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The EnhancES Toolbox

Modelling, Mapping, Assessing and Enhancing

Ecosystem Services in the Planning of Green Infrastructure

IMECOGIP

Implementation of the **Eco**system services Concept in **G**reen **I**nfrastructure **P**lanning to strengthen the resilience of the Metropolis Ruhr and Chinese megacities

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More information: https://sustainable-urban-regions.org/imecogip

EnhancES The IMECOGIP Toolbox

sure FONA Research for Sustainability ILS RUB Institute of Geography

Box 1 **Ecosystem Services**	**in the Toolbox**		
Regulating services	Carbon sequestration	… (or net primary production) models how much C from CO_2 (g C m^{-2} a^{-1}) the biotopes take up from the atmosphere (climate mitigation) (2.1.1.2)	Toolbox α
	and Carbon storage	… informs on how much carbon (g C m^{-2}) is stored in the biomass of the biotopes	Toolbox α
	Temperature regulation	… models the cooling intensity (Kelvin or KWh) of urban green spaces (soil-biotope units) during a user-defined heat wave compared to sealed surfaces (2.2.6.2)	Toolbox α
	Mediation of waste - PM_{10}	… calculates how much particulate matter with a diameter of 10 µm is absorbed by the vegetated surfaces (kg ha^{-1} a^{-1}) (2.1.1.2)	Toolbox α
	Flash flood regulation	… indicates the capability of spatial units to retain the discharge (m^3) of a single heavy rain event (2.2.2.1)	Toolbox α
	Visual screening	… calculates percentages of a buffer area where an unsightly object(s) are screened from people`s view (2.1.2.3)	Toolbox α
	Maintaining nursery populations and habitats	… estimates the capabilities of biotope types to maintain nursery population of birds as indicator species (ranked by order)	Toolbox γ
	Pollination	… models the capability of biotopes to support pollinators (ranked by order)	Toolbox γ
	Base flow regulation	… assesses the yearly quantity of groundwater recharge (mm a^{-1}) of soil-biotope units that contributes to base flow maintenance of streams (2.2.1.3; equiv. to 4.2.2.1 und 4.2.2.3)	
Cultural services	Recuperation through physical interaction with nature	… evaluates delineated complex areas, such as parks, that combine characteristics of biotopes and technical infrastructure in a way that, through active or immersive interaction with nature, enable recuperation or enjoyment and promote health (ranked by order) (3.1.1.1)	Toolbox β
	Recuperation through passive interaction with nature	… evaluates delineated complex areas, such as parks, that combine characteristics of biotopes and technical infrastructure in a way that, through passive and observational interaction with nature, enable recuperation or enjoyment and promote health (ranked by order) (3.1.1.2)	Toolbox β
	Aesthetic experiences	… evaluates delineated complex areas, such as parks that combine characteristics of biotopes and technical infrastructure in a way that enables aesthetic experiences (ranked by order) (3.1.1.4)	Toolbox β
Provisioning services	Groundwater	… assesses the quantity of yearly groundwater recharge (mm a^{-1}) of soil-biotope units that can be used for drinking or nondrinking purposes (4.2.2.1 und 4.2.2.3)	Toolbox γ
	Cultivated plants for nutritional purposes	… evaluates the site (landform, soil, climate, natural hazards) to repeatedly and sustainably bear edible plants (ranked by order) (1.1.1.1)	Toolbox γ

Which ecosystem services are covered by the toolbox?

At the current state, the ecosystem services indicated by a red circle are implemented, others are being prepared or currently developed (s. legend Fig. 1 and Box 1)

