7 Urban green and health effects

7.1 Overview

Urban green provides health benefits to people in their living environments and reduces the number of people that need to visit a doctor (Maas, 2008). Urban green has a positive effect on air quality, stress reduction, urban cooling, concentration and physical activity, among other things (e.g. Maas, 2008 and KPMG, 2012). Urban green in the surroundings of people's homes reduces the prevalence of multiple health risks and diseases, including respiratory diseases, migraine, diabetes, depression, neck and back pain, depression and coronary heart disease (KPMG, 2012). For this model, an aggregated methodology has been applied to assess the effect of urban green on nine health risks (cf. the TEEB-Stad tool, see www.teebstad.nl).

For the ecosystem service 'urban green and health effects', five output maps have been produced for the Atlas of Natural Capital based on the TEEB-Stad methodology and using the same input values as the TEEB-Stad tool. Tables 7.1 and 7.2 provide an overview of the input and output maps model for the ecosystem service 'urban green and health effects'.

Table 7.1. Output maps generated for the ecosystem service 'urban green and health effects'.

Output map	Unit	Short description
Amount of urban green in a 1 km radius	% urban green	The percentage of urban green in a 1 km radius around the cell
Reduced number of patients due to urban green surrounding homes	Reduced # patients $cell^{-1}$ yr^{-1}	The reduced number of patients per cell per year as a result of the surrounding amount of urban green.
Health effects of urban green on urban living environment	Reduced doctor's visits per ha urban green yr^{-1}	The effect a specific green area has on the reduction of doctor's visits by inhabitants in the surrounding area.
Avoided health costs due to urban green	€ ha^{-1} yr^{-1}	The reduction of public health costs as a result of urban green in the surroundings of homes.
Avoided health-related labour costs due to urban green	€ ha^{-1} yr^{-1}	The reduction of labour costs due to better health of employees as a result of urban green in the surroundings of their homes.

Table 7.2. Input maps applied to estimate the ecosystem service 'urban green and health effects'.

Input	Unit	Short description	Source
Inhabitants	# inhabitants per cell	Shows the number of inhabitants per cell	RIVM (see Appendix II)
Agricultural crop parcels	Categories for crop types	Yearly updated cadastral map of agricultural parcels with information on crop types per parcel.	RVO 2013
Vegetation cover	% cover per cell	The percentage of a cell that is covered by vegetation (low vegetation, bushes and shrubs and trees combined).	RIVM (see Appendix I)
Percentage non-green area	% non-cover per cell	Percentage of a cell that is not covered by vegetation (inverse of the vegetation cover map).	VITO

7.2 Modelling the ecosystem service

The service 'urban green and heath effects' results in five output maps. The modelling of these maps is described in the following sections. Figure 7.1 provides a schematic overview of the way input data has been modelled in order to produce the output maps. Two versions of the model have been developed. The first version includes agricultural areas surrounding cities and towns. A second version excludes agricultural areas to emphasize the impact of urban vegetation and (semi)natural vegetation surrounding urban areas. Both models use the same calculations described below.

7.2.1 *Avoided health costs due to urban green*

The monetary value of reduced health costs due to urban green in the surroundings of people's homes is calculated as follows:

$$€_{reduced\ health\ costs} = \boldsymbol{HealthEffects}_{urban\ green} \times \boldsymbol{HealthCosts}$$

Where:

- $€_{reduced\ health\ costs}$, is the monetary value of avoided health costs [€ ha^{-1} yr^{-1}];
- $HealthEffects_{urban\ green}$, is the health effects of an area of urban green [reduced doctor's visits per ha urban green yr^{-1}];
- *HealthCosts*, the annual avoided health costs per patient [€ $patient^{-1}$ yr^{-1}].

The avoided health costs per patient that were applied in the TEEB Stad tool were used (2016 € values). These values are based on KPMG (2012) and the Cijfertool Kosten van Ziekten of RIVM, which valued the average health costs for nine diseases that had a relation to urban green at €868 per patient per year.

7.2.2 *Avoided health-related labour costs due to urban green*

The monetary value of reduced health-related labour costs due to urban green in the surroundings of people's homes is calculated as follows:

$$€_{reduced\ labour\ costs} = HealthEffects_{urban\ green} \times HealthLabourCosts \times ParticipationFactor$$

Where:

- $€_{reduced\ labour\ costs}$ is the monetary value of avoided health-related labour costs [€ ha^{-1} yr^{-1}];
- $HealthEffects_{urban\ green}$ is the health effects of an area of urban green [reduced doctor's visits per ha urban green yr^{-1}];
- *HealthLabourCosts* is the annual avoided health-related labour costs per patient [€ patient^{-1} yr^{-1}].
- *ParticipationFactor* is the fraction of people that participate in the labour market [%].

