D.T1.3.3 Final Model on GIS-based solutions for UGS assessment (TWG 1)

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1. Structure and project context

This document represents the final version of the smart model to effectively assess and manage urban green spaces with the help of GIS methodology. It is part of the work of thematic working group 1 (TWG 1) who deals with GIS-based solutions during the course of the project (see figure 1). It is based on the respective framework concept by TWG 1 (D.T1.3.1) and develops its theoretical foundations further by giving practical propositions, hints and solutions to the users. On the other hand, it is the initial document for pilot actions: The three members of TWG 1 pick certain approaches that are introduced in the draft model and test it in their respective pilot sites. This will contain a sample of indicators that are most appropriate for their region as well as a set of fitting implementation strategies, e.g. processing and visualisation options. Based on the experiences and lessons learned during the pilot actions, the draft model will continuously be adapted and improved and results in the final smart model of TWG 1. This one will serve as a foundation for the UGS smart governance manual together with the models of the other TWGs as final output of the whole UGB project.

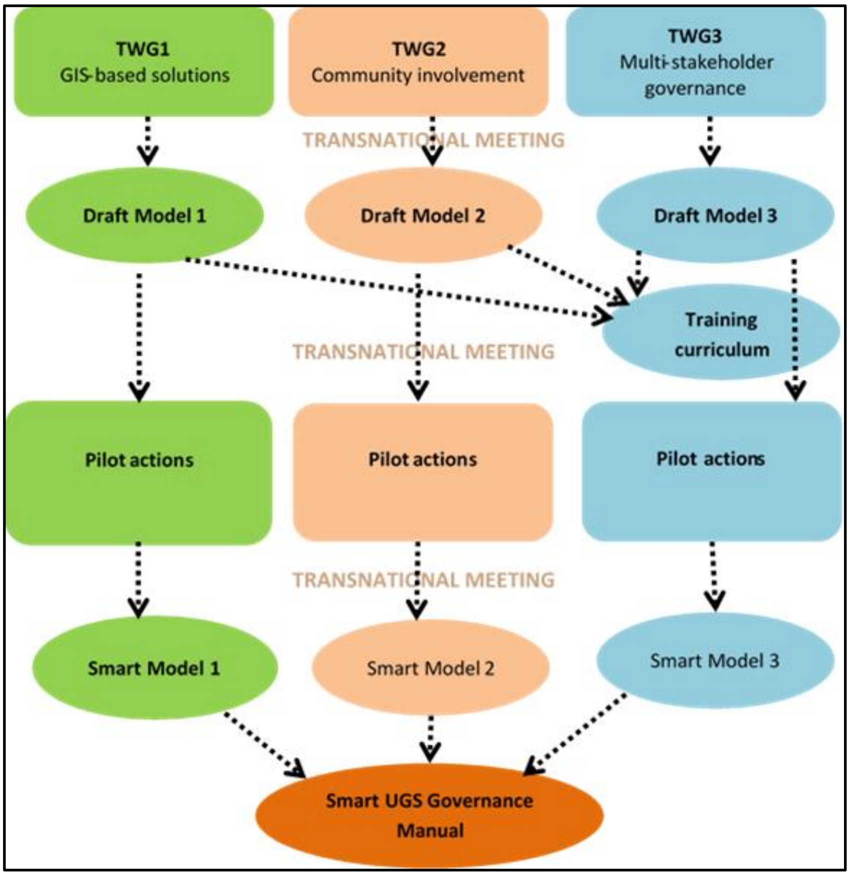

Figure 1: Role of the smart model in the course of the project

The model on GIS-based solutions gives a rather general overview and practical instructions on jointly elaborated and evaluated methods and tools for UGS assessment and serves as a compilation of approaches that are part of a thematic framework where users can find most fitting solutions for their specific interests and purposes and consequently implement them into local planning and development policies. This thematic framework is built on the thoughts and ideas of the framework concept and mainly consists of two analytic paths (see chapter 2). Chapter 3 comes up with many suggestions on potential indicators that are placed in the structure of the framework, of course. Each indicator is presented alongside its scientific and practical significance for UGS monitoring and assessment and also with recommended (spatial) reference units and roles in applications and tools. Chapter 4 deals