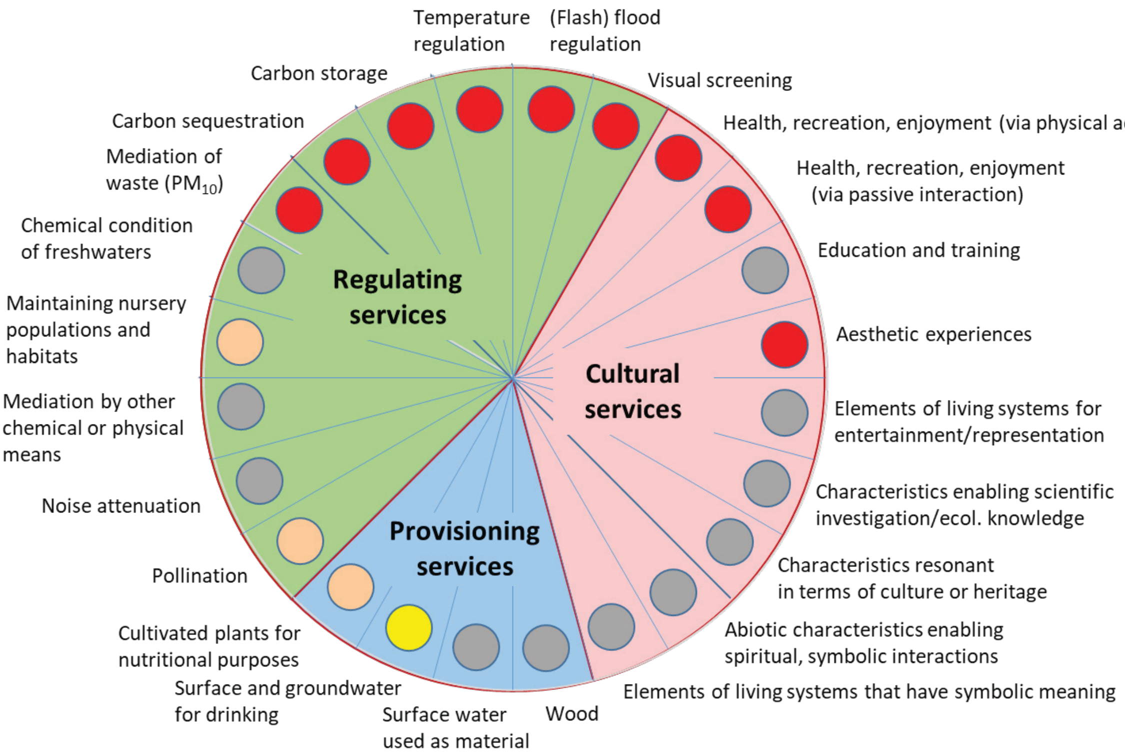

Fig. 1: Ecosystem services covered by the toolbox – now and in future

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How does the toolbox work?

Input: The toolbox models ecosystem services using geodata previously provided by the user in a map data format (shape files). They cover important compartments of urban ecosystems (Fig. 2). To run the models, the toolbox needs additional non-spatial parameters, which are either available in the toolbox or have to be entered by the users before they run the model. The model output comes in maps and in tables. Typically, the users does not look inside the heart of the toolbox, shaded yellow in Fig. 2. Before running the models, he should have achieved a general understanding of the assessment tools (e.g., by consulting the manual) to estimate if they are appropriate to the problem at hand.

