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Reuse of dredged material as a way to tackle societal challenges

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Abstract Sediment is a natural resource that provides the foundation for living, working and building in lowland delta areas. A sustainable society, therefore, reuses dredged material as a valuable resource. Such reuse matches perfectly to the philosophy of a circular economy. However, it is not yet a common practice. Why is this, what are the bottlenecks and how do we overcome them? Here, we use the Netherlands as an example to illustrate possible solutions to these questions, although we believe that our messages and recommendations can be applied generically.

Keywords Circular economy · Dredged material · Ecosystem services · Natural resource · Reuse · Societal challenges

1 Introduction

The famous Dutch writer Multatuli wrote in 1877 that the national 'appreciation of river dikes' was leading to the 'abandonment of an opportunity to raise land levels' (Multatuli 1877). Today, combined with the present day awareness of sea level rise, this is truer than ever. Our delta, as the Dutch say, is 'dying'. The combination of a rising sea level, land subsidence, an obstructed natural sediment flux and an anthropogenically disturbed distribution of that flux experienced in the Netherlands as in many other deltas in the world making it necessary to deliberately manage the sediment balance. It is through this management that a balance between water and sediment is secured, which keeps our feet dry and our waterways and harbours navigable and accessible. In the Netherlands, the amount of material dredged annually for navigation is approximately 5 million m^3 in freshwaters and 20 million m^3 in marine waters (unpublished data from Rijkswaterstaat). This material is locally redistributed in the water system or transported to other destinations. The ever recurring question here is how to do this (cost) effectively?

In addition to flood prevention, there is a huge and continuous need for (primary) building and land-raising material as well as material for coastal reinforcements, for which sand and clay are mined. Thus, in the Netherlands, ~30 million-m^3 sediment is redistributed annually from inland sources and another 35 million m^3 is extracted from marine sources (van der Meulen et al. 2007). It is clear that clever reuse of sediment can significantly reduce the demand for new building material, and it is Dutch policy and ambition to do so. However, there is significant room for better exploitation of these reuse opportunities. We believe that this can be achieved by a better coupling of supply and demand, by better (re)use, and in turn, by improving the societal image of dredged material.

2 Supply and demand

Projects in which sediments are (re)distributed are generally—like related policy and legal conditions—traditionally targeted to one (main) objective. These projects are often funded through different sources that may have different targets. For

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example, maintenance dredging, for keeping waterways navigable, creates a supply of sediment, but the responsible body is not linked with those with a demand for sediment, i.e. new infrastructure. In practice, it appears very difficult to couple different projects that have their own specific objectives, dynamics, financing, quality and—above all—planning cycles. The situation has significantly improved in the Netherlands since the policy recommendations from the 'Elverding Commission' (Commissie Elverding 2008) are now being followed. The key recommendation was to take an integrated and regionally oriented approach when creating new infrastructure. In fact, this means that one should consider the coupling of supply and demand of sediment by geographic regions. Examples of this approach can be found in the Dutch 'Room for the River[1]' programme (for example, see McVeigh 2014).

3 Better (re)use

A significant amount of dredged material does not have the right physical properties for reuse in certain industries. In the building materials market place, in particular, it has a low value or is even avoided. Treatment of dredged material to create a higher value product is possible. However, in our current, not yet fully circular economy, it is still too costly a procedure to compete with primary resources obtained through other means, as it consumes too much energy and emits a lot of CO_2. In situations where relocation becomes extremely costly, treatment may be a cost-effective option, but such conditions also increase dredging costs. Thus, it is more attractive to try to minimize the dredging of non-reusable dredged material as much as possible. New, more cost-effective technologies to adapt the physical properties of dredged material in situ may enhance opportunities.

An additional challenge is to optimize ways of moving large volumes. A 'Working with Nature' kind of approach proves to be very promising in the Netherlands, demonstrated by the 'Sand engine[2]' experiment along the Dutch North Sea coast, where a concentrated mega nourishment of 21 Mm^3 has been placed in 2011, with the objective to gradually reinforce a 16-km stretch of coast by natural redistribution of sediment (Stive et al. 2013).

4 Societal image

The negative image of dredged material results not only from its unattractive physical properties for construction but also from potential contaminants and the (presumed) impact of dredging on many environmental compartments simultaneously. Therefore, dredging and dredged material management touches upon several, sectorial policies and legislation. This makes dealing with dredged material complicated and, as such, not a very popular policy and management topic. The results from our mini-questionnaire (Fig. 1) among members of the Dutch sediment professionals network 'BaggerNet' revealed that image also relates to the synonyms or terms used to describe sediment. It was remarkable here that 'dredged material' scored neutral.[3] However, it is this negative image associated with dredged sediments that recently ended a common practice in the Netherlands, that this material was welcomed as a fertilizer on farmland and in private gardens.

