A holistic framework for assessing co-benefits of street-scale green infrastructure interventions

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Core urban areas tend to be made up of street-canyons and are one of the most polluted urban environments, due to the restricted dispersion of traffic emissions by surrounding buildings.

Use of green infrastructure (GI) such as roadside hedges, trees, green walls and roofs in urban areas are on the rise since they can help to abate the exposure to traffic emissions in roadside environments and offer many other co-benefits such as heat amelioration to reduce the impact of urban heat island, noise reduction and increased biodiversity (Figure 1). However, these benefits (including moderating air pollution) are very sensitive to local contexts, and badly planned GI can make situations worse or achieve only limited co-benefits.

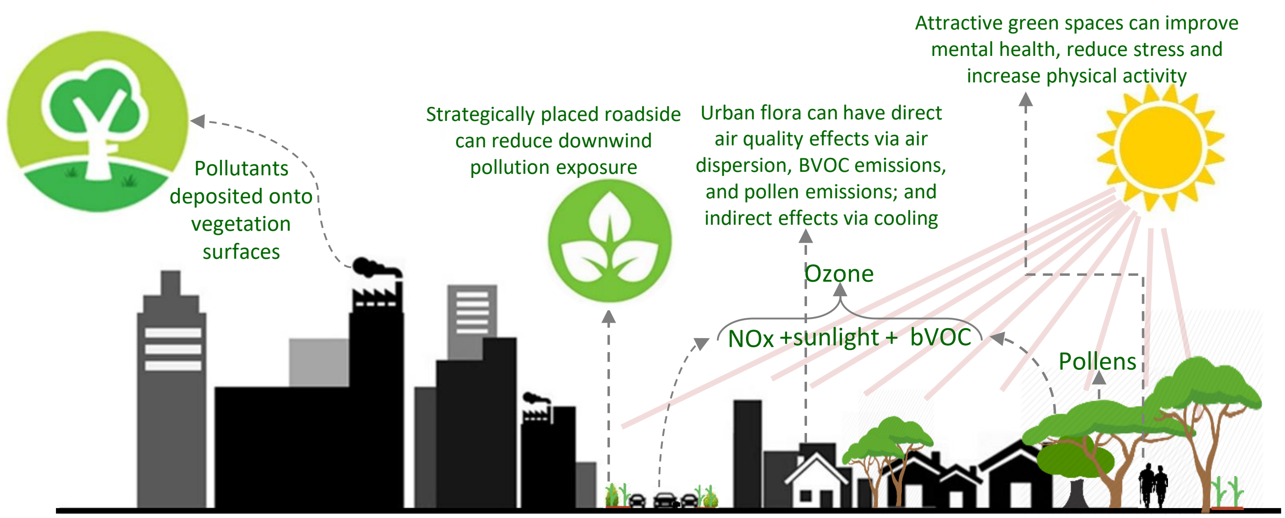

Figure 1. Schematic diagram showing the benefits and downsides of GI in the built environment (Kumar et al., 2019).

For example, dense trees in deep street canyon environments can increase pollutant exposure by trapping air pollutants at ground-level yet the same configuration can be beneficial in cooling the street. Such two-way trade-offs (e.g. pollution versus cooling) are rarely considered in GI implementation. Furthermore, other factors such as noise reduction and biodiversity are very seldom considered in such assessments. Additional complexity arises when vegetation releases biogenic volatile organic compounds that combine with traffic-emitted pollutants to produce secondary pollutants such as ozone and particulate matter. All these factors interact with the built environment (height to width ratios of buildings, and their spatial arrangement), leading to a wide range of potential outcomes from highly positive to net negative.

To support decision-makers and address this global need, there is a need to develop an evidence-based holistic assessment framework for street-scale greening that is generic, inclusive of pollution-cooling-noise-biodiversity trade-offs, and also easily implementable.

This project will use a combination of experimental and modelling approaches to build such a framework. The student will undertake trial demonstrations, and modify and apply existing models for pollution, noise and heat, and integrate their results to create a holistic framework for assessing co-benefits of street-scale green infrastructure interventions.

In year 1, the student will create a practical framework for the model and will focus on developing scaling functions to bridge the current gap that exists between large-scale atmospheric transport models for air quality and numerical/computational models, which operate at street-canyon scale. The outcome will be a meta-model or set of generalizable transfer-functions to extrapolate from individual streets to other contexts, based on key parameters. In year 2, the student will build on this experience using spatial models developed by the UKCEH for heat and noise mitigation provided by urban GI. In Year 3, the student will review the main spatial biodiversity functions used in the literature, to create an urban meta-model for biodiversity benefits of small-scale GI features. All these components will then be consolidated into the assessment framework.

Each step of the project will produce high quality science innovations, and the student will be encouraged to publish these in ISI journals. The outcome of the project will be an ‘easy to use’ assessment framework that helps plan multiple co-benefits for small scale GI features, accounting for local context, which is sorely needed in urban planning. The student can work with city councils in Liverpool and Guildford.

Training opportunities: The Air Quality Laboratory of Surrey’s GCARE is equipped with state-of-the-art equipment and novel indigenous setups, offering direct opportunity for the student to work with research grade instrumentation and affordable sensors. The GCARE/UKCEH team is specialised in running street/city scale models, allowing the student direct access and training opportunities to apply relevant models. UKCEH has developed urban GI models for a range of benefits, including heat mitigation and noise reduction, designed to work at city scale. The student will learn how to use and adapt these.

Student profile: This project will be suitable for a student with a degree in science (atmospheric/physics/mathematics/forestry), engineering (environmental/civil/mechanical/chemical/computer), or a closely related environmental/physical science discipline. Some experience of running models, and spatial analysis would be extremely useful.

References:

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