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Geotechnology in harmony with the global environment: dream or deliverable?

La Géotechnique en Harmonie avec l'Environnement: un rêve ou une réalité?

Stephan A. Jefferis
Environmental Geotechnics Ltd and The Centre for Environmental Strategy, University of Surrey, Guildford, England, GU2 7XH

ABSTRACT
This paper addresses issues raised by the sub-title of the conference "Geotechnology in harmony with the global environment" and considers how harmony may be assessed. It is argued that harmony with the environment cannot be achieved without sustainability and therefore sustainability must be considered as a first step. An attempt is made to develop a procedure to assess sustainability using life cycle assessment as a model and taking into account human values.

RÉSUMÉ
Cette communication concerne les principes contenus dans le sous-titre de la conférence "La Géotechnique en Harmonie avec l'Environnement" et considère la possibilité d'évaluer le concept d'harmonie. On ne peut pas atteindre harmonie avec l'environnement sans développement durable et donc le développement durable doit être évalué en premier. L'auteur élabore un procédé d'évaluation pour le développement durable prenant comme modèle le procédé d'évaluation du cycle de vie (ÉCV) et prenant aussi en compte les valeurs humaines en cause.

1 INTRODUCTION

The sub-title for this conference is "Geotechnology in harmony with the global environment". Whilst it is important that geotechnical engineers should understand and minimise their impact on the environment, one must question whether as a profession we can yet offer a coherent vision as to what is meant by harmony with the global environment and how it might be assessed. Challenges include:

- Peoples: recognising their diverse visions and perspectives;
- Time: ideas of harmony have and will change over time;
- Place: recognising the diversity of geography and climatic conditions;
- Acceptance: (Jesinghaus (2000) states 'an index that tells people what should be really important for them is bound to fail – there is no shortage of attempts to tell people what they have to do';
- Utility: can harmony (or indeed sustainability) become a quantifiable driver for change in the built environment?
- Limitations: are the uncertainties and limitations any assessment clearly identified and not so manifold that the results can be easily dismissed?

This paper will try to establish a framework for assessment that is appropriate both for the individual geotechnical engineer and at the level of an international society such as the ISSMGE.

As a first step, it is useful to question the relationship between harmony and sustainability. Sustainability is a concept that we are beginning to understand but for which we have no agreed delivery procedures. If harmony is to be achieved across the world, now and for future generations it is a stricter criterion than sustainability. However, we can say that harmony cannot be achieved on a project that is not sustainable and thus the first step is to work towards more sustainable geotechnical engineering. At the ISSMGE, Fourth International Congress on Environmental Geotechnics the author analysed some of the tenets of sustainability in relation to geotechnical engineering and contaminated land (Jefferis, 2002). This included consideration of economic, social and environmental-technical issues, industrial ecology and supply chain analysis.

2 WHAT DO WE UNDERSTAND BY SUSTAINABILITY?

The Bruntland statement on sustainability is perhaps the most often cited definition of sustainability (World Commission on Environment and Development, 1987):

> 'Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs'.

However, this definition focuses on inter-generational equity and does not specifically address intra-generational equity. It is important to remember Indhira Ghandi's words at the Stockholm summit in 1972 'of all the pollutants we face, the worst is poverty. We want more development' (quoted in Anon, 1992). A more economics-focused definition of sustainability is 'non-declining capital' (Pearce, 1989). The various forms of capital are analysed by Hawken et al (1999):

- human capital, in the form of labour and intelligence, culture, and organization;
- financial capital, consisting of cash, investments, and monetary instruments;
- manufactured capital, including infrastructure, machines, tools, and factories;
- natural capital, made up of resources, living systems, and ecosystem services.

From consideration of the various forms of capital, definitions of strong and weak sustainability can be advanced (Dresner, 2002). Strong sustainability requires non-declining natural capital (impossible in the world today, for example, consider the use of oil). Weak sustainability allows human-made capital to substitute for natural capital. If the Bruntland statement is considered in the light of the above four capitals, it can be interpreted as requiring that we manage ourselves so as to allow future generations to have their share of all the capitals and not just natural capital. That is we have a responsibility to balance what we pass on. Could an undue focus on natural capital deny future generations key infrastructure capital?

Furthermore, in developing an operational definition of sustainability we must recognise that we live in a world of finite resources (capitals). The engineer has a fundamental role in properly managing each of the capitals. Wasting any of them makes the world less sustainable.

3 THE IMPACT OF THE GEOTECHNICAL ENGINEER

Geotechnical engineers have the potential for major impacts on the environment. Often they will be involved in site selection for major infrastructure works, large movements of soil with matching large energy consumption and the use of substantial amounts of raw and man-made materials. These impacts are an inevitable consequence of the work but the scale of the impacts becomes stark if environmental impact is considered as a function of added value (see Figure 1, Clift and Wright, 2000).

