Environmental Impact Assessment Review 61 (2016) 52–60

Contents lists available at ScienceDirect

Environmental Impact Assessment Review

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

Global megatrends and their implications for environmental assessment practice

Francois Retief [a,*], Alan Bond [b,c], Jenny Pope [d], Angus Morrison-Saunders [e], Nicholas King [f]

[a] Research Unit for Environmental Sciences and Management, North-West University, South Africa
[b] School of Environmental Sciences, University of East Anglia, United Kingdom
[c] Research Unit for Environmental Sciences and Management, North-West University, South Africa
[d] Integral Sustainability, Australia; Research Unit for Environmental Sciences and Management, North-West University, South Africa
[e] Murdoch University, Australia; Research Unit for Environmental, Sciences and Management, North-West University, South Africa
[f] Research Unit for Environmental Sciences and Management, North-West University, South Africa

ARTICLE INFO

Article history:
Received 9 December 2015
Received in revised form 7 July 2016
Accepted 7 July 2016
Available online xxxx

Keywords:
Environmental assessment
Megatrends
Challenges
Value
Effectiveness
Uncertainty
Complexity
Efficiency
Significance
Communication
Participation
EA practice
Future of EA

ABSTRACT

This paper addresses the future of environmental assessment (EA) practice in light of a rapidly changing world. We apply a literature review-based methodology to firstly identify key global megatrends and then reflect upon the implications for EA practice based on some known challenges. The key megatrends identified are synthesised into six categories: i) demographics, ii) urbanization, iii) technological innovation, iv) power shifts, v) resource scarcity and vi) climate change. We then discuss the implications of these megatrends for EA practice against four known EA challenges namely: dealing with i) complexity and uncertainty, ii) efficiency, iii) significance and iv) communication and participation. Our analysis suggests important implications for EA practice such as: increased difficulties with accuracy of prediction; the need for facilitative adaptation; an increase in the occurrence of unexpected events; higher expectations for procedural efficiency; challenges with information and communication management; dealing with significance judgements; and mitigation amidst resource scarcity and increasing pressures on earth systems. The megatrends underscore the need for continued evolution of EA thinking and practice, especially moving away from seeking a predictable single future or outcome towards the possibility of multiple scenarios with associated adaptability and enhanced system resilience capable of responding to rapid change.

1. Introduction: a rapidly changing world

Environmental Assessment (EA) is arguably one of the most successful environmental policy interventions of the past four decades being now applied in almost 200 countries (Morgan, 2012). EA is founded on the basic premise that it makes sense to consider consequences before decisions are made and actions taken (Caldwell, 1989). EA is predicated on the founding assumption that future development can be anticipated and formally planned for, in a relatively static world. However, the world in which EA was initially introduced during the 1960s and 70s was very different from that of today and, moreover, it is predicted that humanity is now entering a period of potentially unprecedented and even more rapid global change driven by human activities, the so-called Anthropocene (Steffen et al., 2015). These global changes are typically referred to as megatrends (Sadler, 1996; Sunter, 2013).

The Oxford English Dictionary defines a megatrend as "an important shift in the progress of a society or of any other particular field or activity" (oed.com). Ilbury and Sunter (2004) note that the term megatrend is frequently used within the scenario planning literature, especially as a particular step in scenario planning methodology, where it is commonly understood to mean those global influencing factors which have a high degree of certainty but over which there is little control. Megatrends therefore refer to trends that are global and call for strategies for adaptation, rather than strategies for effecting change to the trends themselves. Because understanding these trends is highly relevant to major fields of human 'development' such as economics, agriculture, energy, urban planning, resource planning, etc. a body of practitioner literature around megatrends has emerged in recent years (EEA, 2015; KMPG, 2012; PWC, 2014; EY, 2015; Hajkowicz et al., 2012; Vielmetter and Sell, 2014). The earliest example in the EA literature we can find where explicit reference is made to megatrends and subsequent implications for EA practice is the effectiveness of environmental assessment study by Sadler (1996). In this instance Sadler (1996) drew attention to

* Corresponding author.
E-mail address: francois.retief@nwu.ac.za (F. Retief).

http://dx.doi.org/10.1016/j.eiar.2016.07.002
0195-9255/

megatrends in the context of thinking about the future of EA, but with little suggestion as to what the implications for EA practice might be. The topic has since received scant attention by the EA community. Given the wide ranging implications of megatrends, and the inherent challenges they pose, we are interested in how EA practice might need to adapt to remain an effective and value adding policy implementation intervention into the future.

Since EA emerged in the 1970s, it has been adapted to changing circumstances and government rhetoric. For example with the advent of the sustainable development discourse, entrenched in global policy after the Rio 'Earth Summit' in 1992, it has generally been interpreted as a tool for achieving sustainable development (Sheate, 2010; Pope et al., 2013; Morrison-Saunders et al., 2014; Bond, 2015). This adaptation has led to changes in the scope of assessments, and also general improvements over time in the extent to which the process engages with citizens. Going forward it is clear that there will be a continuing need for EA to evolve and adapt in light of current and future trends and challenges. The megatrends are global and will likely play out in different ways within the different jurisdictions in which EA takes place depending upon the process and capacity characteristics and specific environmental and social setting. However some common challenges and experiences can be expected. It is thus timely to reflect on what the implications of current global megatrends might be for EA practice, and how EA practice might change or adapt if it is to remain as the decision-aiding tool of choice for countries across the globe. Thus the aims of this paper are to:

1. Identify consensus on the key global megatrends;
2. Reflect upon the implications of the key global megatrends for EA practice based on four main challenges.

The next section describes the identified key global megatrends. This is followed by a discussion on the implications of the megatrends for EA practice framed against four challenges. In light of these challenges and implications we conclude in the final section by making recommendations for future EA research, especially the need to identify specific strategies to deal with the different implications.

1.1. Identifying key global megatrends

In order to address the first aim of identifying consensus on key global megatrends we conducted a literature search on the term 'megatrends'. Since the academic literature on megatrends is limited, our approach focused on internet search engines rather than academic databases. We identified mainly work from the business sector that operates at a global level and recognises the strategic importance of considering megatrends in forward planning. Megatrend reports have been produced recently by global accounting and management consultancy firms KPMG (2012), EY (EY, 2015), Hay Group (Vielmetter and Sell, 2014) and Price Waterhouse Coopers (PWC, 2014), as well as research organisations such as the Australian Commonwealth Scientific and Industrial Research Organisation (Hajkowicz et al., 2012) and the European Environment Agency (EEA, 2015). This 'grey' literature is not peer-reviewed, but arguably it does reflect the agendas and policies of multilateral agencies and global companies; as such it reflects the current scenario planning focus of international organisations that drive practice in resource management. Consensus is defined as agreement across the source literature whereby at least five of the six sources must identify the megatrend. This definition is pragmatic: requiring complete consensus would limit the number of megatrends identified for analysis.

