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Ecological engineering: from concepts to applications

Benefits of ecological engineering practices

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Abstract

With the intention to further promote the field of ecological engineering and the solutions it provides, a workshop on "Benefits of Ecological Engineering Practices" was held 3 Dec 2009. It was conducted by the International Ecological Engineering Society in Paris at the conference "Ecological Engineering: from Concepts to Application" organized by the Ecological Engineering Applications Group GAIE. This paper presents the results of the workshop related to three key questions: (1) what are the benefits of ecological engineering practices to human and ecosystem well-being, (2) which concepts are used or useful to identify, reference, and measure the benefits of ecological engineering practices, and (3) how and to whom shall benefits of ecological engineering practices be promoted.

While benefits of ecological engineering practices are diverse, general conclusions can be derived to facilitate communication. Identifying benefits requires valuation frameworks reaching beyond the scope of ecology and engineering. A distinction between human and ecosystem well-being in this regard may not be easy or useful, but instead humans embedded in ecosystems should be addressed as a whole. The concepts of resource efficiency, ecosystem services, ecosystem health, and multifunctional land use could serve as suitable references to frame ecological engineering benefits, as well as referring to international political goals such as biodiversity protection, climate change mitigation and poverty reduction. Sector and application specific criteria of good practice could be worked out. Regional, area specific reference systems for sustainable development could provide comparative advantages for ecologically engineered solutions. Besides people with high decision making power and people with high motivation for change are good target groups to be addressed.

Keywords: benefits; ecological engineering; reference systems

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1. Introduction

Since the concept of ecological engineering was seeded by H.T. Odum in the 1960s and further emerged in the 1990s, many useful ecological engineering practices have been developed and are now readily available in various fields of application. They have proven their feasibility and demonstrated promising solutions to pressing global sustainability problems. However, these practices still lack widespread recognition and implementation. Why ecological engineering is not really moving out of its niche remains a question to be addressed. On the other side there is a trend of sustainability assessments increasingly being required for technologies, e.g. in biomass production, which offer opportunities to show the advantages of ecological engineering compared to other engineered solutions. Additionally, based on the visionary work of ecological engineers, more and more of the underlying principles are adopted by the wider engineering community.

A workshop was conducted by the International Ecological Engineering Society (IEES) at the conference "Ecological Engineering: from Concepts to Application" held 3 Dec 2009 in Paris to identify and discuss benefits of ecological engineering as well as suitable communication pathways. Starting with the widely adopted definition of ecological engineering as the "design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both" provided by Mitsch 1993 [1] and later by Mitsch and Jørgensen (2004) [2] in a variation of the an initial definition by Mitsch and Jørgensen 1989 [3] the workshop was structured around three key questions: (1) What are the benefits of ecological engineering practices to human and ecosystem well-being? (2) Which concepts are used or useful to identify, reference, and measure the benefits of ecological engineering practices? (3) How and to whom shall benefits of ecological engineering practices be promoted? Discussion input was collected through case study presentations, panelists' statements and brainstorming in the first part of the workshop. The second part of the workshop served for moderated open floor discussion and consensus building. This paper presents the workshop results.

2. Benefits to both human and ecosystem well-being

As diverse as ecological engineering applications are – ranging from wastewater treatment and ecosystem restoration [2] to green roofs and mitigation measures (like ecoducts) to reduce animal road kill etc. [4] – as well as the local circumstances in which they are embedded, the benefits resulting from these solutions are also diverse and need to be worked out in a project and context specific way. However, general conclusions about the benefits of ecological engineering practices may help to communicate the essence of ecological engineering more clearly, facilitate collaboration across the ecological engineering community and support decision-making towards ecologically engineered solutions in the light of sustainable development.

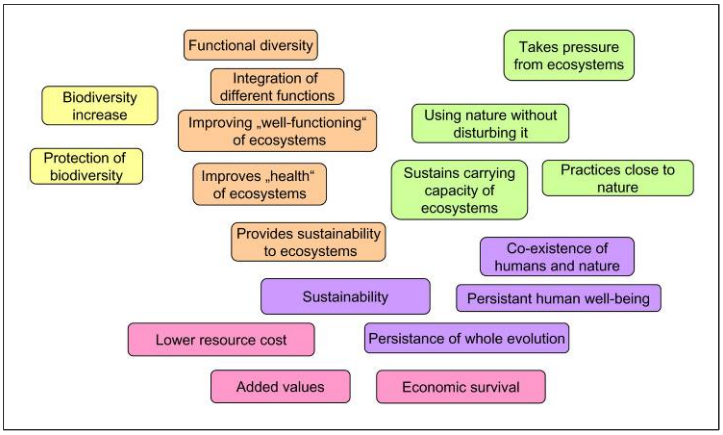

Fig. 1. Brainstorming results on the benefits of ecological engineering practices to the natural environment or ecosystem well-being

