Addendum B

The ecosystem service models that were implemented in ECOPLAN-SE make use of both quantification and valuation methods. They are to a large extent based on the methods that are used in the Nature Value Explorer and other previous studies (Broekx, L. De Nocker et al. 2013, Liekens, Schaafsma et al. 2013, Stevens, Demolder et al. 2015, Staes, Broekx et al. 2017). Additional and improved procedures were developed during the ECOPLAN project and implemented within ECOPLAN-SE. All models give values in # / ha \* year. When needed procedures were adapted to fit the datasets incorporated in ECOPLAN-SE. More extensive information regarding the models (methods, input data, etc.) can be found in the manual of ECOPLAN-SE (Dutch) (Vrebos, Staes et al. 2017).

# Food production

**Quantification:** The model does not incorporate a quantification.

**Valuation:** Because of the nature of the primary data, valuation is done directly in €/ha\*yr. Typical agricultural net revenues are derived from different reports on profits and loss accounts at the farm level. These values are then used in combination with the land cover map that incorporates the parcel crop registration data of 2015 and crop specific soil suitability maps to account for spatial variations in crop specific productivity.

Soil suitability maps for agriculture and horticulture are calculated within ECOPLAN-SE by combining soil texture, soil MHG and MLG and other soil characteristics build-in in the model. A suitability class groups the soil types that can provide a comparable production for several crop types when uniform cultivation and fertilization practices are applied. For each crop type, a 5 class ranking is provided, where class 1 is very suitable and class 5 is unsuitable (Bollen 2012). The classes 1-2 are associated with the P75 values of the crop revenue values, the classes 3-4 are associated with the P50 values and class 5 is associated with the P25 values.

The profits and loss accounts reflect the state of revenues and costs for particular agricultural sectors. The net revenue is the difference between the total revenue from agricultural production (excluding subsidies) minus the operational costs. For the year 2012 this was derived from detailed data from a random check of 749 particular farms (Van Broekhoven, Somers et al. 2012). Because of the variability between years we used data from 2008, 2009 and 2010 to estimate the values per crop type. For fodder crop types, an alternative method is used by the agricultural administration (D’Hooghe 2012). In general, fodder crops are not sold on the market, but are used as fodder within the agricultural production chain. The net revenues from dairy and meat production are therefore distributed among the fodder production parcels at the farm level to estimate a revenue factor for fodder crops. Based on this data, a P25, P50 and P75 revenue value (per ha) was derived for the most important crop types (e.g. for corn P25=€ 1.003, P50=€1.300, P75=€1.526).

# Wood production

**Quantification**: Wood production depends on soil characteristics and applied harvest regime (HR). A more detailed model, specifically designed to manage wood plantations in Flanders - Sim4Tree (Dalemans, Jacxsens et al. 2015), was used to derive minimal and maximal wood production for the most important (commercial) tree-species in Flanders. For each species a minimum and maximal mean growth of stem wood (m³/ha\*year) was calculated (Table 1). This allows the user to select two different types of forest management. Depending on the management and ownership structure, private or public property, a harvest factor is applied that estimates the proportion of the annual maximal mean growth that is harvested annually (0.6 in private and 0.7 in public forests).

Table 1: Overview of the relationships between soil suitability and the maximal mean growth of stemwood (m³/ha\*yr).



**Valuation**: Valuation of wood production is done on the basis of m³ harvest and per tree species. The value for each species was based on the database available in Sim4Tree (Borremans, Jacxsens et al. 2014) (Table 2).

Table 2: Overview of timber values (€ per m³) sold as standing timber per circumference class for most important commercial tree species.



# Energy from biomass

Energy crops are evaluated as three distinct groups: agricultural energy crops, biomass from forestry and biomass from nature conservation areas.

**Quantification:**

Agricultural energy crops: yield tables for different energy crops (maize, grain, different seeds and sugar beet) are combined with soil characteristics to estimate the energy yield (Van Kerckvoorde and Van Reeth 2014).

Biomass from forestry: only excess wood from forestry, (branches and trees from first thinnings that cannot be used as production wood, are taken into account. Using information from the wood production model, estimates are made on the amount of excess wood that will be produced and the amount of energy this wood can provide (Van Kerckvoorde and Van Reeth 2014).