For the purposes of our analysis we prepared a matrix, shown in Table 1, listing our sources against the megatrends identified therein. The sources included in Table 1 cover a total of 16 recently identified megatrends. The purpose of the matrix analysis, however, was to identify megatrends that are common to the majority of sources, suggesting some level of consensus, or at least convergence. In doing so, we adopted the labels and descriptions employed in each study, some of which overlap with labels used in different reports. The analysis identified the following six categories of key global megatrends to be common in some form to five or more of the sources, namely: i) rapidly changing demographics, ii) rapid urbanization, iii) accelerated technological innovation, iv) power shifts, v) resource scarcity and vi) climate change. Each of these is introduced in more detail below. However, it is stressed that these key megatrends all interact and therefore there is no suggestion that these trends could be isolated or should be considered in isolation. For example changing demographics is also reflected and influenced by urbanization, and power shifts are made possible by accelerated technological innovation. Furthermore, we acknowledge that there are regional variances across the different trends and that some have been ongoing in certain regions. For example, demographic trends differ widely between regions and the impacts of urbanization have already been felt for a considerable time, particularly in the developing world. However, notwithstanding these regional differences, the global interconnected nature of the world means that global megatrends warrant consideration across regions. For example, the young demographic profile and low levels of urbanization in Africa has implications for other regions in terms of migration patterns, trade, consumption, etc.

Table 1
Megatrend matrix analysis.

International megatrends	Selected megatrends literature					
	European Environment Agency (2015)	KPMG (2012)	PWC (2014)	EY (2015)	Hajkowicz et al. (2012)	Vielmetter and Sell (2014)
1. Rapidly changing demographics	✓	✓	✓	–	✓	✓
2. Rapid urbanization	✓	✓	✓	✓	✓	–
3. Accelerating technological innovation	✓	✓	✓	✓	✓	✓
4. Power shifts	✓	✓	✓	–	✓	✓
5. Resource scarcity	✓	✓	✓	✓	✓	✓
6. Climate change	✓	✓	✓	–	✓	✓
7. Global health risks	✓	–	–	✓	–	–
8. Continuing economic growth	✓	–	–	–	–	–
9. Ecosystem pressure	✓	–	–	–	–	–
10. Increasing environmental pollution	✓	–	–	–	–	–
11. Diversifying approaches to governance	✓	–	–	–	–	–
12. Individualism	–	✓	–	–	–	✓
13. Economic interconnectedness	–	✓	–	✓	–	–
14. Public debt	–	✓	–	–	–	–
15. Entrepreneurship rising	–	–	–	✓	–	–
16. Technological convergence	–	–	–	–	–	✓

1.1.1. Megatrend 1: rapidly changing demographics

Rapidly changing demographics was identified as a key megatrend (Table 1) with the world population expected to level off by 2050 somewhere between 9 and 11 billion people (KPMG, 2012; UNFPA, 2014; PWC, 2014; UNFPA, 2014; Vielmetter and Sell, 2014). However, developed and developing countries exhibit different demographic profiles and trends. For example between 2015 and 2050 the population of Africa is expected to double while that of Europe will likely decline, and by 2050 the average age in Nigeria is expected to be 21 years while in Japan it will be more than twice that at 53 (KPMG, 2012; UNFPA, 2014; PWC, 2014). The variability in the age distribution suggests that the more developed countries will have to contend with an older population placing pressure on the tax base while developing countries will have to accommodate the higher proportion of young people with resultant pressure on demands for education, employment and resources (Sunter, 2013; UNFPA, 2014). A larger proportion of young people within a population is in economic terms considered a 'demographic dividend' due to the expanding working age population, which in turn means that society can benefit from having more people who are both able to work and eager to consume (Sunter, 2013; UNFPA, 2014). However, a growing younger population on its own cannot provide the expected benefits, particularly in the light of growing resource scarcity. Preparing these young people to contribute economically means first providing quality education, access to healthcare and investment in the economy to generate productive employment. If these elements are not in place, demographic dividends can easily turn into demographic burdens in the form of mounting youth unemployment and underemployment with resultant social and political discontent (UNFPA, 2014). It is evident that future policy directions internationally as well as within nation states will have to consider these demographic profiles especially in relation to their implications for inter- and trans-generational equity, which are key considerations in EA (Gibson, 2006; Bond et al., 2013).

1.1.2. Megatrend 2: rapid urbanization

In 1800 only 2% of the world population lived in cities but by 1950 this had increased to 30%. The UN forecasts that by 2050 around 70% of the global population will live in cities (UN Habitat, 2012; UN Habitat, 2014). The main reasons why people urbanize is reflected in the UN Habitat's *The State of the World's Cities 2012/13* Report, which shows that the Human Development Index (HDI) for almost all major cities exceeds that of the country's national average HDI (UN Habitat, 2012). This applies to developed and developing countries alike although the gap between the urban and national average HDI is greater for developing countries. Reflecting the rapid urbanization trend, the 100 year period 1950 to 2050 is sometimes described as the 'age of city building' (Howard, 2013) and hence, it is not surprizing that five of the six sources identified rapid urbanization as a key megatrend (Hajkowicz et al., 2012; KPMG, 2012; EY, 2015; PWC, 2014; EEA, 2015). Such significant growth in urbanization suggests a critical challenge in EA for more effective and far-sighted planning of urban areas towards more sustainable and liveable places. The policy direction societies take now and in the coming decades will therefore have significant implications for future generations primarily because poor city and land use planning is exceedingly difficult to reverse due to the decades-long 'lock-in' of investment into physical built infrastructure. Consequently, EA as a proactive decision aiding tool has an important role to play to inform and guide city planning at different tiers of decision making, towards more innovative and sustainable outcomes.

1.1.3. Megatrend 3: accelerating technological innovation

The rate of technological progress over the past 100 years is unprecedented in human history and has laid the foundation for much of the dominance humans are exerting over the planet. All six of the future megatrends studies reviewed (Table 1) suggest that the pace of technological innovation will continue to accelerate, especially in critical areas such as communication and energy technology. 'Moore's Law' dictates that the capabilities of many digital devices such as quality adjusted microprocessors, memory capacity, sensors, and screen resolution have been improving at roughly exponential rates for decades, and is expected to continue to increase rapidly, albeit not necessarily at such rates (Moore, 2006). Future scenarios for technology put forward by the Rockefeller Foundation and Global Business Network (RF and GBN, 2010) suggest that the main challenge will not simply be development of technology, rather it will be providing access to technologies that could provide important contributions to human well-being such as education, health care or access to energy, and importantly also governance arrangements in dealing with the disruptive technologies countries might not want such as those supporting global terrorism or illegal trade. In this regard EA has more recently been applied in both considering the impacts of technology (such as genetically modified foods) through so-called Technology Impact Assessment and putting in place appropriate governance arrangements for proposal implementation and follow-up (Shrader-Frechette, 1985; Porter, 1995; de Jesus-Hitzachky and da Silveira, 2009; Russel et al., 2010).

