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Towards a more sustainable transport infrastructure: how spatial geological data can be utilized to improve early stage Life cycle assessment of road infrastructure

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Environmental impacts during the life cycle stages of transport infrastructure are substantial, including among other greenhouse gas (GHG) emissions, as well as resource and energy use. For transport infrastructure to be sustainable, such issues need to be integrated in the planning process. Environmental Impact Assessment (EIA) is required by the European Union (EU) in order to ensure that all environmental aspects are considered during planning of road infrastructure projects. As a part of this process, the European Commission has suggested the use of the tool life cycle assessment (LCA) for assessing life cycle energy use and GHG emissions. When analyzing life cycle impacts of the road infrastructure itself, it was shown that earthworks and materials used for the road construction have a big share in the total energy use and GHG emissions. Those aspects are largely determined by the geological conditions at the site of construction: parameters such as soil thickness, slope, bedrock quality and soil type. The geological parameters determine the amounts of earthworks (i.e. volumes of soil and rock that will be excavated and blasted), transportation need for excavated materials as well as the availability of building materials.

The study presents a new geographic information system (GIS)-based approach for utilizing spatial geological data in three dimensions (i.e. length, width and depth) in order to improve estimates on earthworks during the early stages of road infrastructure planning. Three main methodological steps were undertaken: mass balance calculation, life cycle inventory analysis and spatial mapping of greenhouse gas (GHG) emissions and energy use. The proposed GIS-based approach was later evaluated by comparing with the actual values of extracted material of a real road construction project.

The results showed that the estimate of filling material was the most accurate, while the estimate for excavated soil and blasted rock had a wide variation from the actual values. It was also found that the total volume of excavated and ripped soils did not change when accounting for geological stratigraphy.
The proposed GIS-based approach shows promising results for usage in LCA at an early stage of road infrastructure planning, and by providing better data quality, GIS in combination with LCA can enable planning for a more sustainable transport infrastructure.