Biomass from nature conservation: management of nature areas, such as reed cutting and mowing grassland, provides biomass that can be used in energy production. For different types of natural vegetation that are managed, an estimation is made of the amount of biomass each type produces yearly and the amount of energy it contains (Van Kerckvoorde and Van Reeth 2014, Van Meerbeek, Van Beek et al. 2014, Van Meerbeek, Hermy M. (sup.) et al. 2015).

**Valuation:** There is currently no valuation of “energy from biomass”.

# Water production

**Quantification**: Water provisioning is derived from the ES infiltration and only covers water provisioning from groundwater abstractions. The Flemish region has licensed approximately 22.600 permits for groundwater abstractions for an annual maximal abstraction of 420 million m³ per year. About 282 million m³ is licensed for abstractions from phreatic layers. It is estimated that about 60 % of the permitted volumes are effectively abstracted.

In a first step the point data on abstracted volumes are distributed to virtual infiltration equivalent buffers, and then the average abstraction ratio is calculated within a radius of 12.5 km. This is assumed to be an appropriate spatial (and temporal) scale to assess the sustainability of the groundwater abstractions (to compare these values to average annual infiltration at the same spatial scale). By combining both spatial supply (infiltration) and spatial demand (abstraction), the model can estimate the amount of infiltration that is abstracted. From a sustainability viewpoint, we make the assumption that the current infiltration should be able to sustain the current water provisioning on the long term.

**Valuation**: Valuation of water provisioning, quantified by supply through infiltration, is explored from two viewpoints. The first is the substitution cost: In times of scarcity, water is purchased in the Walloon region. A recent benchmark study of the drinking water companies revealed the average additional costs of purchasing treated water versus own production at the level of the Flemish Region. This difference in costs is approximately 0.2 €/m³. The second method used is based on the groundwater water abstraction tax. This tax is 0.075 €/m³ and can be seen as a compensation for the environmental and resource costs as formulated within the Water Framework Directive. This is the existing effective contribution from water companies and should be regarded as the absolute bottom threshold.

# Pollination

**Qualitative indicator:** Pollination is a regulating service that is vital to sustain certain types of agricultural production. The calculation for pollination is based on the method incorporated in INVEST (Tallis and Polasky 2009). This methodology was adapted to better fit the aims of ECOPLAN-SE and populated with data from a previous study which used the INVEST model in Flanders (Van Gossum, Peters et al. 2014).

Different types of pollinators were selected that are important for pollination in Flanders. For each land cover type, nesting suitability and food availability (floral resources) were determined. (Table 3).

Table 3: Overview of the different pollinators and their characteristics in Flanders.



With these characteristics and formulas taken from INVEST, pollinator availability and potential pollination for the different pollinator dependent corps is calculated as relative patterns of abundance. Unlike INVEST, no further calculation of its importance to the farm is performed. However, the relative contribution of each pollinator supply pixel (green area) to the delivery is calculated by attributing the resulting abundance indicator back to the supplying green areas (Figure 1). This results in a map that indicates the relative importance of each green area to pollination.