1.1.4. Megatrend 4: power shifts

The megatrends analysed (Table 1) show that the future presents an increasingly interconnected and bi-polar world without a single dominant player. The wide ranging international effects of the global economic crisis that began in 2008, continually highlights and reinforces this progressive trend of global power shifts and interconnectedness. This is also reflected by the structure of the global economy and especially the global financial system that shapes power relations. The reliance of countries on each other is further entrenched through global trade and lending. The 2015 World Bank report on international debt statistics shows that global debt has grown by $57 trillion to reach $199 trillion in the seven years following the financial crisis (WB, 2015). All major economies are now recording higher levels of borrowing relative to gross domestic product (GDP) than they did in 2007. For example, in 2014 the United States had a national debt level of 105% of GDP with the major foreign holders of US debt being countries like China and Japan (WB, 2015). This establishes significant economic interdependence and interconnectedness. Humanity is therefore increasingly living in a world whereby our common future would seem better served by alliances around common interests than attempts at hegemonic self-interest.

A further megatrend affecting power relations, especially between citizens and their leaders, is the rapidly increasing access to information and empowerment of individuals through digital media. For example, between 2010 and 2020 three billion additional people are projected to be connected to the Internet (66% of the total world population are predicted to be connected to the Internet by 2020) thereby joining the global conversation for the first time (Diamandis, 2012). The role of power in decision making has always been recognised as a key component of EA and for example directly affects the way stakeholder and public engagement is conducted in EA (O'Faircheallaigh, 2010; Morgan, 2012). Increased access to the Internet empowers individuals to engage in decision making, thereby potentially shifting power from the traditional elites to the broader population. The megatrend of rapid urbanization also implies power shifts from nation states to city governments. Barber (2013) suggests that this rise of city power is already being experienced in countries where the majority of citizens live in cities, and associate more with their local governments, than with national governments or nation states. Moreover, there is also increasing power vested beyond nation states at international level in the form of for example multinational companies, who are not bound by national laws and are increasingly requiring additional governance mechanisms such as international agreements and treaties. The future therefore heralds an even more complex world of power-broking and increased global interconnectedness, interdependence and interconnectivity.

1.1.5. Megatrend 5: resource scarcity

All the megatrend sources (Table 1) suggest that humanity faces a future of resource scarcity. Other sources show trends in global water, energy and food demand to increase by 40% (from 2005), 50% (from 2014) and 35% (from 2014) respectively by 2030 (WRG, 2009; FAO et al., 2014; IEA 2014), while the stress on earth systems to provide these resources are exceeding critical limits (Steffen et al., 2015). There are geographical variations in demand and supply but in general these variations tend to make matters worse with regions of higher demand also being regions with limited supply (WRG, 2009). Moreover, the demand for food will be highest in regions with very low agricultural potential (FAO et al., 2014). The age of resource scarcity and growing demand is likely to result in so-called 'super cycles' of rising and volatile commodity prices (KPMG, 2012). For example it is predicted that food prices for staple foods such as wheat, paddy rice and maize will increase by 70–90% between 2010 and 2030 (FAO et al., 2014). Moreover, the most recent annual global CEO survey conducted by PWC (2015) identified water scarcity as the number one future Global Risk for Business. In this survey water scarcity was ranked higher than traditional business risks such as fiscal crises or energy price shocks. Based on these forecasts it is evident that EA practice will have to contend with a world of increased global resource scarcity and find innovative ways to reduce resource use, improving efficiency, promoting re-use and recycling as well as exploring substitute material solutions. Fortunately, the rapid advancement in technological innovations as outlined above offer a myriad opportunities to rise to these challenges.

1.1.6. Megatrend 6: climate change

The evidence that the planet is experiencing human-induced climate change through greenhouse gas (GHG) emissions related to industrial burning of fossil fuels and land-use changes, is largely accepted across the scientific community and governments worldwide (IPCC, 2014). Equally it is acknowledged that current policy will do little to prevent the extent of climate change that humanity is already locked-in to through ongoing GHG emissions – it can only affect the degree of change (Arnell et al., 2013). The implications of climate change overlap with other megatrends, and are largely recognised as exacerbating existing stressors on natural systems and existing challenges to social development. For example, resource scarcity is expected to be significantly exacerbated by climate change (Gibson et al., 2011); changing demographics and disease can be driven by climate and rapid environmental change (McLeman and Smit, 2006; Adlard et al., 2015); and evidence suggests that increased urbanization contributes to increasing climate change (Kalnay and Cai, 2003). What is less certain are the local scale ramifications of climate change which, given projections of differences at the regional scale (Joshi et al., 2011), are expected to vary across the globe thereby increasing the uncertainty at the scale typically covered by project-level EA. Further, we recognise the issue of ocean acidification, which, although not climate change per se, is a related issue in that it is driven by emissions of the same GHGs and poses significant, additional and compounding challenges for development. In contrast with the previous five megatrends we have discussed so far, we are aware that there is a growing body of literature arising from the EA community around how both mitigation (reduction in emissions) and adaptation to climate change might best be tackled by EA practitioners (which we do not intend to replicate here).

1.2. Implications of key global megatrends for EA practice

We frame our discussion on the implications of the key megatrends for EA practice around four known generic EA challenges, namely: dealing with i) complexity and uncertainty, ii) efficiency, iii) significance and iv) communication and participation. We identified and justified these four challenges from the peer reviewed literature and against the following two simple criteria, namely 1) They are pervasive challenges through the EA literature and 2) They are likely to have continuing, or enhanced, relevance for megatrends. Although we accept these challenges as being important generic challenges for the purpose of this paper, we do recognise that they are not exhaustive and that other generic challenges and more context specific challenges might also exist which could be justified equally well. As one of our aims is to stimulate further research into the implications of megatrends for EA practice, this is a point we return to in the concluding section. As evidenced by our selection criteria, we also acknowledge that these challenges are not new, but we argue that in light of the megatrends they are elevated in importance. Finally, we acknowledge the interconnectedness of these challenges, for example, the potential implications of a more uncertain future (challenge 1) for efficiency (challenge 2) and dealing with significance (challenge 3), etc. However, the increased ability to share and disseminate information might also provide opportunities to improve communication towards better efficiency. Therefore, there are no simple answers and ultimately integrated solutions will probably have to be sought within context.

Our first challenge (complexity and uncertainty) is justified based on work by Bond et al. (2015) who argue that existing EA practice is poor at dealing with complexity and uncertainty, meaning that predictions can be plain wrong (e.g., Holling, 1978; Dipper et al., 1998; Bennett et al., 2001). Indeed, arguments are made that EA should include consideration of system resilience in order to better consider uncertainty (Benson and Garmestani, 2001; Slootweg and Jones, 2011; Matthews et al., 2014). Megatrends are characterised by certainty in terms of their occurrence, but uncertainty in terms of their implications.

The threat caused to EA by the global recession as highlighted by Bond et al. (2014), justifies our second challenge of efficiency. This challenge was also identified by a number of authors contributing to a special issue of Impact Assessment and Project Appraisal that examined the state of the art of different EA tools. In this, the need for efficiency to counteract the perceived threat to EA was identified in relation to EIA (Morgan, 2012), SEA (Fundingsland Tetlow and Hanusch, 2012) and Sustainability Assessment (Bond et al., 2012). We expect the drive for efficiency to remain as there is for example increasing competition for scarce resources (one of the megatrends).

