Resource Efficiency in Infrastructure and Buildings

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Urbanization drives resource use and GHG emissions

More people and changing lifestyles lead to increases in living space, infrastructure for supply and disposal, means of transport and communication. This entails a rise in global resource use in business-as-usual scenarios. In the next three decades alone, about as much infrastructure needs to be built as has been created since the beginning of industrialization. This growth will mainly take place in cities, where more people will be living in 2050 than today all over the world. The challenge will be even greater considering the fact that a significant percentage of the built infrastructure since 1990 will deteriorate prematurely due to the massive use of poor-quality building materials and the severe environmental influences and industrial pollutants.[1]

In addition to that, urban infrastructure development over the last decades failed to keep pace with the rapid urbanization process in many developing countries and emerging economies: Around the world, approx. 750 million people have still no access to adequate sanitation, 150 million are lacking access to clean drinking water, and 850 million city residents live in inadequate housing.[2]

Around the globe, the predominant materials for buildings and infrastructure solutions are steel, sand and cement. Between 1959 and 2010, the global steel production went up by a factor of eight while 25 times more cement was produced. The demand for non-metallic industrial and construction minerals[3] even witnessed over the last 30 years a disproportional increase by more than 240%. This boom has not only spurred demand for raw materials but also increased global CO_2 emissions considerably: The cement industry[4] contributes about 5% to global anthropogenic greenhouse gas emissions, steel industry[5] about 6%.

As infrastructure and buildings have a lifespan of many decades, the choices concerning the design, technologies and materials have a strong impact on the ecological footprint not only during construction but operation as well and therefore can lock societies into GHG-intensive emissions pathways that are difficult or very costly to change.

If the expansion of infrastructure and buildings follow the same raw material and energy intensive patterns as today in industrialized countries, this alone could lead to 350 Gt of CO_2 emissions. This corresponds to around a third of the total available CO_2 budget remaining under a two degrees pathway, limiting global warming to less than 2°C.[6]

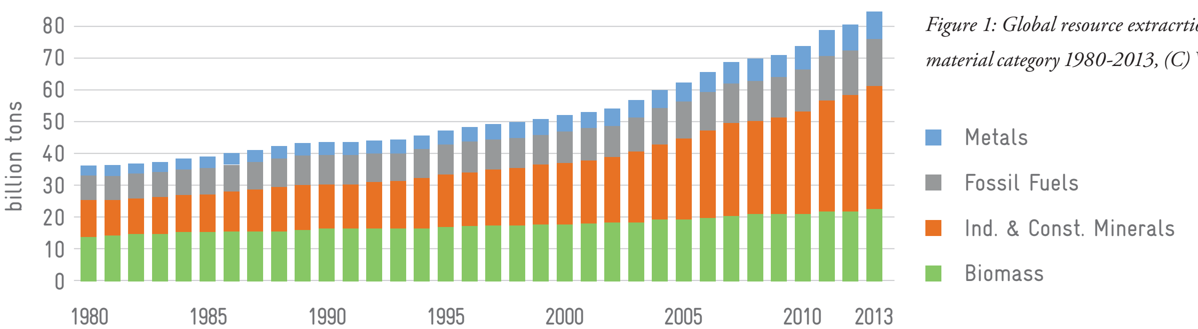

Figure 1: Global resource extracrtion by material category 1980-2013, (C) WU 2015

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BOX 1

Sand: Seemingly infinitely available

Although sand seems to be available all over the world, sand is not equal to sand. In deserts, for example, sand grains are too strongly rounded due to abrasion by the wind so that such material is not well suited for concrete production. Sand is often mined or dredged from the sea, rivers that are frequently polluted and beaches, which causes serious environmental impacts in the respective ecosystems and endangers biodiversity. Mining sand from beaches facilitates erosion leading to land-losses, increasing the vulnerability of countries caused by sea level raise due to climate change.