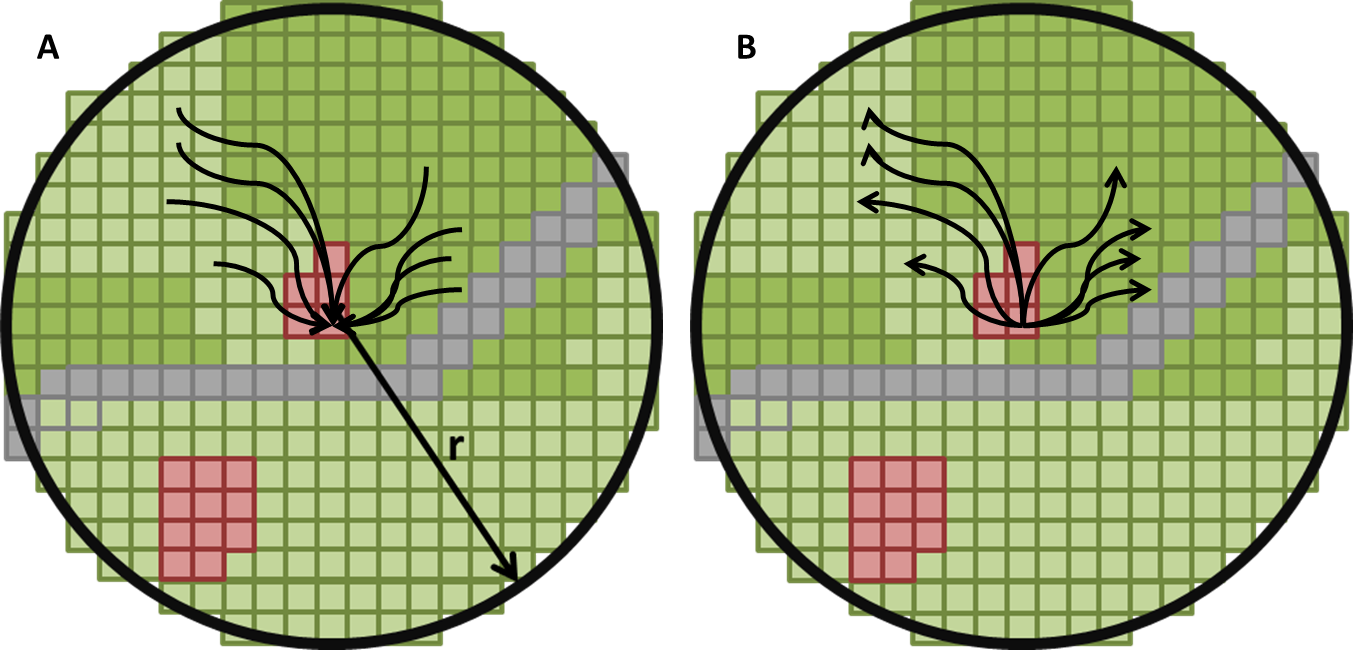


Figure 1: Calculation process during which in first instance the value of each pixel is calculated and after which this value is dispersed over the attributing green cells. This method is not only applied in the pollination model but also to calculate “Health benefits” and “Quality of the environment and estate value”. A) in a first step the value of ES delivery is calculated by evaluating the available amount of green areas within a specific range. The weight of each green area in the calculation can be changed based on distance (e.g. Euclidean distance) and type (e.g. grass or forest). B) The resulting value is dispersed over the green areas again based on distance, type or other weight factors. This calculation is done for each pixel and results of each calculation are added up. This way the ES delivery can be attributed to each ES supplying cell and the importance of each green area can be determined.

**Valuation:** Unlike in the INVEST model, no valuation of pollination is performed.

# Water infiltration

Quantification: Water infiltration is the movement of water from the soil surface into the soil profile. Potential infiltration is limited by soil texture and groundwater depth (Batelaan and De Smedt 2007). The groundwater depth has a limited effect and is an intermediate result of the water retention calculation method. More important variables are interception by vegetation and runoff from paved surface to storm drain infrastructure. By combining these different variables spatially, the infiltration (m³ / ha\*year) is calculated.

**Valuation:** This regulating ecosystem service has not been valued, but affects other final services which can be valued (Figure 1). The effect of infiltration on, for example water provisioning, has been quantified and valued. Effects on other services, like flood risk reduction, have not been quantified.

# Water retention

**Quantification**: Water retention occurs at sites that are at least temporarily waterlogged. Many of these waterlogged sites have been drained for agriculture, housing etc… ECOPLAN-SE quantifies the retention as the mean level of water saturation in the topsoil (% waterlogged up to 1-meter depth). In combination with the soil porosity, we can express this as a retention volume (m³) per area unit. Potential water retention is derived from a) Mean historical high water levels, interpolated from soil data (indication of the depth of oxidation- reduction fronts); b) information on infiltration-seepage patterns at multiple scales, which is derived from a multi-scale topographic position index on a high resolution DEM (De Reu, Bourgeois et al. 2013). Actual retention is limited by drainage intensity, which is derived from land-use intensity (desired drainage depth) and drainage network density (distance decay principle). Also groundwater abstraction cones are taken into account as a limiting factor for water retention.