Determining significance is a critical and recurring element in any form of EA, and is our third identified challenge. Screening and scoping both require judgements to be made on significance, and impact evaluation focusses on significance in context (of the sensitivity of the receiving environment). Thus it is a central concept in EA (Lyhne and Kørnøv, 2013). Significance methodology has been examined over the years (e.g., Thompson, 1990; Wood et al., 2007; Wood, 2008) but no consensus exists given the ambiguous nature of the term. The various megatrends may challenge our views of what the thresholds for significance judgement should be given the changing context of the environment (e.g. through climate change, diminishing resources, etc.).

Finally and in relation to our fourth challenge of communication and participation, the need to improve public participation in EA has been a key concern for years (e.g., Petts, 1999; O'Faircheallaigh, 2010, Esteves et al., 2012; Rega and Baldizzone, 2015) with some attempts at offering remedies (e.g., Renn et al., 1993; Sinclair and Fitzpatrick, 2002). In the context of power shifts and technological innovation in particular (two of the megatrends), we can anticipate increasing emphasis on the need for good public participation (e.g., Sinclair and Fitzpatrick, 2002; Partidario and Sheate, 2013).

We now move in the following sections to discussions on the implications of the megatrends for EA practice in relation to these four challenges.

1.2.1. Challenge 1: dealing with complexity and uncertainty

With a rapid increase in population, urbanization, interconnectedness and technological innovation at a scale beyond previous experience and/or comprehension, decision making complexity and

accompanying uncertainty is bound to increase. Therefore we suspect that prediction of events will become more uncertain and the events themselves will become more volatile and unpredictable, as already being experienced in relation to climate change (IPCC, 2014). Hence highly improbable events or so-called 'unknown unknowns' will likely become more frequent (Taleb, 2007). In short, because the future represents uncharted waters, using the past to predict the future will become increasingly problematic and challenging, especially within a technical rational and/or linear thinking paradigm typically reflected in EA practice to date (Owens et al., 2004; Bond et al., 2015).

When considering EA practice against a more complex and uncertain future, various issues arise. For example, it is unclear what the appropriate methodologies and techniques might be to ensure rigour, and what level and type of information and outputs would be practical. It has already been argued that current long term assessment techniques to deal with inherent complexity and uncertainty are overly resource intensive and impractical (Bond, 2015). Owens et al. (2004) referred to the 'trans-scientific' nature of complex issues in EA where science is unable to provide answers. The recommendation by Bond et al. (2015) that a post-normal understanding of science be followed where a lack of knowledge is assumed and made explicit during the EA process rather than disregarded is bound to be more appropriate for the future of EA best practice. The extent to which normal science will be able to provide conclusive answers amidst the uncertainty is questionable, and this again is an argument against the technical rational view of EA going into the future. There is also an argument that EA practice probably needs to embrace more systems thinking, in contrast with the linear thinking that dominates traditional EA practice (Nooteboom, 2007). A systems approach highlights that action A does not just cause impact B, but will have other effects on the system that may not be apparent through a linear thinking lens (what is typically termed 'side effects'), that can themselves have impacts on system behaviour (Sterman, 2000). Furthermore, linear approaches to EA fail to acknowledge that systems are dynamic, i.e. they exhibit behaviours over time that arise from their structure (Meadows, 2009). Concepts such as thresholds (or tipping points) and resilience are systems concepts that demand systems approaches, and increasingly are being recognised as important for best practice EA (e.g. Gunn and Noble, 2011, Slootweg and Jones, 2011). Linear thinking can only ever offer an approximation of a small part of a socio-ecological system, and while this can be adequate in some circumstances, we would argue that increased complexity and uncertainty in a more inter-connected and populous world demands a more rigorous systems-based approach to EA. This should include exploring system behaviour over time under different scenarios, and ongoing monitoring of key parameters as part of a robust adaptive management process (Grace and Pope, 2015).

Furthermore, being transparent by acknowledging limitations and difficulties will become more challenging because, with growing volatility and more 'unknown unknowns', EA practitioners might even be unaware which uncertainties exist. Therefore, work to date on dealing with complexity and uncertainty in specialised forms of EA such as Social Impact Assessment (SIA) (Marx, 2002) and Ecological Assessments (Geneletti et al., 2003), as well as quantitative mathematical methods to deal with uncertainty in relation to air and water pollution assessments (Spadaro and Rabl, 2008; Zhou et al., 2010), are likely in future to become even more difficult. Finally, because the future will become less predictable and therefore accuracy of prediction and rigour will become more elusive, it is also evident that adaptation will become more important and that practical ways of achieving and designing opportunities for adjustments, learning and iteration throughout the life cycle of the proposal will have to be found.

The apparent fixation within the EA community on information provision and overly structured processes needs to be tempered towards more flexible ('adaptive') value driven approaches to EA. In view of the megatrends and the challenge of dealing with complexity and uncertainty we identify the following implications for EA practice:

- *Accuracy of prediction*: because the future is increasingly less like the past EA practitioners cannot use the past as accurately to predict the future. For example, statistical analyses from the past such as mean annual run-off in rivers or 1:100 year floodlines, become meaningless under climate change extremes and shifting baselines. Also significantly affecting our ability to predict will be having to deal with a higher frequency of unexpected events or unknown unknowns, thereby magnifying uncertainty. These include those events which are not anticipated or even considered in the EA process, therefore going beyond the application of the precautionary principle, which acknowledges a possible event/impact but admits to insufficient information or understanding. One way of dealing with unknowns is to avoid linear thinking in favour of more systems understandings as explained previously. A better understanding of tipping points, thresholds and system resilience is also required to better understand the implications of events. Prediction should rather consider various possible future scenarios instead of a single predicted future and therefore scenario planning could become a more commonly used method in EA, as recommended by Duinker and Greig (2007).
- *Facilitative adaptation:* Tol (2005) writes about 'facilitative adaptation' which he equates to 'enhancing adaptive capacity'. The argument here is that adaptation should not be simply about responding to impacts *ex post*, instead it is possible to recognise that unforeseen impacts may occur and to plan for the capacity to adapt in those circumstances. We would argue that facilitative adaptation should become a key part of EA processes as it preserves the value of EA, rather than relegating it to an increasingly marginalised role where the ability to predict accurately decreases alongside increasing reliance on adaptation, which may not be economically viable if the capacity has not already been planned for. Consequently EA is not essentially about accuracy of prediction per se, but rather about allowing for flexibility and adaptation (adaptive management), a point made very early on in the development of EA by Holling (1978).