with the implementation of such applications and tools and gives instructions on the appropriate usage of the GIS model at hand. At first, the thematic part of choosing reasonable indicator paths is documented, followed by a description of the technical path consisting of data management, analytic routines and visualisation options. The concepts and approaches of the parallel operating other TWGs have been integrated constantly into the GIS model in order to identify and utilise interconnections for the pilot actions and beyond. The document is closed by best practice examples of analytic and technical paths and thus leads directly to the pilot activity concepts.

During the pilot actions each TWG 1 member validates a part of the draft model in accordance with local data availability and purposes and integrates the experiences into the evolvement of the model. These findings were incorporated to this final version and a chapter was added to the end of the document to reflect on the results. However, the envisaged smart model is generally not supposed to be applied only for TWG 1 actions, but should be transferable at transnational level and thus be useful for all interested institutions on the long term.

2. Theoretic foundations

This smart model for the assessment and monitoring of urban green spaces via GIS methodology and technology is built mainly on **spatial indicators** that are ordered systematically by two analytic paths.

a. Indicator types and vertical analytic path

The EEA (European Environment Agency) (2003) defines indicators as follows:

> *"An indicator is an observed value representative of a phenomenon of study. In general, indicators quantify information by aggregating different and multiple data. The resulting information is therefore synthesized. In short, indicators simplify information that can help to reveal complex phenomena."*

According to this, indicators are used if a complex issue or process that, e.g. due to a high complexity or high expenses, cannot be measured directly has to be analysed (PRINZ 2007: 32). Figure 2 represents an overview of indicator development related to green spaces and GIS. It combines the indicator set itself and geodata and methods needed for analysis.

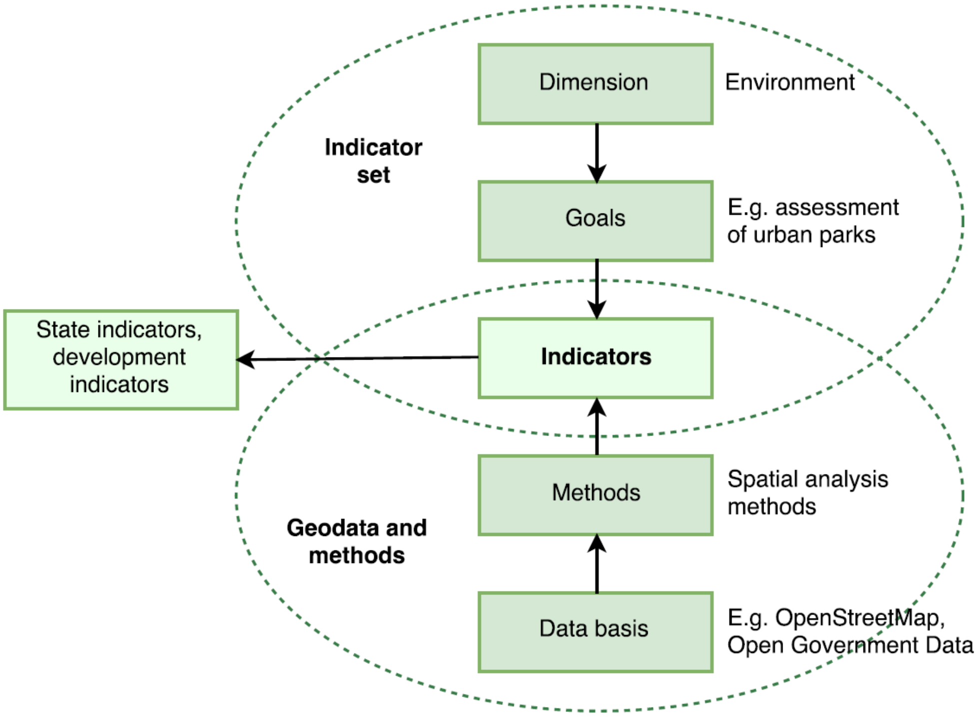

Figure 2: Indicator development (adapted from PRINZ & SPITZER 2007)