The exponentially growing use of sand and gravel mainly due to the rapid urban growth in emerging economies greatly exceeds natural renewal rates.[7] Nevertheless, sand loss and potential scarcities of sand have not yet reached the political agenda. Against this background, UN-Environment sees the need for regulating sand extraction in both national and international waters.[8]

A more resource efficient use of sand and gravel, recycling of demolition waste, the use of sand substitutes and new building technologies are needed to cope with growing demand for these bulk materials for construction.

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Potentials

As a large portion of the world's urban areas will be developed during the next two decades, this period presents a window of opportunity for both, preserving natural resources and reducing the ecological footprint of buildings and infrastructure along the whole value chain, from extraction to use, deconstruction and recycling.

Use of secondary raw materials

Using secondary raw materials in construction can contribute not only to substituting partially sand and gravel but also to managing scarce landfill capacities more effectively where the construction and demolition waste would go to. However, an important prerequisite for this is that the deconstruction of buildings and infrastructure is coupled with the most effective separation of recyclables already at source. For this purpose, the later reusability should be taken into account already as a criterion when designing and electing the materials for new buildings considering recyclability at the end of life. Modular building and design methods can help to adapt buildings flexibly to changing demands, reducing demolition waste.

To reduce the use of sand and gravel, secondary raw material aggregates are usable for many civil engineering applications, e.g. carriageways, prefabricated components for tunnel formwork or sleepers as well as buildings itself. However, this still requires targeted measures to increase their acceptance. These range from demolition permits with respective requirements for separation, specifications for the recycling of demolition waste to modifications to modifications of construction standards, warranty provisions, requirements in tendering procedures to calculating longer curing times of concretes containing a higher percentage of secondary components. As nearly all countries are facing similar challenges in this context, international exchange of experience is crucial.

Low-carbon construction material

Cement is an almost indispensable binder. The energy intensity of the different types varies depending largely on the clinker content. To produce clinker, limestone and other clay-like materials are heated in kilns up to more than 1400°C, resulting in between 0.8 and 1 tons of CO_2 generated on average during the production of one ton of cement.[9] Resource efficiency measures can contribute to reduce the carbon footprint of cement: The use of efficient grinding and milling technologies, for example, can decrease the global electricity intensity of cement by 14% by 2050 compared to 2014[10], while refuse-derived fuels from waste reduce consumption of fossil fuels.

New types of cement can lower the clinker content, using alternative materials such as fly ash from coal fired power plants and blast furnace slag. Low Carbon Cement based on a blend of limestone and calcined clay can even reduce CO_2 emissions by up to 30%.[11] Once hydrated and hardened there are at the few approaches to recover cement and render it reactive again.

Another alternative becoming more popular consists in using renewable building materials such as bamboo and timber even for constructing high-rise mass buildings.

Resource efficient urban planning

The density of cities allows economies of scale in citizen-oriented services such as collective transport, power, water and sanitation services, waste management and district heating, reducing commuting distances, air pollution, energy demand, land take and soil destruction. Resource efficient urban planning integrates urban flows and urban forms, linking spatial development and planning of infrastructure systems. It minimises the use of resources on the supply and demand side, combining upstream measures as avoidance, prevention, and reduction with downstream action focusing on reusing, recycling, and harvesting e.g. rainwater. This requires more decentralized infrastructure systems and moving away from end-of-pipe utilities. For both, the compactness of cities is key as it contributes to minimising input and output flows. Land recycling like the redevelopment of brownfield sites from former industrial areas allows preserving land as a finite resource.

Sustainable Industrial Areas

Industrial areas are drivers of economic development. Nevertheless, they frequently concentrate environmental pollution and ineffective resource use. Sustainable Industrial Areas (SIA) turn these challenges into opportunities: The spatial proximity between different companies facilitates not only pooling of state-of-the-art environmental infrastructure as zero-emissions plants and sharing of services and social infrastructure. Such clusters can also be a breeding ground for industrial symbiosis in which the residues of one company become raw material of another. Having to consider the economic, ecological and social dimension in an integrated manner, such industrial areas require particular management structures, enhancing communication and collaboration.

