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Factor analysis and structural equation modelling of sustainable behaviour in contaminated land remediation

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ABSTRACT

Contaminated land remediation has traditionally been viewed as sustainable practice because it reduces urban sprawl and mitigates risks to human being and the environment. However, in an emerging green and sustainable remediation (GSR) movement, remediation practitioners have increasingly recognized that remediation operations have their own environmental footprint. The GSR calls for sustainable behaviour in the remediation industry, for which a series of white papers and guidance documents have been published by various government agencies and professional organizations. However, the relationship between the adoption of such sustainable behaviour and its underlying driving forces has not been studied. This study aims to contribute to sustainability science by rendering a better understanding of what drives organizational behaviour in adopting sustainable practices. Factor analysis (FA) and structural equation modelling (SEM) were used to investigate the relationship between sustainable practices and key factors driving these behaviour changes in the remediation field. A conceptual model on sustainability in the environmental remediation industry was developed on the basis of stakeholder and institutional theories. The FA classified sustainability considerations, institutional promoting and impeding forces, and stakeholder's influence. Subsequently the SEM showed that institutional promoting forces had significant positive effects on adopting sustainability measures, and institutional impeding forces had significant negative effects. Stakeholder influences were found to have only marginal direct effect on the adoption of sustainability; however, they exert significant influence on institutional promoting forces, thus rendering high total effect (i.e. direct effect plus indirect effect) on the adoption of sustainability. This study suggests that sustainable remediation represents an advanced sustainable practice, which may only be fully endorsed by both internal and external stakeholders after its regulatory, normative and cognitive components are institutionalized.

1. Introduction

From the 1987 Brundtland Report (Brundtland, 1987), to the 2012 Rio Earth Summit (UN, 2012), sustainability has become a key word in modern culture. It has drawn a massive increase of attention in political societies, as well as scientific research communities (Kates et al., 2000; Levin and Clark, 2010; Bettencourt and Kaur, 2011). Defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987), sustainability requires the reconciliation of environmental, social and economic demands – the "three pillars" of sustainability (United Nations, 2005). Sustainability science is considered a new research field which is "extraordinarily multidisciplinary", primarily drawing from social science, biological science, and engineering (Kates, 2011). A key task of this new sustainability science field is to better understand human–environment interactions, more particularly, human behaviour patterns in the ongoing sustainability movement and the underlying driving forces (Mihelcic et al., 2003). Enhanced scientific knowledge in this spectrum can assist researchers to provide long-term projections of complex human–environment systems (HES), and benefit policy makers who are tasked to improve the adaptability and resilience of human society as a whole (Hou, 2011; Hou et al., 2012a,b).

While research on the impact of individual consumer behaviour on sustainability is drawing increasing attention (Gatersleben et al.,

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2002; Verbeke et al., 2007), the study of organizational behaviour on sustainability is still of paramount importance. Many existing studies have explored corporate social and environmental performance and the organizational adoption of sustainability from stakeholder and institutional perspectives because they can translate intangible social and environmental issues into tangible organizational interests (Clarkson, 1995; Cordano and Frieze, 2000; Sharma and Henriques, 2005; Freeman et al., 2010; Garvare and Johansson, 2010). Some other studies have examined the impact of individual managerial behaviour on corporate social and environmental behaviour (Ramus and Steger, 2000; Ramus, 2001; Jabbour and Santos, 2008). The present study intends to investigate how sustainability practices are adopted in contaminated land remediation under the influence of various stakeholders and institutional forces. We target a single industry context (i.e. the environmental remediation industry), which provides a unique opportunity to explore future development of sustainability practices. The contaminated land remediation industry is unique for a number of reasons: 1) multiple stakeholders are deeply involved in decision making, providing an opportunity to study enhanced stakeholder interactions; 2) nearly all practitioners in this field have received a certain level of training in environmental science, therefore awareness of the general sustainability concept is not an issue; and 3) as remediation itself is generally considered a sustainable practice, this industry has a potential to progress to advanced sustainability practices. In addition, remediation can broadly represent infrastructure engineering projects, which are less frequently studied than corporate operation in both sustainability science and management science. Study on this subject can broaden the scientific knowledge base of a number of relevant research topics such as sustainable engineering and sustainable infrastructure.

