Journal of Environmental Management xxx (2016) 1–12

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Review

A review of biophysical and socio-economic effects of unconventional oil and gas extraction – Implications for South Africa

Surina Esterhuyse [a, *], Marinda Avenant [a], Nola Redelinghuys [b], Andrzej Kijko [c], Jan Glazewski [d], Lisa Plit [d], Marthie Kemp [a], Ansie Smit [c], A. Tascha Vos [a], Richard Williamson [a]

[a] Centre for Environmental Management, University of the Free State, P.O. Box 339, Bloemfontein, South Africa
[b] Department of Sociology, University of the Free State, P.O. Box 339, Bloemfontein, South Africa
[c] University of Pretoria Natural Hazard Centre, Africa, University of Pretoria, Department of Geology, Private Bag X20, Hatfield, Pretoria, 0028, South Africa
[d] Institute of Marine and Environmental Law, University of Cape Town, Pvt Bag X 3, Cape Town, South Africa

ARTICLE INFO

Article history:
Received 23 June 2016
Received in revised form
14 September 2016
Accepted 19 September 2016
Available online xxx

Keywords:
Review
Unconventional oil and gas
Fracking
Impacts
South Africa

ABSTRACT

The impacts associated with unconventional oil and gas (UOG) extraction will be cumulative in nature and will most likely occur on a regional scale, highlighting the importance of using strategic decision-making and management tools. Managing possible impacts responsibly is extremely important in a water scarce country such as South Africa, versus countries where more water may be available for UOG extraction activities. This review article explains the possible biophysical and socio-economic impacts associated with UOG extraction within the South African context and how these complex impacts interlink. Relevant policy and governance frameworks to manage these impacts are also highlighted.

Contents

1. Introduction

Unconventional oil and gas (UOG) extraction by means of hydraulic fracturing (fracking), the sustainability of this activity and the management of its related impacts is a controversial issue worldwide, as more and more countries plan to extract this source of energy (Dernbach and May 2016). This review outlines the first step that any country needs to take when considering such an activity, which is to develop an understanding of the extraction process and stimulation techniques that are used as well as the possible consequences related to UOG extraction. An understanding of possible impacts associated with the extraction process is also paramount to ensure a proper legal and regulatory framework and the effective regulation of this activity in order to ensure the protection of humans and the environment.

Various countries are in different phases of extracting UOG. For example in the United States, Canada and Australia, development of

* Corresponding author.
E-mail address: esterhuyses@ufs.ac.za (S. Esterhuyse).

http://dx.doi.org/10.1016/j.jenvman.2016.09.065
0301-4797/

UOG resources is at an advanced stage, while in China and Poland these resources are still being explored. Other countries, such as Germany and South Africa, are considering the extraction of UOG and have not yet commenced with exploration or extraction of these resources (see Box 1 for a history of oil and gas in South Africa). The extent to which countries around the world are, to varying degrees, developing their UOG extraction resources, illustrates the importance of this novel oil and gas extraction technique for future energy security.

Since this extraction technique is unprecedented in South Africa, this transdisciplinary group of authors from backgrounds in surface water quality, macro-invertebrates, fish, groundwater, vegetation, seismicity, legal and socio-economic experts performed research on this topic to understand what the extraction process entails and also to identify possible impacts that may emanate from this activity in the South African context.

Review articles that were surveyed focused on the technical aspects related to fracking such as fracturing fluid systems and factors influencing fracture propagation (Mahrer, 1999; Rahman and Rahman, 2010; Vatsa and Wang, 2013; Barati and Liang, 2014) and the economic aspects of these oil and gas resources such as resource availability, estimates and productivity (Clarkson et al., 2012, 2013; McGlade et al., 2013). These aspects are all important for the optimization of production from unconventional deposits. In recent years the linkages between environmental and socio-economic impacts in development have come to be considered paramount in ensuring sustainable human development (DSD, 2015; Morton et al., 2009; O'Riordan, 2007; UNFPA, 2012). The purpose of this review article is to elaborate on the impacts associated with the various phases of the UOG extraction process.

Such a review of possible impacts may assist governments in developing proper regulations that are based on credible scientific knowledge and ensure that cognisance is taken of the potential negative socio-economic and environmental impacts of UOG extraction in the interest of achieving sustainable human development.

2. UOG extraction – understanding the process

A background review on UOG resources (see Box 2) and its extraction is the first step towards understanding the complexities of this novel resource extraction process. A review could assist governments in developing the required regulatory policies and guidelines to manage and monitor UOG extraction and fracking effectively in a way that will protect human health and the environment and ensure sustainable use of resources such as water in water scarce countries. An important first step in the background review is to understand the process of UOG extraction – the different stimulation techniques used as well as ancillary activities - so that possible impacts that may emanate from such a process may be accurately anticipated. Apart from possible impacts associated with fracking (see Box 3 for an explanation of fracking); any of the related activities associated with unconventional gas extraction (water sourcing, wellsite establishment, road and pipeline construction) might have a serious impact on both the biophysical and socio-economic environments.

UOG extraction usually spans larger geographic areas than the extraction of conventional resources. This means that impacts usually occur on a larger spatial scale and are cumulative in nature, which complicates the management of this activity. In South Africa, UOG extraction will coincides with current land-uses such as astronomy and agriculture. UOG extraction is also performed in phases, which include the exploration phase (including firstly the identification of possible UOG reservoirs and secondly assessing the economic viability of extracting the gas in place, usually by means of hydraulic fracturing or fracking), the extraction phase (during which UOG is produced economically) and the post extraction phase (during which well decommissioning occurs in areas that are no longer productive). Chemicals that may be used in the fracking process could include biocides, breakers and friction reducers. Biophysical and socio-economic impacts are associated with all of these phases.

3. Possible impacts associated with UOG extraction

Apart from the possible positive impacts of UOG extraction (providing energy and employment, among others) (Wait and

Box 1
Brief history of oil and gas in South Africa

In the 1960s the South African Oil Corporation (SOEKOR) explored for oil and gas and could only find low permeability gas deposits in the shales of the Karoo basin (De Wit, 2011). At that stage the technology to extract these resources did not yet exist, but with recent advances in technology (for example fracking) extraction of these gas resources has become more feasible. Since 2011, the South African government received various applications to extract UOG by means of hydraulic fracturing and other methods. If viable deposits of oil and gas are found, it could augment primary energy sources in South Africa and possibly displace energy imports.

Box 2
UOG resources defined

Oil and gas that occur in reservoirs with a low permeability (usually less than 1 milliDarcy) and which require fracking (or another stimulation technique) for the extraction of these resources are referred to as UOG resources.

Unconventional resources may include shale oil and gas, coalbed methane (CBM) and tight sand oil and gas deposits. Although fracking is the main technique used to extract oil and gas from shale gas and tight sand deposits, other stimulation techniques may also be used (e.g. acidizing). In coalbed methane reservoirs, depressurisation is usually used to extract the gas and may be used in conjunction with fracking.

Box 3
Fracking explained

High volume hydraulic fracturing (fracking) is a relatively recent stimulation technique that enables the extraction of oil and gas resources by enhancing the permeability of the target oil or gas reservoir. During hydraulic fracturing a water, proppant and chemicals are injected under high pressure into the reservoir to enhance reservoir permeability (Broomfield, 2012) and facilitate extraction of oil and gas from the reservoir.

Please cite this article in press as: Esterhuyse, S., et al., A review of biophysical and socio-economic effects of unconventional oil and gas extraction – Implications for South Africa, Journal of Environmental Management (2016), http://dx.doi.org/10.1016/j.jenvman.2016.09.065