Resources Policy 54 (2017) 117–129

Contents lists available at ScienceDirect

Resources Policy

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

Surface-strip coal mine land rehabilitation planning in South Africa and Australia: Maturity and opportunities for improvement

Vanessa D. Weyer[a,*], Wayne F. Truter[b], Alex M. Lechner[c,d], Corinne J. Unger[e,f]

[a] Centre for Environmental Studies, University of Pretoria, P.O. Box 1456, Kloof 3640, South Africa
[b] Department of Plant and Soil Sciences, University of Pretoria, Private bag X20, Hatfield, Pretoria 0028, South Africa
[c] Centre for Water in the Minerals Industry, Sustainable Minerals Institute, University of Queensland, St Lucia, Brisbane, Queensland 4072, Australia
[d] School of Environmental and Geographical Sciences, University of Nottingham Malaysia Campus, Semenyih, Selangor 43500, Malaysia
[e] Centre for Mined Land Rehabilitation, Sustainable Minerals Institute, University of Queensland, St Lucia, Brisbane, Queensland 4072, Australia
[f] University of Queensland Business School, University of Queensland, St Lucia, Brisbane, Queensland 4072, Australia

ARTICLE INFO

Keywords:
Mine closure and rehabilitation
Mineral legislation
Risk assessment
Environmental planning
Multi-discipline
Integrated modelling
Maturity models
Cumulative impacts

ABSTRACT

At the mine approval phase, there is logically a focus on mine start-up and operational requirements, however, insufficient attention is given to rehabilitation planning aspects. To evaluate how rehabilitation planning is addressed upfront, we proposed a maturity model, which consists of three maturity performance indicators measured for seven environmental domain evaluative criteria. The maturity model, was applied to mine rehabilitation guidelines and mine approval consultant rehabilitation reports in South Africa and Australia, Queensland and New South Wales. We found that these documents were vulnerable to adequate, but not yet resilient, i.e. rehabilitation information was gathered, but seldom analysed, with limited integration and rehabilitation risk determination. Legislation, as well as the temporary and dynamic nature of mining, may inadvertently be contributing to immaturity. We conclude by discussing ways forward and the need to determine upfront, a site's total rehabilitation failure risk, as an aid to improving rehabilitation planning.

1. Introduction

It is estimated that > 50% of the Earth's land surface has been cleared by humans (Hooke et al., 2012). In Southern Africa, 16% of native vegetation was cleared by 2006 (Mucina and Rutherford, 2006). Australia, by 2004, suffered a similar 12% clearance of native vegetation (Thackway et al., 2010). In both these countries mining has claimed large tracts of high potential agricultural land, resulting in competition between agriculture and mining. This is especially true for coal mining, due to its geological formations, which extend over large areas. 1.5% of South Africa has high potential arable soils, with half occurring in the province of Mpumalanga. At current mining rates, approximately 12% of this will be lost, while a further 13.6% is under prospecting rights (Bureau for Food and Agricultural Policy, 2012). In Queensland, Australia, Lechner et al. (2016a) reported approximately 61% of good quality strategic cropping land coincides with coal mining exploration permits.

Land use degradation from coal mining is likely to continue into the foreseeable future with South Africa and Australia playing pivotal roles in coal supply, despite increasing market competition from alternative energy sources (Hancox and Gotz, 2014). Coal accounts for some 40% of global electricity production, is abundant, widely distributed across the globe, affordable and it is estimated that there are enough reserves for approximately 115 years at current production (World Energy Council, 2013). In 2011, South Africa ranked ninth and Australia fourth, in terms of countries, with largest proven recoverable coal reserves (World Energy Council, 2013). Given the ongoing threat to high productivity potential agricultural land and impacts on biodiversity, the science and practice of land rehabilitation is critical for meeting global and national environmental sustainability objectives and achieving future food security.

Our paper's geographical focus is on the Southern Hemisphere countries of South Africa and Australia, specifically Queensland and New South Wales. These countries and jurisdictions were chosen as they share similarities in climate, geology and vegetation. Also, many of the large mining companies are present in both countries and Australia provides an international bench-mark for comparison with South Africa.