BLASCHKE (1997) refers to literature pointing out three main categories of indicators that can be distinguished:

- Classification indicators: used to assign the current status of elements within predefined value-neutral classification systems
- Status indicators: used to determine the status or the evolution of elements
- Assessment indicators: used to define value determining attributes of elements

The first categorization within this model is made by indicator type. It is differentiated between three types of increasing complexity: basic, composite and key (see figure 3). Main reason for this is to display the several roles that indicators can fulfil in the analytic process. **Basic indicators** can be regarded as simple figures that are important for the inventory of UGS in a specific survey site, where the presence, setting and configuration of different UGS types is observed. This is important for maintenance issues, but also as input data for more complex analyses. They are useful as input data for cadastres and public information maps or tools, too. **Composite indicators** are derived by a combination of different basic data sets or indicators. This can be seen as a normalization process, where data are put into a reference unit, may it be a metric unit, population unit, or other. We thus get a surplus value of information and have the opportunity to display indicators in relation to others in order to examine the interconnections between indicators as important step to display the complexity of real phenomena in more depth. **Key indicators**, finally, result from a smart combination of basic or composite indicators and thus possess the highest level of complexity. The recommended form of combination techniques are weighted overlay methods that charge several indicators on a standardized scale and in equal spatial units with certain weighting factors in order to get a highly integrative analysis of the study area. The derivation of weighting factors is part of the joint elaboration process of the final model and will include external scientific knowledge, too.

Type	Description & Role
Basic	Basic facts and figures that mainly serve for inventory reasons and thus have a considerable role for management and maintenance issues and as input for derivation of more complex indicators
Composite	Composite indicators combine basic facts and figures with each other or non UGS-specific data (socio-demography, distances, perceptions etc.) and thus allow in-depth analyses of certain phenomena and their interconnections
Key	Key indicators are used for integrative analyses of UGS by weighted overlay of several basic and composite indicators. A clear analytic purpose is required to effectively choose the appropriate indicators and weighting factors

Increasing complexity (analytic depth)

Figure 3: Indicator types and vertical analytic path

b. Thematic pillars and horizontal analytic path

The second categorization of indicators is made thematically by 5 pillars that are the synthesis of the analytic ideas and objectives elaborated during the configuration of the framework concept and several meetings and discussions within TWG 1. The description & demand, thematic scope, analytic goals & methods and purpose & target groups of each thematic pillar are displayed in the detail in figure 4. This is a very generic approach on meta-level that for sure has to be filled with indicators to gain practical value. However, it may serve as a helpful overview and classification sheet of indicators that have to be defined for specific purposes in the pilot activities.

An increasing thematic depth can be observed from left to right. The first pillar on maintenance issues mainly deals with the inventory of various types of present UGS and aims at putting that into relation with efforts for care and conservation. So it can be seen as fundamental study which nevertheless is of high importance for the administrative bodies of every pilot region. For this reason, the members of TWG 1 aim at analysing maintainability aspects in all their respective pilot sites and thus are able to compare the methodology and also local conditions on transnational level. The next pillars continuously extend the variety of UGS functions to be assessed. Sustainability puts the focus on preserving natural functions, but is often also a precondition for attractiveness. If a green space is highly attractive and well used, it can be regarded as more profitable e.g. in terms of (touristic) marketing. Of course, there can always be more aspects that contribute to one thematic pillar, but for this reason the model is designed in a way of being easily extendable and adaptable. Horizontal, cross-domain analytic paths are conceivable and useful and will be explained in more detail in chapter 4a. The last pillar on fair supply underlines this as it aims at comparing and ranking UGS based on integrative analyses of indicators of all other pillars. Regarding the main purposes and target groups, all pillars play their specific roles in contributing to spatial planning and development processes. While maintainability can be interpreted as fundament, fair supply may figure as synthesis.

