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A quantitative evaluation of the sustainability or unsustainability of three tunnelling projects

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ABSTRACT

There is a perception that tunnelling is sustainable. This is because it occurs underground, and consequently does not significantly interfere with surface or atmospheric processes unlike other anthropogenic activities. However, the tools and assessments used in tunnelling projects to evaluate sustainability in the construction and operational phases are primarily concerned with the reduction of carbon footprint and environmental performance. This does not provide a suitable approach to determining the sustainability of a tunnelling project directly. Environmental Impact Assessment (EIA) on the other hand does have this potential. However, it requires two things: (1) a suitable quantitative-based method of EIA; and most critically and (2) a means to evaluate sustainability from the EIA results. Based upon the recent work of Namin et al. (2014) concerning a new EIA methodology for tunnelling projects, this paper applies an established mathematical model of sustainability to the results of the EIA to determine the sustainability or unsustainability of tunnelling projects. The model's application, in the form of an algorithm, evaluates three case studies assessed by Namin et al. (2014). The results are analysed and discussed in respect to the three projects' construction and operation phases. The broader context of the results is then discussed in respect to the use of underground space as a means to achieve sustainability.

1. Introduction

1.1. Tunnels and sustainability

Sustainability is not only about activities and impacts which occur on the surface and/or in the atmosphere – it is concerned with everything associated with the planet Earth. From the perspective of sustainability science, which this paper adopts, sustainability is concerned with how to manage the relationship between the environment and humans (via social and economic activities or issues) at all spatial–temporal levels. As Schellnhuber (1998, 1999, 2001) has argued, since the Industrial Revolution, humans now have the ability to act with the same force and effect as the environment in enacting change. Therefore, managing this change and its subsequent impacts, and ensuring a co-evolutionary relationship, is necessary if the environment and humans are going to exist. Recent work by Rockström et al. (2009a, 2009b) and Dearing et al. (2014) have highlighted the importance of the thresholds of the environment at the global and regional levels respectively, and humanity not breaching them. If such thresholds were breached, then this poses significant risks to humanity and our potential survival. Hence, sustainability is concerned with ensuring that humans develop a co-evolutionary relationship with the environment, by working within the thresholds of the system.

The problem however has been that humans have tended to use only what they see in their immediate field of vision when meeting their needs. Nevertheless, the significant developments in science and technology have allowed humans to go further on the surface, to travel in the atmosphere, and to go into space. However, the untapped and uncharted worlds of the deep oceans and deep underground have only been really possible in the last century or so. Due to this, new worlds and possibilities are now capable of being explored and utilised, and to which underground space can contribute towards a more sustainable future for humans. Underground space is considered as not only a means to meet certain needs of human society, but perhaps a way of contributing towards the meeting of the fundamental needs of human society. Tunnels within this context may very play an important part in such a sustainable future, as alluded to by Bobylev (2006, 2011). This is because, as Guertin (1996, p3) states, tunnels "*will play an important role in a sustainable future by providing necessary infrastructure. . .while minimizing surface impacts*". They already provide a critical role in urban environments through the transportation of clean and waste water, and significantly reducing urban congestion

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(Parker, 1996), and in the conveyance of cables used in communications. Therefore, these reflect the most common uses of tunnels: utilities and transport (Bobylev, 2009). However, tunnelling projects do cause impacts to both the environment and humans, which can influence the nature and level of sustainability capable of being achieved. Namin et al. (2014) outlined the environmental and socio-economic aspects and impacts of tunnel design, construction and operation, which is illustrated in Fig. 1.

The contention that tunnels are inherently sustainable is based upon their contribution in the mitigation and adaptation to climate

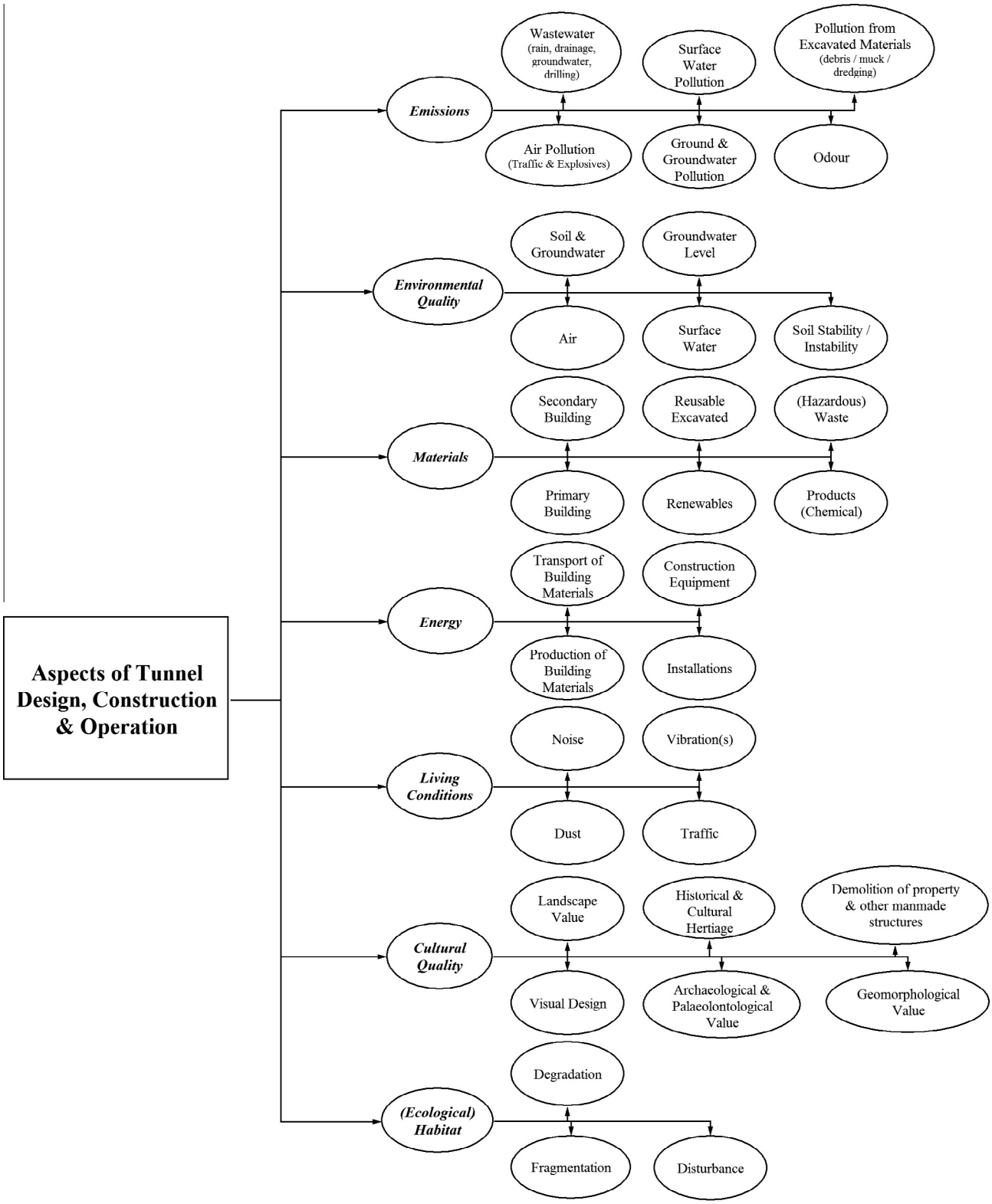

Fig. 1. Environmental and socio-economic aspects of tunnel design, construction and operation, based on and adapted from Namin et al. (2014).