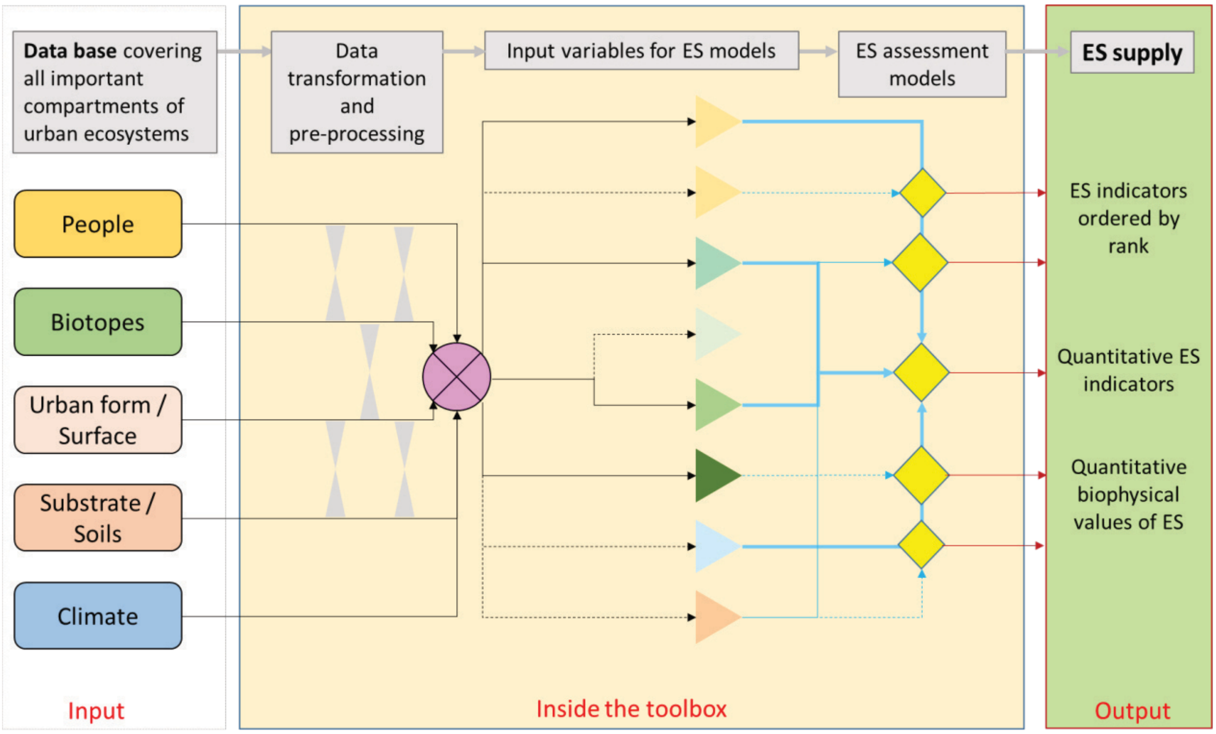


Fig. 2: How the toolbox works

We present the performance of the provisioning and regulating services in biophysical values, e.g. in kg · ha^{-1} · a^{-1} (Tab. 1). The cultural ecosystem services are scaled in ranks. You get a visualization of where in your area a specific ecosystem service becomes manifest (Fig. 4 and 5). At the same time, an integrated relative value informs on the overall performance of each ecosystem service (Fig. 5).

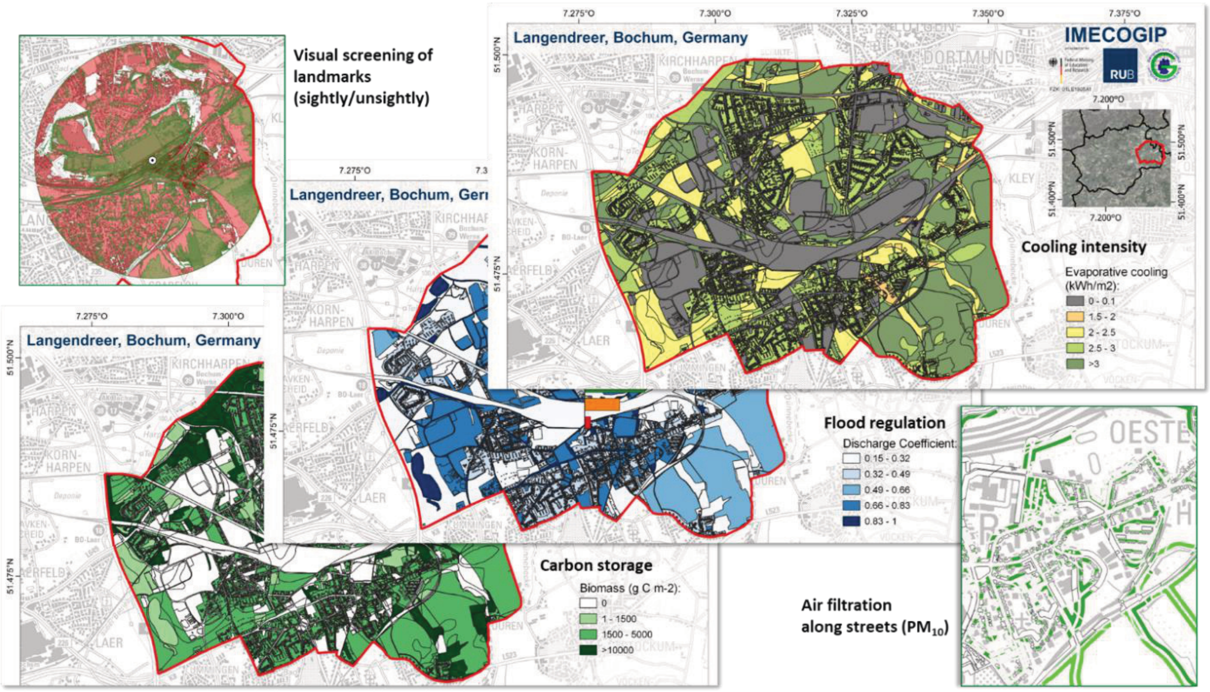


Fig. 3: Output-Maps

Tab. 1: Output table (example)