	Maintenance	Sustainability	Attractiveness	Profitability	Fair Supply
Descrip-tion & demand	Inventory of various UGS types and deduction of effort and costs for conservation	Support a well-balanced supply of natural UGS functions for the study site	Accessibility, forms of use and satisfaction with UGS; contribution to liveability and quality of life	Economic potential of agricultural & forestry, recreational and touristic use of UGS	Balanced fulfillment of demand of various UGS services for communities and regions
Thematic scope	Single objects or total area of various UGS types (defined by purpose of use and/or plant species)	Mainly integrative examination of all UGS types in the FUA as parts of an entire ecosystem	Focus on recreation areas with regular public use, mainly on object level (e.g. playgrounds, parks, sport fields)	Assessment of agricultural areas in terms of productivity and public urban green for marketing potential (link to attractiveness)	Holistic analysis of the variety of UGS types on FUA level with focus on specific demand
Analytic goals & methods	Put into relation the existing UGS types with maintenance costs	Identifying the role of existing UGS types in terms of providing crucial ecologic functions	Service area modelling via network analyses; integrate qualitative data to display individual perceptions	Assigning monetary value to UGS types based on attractiveness or soil quality	Transfer to socio-demographic classes or types of building land; integrative assessment
Purpose & target groups	Monitoring and management support for public authorities	Conservation of natural functions for authorities and ecologists	Acceptance and satisfaction studies for planners and socio-psychologists	Capitalization options for regional developers and business people	Demand and competition analyses for regional planners and developers

Increasing thematic depth and analytic complexity →

Figure 4: Thematic pillars and horizontal analytic path

c. Reference units for indicator building

The indicators that will be used for activities within the project context and beyond can be analysed on multiple levels. In order to establish a comparable and transferable structure with this model, there are certain reference units that have to be specified in the derivation process. In the following, the most relevant **UGS types, reference parameters**, and **spatial dimensions** are presented. As there often occur different informative values based on the spatial and typological reference unit, it is part of the implementation process to figure out which unit is the most fitting for every indicator in order to effectively cope with the specific problems and support local purposes. Figure 5 displays the different **UGS types** that can be analysed within the scope of this framework. All green spaces under examination have to be integrated in one of these categories. However, indicators can be applied on more than one reference unit, e.g. "public green" that sums up all categories except the private green.

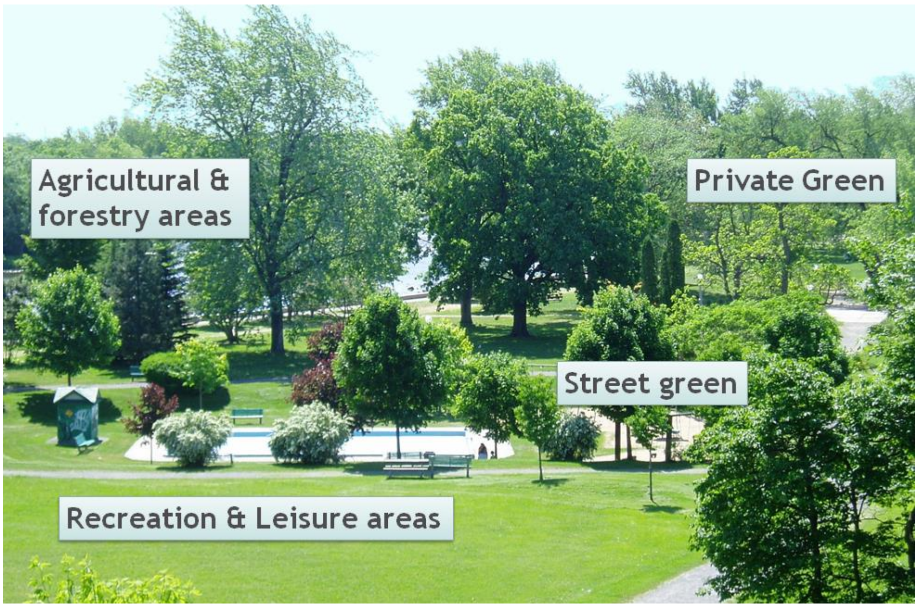

Figure 5: Types of urban green spaces (image source: WIKIPEDIA 2017, own revision)