**Valuation:** This regulating service has not been valued, but affects other final services which can be valued.

# Carbon storage in biomass

**Quantification:** Carbon storage in biomass is an important regulating service to reduce climate change. The quantification of carbon sequestration in living biomass is based on the maximal annual growth of stem wood (table 4, cfr timber production). The growth of branches and roots is added to the stem wood production to estimate the total annual carbon sequestration. For this purpose, we use Biomass Expansion Factors (BEF). As a final step we translate the total growth of biomass (m³/ha\*year) to carbon sequestration values. Therefore, we use the species specific carbon density (kg /m³), as indicated in table A4. Carbon densities typically account for half of the weight. Annual carbon-sequestration (kg C per ha per year) can be calculated as follows: C ha\*year= IV \* BEF \* carbon density.

Table 4: Biomass density (kg/m³) and biomass expansion factors above and below ground.



Table 5: Mean yearly carbon sequestration in long term biomass.



**Valuation**: Parameter values for external costs of air quality and climate change have been identified for the Flemish Environment Agency (De Nocker, Michiels et al. 2010). These values are based on avoided reduction costs. Carbon sequestration in e.g. forests and soils allows avoiding emission reduction costs (measures) elsewhere; while still achieving policy targets. Marginal costs of measures that are needed to maintain the 2° C global warming target, increase gradually over time (20 €/ton CO2-eq. in 2010 up to 220 €/ton CO2-eq. in 2050). A standard value of 220 €/ton CO2-eq. for the year 2020 is chosen. This is consistent with the values of the Flemish reference manual for societal cost benefit assessments of large infrastructure works (Mint en Rebel 2013).

# Carbon storage in the soil

**Quantification:** Soils under unmanaged, natural vegetation types typically have larger carbon stocks than managed vegetation types. Also soil hydrology plays a crucial role in the creation of soil organic carbon (SOC) stocks. Soil organic carbon is especially high for forests and/or hydric soils. The potential equilibrium state for soil organic carbon stocks can be calculated using different regression formulas created within the ECOPLAN project (Ottoy, Beckers et al. 2015, Ottoy, Elsen et al. 2016, Ottoy, De Vos et al. 2017, Ottoy, Van Meerbeek et al. 2017). These formulas include parameters like water retention, soil texture and vegetation type and estimate the carbon stock in the upper first meter of the soil.

**Valuation:** Stocks are difficult to consider in valuation exercises. However, carbons stocks in the soil require on average a 100 years to regain a new equilibrium (Foereid and Høgh-Jensen 2004, Freibauer, Rounsevell et al. 2004). Therefore, when evaluating scenarios, the yearly C sequestration is estimated to increase or decrease by 1% of the expected stock change. As with carbon sequestration in biomass, a standard value of 220 €/ton CO2-eq. for the year 2020 is chosen.

# Nutrient storage in the soil

**Quantification**: Nutrient storage in soils can significantly affect nutrient availability in ground and surface waters and its quality. Changes in soil organic carbon also affect soil nutrient stocks. It is known that soil organic matter contains a certain percentage of nitrogen and phosphorus. The C/N ratio in stocks of SOC depends on the vegetation and land-use. Higher C/N ratios in the SOC can be explained by litter production that is more difficult to decompose (high C/N, high lignin concentration). Parameter values for the C/N ratio and N/P ratio in SOC can be found in Table 6. When possible, Flemish or Belgian studies were used (Duvigneaud, Kestemont et al. 1971, Froment, Tanghe et al. 1971, MacLean and Wein 1977, Cole and Rapp 1981, Nys, Ranger et al. 1983, S., B. et al. 1999, Ponette, Ranger et al. 2001, Andre and Ponette 2003, Uri, Tullus et al. 2003, Hytönen and Saarsalmi 2009).

Table 6: C/N ratio and N/P ration of SOC for several vegetation types



A decrease of the SOC and C/N ratio due to land-use and/or drainage can be regarded as an additional release of nutrients, comparable to fertilizer application. This mechanism is not accounted for in the calculation of the (avoided) nitrate leaching because of controversy, but could be included in the future when this mechanism is accepted.

The reverse mechanism, an increase of SOC and nutrient stocks due to land-use change and rewetting, can be categorized as the process of soil formation and maintenance. Linking this process to the improvement of water quality is highly debatable. Non-fertilized ecosystems tend to have negligible losses of nitrate to the groundwater. Ecosystems naturally tend to accumulate nutrients in SOC and biomass throughout their ecological succession if these nutrients are not removed (denitrification, grazing, harvesting, wildfires, leaching). But it is questionable whether they actively withdraw nutrients from ground and surface water. Most nitrogen is supplied from atmospheric N-deposition and the ability of some vegetation types to fixate N from the air.