1.2.2. Challenge 2: dealing with efficiency

Due to the rate of change in terms of demographics, urbanization and technological innovation EA will function in a context of increasingly rapid change, notwithstanding that some of these changes have been occurring, and thus challenging EA practice, for some time already. By 2050 the world population is expected to have stabilised with urbanization at a level of 70% of the global population, while billions will have access to the internet for the first time. This means that in order for EA to add value, practitioners will have to manage increasing amounts of information increasingly efficiently in order to facilitate timely decision making. In practice EA is still very much fixated on legislative compliance and straightjacketed into procedural regimes that are not always designed to deal with increasing volumes of information in an efficient manner. The need for EA efficiency is frequently recognised, often driven by a better (meaning bureaucratically lighter) regulation agenda. Various governments are in the process of reconsidering their EA policy and legislation precisely to speed up decision making, cut "green tape" and 'streamline' authorization processes (Retief and Chabalala, 2009; Bond et al., 2014).

It is notable that the megatrends identified in the Sadler (1996) international EA effectiveness study included as a near-term trend, the increased pressure for process efficiency and fast-track approaches and methodologies. At that stage though it was seen primarily in relation to cost-recovery rather than a time saving issue as it is currently. The international EA best practice principles (IAIA and IEA, 1999) explicitly include the principle of 'efficiency' as well as four more supportive principles namely the requirement to be 'relevant', 'cost effective', 'focussed' and 'credible'. To be relevant and cost effective require that '…

sufficient, reliable and usable information …' be provided and that EA objectives be achieved within '… limits of available time, resources and methodology' (IAIA and IEA, 1999). In a rapidly changing world, especially in relation to advances in information technology, what will constitute sufficient, reliable and usable information in future as well as the notion of available time, resources and methodologies might change in ways that are currently difficult to predict or comprehend.

The megatrends therefore present the following implications for EA practice related to dealing with efficiency.

- *Ensuring procedural efficiency*: the implication of a fast changing world is that processes to inform decision making need to keep up with the rate of change. This means that EA practitioners need to find ways to deal with the two main reasons for having set process timeframes namely, to provide legal certainty to all role players and provide time for the information/scientific inputs to the decision making process, which will themselves need to be increasingly adaptive as argued previously. Where there are conflicting values, high levels of uncertainty and a general lack of trust in the system, decision making is slow and legal certainty (and limited allowance for flexibility) as well as the scientific justification are typically over emphasized (Retief et al., 2013). However, in order to deal with efficiency, ways will have to be found to simultaneously inject more trust and flexibility into the decision making process. Clearly, trust is not something that can be designed into a system. However, decision making flexibility can be provided through legal provisions which could significantly improve efficiency. Mechanisms enabling flexibility in EA will need to be supported and balanced in relation to human capacity as well as being appropriately transparent and accountable.
- *Information generation and management*: the ability to generate and disseminate information will improve significantly in the future. This presents opportunities to improve efficiency but also brings with it the threat of potentially reducing effectiveness through incorporation of unmanageable information loads. The challenge will therefore be to distil the most significant information for decision-making while at the same time moving towards more iterative decision-making, whereby EA practitioners constantly update the information and are able to rapidly change decisions if needed. Clearly, information generation and management is bound to become a particularly important consideration for EA efficiency in the future, while innovative information use will determine EA effectiveness in a rapidly changing world.

1.2.3. Challenge 3: dealing with significance

The analysis of the megatrends clearly shows that the future will be a world of growing demand for resources amidst increasing scarcity. Furthermore, the most recent update on the planetary boundaries(scientifically-based limits of human perturbation of the earth systems beyond which earth system functioning may be irreversibly altered), shows that humanity has already exceeded four of the seven primary earth system boundaries which include the two so-called core systems, namely the climate system and biosphere integrity (Steffen et al., 2015). EA best practice typically requires EA to concentrate decision making on the most significant environmental effects and key issues and deliver appropriate levels of environmental protection and community well-being (IAIA and IEA, 1999). The question therefore is, what would appropriate levels of environmental protection and community well-being be in the future, and how should EA practitioners define and determine significance and key issues in a world of acute scarcity and critical pressures on earth systems? Various authors have raised the issue that dealing with significance is one of the weakest aspects of typical EA practice (Wood, 2008; Ehrlich and Ross, 2015). These views have also been backed up by empirical studies on EA quality (e.g., Wang et al., 2003; Sandham et al., 2010, 2013). The main reasons put forward for the difficulties in dealing with significance is that it involves a value driven normative process of subjective judgements of what is important within any given society at a given point in time. As Haug et al. (1984) point out, there is a difference between predicting the *fact* of an impact (in terms of magnitude, duration, frequency, likelihood and reversibility) and the *meaning* of an impact. The meaning of impacts is about significance judgements.

In our view the implications of megatrends for dealing with significance in EA are the following:

- *Dealing with thresholds that support significance judgements*: generally speaking thresholds determine when impacts are significant i.e. within the realm of acceptable or unacceptable (Ehrlich and Ross, 2015). In a world of increasing scarcity, development options that continue to erode critical natural capital, and thereby reduce resilience, should therefore by definition be viewed as unacceptable. While this might suggest a return to more of a restoration and conservation focus for EA (Morrison-Saunders and Therivel, 2006), the ecosystem services concept (Geneletti, 2013) makes it clear that increasing scarcity has anthropogenic impacts which will increasingly come to the fore and threaten to exacerbate trade-offs between social and environmental impacts (Martín-López et al., 2014). Best practice EA will increasingly have to deal with significance judgements in relation to new proposals where existing thresholds, even without the proposal, have already been exceeded for various valued components.
- *Applying the mitigation hierarchy in tandem with facilitative adaptation*: when impacts have been identified as unacceptable then the next step in generic EA is to consider possible mitigation options to make the residual impact acceptable (Glasson et al., 2012; Ehrlich and Ross, 2015). However, in a world of increasing scarcity, applying and moving down the mitigation hierarchy from avoidance to minimization becomes problematic because by merely minimizing impacts, resources and natural capital are still being eroded further, a trend EA practitioners should be actively seeking to reverse. Therefore, the option of minimizing impacts needs to be substituted with thinking about enhancing benefits and no net loss or win-win outcomes, as already incorporated in sustainability assessment thinking (Gibson, 2006; Bond et al., 2013). Facilitative adaptation as already discussed should then be put in place to address the potentially significant impacts for which mitigation may prove to be ineffective when faced with the implications of the megatrends (Tol, 2005).

1.2.4. Challenge 4: dealing with communication and participation

The identified megatrends show that in future further development in communication technology, increased interconnectedness and rapid urbanization can be expected and collectively these have important implications for communication and participation in EA. The megatrends imply that people in general will become more connected and individually empowered through technology and have better access to services and education as they become more urbanized. EA best practice principles are explicit in the requirement to provide for participation in that EA should inform and involve interested and affected parties and that their inputs and concerns should be explicitly addressed in the documentation and related decision making (IAIA and IEA, 1999). The best practice principles also have extensive reference to information requirements. For example, IAIA and IEA (1999) specify that EA should:

i) Result in information and outputs which assist with problem solving and are acceptable to and able to be implemented by proponents (in relation to 'practical' principle),

ii) Provide sufficient, reliable and usable information for development planning and decision making (in relation to 'relevant' principle),

iii) Ensure public access to information (in relation to transparent principle) and

iv) Result in full consideration of all relevant information on the affected environment, of proposed alternatives and their impacts, and of

the measures necessary to monitor and investigate residual effects (in relation to systematic principle).