ES: Carbon sequestration (kg ·ha^{-1} · a^{-1})	
Number of polygons	7244
Minimum value	0.0
Maximum value	2915.0
Range	2915.0
Arithmetic mean	72.0
Median	0.0

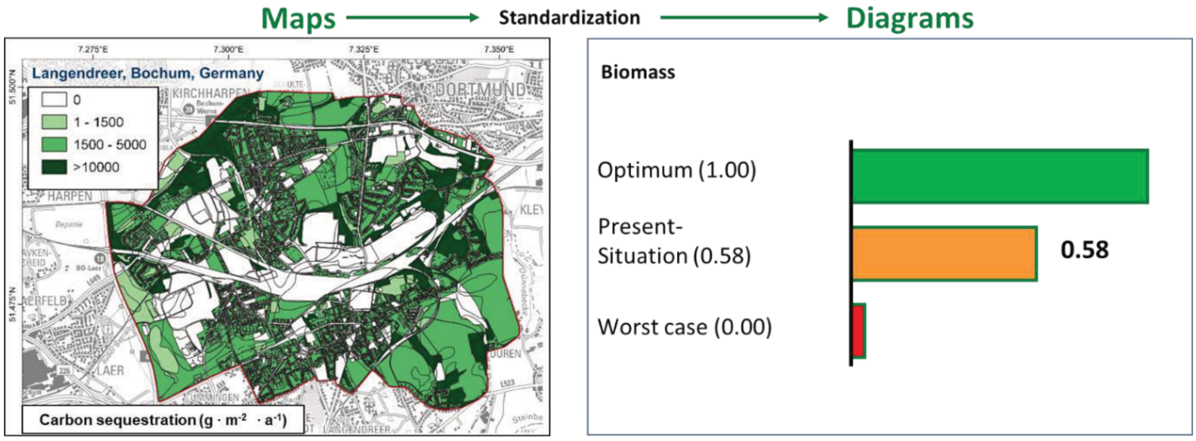


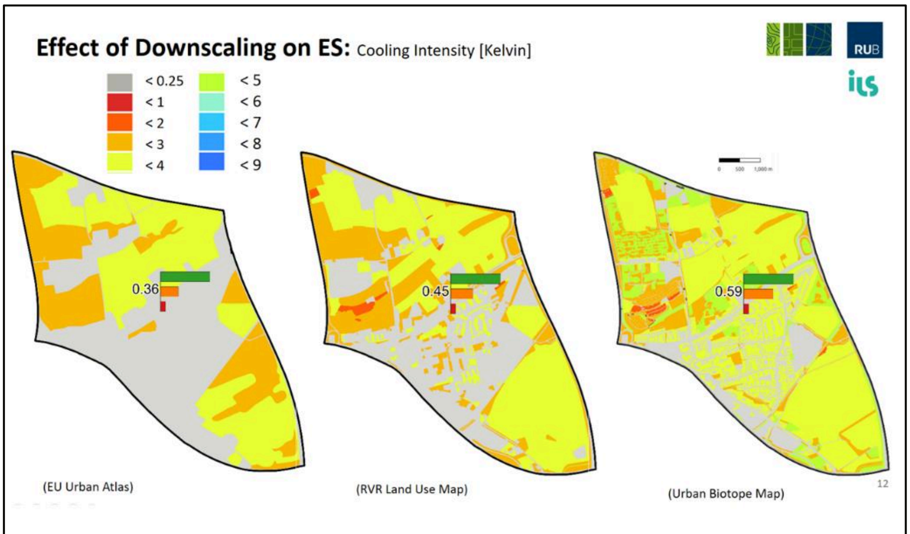
Fig. 4: From maps to standardized rating of the overall ecosystem service performance of the total area.