Sustainable development relates to both well-being of humans and other living communities especially with respect to future generations, since human society vitally depends on ecosystems integrity and the life-support-functions ecosystems provide. Such a co-evolutionary perspective is also reflected in the abovementioned definition by the phrase "for the benefit of both".

Since non-human living communities as intentional beneficiaries of design cannot express themselves in the same way that humans can speak for themselves regarding how well they are and what they value, 'ecosystem well-being' or 'benefitting the natural environment' cannot be isolated from human projection and implies epistemological questions. Thus, it is not easy (and it may not be necessary) to separately identify benefits to ecosystem well-being from human well-being as the quick brainstorming on the question "what are the benefits of ecological engineering to the natural environment or ecosystem well-being?" illustrates (Fig. 1).

Instead, the phrase "benefitting both" may be interpreted as addressing 'the whole': humans and other organisms as an inseparably interlinked system, or humans as embedded in the rest of nature, or benefitting life in general.

3. Reference concepts framing benefits

Benefits may exist whether or not the beneficiaries are aware of them. Consciously identifying, designing for and communicating benefits though, requires an act of value assignment by individuals, collective agreements or normative societal frameworks, reaching beyond the scope of ecology and engineering. Therefore reference concepts are necessary, or at least useful, to reach common understanding and collective agreements on respective values and the benefits provided by ecologically engineered solutions, i.e. in stakeholder discussions.

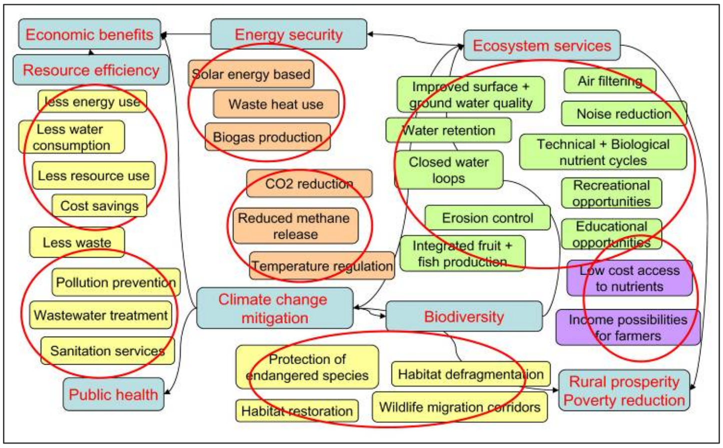

Fig. 2. Reference concepts and goals used to determine benefits of ecological engineering practices extracted from case studies presented at the workshop and in the IEES case study collection [5]

Using fewer resources, (e.g. energy, water and nutrients), and the resulting economic benefits are often specified in case studies of ecological engineering practices, since these are easily understood and widely accepted benefits. The related reference concept of "resource efficiency" implies 'benefitting through less damage' by creating more 'goods' from less resources and at the same time creating less 'bads' imposed on ecosystems. Ecological engineering though, holds a more positive attitude striving for an integration of human activities with those of other living communities by using ecological models and derived principles of how ecosystems work in developing its designs.

A useful concept often referred to in case studies is the concept of "ecosystem services" - attempting to internalize the value of natural capital into economical and political decision-making. In some cases the benefits are named as ecosystem services while in others specific services are mentioned (Fig. 2). Ecosystem services are by definition benefits to human well-being [6] and thus inherently "anthropocentric". However, the distinction between anthropocentric and biocentric dissolves, and even becomes counterproductive, when one thinks of the 'whole system' as benefiting, as we discuss above.

As an approach to assess ecosystem well-being and as an explicit goal of ecological engineering the concept of "ecosystem health" may serve. One definition of ecosystem health employs a balance of the three categories of vigor, organization, and resilience [7]. This definition refers to a broad-based understanding of 'well-functioning' ecosystems, whether humans are part of or benefit from those ecosystems or not. However, well-functioning ecosystems probably also produce the highest possible level of ecosystem services to humans.