In view of the latter information requirements the implications of the megatrends for communication and participation in EA are the following:

- *The empowerment of individuals*: O'Faircheallaigh (2010) argues that dealing with power relations is one of the main purposes of public participation in EA. Morgan (2012) agrees with this view and highlights that through public participation EA provides the opportunity to shape and influence power relations in existing policy and decision making. Admittedly, the extent of public participation differs between different EA systems, but in future the empowerment of individuals through access to information, increased connectivity and proximity in cities could unavoidably lead to a more prominent and influential role being played by individuals. Assuming a more equal access to technology across all parts of society the disadvantage during participation processes typically experienced, for example, by rural communities as highlighted by Lastarnau et al. (2011) should become less common (although probably never totally eradicated). Both scenarios imply increased pressure on practitioners and decision makers to 'do the right thing' in the eyes of the affected individuals and communities. In short, people power will increasingly shape EA practice (at least in the context of nations where public participation in EA is already well established).
- *Communication management*: as noted previously, EA best practice places a particular emphasis on the role and importance of information in EA. The global availability of information in what is essentially an unregulated global space, presents various opportunities but also challenges. The opportunities clearly lie in providing improved access to information through various information technology options, while the challenges relate to the management of information to ensure that it is sufficient, reliable, and usable to decision makers. We therefore foresee a bigger role for information management in EA process design and communication strategies, which will have to be tailor made for particular contexts and EA systems. This realisation and resultant recommendations does not seem to have received much attention in the EA literature to date.

2. Concluding thoughts and future directions for EA research

In this paper, we have identified and discussed implications of six megatrends in relation to four challenges for EA practice. By way of conclusion, we return to the founding assumption of EA practice described in the first section which is that future development can be accurately anticipated and formally planned for. Amidst a more complex and uncertain future this assumption must be questioned. Moreover, the extent to which EA practitioners can accurately predict adverse future impacts and then mitigate these to a point where overall residual impacts are deemed acceptable is also becoming more doubtful, and less desirable in a world of scarcity where the expectation should increasingly be for net gain (or no net loss) EA outcomes. So the question that arises is: how should practitioners adapt EA, as an anticipatory mechanism, to remain effective in a world where the future is becoming less and less predictable? Further to the suggestions for EA practice made in the previous sections, we are of the view that the most promising approach is a shift in practitioners thinking towards the possibility of multiple possible futures of any one proposal because thinking of a predictable single future or outcome is unlikely to succeed. Methods like scenario planning and systems approaches referred to previously are well suited to this, along with the thinking and approaches underpinning resilience and sustainability assessment which we believe could further lead the way (Holling, 1978; Gibson, 2006; Bond et al., 2013). Facilitative adaptation should also become a core part of EA activity, on par with mitigation, to ensure there is resilience to unforeseen impacts in terms of the capacity to respond and adapt as needed.

Based on the limitations of the research methodology described in previous sections we recognise that neither the megatrends nor the challenges/implications for EA highlighted in this paper are exhaustive, and that there is much room to in future, with different methodological approaches and designs, change or expand the scope of research. For example, although this paper dealt with four specific challenges, we also recognise that there are other challenges that could form part of further future research, such as the implications of megatrends for cumulative effects assessment, effective implementation of EA mitigation measures as well as the consequences of the increasing global reach of certain impacts such as climate change for project level EA. Another important next step in progressing EA practice would be to explore specific strategies to deal with the implications of the megatrends. We have made various recommendation on different responses to the implications, but these need to be considered in more detail and translated into specific strategies. Identifying and formulating strategies would probably require a more context specific research approach, taking cognisance of local policy and understandings of EA.

Finally, the basic premise of EA of thinking about consequences before action is taken (Caldwell, 1989; Wood, 2003) will likely always be valid and even more so in future. We agree with Morgan (2012, p12) who states that *"The profile of EIA can only increase as concerns over issues such as climate change grow and communities and governments recognize the importance of true anticipatory mechanisms."* Therefore we are confident that EA will continue to serve a valuable role despite the global megatrends identified. However, we have reasoned that existing challenges posed for EA practice will be magnified and therefore methods employed by EA practitioners and expected outcomes must appropriately evolve to deal with the shifting demands of a rapidly changing world.

References

Adlard, R.D., Miller, T.L., Smit, N.J., 2015. The butterfly effect: parasite diversity, environment, and emerging disease in aquatic wildlife. Trends Parasitol. 31 (4), 160–166.

Arnell, N.W., Lowe, J.A., Brown, S., Gosling, S.N., Gottschalk, P., Hinkel, J., Lloyd-Hughes, B., Nicholls, R.J., Osborn, T.J., Osborne, T.M., Rose, G.A., Smith, P., Warren, R.F., 2013. A global assessment of the effects of climate policy on the impacts of climate change. Nat. Clim. Chang. 3 (5), 512–519.

Barber, B.R., 2013. If Mayors Ruled the World: Dysfunctional Nations, Rising Cities. Yale University Press, New Haven.

Bennett, D.H., Scheringer, M., McKone, T.E., Hungerbühler, K., 2001. Predicting long-range transport: a systematic evaluation of two multimedia transport models. Environ. Sci. Technol. 35 (6), 1181–1189.

Benson, M.H., Garmestani, A.S., 2001. Embracing panarchy, building resilience and integrating adaptive management through a rebirth of the National Environmental Policy Act. Environ. Manag. 92 (5), 1420–1427.

Bond, A., Morrison-Saunders, A., Pope, J., 2012. Sustainability assessment: the state of the art. Impact Assess. Proj. Apprais. 30 (1), 53–62.

Bond, A., Morrison-Saunders, A., Howitt, R., 2013. Sustainability Assessment: Pluralism, Practice and Progress. Routledge, London.

Bond, A., Pope, J., Morrison-Saunders, A., Retief, F., Gunn, J., 2014. Impact assessment: eroding benefits through streamlining? Environ. Impact Assess. Rev. 45, 46–53.

Bond, A., 2015. What is the role of impact assessment in the long term? J. Environ. Assess. Pol. Manag. 17 (1550006-1-1550006-6).

Bond, A., Morrison-Saunders, A., Gunn, J., Pope, J., Retief, F., 2015. Managing uncertainty, ambiguity and ignorance in impact assessment by embedding evolutionary resilience, participatory modelling and adaptive management. Environ. Manag. 151, 97–104.

Caldwell, L., 1989. Understanding impact analysis: technical process, administrative reform, policy principle. In: Bartlet, R. (Ed.), Policy Through Impact Assessment. Greenwood Press, New York.

de Jesus-Hitzachky, K.R.E., da Silveira, J.M.F.J., 2009. A proposed impact assessment method for genetically modified plants (AS-GMP Method). Environ. Impact Assess. Rev. 29, 348–358.

Diamandis, P., 2012. Abundance is Our Future available at http://www.ted.com/talks/peter_diamandis_abundance_is_our_future last accessed 14 September 2015.