Geotechnical projects are often undertaken with constrained budgets so not only is the environmental impact high but the added value low compared with, for example, a worker in a service industry. However, service industries cannot exist without the work of the geotechnical engineer and analysis of the whole supply chain is key. Those higher up the chain 'buy in' their environmental impact from those lower down the chain. To reduce the overall environmental impact, the higher members of the chain must be persuaded to spend some of the added value that they create to reduce the impact generated by those lower down the chain.

A good example of this is in the management of the use of hardwoods. Many companies will not now use or sell hardwoods that do not come from sustainable forestry even if this leads to higher costs. Reducing wood use is not effective; ensuring that the wood that is used is sustainably produced is the key issue. It follows that reducing geotechnical activity will not improve sustainability. Better geotechnical practice will help but ultimately the greatest reduction in impact will be achieved when those higher up the chain recognise that they buy in their environmental impact and that they can achieve the greatest reductions in the total impact by recycling some of their added value to activities lower down the supply chain. This points towards the radical conclusion that the geotechnical engineer should refuse to work on projects where the funding is insufficient to provide a sustainable (and harmonious) solution.

Such action cannot be effective individually but as the international geotechnical society, we should be aware that collective action may be essential if we are to be the foundation for "harmony with the global environment". For this, the human challenges may prove to be much more demanding than the technical challenges but it should be noted that others including the mining industry are already addressing them.

Figure 1 shows environmental impact as a function of financial value added. However, financial value does not fully represent the benefits derived from geotechnical work.

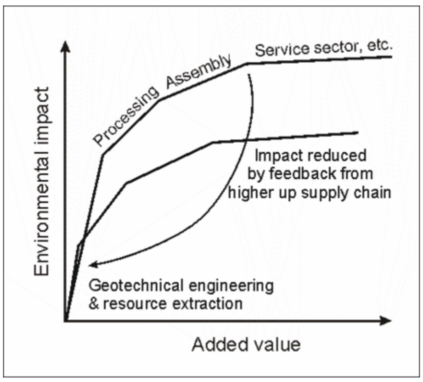

Figure 1: the environmental impacts of geotechnical engineering

The social benefits also must be considered (it can be justly argued that the whole built environment is founded on geotechnical engineering). It is therefore essential that in any assessment of the impact of the geotechnical engineer we give full credit for the social benefits i.e. that we consider sustainability.

In an attempt to identify a common procedure for the assessment of sustainability, it is useful to draw parallels with the Life Cycle assessment procedures. This helps to define the key steps and clarify the separation between data which will be constant regardless of where in the world it is collected and by whom and interpretation which is based on human values.

4 LIFE CYCLE ASSESSMENT

British Standard BS EN ISO 14040: 1997 states that Life cycle assessment (LCA) is 'a technique for assessing the environmental aspects and potential impacts associated with a product. LCA studies the environmental aspects and potential impacts throughout the life cycle of a product from raw material acquisition through production, use and disposal'. The Standard continues 'LCA can assist in:

- identifying opportunities to improve the environmental aspects of products at various points in their life cycle;
- decision-making in industry, governmental or non-governmental organizations (e.g.. strategic planning, priority setting, product or process design or redesign):
- selection of relevant indicators of environmental performance, including measurement techniques; and
- marketing (e.g. an environmental claim, ecolabelling scheme or environmental product declaration)'.

LCA provides a formal and structured procedure by which environmental impacts can be quantified but a substantial amount of detailed information is always essential if transparent, auditable assessments are to be achieved. Harmony and sustainability will require yet more detail as LCA does not consider social factors.

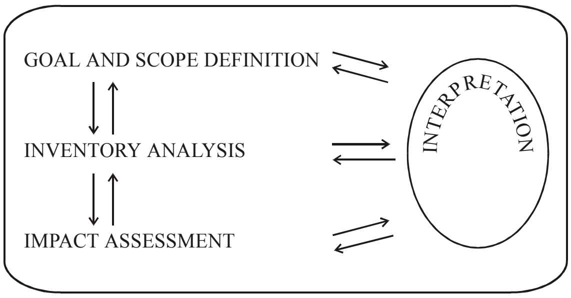

Figure 2 Key elements of LCA

The key elements of an LCA are shown in Figure 2 and are discussed below with their possible relationship to sustainability assessment. Development of an LCA should be an iterative process considering the four elements identified in Figure 2.