Contaminated land remediation deals with the removal or control of contaminants from polluted environmental media (e.g. soil, groundwater and sediment) in or under a land site, to protect human health and the environment. The contaminated material can be removed from its original place and then treated to remove the contaminants (i.e. ex-situ treatment) and/or treated at its original place (i.e. in-situ treatment). An array of physical, chemical, and biological processes can be used in both ex-situ and in-situ treatment. Contaminated land remediation emerged in the 1970s and has grown from a niche field to a burgeoning industry within the span of a few decades. During recent years, the adoption of sustainability is becoming a new trend in environmental remediation practices, especially in the US and Europe (CLARINET, 2002a,b; NICOLE, 2002, 2005, 2008; USEPA, 2008; AFCEE, 2010; Surf-UK, 2010; USACE, 2010; NAVFAC, 2011; Hou et al., 2014). There are strong demands for sustainable remediation from both the industry and governments. Subsequently we have seen increasing usage of sustainability in decision making in the remediation field. However, it is unclear how various sustainability considerations are perceived and adopted, and what forces are driving this sustainability movement. In the present study, a questionnaire survey was conducted to collect information regarding the sustainability practices of remediation practitioners. Responses were received from participants in 16 countries, primarily from the US, the UK, and China. The multivariate relationship among stakeholder influences, institutional promoting and impeding forces, and sustainability practices was examined. This study attempts to link sustainability practices with stakeholder influence and institutional forces with a parsimonious and structural understanding. The objective of this study is to measure the impact of stakeholder influence and institutional promoting/impeding forces on the adoption of sustainable practices, which is a crucial question to both HES researchers and policy makers.

2. Theoretical framework

Environmental remediation involves a wide range of stakeholders with possibly conflicting perspectives and objectives (Sullivan et al., 2001). The stakeholders impose institutional coercive and normative pressures on organizations and influence their environmental management practice (Delmas and Toffel, 2004). Some existing studies have examined the attitude, action and interaction of stakeholders and various institutional pressures as they relate to remediation practices. Doak and Karadimitriou developed an actor network around brownfield regeneration, and argued that network schemata (e.g. decision making rules and techniques) are applied based on past experience, and the schemata is revised with practice experience which feeds back into the network system through corporate accounts, individuals' lived experience, professional meetings, and academic studies, etc (Doak and Karadimitriou, 2007). Catney et al. found that the UK failed to pass a remediation legislation in the early 1990s due to resistance from lobby groups representing property interests (Catney et al., 2006). In general, it is evident that stakeholders act in a broad socioeconomic and public policy context, which affects decision making in remediation as well as sustainable practices. For instance, Dixon found that there is a large degree of scepticism from key stakeholders regarding the incorporation of sustainability within brownfield regeneration projects (Dixon, 2007a). Land developers are increasingly willing to hold contaminated sites in their land banks and conduct new development on such brownfield sites, mainly due to lack of land and government policy encouraging brownfield redevelopment (Dixon, 2007b). However, the new EU Landfill Directive may discourage such a trend because this new directive makes it harder to implement "dig and dump", the most frequently used technology in dealing with contamination. On the other hand, alternative treatment technologies, such as solidification/stabilisation and soil vapour extraction and other more sustainable methods of remediation, may gain additional usage in this regulatory context.

A number of studies have also particularly examined stakeholder involvement and public participation in remediation. For instance, a questionnaire survey conducted by Eiser et al. found that local residents' trust with contaminated land management practices arises from local council's perceived openness and motives, rather than their perceived knowledge or expertise (Eiser et al., 2007). Similarly a case study by Sparrevik et al. found that transparency was a critical factor in stakeholder risk perception (Sparrevik et al., 2011). Wolfe et al. argued that technology acceptability, as a social decision-making dimension, affects whether and when proposed hazardous waste remediation technologies would be considered as serious options (Wolfe et al., 2003). Senier et al. further proposed that, "in the broadest possible eco-social sense, remediation ought to restore a community's sense of wholeness, safety, and integrity". They also found that academic researchers can potentially bridge the gaps between community groups and state regulators (Senier et al., 2008). These studies tend to focus on stakeholder involvement and public participation as a social objective, however, with limited attempt to use stakeholder influence and institutional pressures to explain observed decision making patterns in remediation practices. There is also a general lack of a quantitatively structured model in explaining such phenomena. Therefore, this study attempts to make an innovative contribution by establishing a structural equation model (SEM) to link sustainable practices in remediation with stakeholder influence and institutional pressures.

A hypothetical model is established, as shown in Fig. 1, based on the literature review. The theoretical underpinnings are stakeholder theory and institutional theory. Stakeholder theory is an

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