Surface-strip coal mining can disturb landscapes extensively, typically affecting ten times more land than that affected by underground

* Corresponding author.
E-mail addresses: vweyer@global.co.za (V.D. Weyer), wayne.truter@up.ac.za (W.F. Truter), a.lechner@uq.edu.au, alex.lechner@nottingham.edu.my (A.M. Lechner), c.unger1@uq.edu.au, c.unger@business.uq.edu.au (C.J. Unger).

http://dx.doi.org/10.1016/j.resourpol.2017.09.013
Received 25 April 2017; Received in revised form 14 August 2017; Accepted 28 September 2017
0301-4207/

coal mining (Tongway and Ludwig, 2011). Surface mines have a disturbance potential that is unmatched by any other human activity, except for urban development. Surface-strip coal mining may involve the use of walking draglines which can excavate pits 2 km long, 50 m wide and 50 m high, thus potentially disturbing 5 million m^3 of soil per pit (Thompson, 2005).

Following coal extraction, disturbed lands require rehabilitation. Failure to rehabilitate mined land effectively may result in the occurrence of negative rehabilitation risks such as soil erosion and loss of valuable soil resources, soil and water contamination, soil compaction, ponding, surface cracking, spontaneous combustion and subsidence, which could lead ultimately to site rehabilitation failure (Australian Government et al., 2016b; Gauteng Department of Agriculture Environment and Conservation, 2008; Limpitlaw et al., 2005; Rethman, 2006). Site rehabilitation failure may include weed infestation and unproductive land with the substrate unable to support sustainable end landuses such as grazing and cropping. Withdrawal of social license may also result from poor rehabilitation performance, as well as company reputational damage and heightened community opposition to new and expansion mining applications and public campaigning for stronger regulatory controls, with added costs to mining companies. Mined landscapes are highly-disturbed (Erskine and Fletcher, 2013). Doley et al. (2012) state within the post-mining context, the inability to achieve true restoration, in terms of the 'pure restoration' definition, is due primarily to the radical differences between the physiochemical and biological characteristics of the original vs. rehabilitated mine environments. Rehabilitation may only be achieved in-part through a multi-disciplinary approach and restoration in its pure definition is seldom achievable.

Rehabilitation falls within mine closure planning, exerting an influence throughout the mine life-cycle (Australian Government et al., 2016a). The rehabilitation process is conceptualised as five stages of planning and implementation by Australian Government et al. (2016b): Stage 1. Defining rehabilitation objectives and targets; Stage 2. Conducting rehabilitation planning; Stage 3. Implementing rehabilitation techniques, which is split into five categories, i) Landform design and construction; ii) Reconstruction of the soil profile; iii) Selection of suitable species; iv) Establishment of vegetation and v) Fauna recolonization; Stage 4. Setting completion criteria; and Stage 5. Undertaking rehabilitation management and monitoring.

Sustainable development principles are of importance for rehabilitation planning. Sustainable development was first defined by the World Commission on Environment and Development as, 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland, 1987). The 1992 and 2002 World Summits on Sustainable Development were further key milestones. Sustainable development principles have evolved with applicability to mine closure and rehabilitation in South Africa and Australia (Australian Government et al., 2011, 2016a, 2016b; Australian Government and Department of Industry Tourism and Resources, 2006; International Council on Mining and Metals, 2003, 2008; International Institute for Environment and Development and World Business Council for Sustainable Development, 2002; Minerals Council of Australia, 2005). Sustainable development principles are not static, are often not universally agreed upon and have different compliance standards depending on local policy and legislation requirements. Sustainable development as applied to the Australian context means that, investments in minerals projects should be financially profitable, technically appropriate, environmentally sound and socially responsible (Australian Government et al., 2011, 2016a). In South Africa sustainable development is defined as, the integration of social, economic and environmental factors into planning, implementation and decision making so as to ensure that mineral and petroleum resources development serves present and future generations (Department of Minerals and Energy, 2002).

