Scientific Facts on

The mining of sand, a non-renewable resource

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Summary & Details:
GreenFacts

Level 2 - Details on The mining of sand, a non-renewable resource

This is a faithful summary of the leading report
produced in 2014 by the United Nations Environment Programme (UNEP):
"Sand, rarer than one thinks - Why is this issue important?"

The full Digest is available at: https://www.greenfacts.org/en/sand-extraction/

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- Each question is answered in Level 1 with a short summary.
- These answers are developed in more detail in Level 2.
- Level 3 consists of the Source document, the internationally recognised scientific consensus report which is faithfully summarised in Level 2 and further in Level 1.

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1. Introduction

Sand and gravel are used extensively in construction. In the preparation of concrete, for each tonne of cement, the building industry needs about six to seven times more tonnes of sand and gravel (USGS, 2013b). Thus, the world's use of aggregates for concrete can be estimated at 25.9 billion to 29.6 billion tonnes a year for 2012 alone. This production represents enough concrete to build a wall 27 metres high by 27 metres wide around the equator. Aggregates also contribute to 90% of asphalt pavements and 80% of concrete roads and the demand for aggregates stems from a wide range of other sectors, including production of glass, electronics and aeronautics. Added to this are all the aggregates used in land reclamation, shoreline developments and road embankments (for which the global statistics are unavailable), plus the 180 million tonnes of sand used in industry.

This sand and gravel are mined world-wide and account for the largest volume of solid material extracted globally and the highest volume of raw material used on earth after water (about 70-80% of the 50 billion tons material mined/year). Formed by erosive processes over thousands of years, they are now being extracted at a rate far greater than their renewal.

Despite our increasing dependence on the colossal quantities of sand and gravel being used and the significant negative impact that their extraction has on the environment, this issue has been mostly ignored by policy makers and remains largely unknown by the general public. Indeed, the absence of global data on aggregates mining makes environmental assessment very difficult and has contributed to the lack of awareness about this issue. As a consequence, a large discrepancy exists between the magnitude of the problem and public awareness of it.

2. Why is marine sand used?

The amount being mined is increasing exponentially, mainly as a result of rapid economic growth in Asia and the resulting boom in construction. A conservative estimate of 40 billion tonnes /yr for the world consumption of aggregates is twice the yearly amount of sediment carried by all of the rivers of the world. Cement demand by China has increased exponentially by 430% in 20 years, while use in the rest of the world increased by 60%. Surprisingly, reliable data on their extraction in certain developed countries are available only for recent years. Sand was until recently extracted in land quarries and riverbeds; however, a shift to marine and coastal aggregates mining has occurred due to the decline of inland resources. River and marine aggregates are now the main sources for building and land reclamation.

The sand that is found in most deserts is paradoxically unsuitable for concrete and land reclaiming, as the wind erosion process forms round grains that do not bind well. On the other hand, marine aggregate needs to be thoroughly washed to remove salt. If the sodium is not removed from marine aggregate, a structure built with it might collapse after few decades due to corrosion of its metal structures. For concrete, in-stream gravel requires less processing and produces high-quality material.

3. What are the main issues with sand mining?

Negative effects on the environment are unequivocal and are occurring around the world. The volume being extracted is having a major impact on rivers, deltas and coastal and marine ecosystems, sand mining results in loss of land through river or coastal erosion, lowering of the water table and decreases in the amount of sediment supply. Table 1 summarizes some of the impacts that are observed.

Table 1: Summary of the main consequences of extraction of aggregates

Impacts on	Description
Biodiversity	Impacts on related ecosystems (for example fisheries)
Land losses	Both inland and coastal through erosion
Hydrological function	Change in water flows, flood regulation and marine currents
Water supply	Through lowering of the water table and pollution
Infrastructures	Damage to bridges, river embankments and coastal infrastructures
Climate	Directly through transport emissions, indirectly through cement production
Landscape	Coastal erosion, changes in deltaic structures, quarries, pollution of rivers
Extreme events	Decline of protection against extreme events (flood, drought, storm surge

Extraction has an impact on biodiversity, water turbidity, water table levels and landscape and on climate. There are also socio-economic, cultural and even political consequences. The problem is now so serious that the existence of river ecosystems is threatened in a number of locations, damage being more severe in small river catchments. The same applies to threats to benthic ecosystems from marine extraction . In some extreme cases, the mining of marine aggregates has changed international boundaries, such as through the disappearance of sand islands in Indonesia.