Secondly, users will have to set **reference parameters** in order to get surplus values out of basic figures (cf. chapter 2a) and develop them to composite indicators. A simple, but nonetheless effective way of doing this, is to allocate the data on metric or demographic units (e.g. analyse a phenomenon per square meter or kilometre, per capita or 1000 people, or per members of certain age classes). A more complex way of analysis is for example to display data per all inhabitants within walking distance of 500m or per a certain tree species. So nearly every (basic) indicator is imaginable as reference unit. Users will have to find the most appropriate for their purposes and build their indicators accordingly. The third important aspect to be defined is the **spatial extent** of each indicator that comes into analysis. Figure 6 represents the five spatial dimensions of monitoring and assessment. Depending on regional specifications, the pilot site can either be part of a municipality or contain one or more municipalities or even equals with the FUA. The smallest analytic dimension would be anyhow either object level (e.g. parks) or grid cells.

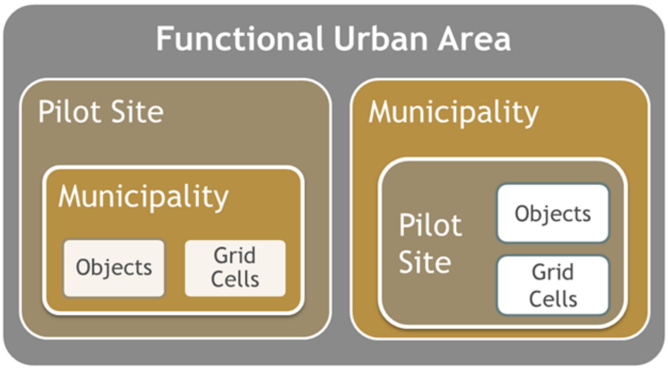

Figure 6: Spatial dimensions of indicators

General aim of the project is to gain and transmit knowledge on FUA level, but for certain reasons a sample study on smaller level might be useful or is inevitable because of data availability etc. A practical application of an exemplary indicator building process by defining UGS type, reference parameter and spatial dimension is described in figure 7. Regarding the resulting indicators, it becomes clear that there are infinite combination options, usually with differing informative value: If one puts playgrounds as input data for the first example, the result could be the number of playgrounds per 100 children within walking distance. Of course, it is also possible to conduct this analysis on every recreational area within the pilot site or the whole FUA.

