Spatial optimization of a portfolio of centralised and decentralised technologies for planning sustainable sanitation

The University of Tokyo Vajira Lasantha, Kiyo Kurisu, Kensuke Fukushi
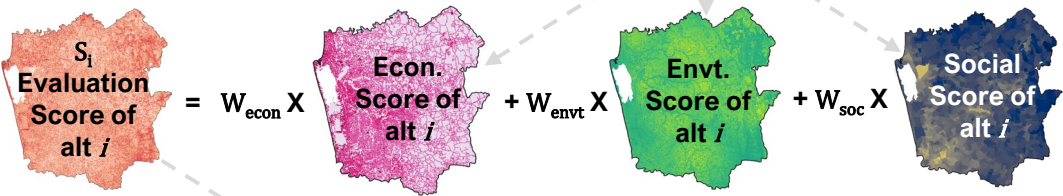
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Problem

Can we provide a better sanitation service for the urban and peri-urban areas of the developing world with highly dynamic and heterogeneous spatial characteristic, by applying a portfolio of centralised and decentralised sanitation technologies ?
How to find the optimum spatial distribution of alternatives when using a portfolio approach ?

Proposed solution

A framework to evaluate a diverse portfolio of sanitation technology alternatives in terms of the overall sustainability and the suitability to a location
Optimised sanitation plans under different development scenarios, produced using the evaluation framework.

Sanitation technology alternatives are pre-selected.
For alternative i in a set of n,

$$S_i \text{ Evaluation Score of alt } i = W_{econ} \times \text{Econ. Score of alt } i + W_{envt} \times \text{Envt. Score of alt } i + W_{soc} \times \text{Social Score of alt } i$$

Sanitation development scenarios

Defined by the weightages applied to the three scores
Result shown here are for a scenario which gives equal preference for economic and environmental factors irrespective of the rate of adoption considered the social score. Defined by W_{econ}, W_{envt}, W_{soc} = (10, 10, 0)

Evaluation of alternatives

Economic
appropriateness and its spatial distribution, evaluated by
- The life-cycle cost of complete service coverage with an individual technology
- Cost of Alt 1 centralised estimated using a data-driven prediction model
- Costs of other alternatives estimated based on per capita costs

Environmental
appropriateness and its spatial distribution, based on four criteria,
1. Capacity for reception of effluent from onsite systems, mapped based of population density and impervious surfaces
2. Suitability of soil for onsite disposal
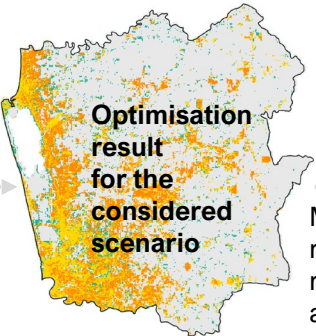3. Surface water pollution risk
4. Water reuse potential

Social
appropriateness and its spatial distribution, evaluated by
The expected rate of service adoption, estimated based on the socioeconomic level of the households.
Mapped based on a socioeconomic index derived from 70 variables of household and population statistics.
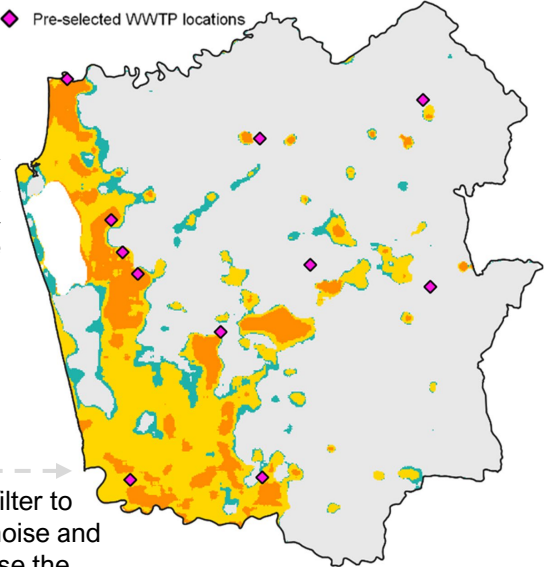
Conclusions & Recommendations

Optimised sanitation plans are found to be a mix of multiple technologies in most scenarios
Recommended to consider portfolio approaches to sanitation supported by scenario analysis

Study area
Gampaha District, Sri Lanka
Growing urban centres & expanding peri-urban zone

In the optimum sanitation technology grid $\mathbf{A}$, value of grid cell
$$a_{j,k} = \max_{i \in n}(S_{i_{j,k}})$$

Optimisation result for the considered scenario

Median filter to reduce noise and regionalise the alternatives

Optimised sanitation plan
for the considered scenario

◆ Pre-selected WWTP locations

Selected sanitation technology alternatives

1 **Centralised Sewerage**
gravity sewers, forced mains, central wastewater treatment

2 **Simplified Sewerage**
Interceptor tanks, small-bore sewers, semi-central WWTPs

3 **Septic Tanks + Faecal Sludge Management**
Septic tanks, sludge transport and treatment

4 **Improved Septic Tanks**
Septic tanks, anaerobic filters, disinfection

Interactive tool for exploring different scenarios