Multifunctionality of ecologically engineered solutions is often named as well. "Multifunctional land use" addressing multiple demands of society imposed on the land surface [8] could be consulted as a useful reference concept in this regard.

Other benefits refer to values expressed in concepts which have already been translated into international agreements and political goals such as the protection of biodiversity (CBD), mitigation of climate change (UNFCCC), and reducing poverty (Millennium Development Goals).

Many of the mentioned benefits are not realized on a single plot of land, but through a discrete distribution of land-uses and ecosystems in the landscape. Therefore actual benefits should be assessed against a consensus of which functions, services and qualities are to be sustained on the landscape area and how ecologically engineered (and other) solutions perform with regard thereto over time. Such context specific reference systems, integrating knowledge (i.e. ecological principles applied) with value systems (i.e. stakeholder agreements on ecosystem services), and elaborated as a professional task of landscape management [9] could create a design aid and comparative advantage for ecological engineers as well as decision support for decision makers.

While on the one hand sector and application specific criteria for good (ecological) engineering practice should be developed, on the other hand reference systems would allow for area specific criteria and indicator sets to assess sustainability performance.

4. Target groups and communication pathways

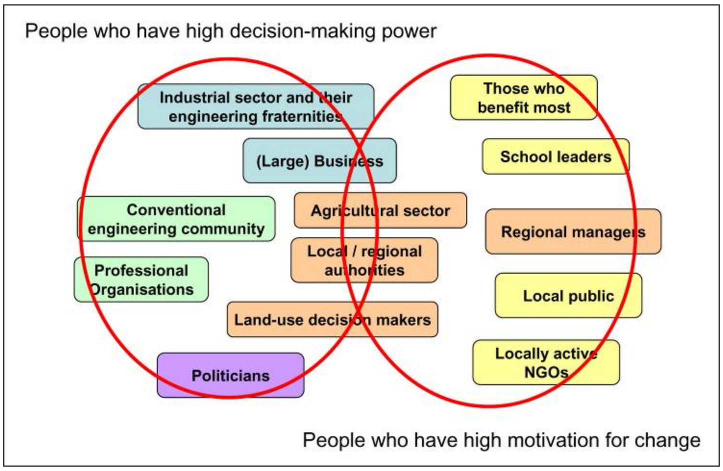

Fig. 3. Potential target groups to be informed about benefits of ecological engineering practices

It was agreed, that the best way to communicate the benefits of ecological engineering practices is through well-working demonstration projects. That was the purpose of the establishment of the journal *Ecological Engineering* [10] in 1992. The journal, which currently publishes about half of the more than 400 manuscripts it receives annually has published many case studies (as well as scientific studies of ecological engineering) to establish a major peer-reviewed "data base" of successful (and unsuccessful) ecological engineering approaches. New authors are required to cite at least 3 papers already published in the journal to enhance the learning experience of ecological engineering. The International Ecological Engineering Society is building up a web-based case study collection for a broad range of users and encourages all ecological engineers to contribute their project descriptions via a template available at the website [5]. The journal *Solutions* [11] may also serve as a good place to publish project results and good practices of ecological engineering reaching an audience beyond the scientific community.

Besides people with high decision-making power (i.e. municipalities), people with a high motivation for change (i.e. school initiatives) are good target groups to be addressed (Fig. 3). Also, other design professionals and their networks such as architects, landscape architects and the wider engineering community should be informed about alternatives to conventional solutions, i.e. through their professional media.

5. Conclusions

The benefits of ecological engineering practices are many [3,4] and need to be worked out in a concrete context. Generally ecological engineering offers pragmatic, low cost solutions for engineering services (i.e. wastewater treatment) and production techniques (i.e. bioenergy production), while at the same time providing multiple ecosystem services as an added value. By maintaining a multifunctional perspective, ecological engineering can achieve synergies rather than trade-offs between economic benefits, ecosystem services and biodiversity protection. It integrates land-use practices with conservation approaches.

Ecologically engineered solutions address major global issues and increasing demands imposed on the land surface, such as providing for energy, water and sanitation, nutrients, carbon sinks and education etc. By incorporating ecological knowledge into the design process from the beginning and allowing for broad stakeholder participation, more desirable social-ecological effects and fewer undesirable side-effects can be achieved.

Therefore Ecological Engineering, as also summarized by Mitsch and Jørgensen 2003 [12] is an effective tool for sustainable development.

It is appropriate engineering for a "full-world".

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