Supporting urban sanitation management through the integration of EO-based indicators

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Abstract
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The challenge

Sanitation refers to the provision of facilities and services for the safe disposal of human excrements and is included in SDG 6 "Ensuring the availability and sustainable management of water and sanitation for all". With more than 2.5 billion people without appropriate facilities mainly living in cities, urban sanitation is critical to avoid harmful effects on human health and environment. Largely relying on onsite sanitation, the coordination of safe collection, treatment and disposal is essential. This requires reliable, up-to-date information that can be provided by EO data through its wide availability and objectivity. This is of particular importance in areas difficult to access and large, growing cities with urban sprawl. To facilitate the planning of faecal sludge management (FSM), priority areas where improvements are urgently needed can be identified using EO-based indicators, additionally enabling regular monitoring, evaluation of measures and targeted in-situ sampling.

Methodology

In close collaboration with urban sanitation experts, eight EO-related indicators relevant for FSM in Lusaka, Zambia were identified, covering demographic, environmental and technical aspects: 1) Building density, 2) Building size, 3) Building use, 4) Urban greenness, 5) Groundwater vulnerability, 6) Distance to water, 7) Street conditions and 8) Distance to treatment plants.

Some indicator were directly derived from VHR satellite imagery, e.g. NDVI for Urban greenness and NDWI for the identification of water bodies; others such as Groundwater vulnerability and locations of treatment plants are based on local data. For Building use and Street conditions OpenStreetMap data and local expert knowledge, such as conditions required for different emptying methods (street width, underground, action radius of emptier) were integrated. Building density and Building size are based on building footprints, extracted through integration of an automatic OBIA approach, manual delineation and existing datasets.

With the overall aim of supporting decision-making, the aggregation into a composite index allows an easy interpretation of results. Required steps such as harmonization, descriptive statistics, expert-based weighting and aggregation of single indicators were implemented. As administrative boundaries often do not represent real-world conditions, spatial regionalization based on the same indicator set resulted in homogenous city zones, in this case priority areas for FSM.

Results

As an example for supporting urban sanitation management, priority areas for FSM in Lusaka, Zambia were demarcated through the integration of EO-based indicators. Wide parts of Lusaka use onsite sanitation with irregular emptying schedules, potentially causing health-related problems.

The eight identified indicators covering the whole city extend show distinctive geographical pattern and provide useful information on its own, such as the identification of inaccessible areas for emptying by trucks. They can be used and integrated in political decision-making processes by local experts for improving urban sanitation in Lusaka, e.g. for the coordination of emptying practices, the planning of sewer systems or the installation of new treatment plants.

Priority areas delineated through regionalization on basis of the same indicators and subsequent aggregation to a composite index reveal hotspots of need for interventions. In the case of Lusaka, such high-priority areas can be found in the low-income residential area Kanyama in the west, residential areas southeast of the city centre and the commercial strip along Kafue Road to the southwest. These hotspots are characterized by high building density, assuming high population density; small building sizes in combination with a low portion of vegetation, serving as proxies for low income; poor street conditions, preventing the use of trucks for emptying onsite sanitation systems and highly vulnerable groundwater conditions.

Outlook for the future

This study shows that the integration of EO-based indicators can support urban sanitation, providing an up-to-date overview, potentially allowing regular monitoring and the evaluation of impact of measures. A big advantage lies in the delineation of homogenous city areas independent of district boundaries that often do not reveal patterns of population distribution or infrastructure availability. While the composite index is easy to interpret, additional information about influence of single indicators could facilitate the targeted implementation of interventions. The approach can easily be transferred to other cities with site-specific adjustments, such as the integration of elevation models, minor in Lusaka, but important for other cities e.g. for the assessemnt of natural hazard risk areas. The described methods can also support related challenges in FSM such as a citywide estimation of faecal sludge characteristics and can be used for other infrastructure planning.

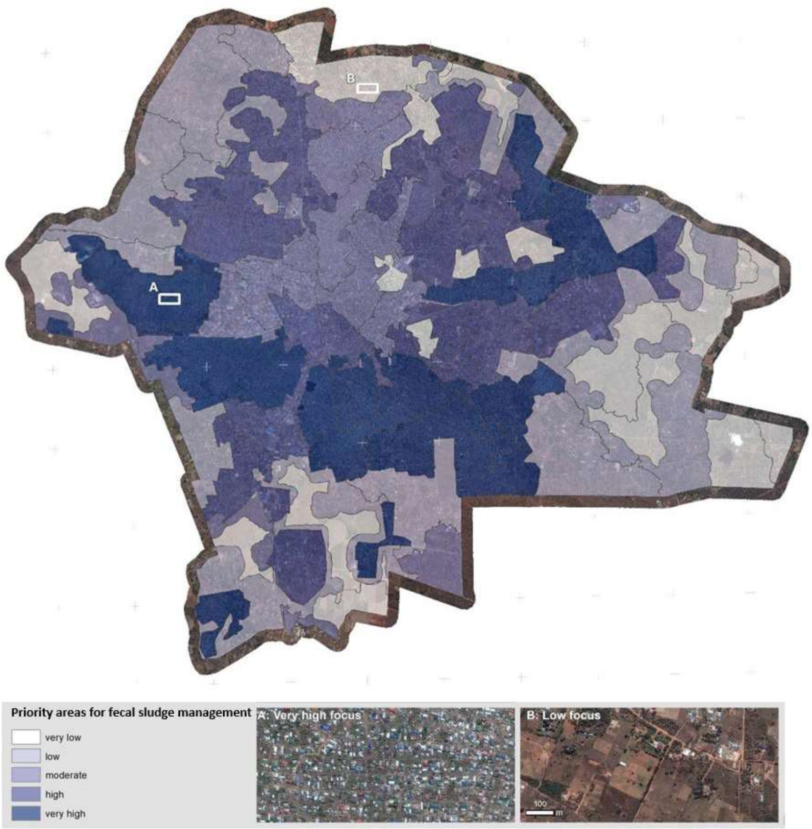

Figure Potential priority areas for faecal sludge management in Lusaka, Zambia