Table 1: Input Variables for the IMECOGIP-Toolbox – mandatory and optional

	Primary (preset; may be adapted or changed by users)	**Secondary** (mandatory inputted; internally attributed, calculated, or optionally user-inputted; *internally calculated only*)	PM_{10}- Attenuation	Cooling intensity	C– Sequestr.	C-Storage	Water Flow Regulation	Visual Screening	Recupera-tion active	Recupera-tion passive	Aesthetic experiences
Vegetation/Land Cover											
	Land use/land cover classes or urban biotope types		x	x	x	x	x	x	x	x	x
		Canopy height (< 2 m/> 2 m)	x	x	x	x	x	x	x	x	x
		Deposition velocity (Vd)	x								
		Leaf area index (m/m)	x		x	x					
	Building perimeters		x	x	x	x	x	x	x	x	x
		Crop coefficient (-)		x							
		Runoff coefficient (-)					x				
	Park boundaries	Perimeter border of park mosaics							x	x	x
		Landscape metrics of parks and park buffer areas							x	x	x
	Digital Terrain und Digital Surface model							x			
Soil											
	Soil units		x	x	x	x	x	x	x	x	x
		Available water capacity (AWC; mm)		x							
		Initial soil water condition (% of AWC)		x							
		Presence of groundwater (y/n)		x							
Climate											
	average ambient daytime temperature during heat wave (°C)			x							
	grass reference evapotranspiration during heat (ETo; mm)			x							
	length of heat wave (no. of days)			x							
	Daily precipitation (mm) (period for which PM_{10} is calculated)		x								
	Daily PM_{10} concentration (µg/m³) (period for which PM_{10} is calculated)		x								

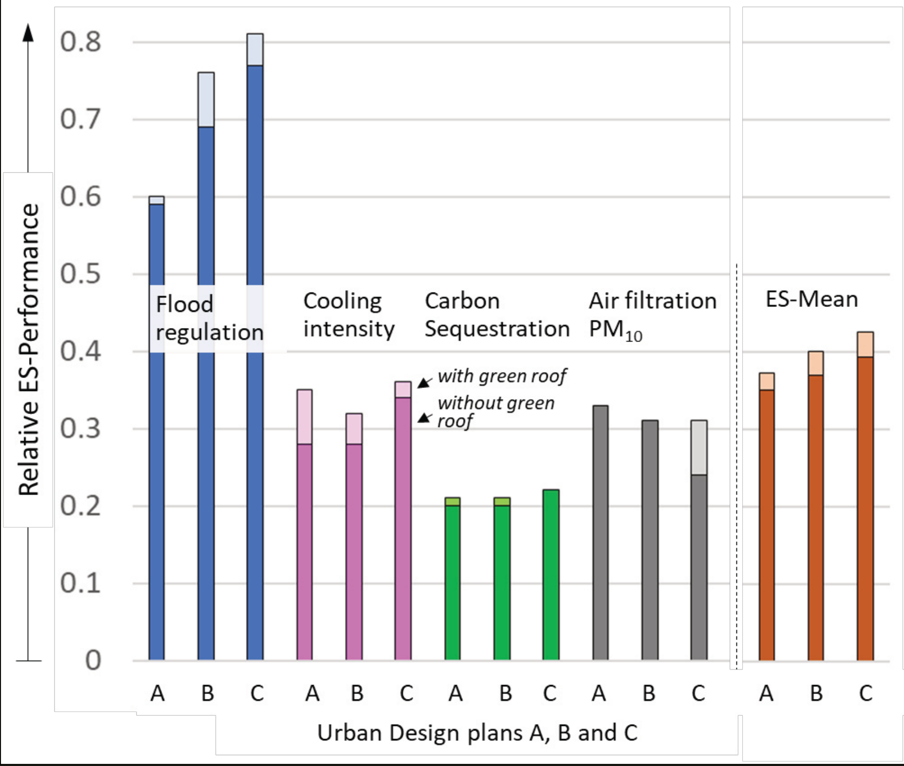
In general, the accuracy of the results depends on the specificity of the input variables, the assessment model chosen and the spatial differentiation of the input. For many countries, standardized land use/land cover (LULC) classes or biotope types are available. As default data set, the toolbox offers EU Urban Atlas for the reconnaissance level, the LULC of the RVR (Regional Authority Ruhr Area) and the Urban Biotope Types on the detailed level for small scale analyses. The toolbox being an open system, the users can adapt own datasets to their area of interest by either translating their own LULC/Biotopes to the default ones or by tailoring their own database. In the latter case, they have to make sure that they provide the parameters needed to model certain ecosystem services, e.g., leaf area indices, runoff coefficients that appear in the table among the secondary variables.

