negative impacts from fracking on our ecosystems, there are also operations that are associated with fracking, which further increase the stress on the environment. One of these operations is the construction of roads and road traffic-related impacts of fracking on greenhouse gas emissions, local air quality emissions and noise (Goodman *et al*. 2016). To prevent a possible collapse of the natural ecosystem that we humans depend on for good health and well-being, current politicians need to take powerful socio-economic decisions to reduce the ecological damage. At the moment, there are only few exploratory rights for fracking operations that are granted in South Africa. To achieve a balance between an emerging economy in South Africa and its dependence on mineral and fossil fuel resources and the protection of natural resources, there is a need for a strong structure with integrated strategies towards sustainable development on both local and regional level.

We agree with Soergel *et al*. (2021) that to be able to reach the ambitious goals of Agenda 2030, we humans need to change our lifestyle to a less resource intensive lifestyle. At the same time, poverty is widespread in South Africa and therefore it is critical to find a balance between healthy ecosystems, conservation and development (Turpie *et al*. 2017). To understand the risks associated with fracking in South Africa, a risk assessment is needed as well as an ecosystem services assessment underpinned by the SDGs. This can help to improve environmental planning at local and regional level. It is therefore important that planning policies and strategies for land areas that are affected by an increasing demand for energy, take into account the variety of ecosystem services in the landscape that will contribute to sustainable development. To increase our understanding of the risks associated with fracking operations, drivers and patterns that anticipate ecosystem services and societal consequences of large changes in the environment must be identified for better planning and management of these areas. It is also critical to incorporate the need for what we call 'compensatory justice' into policies and discussions in the event that fracking operations extend their footprint beyond their agreements or damage ecosystems - willfully or not. The importance of fracking for future development in South Africa and its potential impacts on natural resources and the lives of affected communities must be clarified in relation to the goals of Agenda2030. In conclusion, we assert that environmentally sustainable living conditions need to be provided for all citizens and investment is needed to support adequate renewable energy infrastructure, towards a Just Energy Transformation (JET).

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