Synergies with other sectors

Improving resource efficiency in infrastructure and buildings offers multiple co-benefits: It allows achieving important social development goals with less resources: To provide clean water and sanitation (SDG 6), to upgrade infrastructure and retrofit industries (SDG 9) to make cities and communities inclusive, safe, resilient and sustainable (SDG 11). It also reduces pressure on construction materials becoming scarcer and expensive und is an important leverage for mitigating climate change. Finally, enhancing resource efficiency in construction is an important employment factor as this sector engages about 10 % of the global workforce, contributing typically about 10-15 % to national GDP.[12]

3 Recommendations

In view of the rapidly growing demand for infrastructure and buildings not only in emerging countries, tapping the available resource efficiency potentials in construction materials will be key for preserving natural materials and reducing greenhouse gas emissions. This will require not only technical innovations but also favourable framework conditions.

BOX 2

Managing construction and demolition waste in India

India is witnessing a construction boom due to rapid urbanisation which is leading to high rates of exploitation of primary resources for construction materials. For instance, almost 100% of cement and bricks, 40-60% of steel, 85% of paint, and 70% of glass produced in India goes into the construction sector. Sand, soil, stone and limestone are critical resources used in the sector that are already facing supply disruptions and price spikes due to mining bans and restrictions. The construction boom goes hand in hand with large quantities of construction and demolition waste. India is generating each year the estimated amount of 530 million tons. Generally, the most common way of managing the waste is illegal dumping in open areas or mixing it with municipal solid waste.

Against this background, managing construction and demolition waste more effectively for recycling was chosen as one of the fields of activity in the project "Fostering Resource Efficiency and Sustainable Management of Secondary Raw Materials", implemented under the International Climate Initiative (IKI) and funded by the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU). To support informed decision-making, the project elaborated, amongst others, a report on resource efficiency in the construction sector, and commissioned a market study on construction and demolition waste utilisation in Ahmedabad. In 2016, the Indian Ministry of Environment, Forest and Climate Change (MoEFCC) notified the Construction and Demolition Waste Management Rules, assigning the different stakeholders with specific responsibilities concerning collection, segregation, storage, transport, and recycling of construction and demolition waste. The Rules also define criteria for recycling facilities and materials made from construction and demolition waste and its products and foresee penalties for noncompliance. To support the implementation of the Construction and Demolition Waste Rules at the local level, the IKI-project worked out a training manual on construction and demolition waste management in India for cities and towns.[13] Another field of activity focused on low carbon cement as alternative building material, developed in India as Limestone Calcined Clay Cement.

Legal framework

Building codes and standards as well as tender conditions are generally framed for the use of primary raw materials. As long as these do not consider explicitly the use of secondary raw

material or construction material from biomass as alternative or complementary options, warranty risks may arise. From a resource efficiency perspective, the legal framework, including liability and procurement regulations, is key for paving the way to resource efficient and low carbon infrastructure and buildings. In view of the high proportion of publicly financed buildings and infrastructure, public bodies have extensive opportunities to promote resource efficiency under their responsibility.

Fiscal instruments

Aggregates are still cheap in many parts of the world where sand and gravel are freely accessible and only the costs for extraction and transport need to be covered. Against this background, options that are more resource efficient, environmentally friendly and contribute to mitigating climate change are not competitive. UN Environment recommends therefore to price and tax the extraction of aggregates in a way that helps alternative options, using for example recycled materials, to become economically viable.

Green Public Procurement

Resource efficient and low carbon infrastructure and buildings need forward-looking clients that play an important role for developing the market. Governments and local authorities taking over this role can help to demonstrate the viability and reliability of new technologies and innovative construction materials and designs in practice.

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