4.1 *Goal and scope definition*

Defining the purpose is a key first step of an LCA and requires careful consideration of: for whom is the LCA to be carried out and for whom are the results meant; the subject of the study (the functional unit) and the level of detail required. The functional unit is the product which is to be studied. For example, for a geotechnical project the functional unit could be to provide the foundations for a building (especially if the LCA is undertaken by/for geotechnical engineer). At a larger scale and perhaps for a project manager it could be the building plus its foundations. If carried out for a community it could be the whole development. The larger the scale the greater will be the difficulty in obtaining sufficient data and in interpreting the results. The other key steps in goal and scope definition are:

- Definition of the system boundaries;
- Definition of data requirements, including an estimate of the variability associated with the data;
- Assumptions in the study and limitations of the results;
- Identification of impact categories to be
- Determination of the relevant requirements for reporting and peer review.

The system boundaries define the scope of the study. In sustainability assessments, it will be key to define these boundaries – especially in relation to social impacts but it may be particularly difficult. As a result, system boundaries may end up being influenced by personal preferences rather than purely data considerations.

For sustainability, goal definition and scope definition is a key step. Sustainability should not be offered as an argument for action or inaction unless there is a clear statement of the goal and scope of the analysis. .

4.2 *Inventory analysis*

This forms the core of LCA and also can form the core of sustainability assessments. It includes the following stages:

- Development of the process flow chart;
- Collection of the data including on trace emissions as they may have large environmental impact;
- Processing the data.

For an LCA the process flow chart will define what is being produced and the major materials and emissions flows across the system boundary (note for sustainability activities within the system boundary also will have to be considered). For the construction of a foundation pile the process could involve energy inputs for excavation and materials production (e.g. cement production), winning of aggregates for concrete, disposal of arisings from the excavation (these may be used elsewhere in the development and therefore it may be necessary to allocate the environmental burdens between the various components of the development).

Data collection is often a major operation though there is now a considerable body of generic data in the literature and databases/software.

Processing the data involves converting the gathered data into a convenient form for analysis.

4.3 *Interpreting the results*

The first step in interpreting the results requires input on the environmental impacts to be assessed. In LCA there is a developing consensus as to the impacts to be considered. These include parameters such as global warming potential, acidification and photo-oxidant formation. It is important to note that the selection of the list of indicators can influence the outcome of the analysis and thus the geotechnical engineer should carefully consider the indicators used in any sustainability assessment – there is a need to develop sustainability indictors across the geotechnical community (N.B. data collection should precede indicator selection to avoid selectivity in collection).

Once the impacts have been calculated it may be appropriate to normalise them by local, national or world production to give an indicator of relative contribution – though this will not be necessary if the goal of the assessment is comparison of alternative solutions / procedures which perform the same function.

If a single score is required, then weightings can be assigned to each of the indicators and the total aggregated to give an overall score. However, it is important to understand that weightings are not absolute but subjective depending on the individual, group, stakeholders etc. who developed them. They will vary between different peoples and different geographical regions. The degree to which indicators are aggregated should be related to the audience for the results. It may be appropriate to present the same data in different degrees of aggregation within a company, to clients, to project stakeholders, to the local community or to the financial community in a company annual report. All representations will use the same data – the only difference will be the degree of aggregation. However, the greater the degree of aggregation the greater the loss of transparency and the potential for it to be a tool for misinformation. The important point is that the implied sustainability or unsustainability of a project should not change with how the data are presented.

5 SUSTAINABILITY ANALYSIS

The above analysis of the basics of LCA has been presented to demonstrate that LCA is an analytical process capable of definition in an international standard. Parts of the process such as data collection can be objective and user independent but goal and functional unit definition will be subjective to the assessor as will be the selection of environmental indicators and weightings used in their aggregation (valuation), if this step is used in the LCA. From the LCA example, essential steps in a sustainability analysis are:

- Goal and scope definition – establishing the perspective – why are we doing it and for whom?
- Functional unit definition (allows data to be collected and related to a common process).
- Inventory analysis (including process flow charting, data collection and selection of indicators).
- Interpreting the results including aggregation and valuation as necessary to provide the data in the form the user needs but recognising that there will be a loss of transparency.

The indicators for sustainability require careful consideration. For the environmental circle, (see Figure 3) all the indicators common for LCA may be used. For the social circle, indicators might include new jobs, secured jobs, amenity, cleaned land, recreation, local investment.

For the econocentric circle, a key issue will be the discount rates used in financial assessments of future benefits and harms. By choice of discount rate, the financial value of future benefits or of damage from future harms may be manipulated to make them utterly trivial or totally overwhelming – a serious issue when considering inter-generational equity (see also Portney and Weyant, 1999).

If similar processes to LCA are followed for the development of data for each of the environmental (technocentric), econocentric and sociocentric aspects of sustainability then the sustainability assessment process becomes as shown in Figure 3.