Fortunately, there is plenty of evidence to give a positive boost to the image of dredged material. Scientific findings indicate that contaminants in sediment due to natural attenuation (for example, see Alexander 2000; Jonker et al. 2006; De Weert et al. 2010; Förstner and Salomons 2010) are often less hazardous for the environment than perceived by many. Furthermore, due to successful source control measures (for example in the river Rhine, see ICPR 2000), the quality of recently settled sediment layers improves continuously (ICPR 2013).

It must not be forgotten that without sediment there would not have been a low-lying, delta country like the Netherlands. The Netherlands can truly be called a sediment country—and there are many more countries/regions like that. For the past decade, the European Sediment network SedNet[4] has been emphasizing that sediment is an essential, integral and dynamic part of river-, delta- and coastal systems (Brils 2004; Vellinga 2004; Salomons and Brils 2004; Brils 2005; Netzband 2007; SedNet 2010). However, the sediment balance is disturbed in many of these systems (for example, see Walling 2009; Owens et al. 2010): continuous sea level rise alters the sediment input from the sea; dikes protecting inland areas for flooding also block sediment supply; and upstream damming and gravel extraction result in a decreased downstream supply. The shortage of sediment in the downstream reaches of many rivers is a global problem and leads to river bed degradation. For nourishment of floodplains and estuaries—and thus to create habitat for nature—there is a continuous need for sediment of which a minimum amount is needed to support ecology and thus biodiversity.

Thus, it is evident that sediment can help us to tackle several societal challenges in various ways and contributes

[1] See e.g. http://www.ruimtevoorderivier.nl/meta-navigatie/english/
[2] See e.g. http://www.dezandmotor.nl/en-GB/
[3] Note: the Dutch word for dredged material is 'bagger'. In every day, public language 'bagger' is often used to indicate something which is very bad or having a very low quality.
[4] See www.sednet.org