Dipper, B., Jones, C., Wood, C., 1998. Monitoring and post-auditing in environmental impact assessment: a review. J. Environ. Plan Manag. 41 (6), 731–747.

Duinker, P.N., Greig, L.A., 2007. Scenario analysis in environmental impact assessment: improving explorations of the future. Environ. Impact Assess. Rev. 27 (3), 206–219.

EEA - European Environment Agency, 2015. Assessment of Global Megatrends — an Update available at http://www.eea.europa.eu/themes/scenarios/global-megatends (last accessed 12 September 2015).

Ehrlich, A., Ross, W., 2015. The significance spectrum and EIA significance determinations. Impact Assess. Proj. Apprais. 33 (2), 87–97.
Esteves, A.M., Franks, D., Vanclay, F., 2012. Social impact assessment: the state of the art. Impact Assess. Proj. Apprais. 30 (1), 34–42.
EY, 2015. Ernest and Young. Megatrends. Making sense of a world in motion, Ernest and Young Global, London, p. 2015.
FAO, IFAD and WFP, 2014. The state of food insecurities in the world 2014. Strengthening the Enabling Environment for Food Security and Nutrition. Food and Agricultural Organization, Rome.
Fundingsland Tetlow, M., Hanusch, M., 2012. Strategic environmental assessment: the state of the art. Impact Assess. Proj. Apprais. 30 (1), 15–24.
Lyhne, I., Kørnøv, L., 2013. How do we make sense of significance? Indications and reflections on an experiment. Impact Assess. Proj. Apprais. 31 (3), 180–189.
Geneletti, D., Beinat, E., Chung, C.F., Fabbri, A.J., Scholten, H.J., 2003. Accounting for uncertainty factors in biodiversity impact assessment: lessons from a case study. Environ. Assess. Rev. 23, 471–487.
Geneletti, D., 2013. Ecosystem services in environmental impact assessment and strategic environmental assessment. Environ. Assess. Rev. 40, 1–2.
Gibson, R., 2006. Sustainability assessment: basic components of a practical approach. Impact Assess. Proj. Apprais. 24 (3), 170–182.
Gibson, L., Lee, T.M., Koh, L.P., Brook, B.W., Gardner, T.A., Barlow, J., Peres, C.A., Bradshaw, C.J.A., Laurance, W.F., Lovejoy, T.E., Sodhi, N.S., 2011. Primary forests are irreplaceable for sustaining tropical biodiversity. Nature 478 (7369), 378–381.
Glasson, J., Therivel, R., Chadwick, A., 2012. Introduction to Environmental Impact Assessment. Routledge, London.
Grace, W., Pope, J., 2015. A systems approach to sustainability assessment. In: Morrison-Saunders, A., Pope, J., Bond, A. (Eds.), Handbook of Sustainability Assessment. Edward Elgar.
Gunn, J., Noble, B.F., 2011. Conceptual and methodological challenges to integrating SEA and cumulative effects assessment. Environ. Assess. Rev. 31, 154–160.
Hajkowicz, S.A., Cook, H., Littleboy, A., 2012. Our Future World: Global Megatrends That Will Change the Way We Live. The 2012 Revision. Commonwealth Scientific and Industrial Research Organization CSIRO, Australia.
Haug, P.T., Burwell, R.W., Stein, A., Bandurski, B.L., 1984. Determining the significance of environmental issues under the National Environmental Policy Act. Environ. Manag. 18, 15–24.
Holling, C.S., 1978. Adaptive Environmental Assessment and Management. Blackburn Press, New Jersey.
Howard, S., 2013. Let's Go All-In on Selling Sustainability available at http://www.ted.com/talks/steve_howard_let_s_go_all_in_on_selling_sustainability (last accessed 14 September 2015).
IAIA and IEA - International Association for Impact Assessment and Institute for Environmental Assessment UK, 1999m. Principles of Environmental Impact Assessment Best Practice available at http://www.iaia.org/publications-resources/downloadable-publications.aspx (last accessed 12 September 2015).
IEA – International Energy Agency, 2014. World Energy Outlook 2014. International Energy Agency, Paris.
Ilbury, C., Sunter, C., 2004. The Mind of a Fox – Scenario Planning in Action. Human and Rousseau Tafelberg Publishers, Cape Town.
IPCC, 2014. In: Core Writing Team, Pachauri, R.K., Meyer, L.A. (Eds.), Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.
Joshi, M., Hawkins, E., Sutton, R., Lowe, J., Frame, D., 2011. Projections of when temperature change will exceed 2 °C above pre-industrial levels. Nat. Clim. Chang. 1 (8), 407–412.
Kalnay, E., Cai, M., 2003. Impact of urbanization and land-use change on climate. Nature 423 (6939), 528–531.
KPMG International, 2012. Expect the Unexpected: Building Business Value in a Changing World. KPMG Global Centre of Excellence for Climate Change and Sustainability, Melbourne.
Lastarnau, C., Oyarzún, J., Maturana, H., Soto, G., Señoret, M., Soto, M., Rötting, T.S., Amezaga, J.M., Oyarzún, R., 2011. Stakeholder participation within the public environmental system in Chile: major gaps between theory and practice. Environ. Manag. 92 (10), 2470–2478.
Martín-López, B., Gómez-Baggethun, E., García-Llorente, M., Montes, C., 2014. Trade-offs across value-domains in ecosystem services assessment. Ecol. Indic. 37 (PART A), 220–228.
Marx, A., 2002. Uncertainty and social impacts: a case study of a Belgian village. Environ. Assess. Rev. 22, 79–96.
Matthews, E.C., Sattler, M., Friedland, C.J., 2014. A critical analysis of hazard resilience measures within sustainability assessment frameworks. Environ. Impact Assess. Rev. 48, 59–69.
McLeman, R., Smit, B., 2006. Migration as an adaptation to climate change. Clim. Chang. 76 (1–2), 31–53.
Meadows, D., 2009. Thinking in systems: A primer London: Earthscan.
Moore, G.E., 2006. Moore's law at 40. In: Brock, D.C. (Ed.), Understanding Moore's Law: Four Decades of Innovation. Chemical Heritage Press, Philadelphia, pp. 67–84 (ISBN 0-941901-41-6).
Morgan, R.K., 2012. Environmental impact assessment: the state of the art. Impact Assess. Proj. Apprais. 30 (1), 5–14.
Morrison-Saunders, A., Therivel, R., 2006. Sustainability integration and assessment. J. Environ. Assess. Pol. Manag. 8, 281–298.
Morrison-Saunders, A., Pope, J., Gunn, J., Bond, A., Retief, F., 2014. Strengthening impact assessment: a call for integration and focus. Impact Assess. Proj. Apprais. 32 (1), 2–8.
Nooteboom, S., 2007. Impact assessment procedures for sustainable development: a complexity theory perspective. Environ. Assess. Rev. 27, 645–665.
O'Faircheallaigh, C., 2010. Public participation and environmental impact assessment: purposes, implications, and lessons for public policy making. Environ. Impact Assess. Rev. 30 (1), 19–27.