From Figure 3, it follows that assessment of sustainability cannot be a purely mathematical / data analysis process. There must be inputs regarding what indicators to use and the weightings given to them in any valuation, recognising that these weightings will affect decisions based on the assessment, for example, in comparative studies of alternative projects (the weightings make the decision, it is impossible both democratically and consistently to aggregate individual preferences in a plural society, Arrow, 1963).

The circles show the influence of each of the three main components of sustainability. The figure is often interpreted as a Venn diagram with the zone of sustainability at the intersection of the three circles. Jefferis (2002) argues that it is not possible to identify the zone of sustainability with present sustainability analysis tools. However, the procedures can be useful in developing aspirations but problems arise when attempting to trade between the circles to achieve an overall optimum. For example, if better social or environmental benefits can be obtained by spending more money (the econocentric circle), what value should be put on these benefits and is a company with a financial duty to shareholders permitted to spend the money? As yet, this has not become a major issue as the trading process is generally presented as producing an improved financial return – there are still so many easy wins – the low hanging fruit. Once these fruits have been plucked trading will become more of an issue.

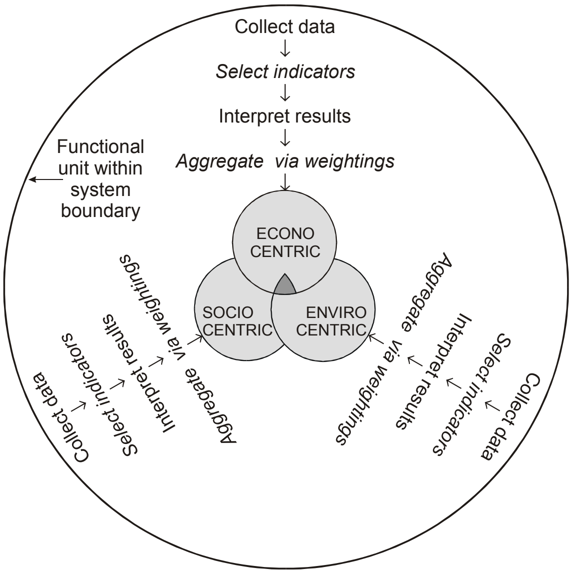

Figure 3 stages in sustainability assessment (note stages shown in italics require value input from individuals, stakeholders

6 CONCLUSIONS

Sustainability is not an abstract principle but a concept informed by human values which will vary locally, nationally and internationally. A common position on sustainability therefore may not be desirable if indeed it were possible. However, this does not mean that sustainability can be assessed by any procedure developed at the whim of the assessor. Consideration of the standards for Life Cycle Assessment show that if transparency is to be achieved and the results used by the wider community, rigorous procedures must be developed. A number of challenges remain:

- Sustainability requires consideration of perspective, for geotechnical engineering. What should be the goal and scope? Should the functional unit be an individual construction element such as a pile or a major pan-national infrastructure project? Both these can be assessed though the data requirements will be very different.
- Indicators of sustainability need to be developed. Many can be ‘borrowed’ from existing procedures but should geotechnical/civil industry specific indicators be developed? For example, Leiper et al (2003) develop a company-focused set of key performance indicators and a framework around them that assess how they contribute to sustainability and benefits to wider society.
- Will consideration of sustainability lead to better construction? Codification of sustainability analyses may promote pressure-state-response thinking, i.e. a mind-set which seeks to identify existing problems and solve them. This can be an enemy of blue-sky thinking. We must be careful that codification does not promote end-of-pipe solutions which manage rather than remove problems.
- How should the results be used and at what scale? Will sustainability become a legal test like human rights?

If the process of consideration of sustainability leads to the development of internationally accepted indicators for each of the circles of sustainability and a common will to achieve appropriate values for each of these indicators then the concept of sustainability will considerably advance both intra and inter-generational equity.

Harmony with the environment is a stiffer test than sustainability and to understand it we must first understand sustainability. For this an understanding of LCA is essential, we should not seek to analyse sustainability or harmony until a process such as LCA is embedded in our thinking. Without this we cannot achieve formal and transparent procedures by which to assess or achieve sustainability.

Our ideas of harmony have and will change with time and our state of industrialisation. For example, in many countries we are now cleaning-up or seeking to manage the pollution of land, waters and air resulting from former industrial activity. At the same time we are also trying to find new uses for and employment in these degraded environments. The result is that some former industrial plants, major chemical and industrial facilities, are being redeveloped as theme parks whilst retaining some of the original plant. These plants would have been built in their time to demonstrate man’s dominance over nature. Now they are offered as environmental icons with no mention of their earlier less eco-friendly role. Do these icons of former industrialisation give the right message to the visitor?

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