The avoided health-related labour costs per patient that were applied in the TEEB Stad tool were used (2016 € values). These values are based on KPMG (2012) and Steenbeek et al. (2010). The costs consist of three components: absenteeism, reduced labour productivity and job losses. Average annual costs per patient were calculated to be €6,341 (€3,221 for absenteeism, €2,691 for reduced labour productivity and €429 for job loss). The participation factor was estimated to be 67% based on KPMG (2012).

7.2.3 *Health effects of urban green on urban living environment*

The health effects of urban green on urban areas is determined as a function of the amount of urban green in a one km radius around a given area of urban green and the population density surrounding the urban green, given the following formula:

$$HealthEffects_{urban\ green} = PercGreenSpace_{1km} \times PopDensity_{1km} \times HealthImpact_{urban\ green}$$

Where:

- $HealthEffects_{urban\ green}$ is the health effects of an area of urban green [reduced doctor's visits cell yr^{-1}];
- $PercGreenSpace_{1km}$ is the percentage of urban green within a one km radius around a cell [% urban green cell^{-1}].
- $PopDensity_{1km}$ is the number of inhabitants within a one km radius around a cell [inhabitants km^{-1}], based on the inhabitants map (Appendix II).
- $HealthImpact_{urban\ gree}$, is the number of avoided doctor's visits per person as a result of the amount of urban green around a home [avoided doctor's visits per person per % urban green yr^{-1}].

The health impact of the percentage of urban green on doctor's visits per person is based on Maas (2008) and calculated to be 0.000835 avoided doctor's visits per person per percent of urban green. The map shows values for all cells that have at least 1% of urban green.

7.2.4 *Reduced number of patients due to urban green surrounding homes*

The reduced number of patients due to surrounding urban green in urban areas is determined as a function of the number of inhabitants in a given cell and the amount of urban green in a one km radius around homes, given the following formula:

$$\boldsymbol{AvoidedPatients}_{\boldsymbol{urban\ green}} = \boldsymbol{PercGreenSpace}_{\boldsymbol{1km}} \times \boldsymbol{PopDensity}_{\boldsymbol{cell}} \times \boldsymbol{HealthImpact}_{\boldsymbol{urban\ green}}$$

Where:

- $AvoidedPatients_{urban\ green}$ is the health effects of an area of urban green [reduced doctor's visits cell^{-1} yr^{-1}];
- $PercGreenSpace_{1km}$ is the percentage of urban green within a 1 km radius around a cell [% urban green km^{-1}].
- $PopDensity_{cell}$ is the number of inhabitants in a given cell [inhabitants cell^{-1}] based on the inhabitants map (Appendix II).
- $HealthImpact_{urban\ green}$ is the number of avoided doctor's visits per person as a result of the amount of urban green around a home [avoided doctor's visits per person per % urban green yr^{-1}].

The health impact of the percentage of urban green on doctor's visits per person is based on Maas (2008) and is calculated to be 0.000835 avoided doctor's visits per person per percent of urban green in a one km radius (KPMG, 2012). The map shows values for all inhabited cells.

7.2.5 *Amount of urban green in a one km radius*

To determine the health effects of urban green on urban areas, the percentage of urban green within a one km radius around every cell needs to be calculated. This was done in two ways – one calculation includes agricultural areas surrounding cities and towns, one excludes agricultural areas. The calculation was done as follows:

$$\boldsymbol{PercGreenSpace}_{\boldsymbol{1km}} = \sum \boldsymbol{VegetationCover}, \boldsymbol{PercNonGreen}$$

Where:

- $PercGreenSpace_{1km}$ is the percentage of urban green within a one km radius around a cell [% urban green km^{-1}].
- *VegetationCover* is the percentage of vegetation cover in a given cell (trees, shrubs and low vegetation combined) [% vegetation cover cell^{-1}] based on the vegetation map (Appendix I).
- *PercNonGreen* is the amount of area per cell that is covered by sealed surface based on the Ecosystem Unit map and the Agricultural Crop Parcels Map [% non-green cell^{-1}].