Owens, S., Rayner, T., Bina, O., 2004. New agendas for appraisal: reflections on theory, practice, and research. Environ. Plan. 36, 1943–1959.
Partidario, M.R., Sheate, W.R., 2013. Knowledge brokerage - potential for increased capacities and shared power in impact assessment. Environ. Impact Assess. Rev. 39, 26–36.
Petts, J., 1999. Public participation and environmental impact assessment. In: Petts, J. (Ed.), Handbook of Environmental Impact Assessment - Vol.1 Environmental Impact Assessment: Process, Methods and Potential. Blackwell Science, Oxford, pp. 145–177.
Pope, J., Bond, A., Morrison-Saunders, A., Retief, F., 2013. Advancing the theory and practice of impact assessment: setting the research agenda. Environ. Impact Assess. Rev. 41, 1–9.
Porter, A., 1995. Technology assessment. In: Vanclay, F., Bronstein, D. (Eds.), Environmental and Social Impact Assessment. Wiley, Chichester, pp. 67–81.
PWC, 2014. Global Annual Review 2014 - Five global Megatrends continue to advance. PWC Global, New York.
PWC, 2015. 18th Annual Global CEO Survey. PWC Global, New York.
Rega, C., Baldizzone, G., 2015. Public participation in strategic environmental assessment: a practitioners' perspective. Environ. Impact Assess. Rev. 50, 105–115.
Renn, O., Webler, T., Rakel, H., Dienel, P., Johnson, B., 1993. Public participation in decision making: a three step procedure. Policy. Sci. 26 (3), 189–214.
Retief, F., Chabalala, B., 2009. The cost of environmental impact assessment (EIA) in South Africa. J. Environ. Assess. Pol. Manag. 11, 51–68.
Retief, F., Morrison-Saunders, A., Geneletti, D., Pope, J., 2013. Exploring the psychology of trade-off decision making in EIA. Impact Assess. Proj. Apprais. 31 (1), 13–23.
RF and GBN - Rockefeller Foundation and Global Business Network, 2010t. Scenarios for the Future of Technology and International Development. Rockefeller Foundation, New York.
Russell, A.W., Vanclay, F.M., Aslin, H.J., 2010. Technology assessment in social context: the case for a new framework for assessing and shaping technological developments. Impact Assess. Proj. Apprais. 28 (2), 109–116.
Sadler, B., 1996. International Study of the Effectiveness of Environmental Assessment - Final Report: Environmental Assessment in a Changing World: Evaluating Practice to Improve Performance. Minister of Supply and Services, Ottawa.
Sandham, L., Carrol, T., Retief, F., 2010. The contribution of environmental impact assessment (EIA) to decision making for biological pest control in South Africa – the case of *Lantana camara*. Biol. Control 55, 141–149.
Sandham, L., Van Heerden, A., Jones, C., Retief, F., Morrison-Saunders, A., 2013. Does enhanced regulation improve EIA report quality? Lessons from South Africa. Environ. Impact Assess. Rev. 38, 155–162.
Sheate, W.R., 2010. Tools, Techniques and Approaches for Sustainability: Collective Writings in Environmental Assessment Policy and Management. World Scientific, Singapore.
Shrader-Frechette, K.S., 1985. Science Policy, Ethics, and Economic Methodology: Some Problems of Technology Assessment and Environmental-Impact Analysis. D. Reidel Publishing Company, Dordrecht.
Sinclair, A.J., Fitzpatrick, P., 2002. Provisions for more meaningful public participation still elusive in proposed Canadian EA Bill. Impact Assess. Proj. Apprais. 20 (3), 161–176.
Slootweg, R., Jones, M., 2011. Resilience thinking improves SEA: a discussion paper. Impact Assess. Proj. Apprais. 29, 263–276.
Spadaro, J.V., Rabl, A., 2008. Estimating the uncertainty of damage costs of pollution: a simple transparent method and typical results. Environ. Assess. Rev. 28, 166–183.
Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., De Vries, W., De Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B., Sörlin, S., 2015. Planetary boundaries: guiding human development on a changing planet. Science 347 (6223), 736–753.
Sterman, J., 2000. Business Dynamics: Systems Thinking and Modeling for a Complex World. Irwin Professional/McGraw–Hill, New York.
Sunter, C., 2013. 21st Century Megatrends – Perspectives from a Fox. Human and Rousseau Tafelberg Publishers, Cape Town.
Taleb, N.N., 2007. The Black Swan. Random House, New York.
Thompson, M.A., 1990. Determining impact significance in EIA: a review of 24 methodologies. Environ. Manag. 30, 235–250.
Tol, R.S.J., 2005. Adaptation and mitigation: trade-offs in substance and methods. Environ. Sci. Pol. 8 (6), 572–578.
UNFPA, 2014. State of World Population 2014: The Power of 1,8 Billion Adolescents, Youth and the Transformation of the Future. United Nations, New York.
Habitat, U.N., 2012. State of World's Cities 2012/13: Prosperity of Cities. United Nations, New York.
Habitat, U.N., 2014. State of Africa's Cities 2014: Re-Imagining Sustainable Urban Transitions. United Nations, New York.
Vielmetter, G., Sell, Y., 2014. Leadership 2030: The Six Megatrends you Need to Understand to Lead Your Company into the Future. Amacon Books, Saranac Lake New York.
Wang, Y., Morgan, R.K., Cashmore, M., 2003. Environmental impact assessment of projects in the People's Republic of China: new law, old problems. Environ. Impact Assess. Rev. 23 (5), 543–579.
WB – World Bank, 2015. International Debt Statistics 2015. World Bank, Washington.
Wood, C., 2003. Environmental Impact Assessment: A Comparative Review. Harlow, Prentice Hall.
Wood, G., 2008. Thresholds and criteria for evaluating and communicating impact significance in environmental statements: 'see no evil, hear no evil, speak no evil'? Environ. Impact Assess. Rev. 28 (1), 22–38.

Wood, G., Rodriguez-Bachiller, A., Becker, J., 2007. Fuzzy sets and simulated environmental change: evaluating and communicating significance in environmental impact assessment. Environ. Plan. 39, 810–829.

WRG – Water Resources Group. Charting Our Water Futures: Economic Frameworks to Inform Decision Making. http://www.google.co.za/url?sa=t&rct=j&q=&esrc=-s&source=web&cd=2&ved=0-CCIQFjABahUKEwjdkKqf8vXHAhXRCNsKHeQwDoQ&url=-http%3A%2F%2Fwww.mckinsey.com%2F~%2-Fmedia%2Fmckinsey%2Fdotcom%2Fclient_service%2Fsustainability%2Fpdfs%2Fcharting%2520our%2520water%2520future%2Fcharting_our_water_future_full_report_.ashx&usg=AFQjCNG0-CWY1sfYzmHfNHbOyZrT0Hq32A&sig2=UBb47f6jvT3GzEjgg6m_uA, 2009. (last accessed 14 September 2015).

Zhou, J., Liu, Y., Chen, J., 2010. Accounting for uncertainty in evaluating water quality impacts of urban development plan. Environ. Assess. Rev. 30, 219–228.