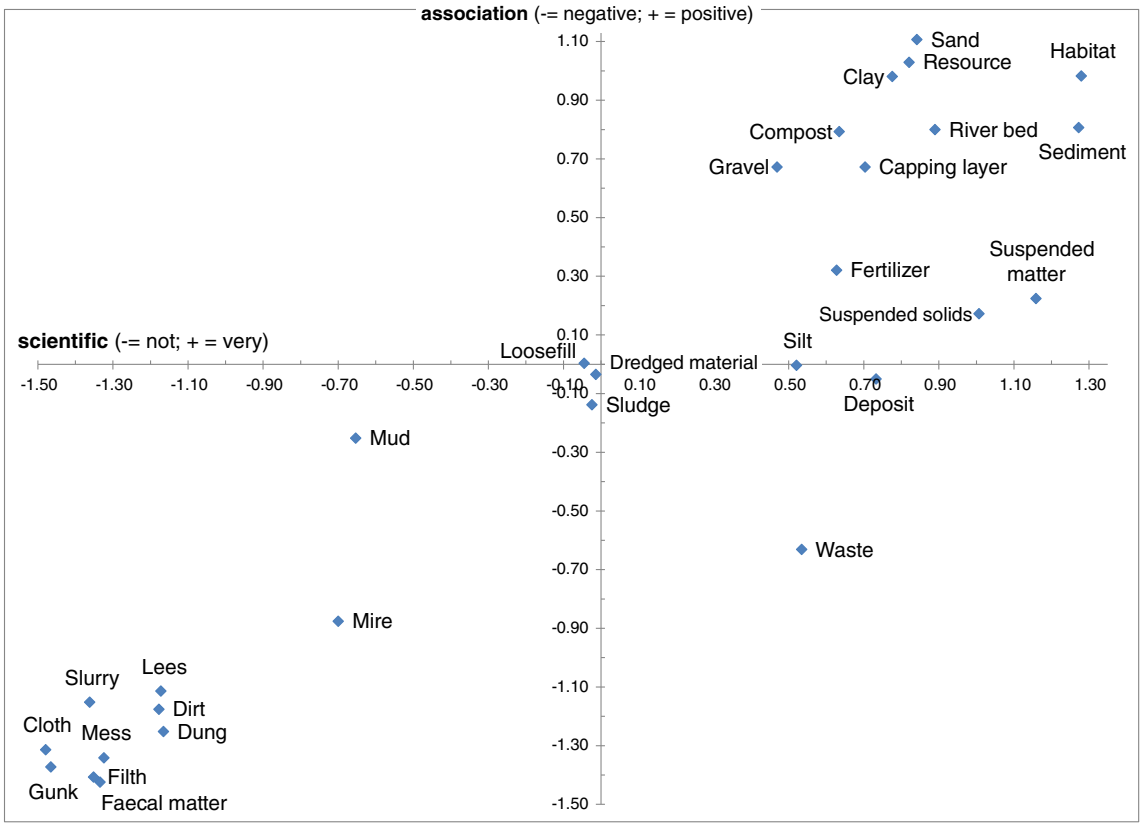

Fig. 1 Average score of synonyms or terms used for 'dredged material' resulting from a mini-questionnaire filled out by 290 members of the Dutch sediment professional's network 'BaggerNet'. Possible scoring options were −2, −1, 0 (neutral), +1 and +2

to our well-being by providing us with important ecosystem services (Fig. 2). It would certainly be worth the effort to invest more time in further clarification of the value of these services (Fig. 2). This will also help improve the image of dredged material. The key objective here is to enhance the rethinking of dredged material from 'useless waste' to 'a valuable, reusable resource' and therefore help to reduce the use of primary resources.

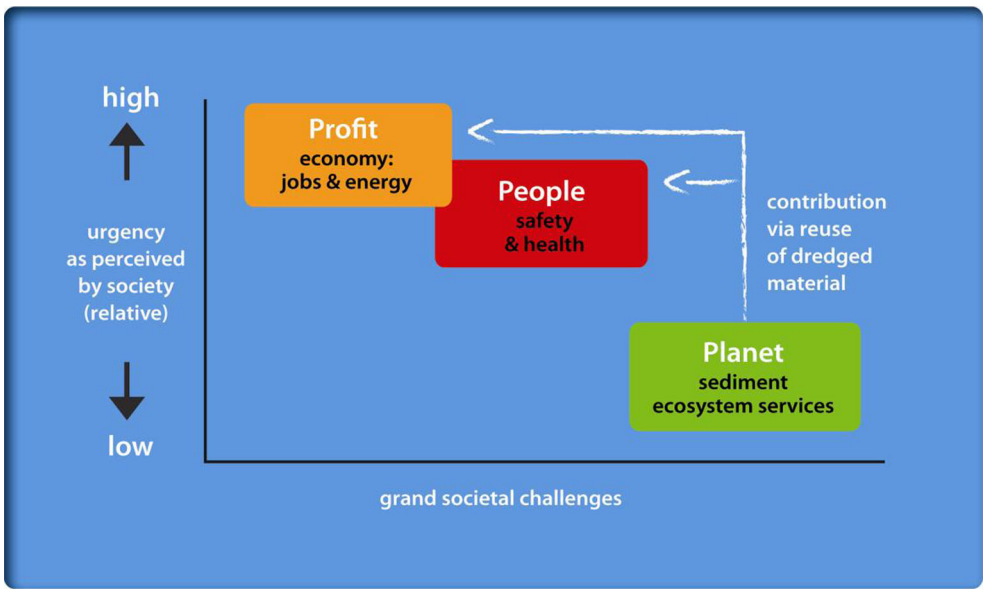

Fig. 2 The sediment ecosystem provides an opportunity to consider how the reuse of dredged material contributes to the tackling of some of our societal challenges

5 Recommendations

In order to open a window of opportunity for entrepreneurs to create innovative, realistic market potential options for large-scale reuse of dredged material, we recommend the following:

- Improve knowledge about, and recognition of, the importance of sediment in its role of supporting functions and delivering (ecosystem) services in delta (and other similar) areas (see also Owens and Xu 2011);
- Use that knowledge to overcome management, juridical, as well as economic, bottlenecks for the reuse of dredged material. The desire to couple better supply and demand could be the starting point for a new, less complex, set of rules and procedures that can be tailored to regional situations. This will also create more space for entrepreneurship;
- Make use of the ecosystem services concept (Millennium Ecosystem Assessment 2005) to define the societal value of dredged material reuse; for example, how it can be integrated into a circular economy;
- Use new projects and programmes, such as the European Commission's Horizon 2020 programme (European Commission 2011), for experimentation, innovation and practical demonstration of the potential of the reuse of dredged material and other sediment resources.

6 Concluding comments

In lowland delta areas—whose existence depends on the sediment balance—dredged material is a very beneficial, reusable resource: a gift from Mother Nature! Changing the mindset of those who have a negative perception of dredged material, developing low-cost solutions to get the physical and chemical quality right for reuse, and finding ways to move enormous quantities of material with lower CO_2 emission and energy consumption rates should not be viewed as problems but as challenges.

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