**Valuation**: The positive and negative changes in N and P stocks in SOC are quantified, but are not valued since there are risks of double counting. Negative changes (nutrient release) could be added to the nitrate leaching calculations and be valued through ES denitrification (increased nitrate loads to the denitrification zones) and ES water production (avoided treatment costs). Positive changes in N and P stocks in SOC cannot directly be attributed to ES that can be monetized.

# Nutrient removal by denitrification

**Quantification**: Under conditions of (temporal) waterlogging, bacterial processes enable to remove nitrogen from ground and surface water. Denitrification is a microbial facilitated process where nitrate is reduced and ultimately produces molecular nitrogen (N2) through a series of intermediate gaseous nitrogen oxide products. Denitrification usually occurs under conditions of (temporal) waterlogging. To spatially assess denitrification, nitrate concentration in the groundwater, residency time and denitrification potential were taken into account.

Nitrate concentrations in the groundwater are calculated by estimating N-leaching to the groundwater. Therefore, atmospherical and agricultural N-deposition are combined with N-uptake by vegetation and the soil vulnerability for N-leaching, to estimate the N-load that leaches in to the groundwater. In combination with long-term yearly rain surplus which recharges the groundwater (0,25 m³/m²) an approximation is made of the N-concentration in the subsurface groundwater.

Based on maps of mean high and low groundwater levels, the potential degree (%) of N removal through denitrification is calculated. Whet soils that are more than 60% water saturated are suitable for denitrification. The residence time of the groundwater is estimated based the formula of Seitzinger, Harrison et al. (2006). While soil permeability, which depends on the soil grain size, is based on the soil map of Flanders. By combining the different resulting maps an overall map is produced that estimates the current denitrification in the Nete catchment.

**Valuation**: The valuation is based on the marginal reduction cost for nitrate removal. The Environmental Costing Model for Flanders compares different (technical) measures on cost-efficiency (€/kg reduction) and the applicability of those measures. The cost of the most expensive measure, considered in policy approved measure programs, can be seen as the cost the society is willing to pay for a further reduction of nitrate levels in ground and surface water. For nitrate, the marginal reduction cost is 74 €/kg N. As a low estimate we apply 5 €/kg N, based on a literature review (Liekens, Schaafsma et al. 2013).

# Erosion prevention

**Quantification**: Erosion prevention as an ecosystem service helps to protect soils against losses through wind and rain. Vegetation can significantly reduce erosion compared to open, arable land. One of the benefits is a reduced sedimentation in streams and populated areas. Erosion prevention through water is calculated using the RUSSLE equation. The module calculates erosion prevention by comparing erosion under arable land and current land cover.

The following formula is used:

Erosie (ton/ha/jaar) =

* C – factor = erosion vulnerability of the land cover type (dimensionless), based on a study in Flanders(Van Der Biest, Van Gossum et al. 2014).
* K – factor = erosion vulnerability of the soil texture type (Notebaert, Govers et al. 2006)
* R – rainfall/runoff erosion factor (Notebaert, Govers et al. 2006)
* P – erosion control factor is currently not implemented in the calculation
* LS – erosion vulnerability factor due to slope steepness and -length (McCool, Brown et al. 1987, Desmet and Govers 1996).

The method is applied to both the current land cover map and a scenario where everything is arable land. Both results are then compared to each to calculate the erosion prevention.

Valuation: This regulating service has not been valued.

# Air quality regulation – PM10

**Quantification**: Air quality is in general problematic in Flanders and has serious impact on public health (Amann, Bertok et al. 2011, Buekers, Stassen et al. 2011, Dhondt, Beckx et al. 2012). The removal of fine dust by vegetation can improve air quality and depends on the vegetation type and structure (height and specific leaf area). More leaf area effectuates a higher capture. However also the actual concentration in the air effects the deposition. In ECOPLAN-SE a map is incorporated that gives the mean PM10 concentration in Flanders This is combined with the different deposition speeds that are available for the land cover types in ECOPLAN-SE (Table 7). These deposition speeds are derived from previous studies (Oosterbaan, Tonneijck et al. 2006, Oosterbaan and Kiers 2011).