As agricultural areas are considered as urban green on the vegetation cover maps, in the calculations in which agricultural areas were excluded, the Agricultural Crop Parcels map was used to remove these agricultural green areas from the vegetation map.

7.3 Remarks and points for improvement

- There is a lot of new and upcoming research on the relationship between green and different health aspects. Studies focusing on specific health aspects can be incorporated into model updates.
- Maas (2008) did not find a relationship between urban green and health in highly urbanized areas, but this relationship is currently being applied in all urban areas to keep the model in line with the TEEB-Stad tool.

7.4 References

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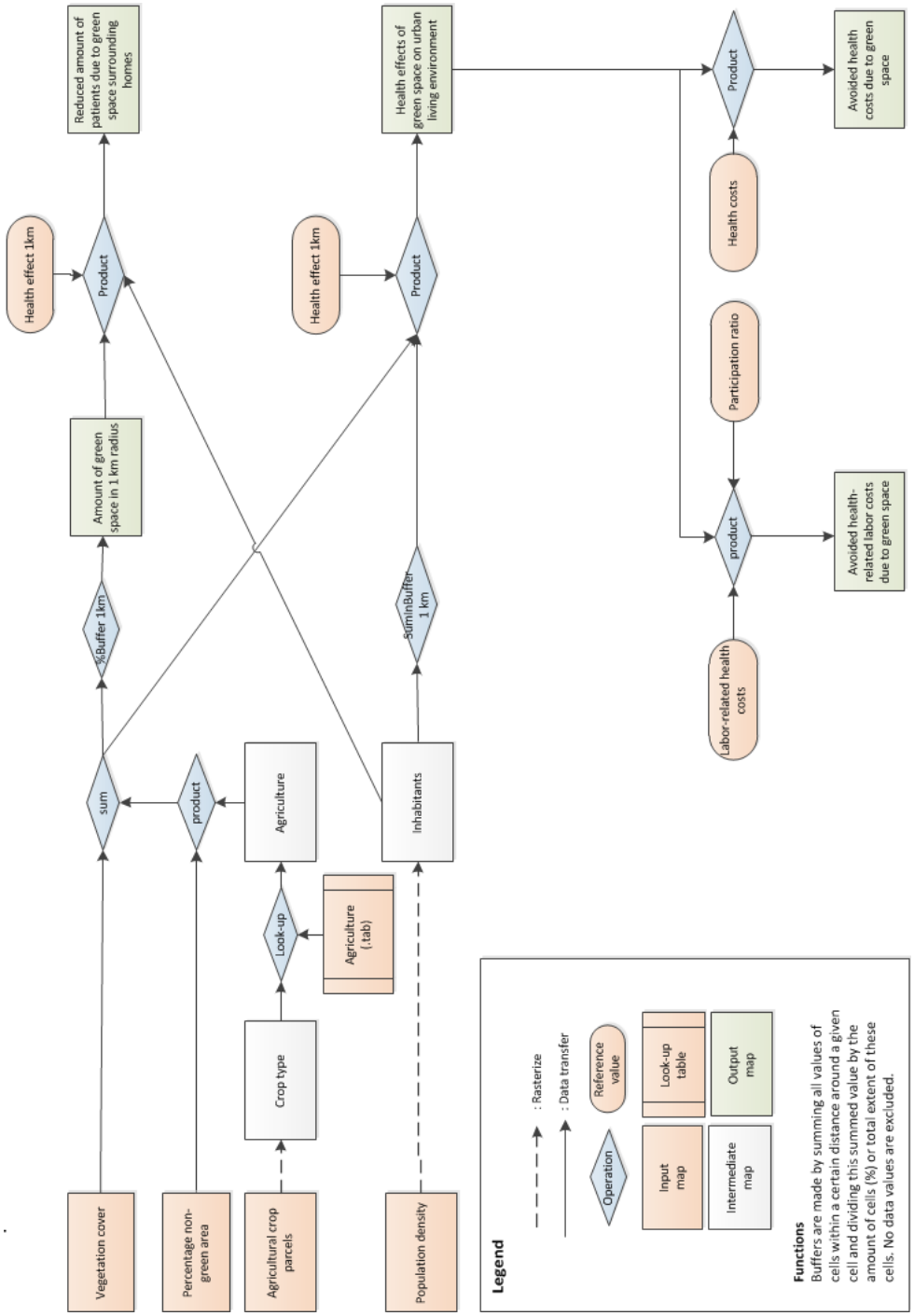

Figure 7.1. Schematic overview of 'urban green and health effects' model