Mine rehabilitation legislation in both South Africa and Australia has developed in response to the sustainable development movement. In South Africa, prior to 1956, no mine closure and rehabilitation legislation existed (Limpitlaw et al., 2005). The first voluntary rehabilitation guideline document was compiled in 1981 (Chamber of Mines of South Africa, 1981). At this time rehabilitation was approved simultaneously with mining applications by the Department of Water Affairs & Forestry and the Government Mining Engineer (Wells, 1986).

Legislation promulgated thereafter included: Minerals Act, Act No. 50 of 1991; Environmental Impact Assessment Regulations of 1997 in terms of the Environmental Conservation Act, Act No. 73 of 1989; National Environmental Management Act, Act No. 107 of 1998, National Water Act, Act No. 36 of 1998; Minerals and Petroleum Resources Development Act, Act No. 28 of 2002 and its 2004 Regulations (GNR No. 527); and National Environmental Management: Waste Act, Act No. 59 of 2008 (Supplementary material, Table 2). The Environmental Impact Assessment Regulations has had four amendments, the most recent in 2017. More recently the 2015, Financial Provisions Regulations were promulgated (Department of Environmental Affairs, 2015). These operate in conjunction with the Environmental Impact Assessment Regulations of 2014 and their 2017 amendments (Department of Environmental Affairs, 2017).

Queensland, Australia was one of the first states to introduce Environmental Impact Assessment procedures, with the State Development and Public Works Organisation Act, 1971 (Elliott and Thomas, 2009). The Mineral Resources Act, 1989; Environmental Protection Act, 1994; Integrated Planning Act, 1997; and the Environmental Protection Regulations, 2008, followed (Supplementary material, Table 2). Currently, mined land rehabilitation is regulated by Sections 125 (1) (l) (i) (E); 264; 268; and 318Z of the Environmental Protection Act, 1994 (Department of Environment and Heritage Protection, 2014; State of Queensland Australia, 1994).

In New South Wales, the Environmental Planning and Assessment Act, 1979 was the first protective environmental legislation promulgated (Elliott and Thomas, 2009). The Mining Act, 1992 and the Protection of the Environmental Operations Act followed (Supplementary material, Table 2).

Despite the good intentions of guiding policy and legislation, sustainability objectives are rarely achieved, with rehabilitation failures often evident. A worst-case failure example is negative mining legacies. It is acknowledged that many of these legacy mines are historic and the mining activity most certainly was initiated and likely ceased before environmental or sustainable development legislation- so there was much less emphasis on stakeholder interests and long-term environmental impacts. Negative mine legacies are indeed a grave reminder of what can result from inadequate environmental responsibility. Negative mine legacies include approximately 6000 abandoned mines in South Africa and more than 50,000 in Australia, with 15,380 situated in Queensland and 410 in New South Wales (Auditor-General South Africa, 2009; Department of Mineral Resources, 2009; Unger et al., 2012). Unger et al. (2012) note inconsistency and the ambiguity in the category definitions describing mine characteristics for the Australian data sets. Further, only a percentage of these are surface-strip coal mines and mine site size varies. Therefore, mine numbers may be over representative. The contingent liability to rehabilitate the 15,000 abandoned mines in Queensland is estimated in excess of $1B AUD (Queensland Government, 2012). It is estimated that it would cost almost $3B AUD to rehabilitate the 6000 abandoned mines in South Africa (Auditor-General South Africa, 2009). The long-term treatment of acid mine drainage and the construction and operating fees of plants was excluded in the cost calculation for South Africa. In addition, reputational costs, which are difficult to quantify and end land-use specification have likely too not been included in either calculation.

End land-use rehabilitation costs vary considerably, with 'native ecosystems' costing almost double that for 'permanent pasture' establishment (Department of Environment and Heritage Protection, 2017). Lechner et al. (2016b), using spatial data and the Queensland financial