The secondary variables are those, which the toolbox automatically attributes to the preset LULC classes or bio-topes, and those which the toolbox internally calculates based on the primary variables. A third group is among the secondary variables. These are related to the soil units.



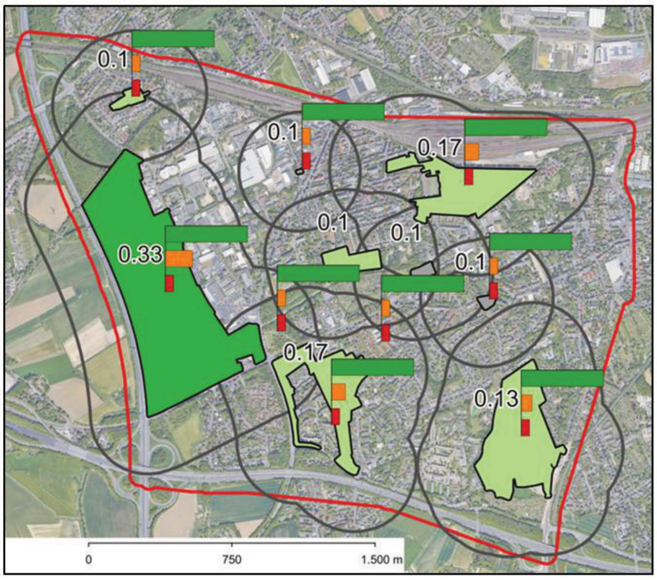
Box 2: Different base maps influence the assessment in two ways. First, the spatial resolution increases from left to right. Second, the spatial units (from land cover to biotopes) reflect an increasing classification depth. The effect of this downscaling results in an apparently better ecosystem service performance, in this case the cooling intensity. The relative value increases from 0.36 to 0.59, simply because of better database.

Box 3: **The schoolyard exercise**. A municipality asked us, to have the toolbox evaluate the effect of the schoolyard renewal. Comparing the two maps, the existing schoolyard (left) and the planned (right), we see that new elements of GI (dark green) shall be inputted and the layout will change. Consequently, air filtration will increase to 150 kg per year. By using the toolbox, the optimization this ecosystem service as well as others become measurable.



Box 4: Ecosystem services of competing urban design plans

Against the background of an urban design competition for a new subdivision, we compared three different plans A, B, and C. Which of them promised the best performance of ecosystem services? The bars depict the standardized scores for the four services flood regulation, cooling intensity, carbon sequestration, and air filtration as well as the mean values. Optional green roofs mostly enhance the ecosystem services to a varying degree. Obviously, the differences are not too large, yet, plan C has the highest mean score. It formed the basis for elaborating the binding land-use plan.



Box 5:

Cultural ecosystem services in parks

The parks differ in assets of green and technical infrastructure as well as in the number of potential park users.

Here, we assess the relative performance of the parks to provide recuperation trough physical interaction with nature. The orange bars and the numbers express the relation compared to the park that scored highest in the cities of Bochum and Gelsenkirchen, Germany

Fields of applications

You can benefit from the toolbox in multiple fields of application (cf. boxes 3-5).

- Screen your area and map the ecosystem services provision. Analyze its strengths and weaknesses. Assess spatial inequalities and inequities. Justify action plans for enhancements.
- Monitor and document temporal changes in ecosystem services provisioning.
- Compare planning variants and decide where and by which measures to optimize your plan to let nature work for the citizens' benefit.
- Develop your own ecosystem services standards that are specific for your city or region.
- Broaden the choice of sustainability indicators complementary to nature conservation requirements.
- Enhance participatory processes by making ecosystem services transparent to the informed citizens.
- Supplement gains or losses in the stock of natural assets by considering ecosystem services.
- Plan nature-based solutions based on ecosystem services.
- Justify and support funding applications by highlighting the benefits of ecosystem services.

The toolbox in comparison to other assessment tools for ecosystem services

- Open source GIS environment
- Some tools consider the interaction of soil-water-vegetation complexes
- Pre-installed land use/biotope and soil classifications for Germany and China
- Open for your own modifications
    - You can model your own biotope types or land use classes
    - You can specify your own soils
- Applicable worldwide
- Scalable: adaptable to a variety of spatial scales
- Fast processing
- Comes with a Manual

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