Sand and gravel mining also has also climate impact. It has a direct impact through greenhouse gas emissions from both the extraction process itself and the transport, sometimes over long distances of the mined materials. It also has an indirect impact from the production of cement for use in concrete together with sand and gravel: for each tonne of cement, an average of 0.9 tonnes of carbon dioxide are produced. Emissions of 1.65 billion tonnes of carbon dioxide were estimated from cement production in 2010 alone (about y 5% of total greenhouse gas emissions) and total carbon emissions from cement amount to about 30 billion tonnes of carbon dioxide.

The absence of global monitoring of aggregates extraction undoubtedly contributes to the gap in knowledge, which translates into a lack of action.

4. What can be done to reduce the problems?

The mining of marine aggregates is increasing significantly and although the consequences of substrate mining are hidden, they are tremendous. Marine sand mining has an impact on seabed flora and fauna. Dredging and extraction of aggregates from the benthic (sea bottom) zone destroys organisms, habitats and ecosystems. It deeply affects the composition of biodiversity, usually leading to a net decline in faunal biomass and abundance or a shift in species composition. Longterm recovery can occur only where original sediment composition is being restored.

Aggregate particles that are too fine to be used are rejected by dredging boats, releasing vast dust plumes and changing water turbidity, resulting in major changes to aquatic habitats over large areas.

Box : The cases of Dubai & Singapore [see Annex 1, p. 7]

5.

Erosion occurs largely from direct sand removal from beaches, mostly through illegal sand mining. In Morocco, sand smugglers have transformed a large beach into a rocky landscape. Erosion can also occur indirectly, as a result of near-shore marine dredging of aggregates, or as a result of sand mining in rivers. Damming and mining have reduced sediment delivery from rivers to many coastal areas, leading to accelerated beach erosion. Onshore sand mining in coastal dune systems can also lead to long-term erosion sometimes of 0.5 to 1.5 metres a year.

Global average sea level rise, which is expected to reach 0.25 to 0.5 metres by 2100 under the best-case scenario (of 70% reduction of greenhouse gas emissions) is particularly acute for small islands states, where retreat options are limited. In the Maldives, to strengthen the capital Male, a large amount of sand is being imported to be used in building higher towers and coastal protection. The sand is taken from offshore sand islands. Paradoxically, the sands extracted for the protection measures in Male are leading to the lowering of these other islands, increasing the need to relocate their populations.

Sand mining has led to deepening and widening of the Lake Poyang channel, the largest freshwater lake in China and a biodiversity reserve of exceptional importance, and to an increase in water discharge into the Yangtze River. This may have influenced the lowering of the lake's water levels, which reached a historically low level in 2008.

6.

The mining of aggregates in rivers can have an effect on pollution and change the level of water acidity (pH). Removing sediment from rivers causes the river to cut its channel through the bed of the valley floor (or channel incision) both upstream and downstream of the extraction site. This leads to coarsening of bed material and lateral channel instability. It can change the riverbed itself.

Incision can also cause the alluvial aquifer to drain to a lower level, resulting in a loss of aquifer storage. It can also increase flood frequency and intensity by reducing flood regulation capacity. However, lowering the water table is most threatening to water supply, exacerbating drought occurrence and severity as tributaries of major rivers dry up when sand mining reaches certain thresholds.

7.

Tourism may be affected through beach erosion. Sand is often removed from beaches to build hotels, roads and other tourism-related infrastructure. In some locations, continued construction is likely to lead to an unsustainable situation and destruction of the main natural attraction for visitors, the beaches themselves.

Fishing — both traditional and commercial — can be affected through destruction of benthic fauna and agriculture could be affected through loss of agricultural land from river erosion and the lowering of the water table. The insurance sector is affected through exacerbation of the impact of extreme events such as floods, droughts and storm surges through decreased protection of beaches. The erosion of coastal areas and beaches affects houses and infrastructure as a decrease in bed load or channel shortening can cause downstream erosion including bank erosion and the undercutting or undermining of engineering structures such as bridges, side protection walls and structures for water supply.

8.

By reducing the consumption of sand

One way is to reduce consumption of sand by optimising the use of existing buildings and infrastructure. Recycled building and quarry dust material can be a substitute for sand. Despite the very high value of minerals found in the sand, it is mostly used for concrete or is buried under highways. Concrete rubble should be recycled to avoid using aggregates, at least for low-quality uses. Recycling glass bottles would also reduce sand consumption. Also, substitutes for sand are available. Quarry dust could be used to replace sand in general concrete structures. The replacement of sand by up to 40% of incinerator ash exhibits higher compressive strength than regular cement mortars. Some desert sand can be used if mixed with other material.