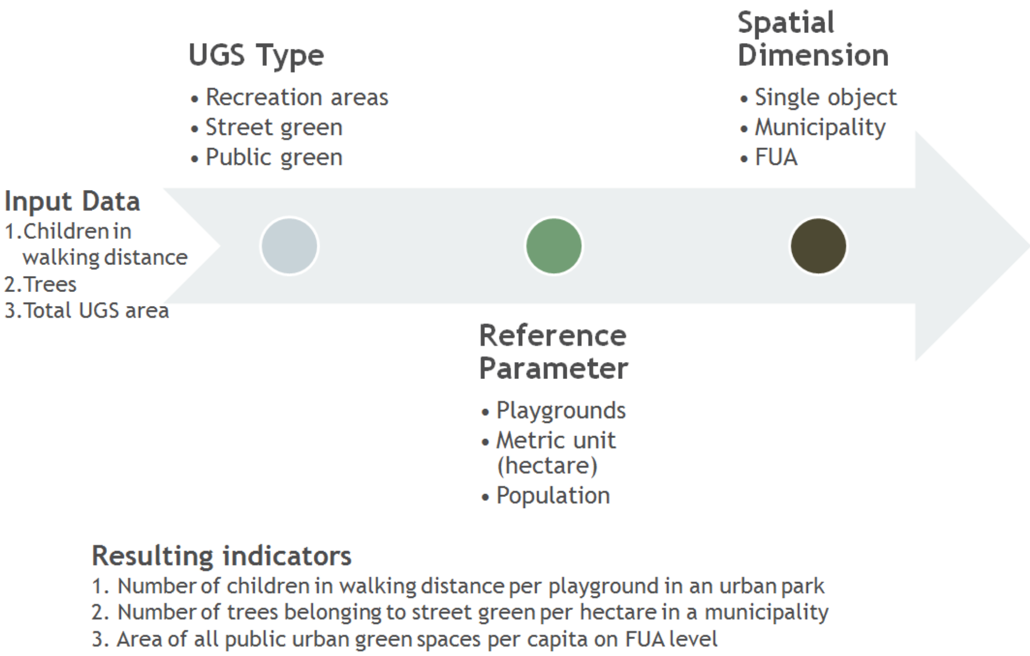

Figure 7: Flowchart of the indicator building process

Practical hint 1

Since the theoretical indicator building process turned out to be a bit confusing considering the different elements to be analysed and appropriate reference units, it is recommended to rely on common sense and always keep in mind the specific objectives and target groups. It often helps to **think the process from the end meaning to break up complex phenomena step by step** and point out what is my main interest as a user, what are the assumptions I want to verify, how can I best support target groups and what kind of statements do I want to give to stakeholders. It is not necessary to aim at the most complicated indicators, but to envisage the local objectives/specific goals as pragmatically as possible. In administrative practice suitable and consistent basic and composite indicators usually have a sufficient effect. Please also refer to chapter 4b for technical options of data collection and spatial analysis when designing indicators.

3. Indicator framework

Since an assessment is always aiming at a specific goal, it is necessary to select appropriate indicators to achieve this goal. They have to be combined within the frame of a meaningful indicator system as one single indicator does not provide enough information. Furthermore, the identification of indicators of course also depends on data availability. The indicator systems developed for Salzburg, Padua, and Zadar will be tested in the pilot activities in the next part of the UGB project in the respective pilot regions. The aim is to develop systems that can be transferred to whole FUAs or even a national or a transnational level.

Based on the theoretical foundations, this chapter supplies a compilation of recommended indicators that are considered as mostly useful for an integrative analysis of UGS. The indicators are subdivided into basic figures, composite and key indicators as well as assigned to one of the thematic pillars. This classification is not meant to be too sharp and still offers the pursuit of horizontal analytic paths (cf. chapter 4a) but contributes to a systematic model structure. Furthermore, the single indicators are just recommendations by the knowledge provider and highly flexible for adaptations regarding e.g. the reference parameters or spatial dimensions following the instructions of chapter 2c. The specifications that are made on local level are part of the pilot concepts and therefore documented and motivated there. Of course, the indicator framework is extendable if certain aspects are not covered.

a. Basic indicators

The basic indicators are only represented within an introductory table followed by the thematic pillars and assigned indicators. So far, the following basic figures serving as inventory input or being necessary for the derivation of the more complex composite and key indicators in the next parts of the model have been defined:

BASIC INDICATORS/FIGURES VALUABLE FOR COMPOSITE AND KEY INDICATORS		
General properties of UGS	**Nature/natural elements within UGS**	**Network & accessibility**
• Area of UGS type [m^2] • Shape Index of UGS • Height difference within UGS (relief) [m] • Share of paved surface within UGS [%] • Protection status [y/n] ...	• Number of plant classes [n] • Objects within a plant class [n/class] • Canopy cover [%] • Existence of natural elements (water, biotopes, etc.) within UGS • Share of unpaved/paved surface within UGS [%] ...	• Distance to closest area of the same UGS type or different type [m] • Distance to public transport (efficient stops) [m] • Distance to local center [m] ...
UGS attractiveness	**Social statistics**	**Other**
• Elements with positive influence on the sojourn quality (benches, playgrounds, sports facilities, etc.) [n] • Noise pollution [dB] ...	• Population [n] • Share of population by age group [%] • Crime rate [%] ...	• Zoning plan • Number of green space visitors [n/d] ...