Table 7: parameter values for capture of fine particular matter by lover classes.



To calculate the deposition in (ton/ha\*year) the following formula is used:

*PM10 capture (ton/ha \* year) = deposition speed (cm/s) \* concentration PM10 (µg/m³) \* 0.0031536*

**Valuation**: Air quality regulation is valued by assessing its impact on the health. Avoided health cost are determined for rural areas in a study for the Flemish Environment Agency and were recently updated at 57 €/ kg PM10 (De Nocker, Michiels et al. 2010).

# Noise reduction

**Quantification**: Traffic noise is the most common source of noise nuisance. The Flemish region has one of the (van Hove, Jacobs et al. 2015) most dense traffic networks of the world (Lammar and Hens 2005). Recent research revealed that 27 % of the population is disturbed by noise pollution. Over 10 % is severely disturbed, with significant health impacts (Stassen, Collier et al. 2004). Approximately 30 % of building facades have a noise exposure over 65dBA during daytime (Van Renterghem, Botteldooren et al. 2012).

Noise exposure maps from major traffic roads are available from the Flemish Agency for Roads and Traffic. These maps express a weighted noise exposure (Lden: Level day-evening-night). Night and evening exposure are weighted stronger, which accounts for the impact of noise disturbance on life quality. The exposure maps are modeled and are based on the type and density of the traffic, speed limits, type of road surface as well as geometry of the surroundings.

Noise reduction is calculated by evaluating the vegetated areas between the houses within these exposure maps and the roads responsible for the noise disturbance. After all vegetation composition and structure are important factors as per 100 m of vegetation noise reduction can range from 7 to 12 dB for the frequency of traffic noise (500-1500 Hz) (Huisman 1990, DeFrance, Barriere et al. 2002). For each house within the evaluated area a minimum and maximum noise reduction is estimated based on the amount of forest and grassland that is available.

**Valuation:** Noise levels affect real estate values (decline up to 1.1 %). Negative effects of noise on house values start at levels of 55 dB and increase up to 1.1 % when there is at least 70 dB noise exposure. Further increase does not seem to affect house prices. As a starting position for the valuation, we assume the average house value in Flanders in 2015, which is 236.634 €/house or 11.015 €/year\*house at a discount rate of 4% over 50 years. The low and high estimate procures from the low and high estimate in noise reduction (respectively 7 and 12 dB/100 m). After estimating the added value of a property, the value is dispersed to the green areas that are responsible for the noise reduction. By calculating each house separately an overall value of the different green areas can be estimated.

# Local climate regulation

**Quantification:** Climate change, in combination with increases in urbanization, can lead to higher mean temperatures and the development of so-called heath islands in urban centers. Heath-islands only persist in highly urbanized areas and are only relevant when inhabitants are present. Large, impervious areas, for example in industry or harbors are less important. Due to a lack of a good heath-island map of Flanders, areas are delineated based on population densities (> 450 inh/km²). For these areas the surrounding green areas are evaluated on their cooling effects according to the formula:

Temperature effect (°C) = % green within range of 250m \* 3.3368

This formula is derived from a Dutch study close to Flanders (van Hove, Jacobs et al. 2015).

In each step of the calculation, the result value is redistributed towards the supplying green areas (Figure 1).

**Valuation:** There is currently no valuation available.

# Recreation and tourism

**Quantification:** The methodology applied within ECOPLAN-SE is a simplified version of an extensive study, which was optimized within ECOPLAN (De Nocker, Verachtert et al. 2016). It estimates the number of recreational visits per year to the different green areas under evaluation based on their attractiveness, demand for recreational visits surrounding the area and the availability of other green areas within travel distance that might compete with the areas under consideration.

In a first step the attractiveness of the green areas is evaluated based on different characteristics (De Valck, Landuyt et al. 2017). This includes both positive elements such as diversity and availability of water and negative effects such as nearby industry or noise disturbance. Besides these effects also visiting arrangements such as hiking trails and visiting centers are taken into account. These effects are aggregated into one value of overall attractiveness for each green pixel within the area.