There are also alternatives to concrete for building houses, including wood, straw and recycled material. However, the current building industry is geared toward concrete know-how and equipment. Training of architects and engineers, new laws and regulations, and positive incentives are needed to initiate a shift for lowering our dependency on sand. Renewable and recycled materials need to be targeted for building houses and roads.

By setting taxes on aggregates extraction to create incentives on alternatives

The current situation will continue unless sand extraction is correctly priced and taxed so that other options become economically viable. Because sand is still very cheap – sand itself is freely accessible; only extraction costs need to be covered – there is little or no incentive to induce a change in our consumption.

Alternative sources of sand and gravel, such as those that accumulate at the bottom of dams, can also be targeted. large amounts of water must reguraly be released from dams to flush out agg; although currently more expensive, these aggregates could be extracted from the dams. Their use would address the problem of their accumulation, which leads to a reduced capacity of dams to store water and could result in the dams' water intakes being blocked.

By reducing the negative consequences of extraction

The environmental impact of in-stream mining might be avoided if the annual bed load were calculated and the mining of aggregates restricted to that value or less. Local environments should be studied to define the limits of acceptable changes.

9.

Sand trading is a lucrative business, and there is evidence of illegal trading such as the case of the influential mafias in India, and in Morocco, half of the sand – 10 million cubic metres a year – comes from illegal coastal sand mining.

The lack of proper scientific methodology for river sand mining has led to indiscriminate sand mining while weak governance and corruption have led to widespread illegal mining. The lack of adequate information is limiting regulation of extraction in many developing countries. Access to data is difficult, and data are not standardised. There is limited collaboration/co-ordination between the marine scientific research establishments and the marine aggregates industry. Except in the European Union, regulation efforts are few, especially in developing countries. Lack of monitoring systems, regulatory policies and

environmental impact assessments have led to indiscriminate mining, triggering severe damage to the environment and related ecosystem services.

As this issue is a major emerging one, there is a need for in-depth research. The implementation of a monitoring mechanism regarding global aggregate extractions and trade would shed light on the magnitude of this issue and bridge the current data and knowledge gap. This would also raise this issue on the political agenda and perhaps lead to an international framework to improve extraction governance, as the current level of political concern clearly does not match the urgency of the situation.

Whilst it is critical for political leaders to take appropriate measures, the mining of aggregates has not yet reached their political agenda. This is primarily because sand loss has not yet reached a level of scarcity that would threaten the economy. Few, if any, measures are being implemented , with the notable exception of the European Union, and the United Kingdom in particular. While no international conventions regulate the extraction, use and trade of land-based sand (sand quarry, riverine and lake aggregate), the United Nation Convention on the Law of the Sea, 1982 (UNCLOS) provides for the delimitation of maritime zones and regulates rights and obligations in respect of usage, development and preservation for these zones, including resource mining. If a number of existing regional Conventions on marine protection , directly or indirectly, references to aggregate exploitation, the governance is not coherent and includes several layers of regulations between national and international conventions.

There is thus a need for regulating sand extraction in both national and international waters and it should be authorized only after sound scientific assessment shows there would be limited impact on the environment. Greater consideration of substitute and sustainable use of the resource could drastically reduce impact on the environment. Other policy actions include the introduction of scientific mining operations, followed by ecological restoration.

Annex

Annex 1:

Box : The cases of Dubai & Singapore

The city of Dubai in the United Arab Emirates is one that has put significant pressure on marine aggregates. The Palm Jumeirah, an artificial set of sand islands required 385 million tonnes) of sand and 10 million cubic metres of rock, As its own marine sand resources were exhausted, Dubai imported sand from Australia. A second Palm project and then the World islands project, a set of 300 artificial islands representing a map of the world, required 450 million more tonnes of sand. Eventually, only a very small number of these islands currently host infrastructures. http://www.arte.tv/guide/fr/046598-000/le-sable-enquete-sur-une-disparition [see http://www.arte.tv/guide/fr/046598-000/le-sable-enquete-sur-une-disparition]

Having imported a reported 517 million tonnes of sand in the last 20 years, **Singapore** is by far the largest importer of sand in the world. Sand is imported mostly from Indonesia, but also from the other neighbouring countries of Malaysia, Thailand and Cambodia. Export of sand to Singapore was reported to be responsible for the disappearance of some 24 Indonesian sand islands. Statistics do not include illegal imports and highlight the need for better monitoring. There is also an alleged illegal sand trade. As the price of sand increases, so does the traffic of sand.