Figure 8: Exemplary basic indicators

b. Composite indicators

The composite indicators are grouped into the four thematic pillars introduced in the previous chapter (cf. Figures 9 and 10). The fair supply pillar is considered as key indicator since it does not necessarily follow one thematic path but may contain indicators analysing all different values of green spaces. Together with this model, an excel table is delivered as a practical tool that builds on this indicator concepts and offers a structure for the documentation of data, metadata and implementation workflow. The following tables serve as a generator of ideas for filling the indicator tool during the local application of the model as part of the documentation process.

CATEGORY			DESCRIPTION	
	Topic	Type	Indicator name with {possible elements to be analysed} and [unit]	Explanation and purpose
	Maintenance	Composite	**Share of {UGS type} per spatial unit [%]**	Evidence on sufficient supply with green in one spatial unit can be offered. This can be applied on single types of green or on the total green area. For Salzburg there is a remote sensing approach (HÖLBLING et al. 2006) on grid cell level (green index).
	Maintenance	Composite	**Area of {UGS type} per population [m²/n]**	Evidence on sufficient supply with green areas for a certain amount of people can be offered. This can be applied on single types of green or on the total green area. The WHO defines a standard of a minimum of 9 m² green space per inhabitant in order to support the quality of life in urban areas (DE LA BARRERA et al. 2016).
	Maintenance	Composite	**Age of objects within {plant class|species} [years/plant class | years/species]**	The age analysis of all objects within the plant class "trees" is useful for public maintenance reasons. Object-level studies of other plant classes may be possible, too.
	Maintenance	Composite	**Costs for cutting and watering per {plant class|species} [€/m² | €/plant class | €/species]**	By this indicator, costs for basic maintenance tasks can be calculated for specific types of UGS (e.g. sport grounds, urban forests) or even distinct species (e.g. several tree classes).
	Sustainability	Composite	**Number of {plant classes} per area of UGS type [n/ha]**	Density and diversity of plants (e.g. trees, flowers) within specific UGB types that are mostly relevant for the UGS unit to be evaluated (e.g. amount or variety of plants in street green or parks). The conservation of important green areas in terms of living space for a variety of plants leads to a high level of biodiversity and ecologic benefit (e.g. mixed orchards). Variety also contributes to attractiveness.
	Sustainability	Composite	**Number of species within {plant classes} [n/class]**	Species diversity (e.g. oaks, beeches) within specific plant classes that are mostly relevant for the UGS unit to be evaluated (e.g. trees in urban forests).
	Sustainability	Composite	**Soil conditions [categories]**	This indicator is supplied by the public authorities in Salzburg (LAND SALZBURG 2014) and includes e.g. habitat function for soil dwelling organisms or natural soil fertility or combinations of single properties.

Figure 9: Exemplary composite indicators for the assessment of maintenance and sustainability