Different types of recreation (walking, cycling and visiting by car) are taken into account over different travel distances (Table 8). For each recreation type each inhabitant accounts for a number of visits per year. These numbers are locally adjusted (on a municipality level) for the amount of available green. People who live in green areas are more inclined to recreate in green areas and will perform more visits. Based on population densities, attractivity, recreation types and travel distances, different allocation functions are applied which assign the number of visits to each of the green areas. These allocation functions are also adjusted for the size of each green area as people who travel a certain distance are more attracted to the larger green areas. Based on this calculation a map is given which estimates the number of visits each green area receives on a yearly basis.

Table 8: overview of the different types of recreation, travel distances and numbers of associated visits for one year.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type of activity | | Max Afstand | Number of visits / year | |
| Km | Flanders | Brussels |
| Local | Walking | 5 | 20 | 10 |
|  | Bike | 20 | 10 | 1 |
| Bovenlokaal | By car | 100 | 5 | 1 |
| Totaal per inwoner |  |  | 35 | 12 |

**Valuation**: For valuation of recreational visits, the approach of the UK National Ecosystem Assessment was used (Bateman Ian J, David Abson et al. 2011). Based on this approach, the average value was estimated at 4.4 €/visit, with slight variations that depend on the nature type (e.g. forest 4.5 €/visit; agroscapes 3.4 €/visit). Adaptations were made according to the relative preferences for certain nature types from choice experiments (Liekens, de Nocker et al. 2009, Liekens, Schaafsma et al. 2013). From the high and low estimates found in literature (Bateman and Jones 2003, Moons, Saveyn et al. 2008, Colson 2009), an average low (3 €/visit) and high (9€/visit) estimate was derived. More information on the valuation function can be found in the publication by Liekens, Schaafsma et al. (2013). The valuation of recreational visits is included in the final benefit assessment.

# Quality of the environment and estate value

**Quantification**: Residential buildings with view and/or proximity to green open spaces offer a higher environmental quality and this is reflected in property values. The added value of a green site depends on the number of houses within a distance of 100 meter. Property values are positively affected up to 1 km distance.

**Valuation**: Literature has demonstrated that the presence of green open space has effect on property values (Kroll and Cray 2010). For the valuation we use a method (Helgers and Vastmans 2016) developed for the Nature Value Explorer (Broekx, Liekens et al. 2013), which was adapted to the following procedure. For each house pixel an estimation of the number of properties (houses or apartments) is made based on population densities and within buffers of 200, 400, 600 and 800 meter the amount of available of green is estimated. A distinction is made between agricultural land and other green areas. For each calculation the following formulas are applied.

* Added value green =

∑zones (% green \*0.0755 \* yearly value house \* number of properties).

* Added value agricultural land =

∑zones (% agriculture \* 0.0472 \* yearly value house \* number of properties)

As a starting position for the valuation, we assume the average house value in Flanders in 2015, which is 236.634 €/house or 11015 €/year\*house at a discount rate of 4% over 50 years . In each step of the calculation, the result value is redistributed towards the supplying green areas (Figure 1).

# Health effects

**Quantification**: The presence of green open space in the direct surroundings of people has a positive effect on the physical and mental health. The effects are related to the number of inhabitants within 3 km of a green area. For health effects, there is also a certain overlap with “recreation and tourism” and “effects on estate values”. However, the effects on physical and mental health are of a fundamental different nature than the benefits visitors to these sites generate for the local economy (e.g. catering, rental, hotel sector). Although the motive of “recharging the batteries” (physical and mental health) can be partly overlapping, there is no indication in literature on the amount of overlap.

The method used to calculate the effects, is based on the concept of DALYs (disability adjusted life years), which is an indicator to compare different health effects. Studies have shown a positive relationship between available green and the impact on the loss of healthy years (Maas, Verheij et al. 2008). The study by Maas (2008) concludes that 10 % of additional green open space results in 2.46 healthy life years per 1000 capita and also gives a relationship additional green open space within a range of 3km and mental health. Both relationships are used to calculate the health benefits of open space:

*DALYs = inhabitants x %green within 1km x 0.000246*

*DALYs = inhabitants x %green within 3km x 0.000078*

In each step of the calculation, the result value is redistributed towards the supplying green areas (Figure 1).

**Valuation**: To estimate the value of the green areas, the supplied DALYs are combined with 87.000 € per DALY (Stassen, Collier et al. 2008).

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