CATEGORY			DESCRIPTION	
	Topic	Type	Name of the indicator {possible elements to analyse} [unit]	Explanation and purpose
	Attractiveness	Composite	**Share of residents within {walking distance (500m) | biking distance (2km)} of an UGS type [%]**	The availability of recreation areas within walking distance offers more leisure time and options, augments the number of users and supports the ecomobility (SCHAD et al. 2007) and the satisfaction of residents. It is important to note that for children lower reasonable distances than for adults need to be considered (GÄLZER 2001).
	Attractiveness	Composite	**{Age distribution} of residents within walking distance (500m) [%]**	This indicator includes age classes of the population into the network-based analysis of surroundings of a recreation area and aims at identifying certain potential user groups. A high share of children could have effects on setting and usage of the recreation area. A recreation area that is easily reachable for young and old people might be of outstanding relevance. It is also an important input for demand-orientated planning processes.
	Attractiveness	Composite	**Number of {residents|visitors} by satisfactory/importance classes [%]**	The satisfaction of visitors is a valuable indicator for the acceptance and usage of UGS. It is highly qualitative data and thus mostly part of surveys, countings, literature review, or estimations. HÖLBLING et al. (2006) include subjective perceptions of green in their green index on grid cell level.
	Attractiveness	Composite	**Number of {elements with positive influence on the quality of sojourn} per area of UGS type [n/ha]**	The number of elements positively influencing the quality of sojourn (e.g. benches, lamps, playgrounds, toilets, sport fields etc.) is an indicator for attractiveness (CETIN & SEVIK 2016, CHHETRI & ARROWSMITH 2008).
	Profitability	Composite	**Share of {zoning types} in the 1km-sorroundings of an UGS [%]**	The dominant zoning type gives evidence of the demanded usage and setting of the UGS via potential user groups. A UGS in a residential area is more likely used by neighbouring people for leisure activities while a spot in a touristic or core area might be marketed and capitalized.
	Profitability	Composite	**Share of {agricultural|forestry areas} with good soil conditions [%]**	Useful areas for the cultivation of crops and wood can be found in soil quality maps or forest development plans. They play an important role in the local supply and the export of goods and thus should be preserved even if they get in conflict with other land uses.

Figure 10: Exemplary composite indicators for the assessment of attractiveness and profitability

c. Key indicators

Key indicators are calculated by smart combination of several basic or composite indicators and are useful for complex analyses of spatial phenomena. Figure 11 displays possible integrative analyses following the single thematic pillars of the model. In practice this broad approach can only be realised with an extensive database and support from different thematic experts. However, it is recommended to envisage one or two key indicators such as the landscape index and recreation index that have been elaborated in the Salzburg pilot.

CATEGORY			DESCRIPTION		
	Topic	Type	Name of the indicator {possible elements to analyse} [unit]	Explanation and purpose	
	Maintenance	**Key**	**Effort for maintenance**	Observation and monitoring of all types (and species) of green areas that have to be maintained by public bodies. Quantification by the distinct maintainance costs for types (and species). By accumulation estimated total effort for maintenance of urban green spaces (complete analysis of the first pillar).	
	Sustainability	**Key**	**Fulfillment of ecologic functions**	Degree/type of provided supporting (e.g. habitat for different species, diversity) and regulating (e.g. air purification, climate regulation) ecosystem services.	
	Attractiveness	**Key**	**Recreational value**	Number of visitors combined with satisfaction and the configuration (e.g. number of benches, playgrounds, existance of water) of the recreation area as well as the reachability by foot and/or public transport.	**Relevant indicators for combined analysis and appropriate weighting factors will be defined during pilot activities**
	Profitability	**Key**	**Capitalisation potential**	Relation of potentials and costs in line with soil productivity for agricultural or forestry usage, ground value for construction sites or scenic/ historical/ infrastructural attractivity for touristic exploitation.	
	Fair supply	**Key**	**Fair supply**	Fulfillment of demand of various UGS functions for communities and regions as fundament for demand and competition analyses for regional planners and developers. Contribution to new green index.	

Figure 11: Key indicators for integrative green space assessment

Practical hint 2

This indicator compilation contains only a selection of indicators that can be used for an initial, integrative green study and never can be complete in all analytic dimensions. In practice, users will have to pick the most useful ones for their intentions and necessarily adapt and complete them. **Each indicator system in practice has to be shaped according to specific application goals**. This can be done with the template supplied supplementary to this document. One sheet is filled with some of the indicators used for the Salzburg UGB pilot activities as a reference.

Some gap between the scientific approaches and practical applicability could be identified. In the case of Salzburg FUA the focus was put on the elaboration of key indicators (defined as green indices) combining various basic and composite indicators. At a certain stage, **the complexity had to be broken up in order to communicate effectively to stakeholders and target groups**. A lean and simple indicator system with some basic and composite indicators can allow in-depth studies of phenomena, too, and can probably be explained to stakeholders more easily.

Another recommendation would be to **assign of expert knowledge from other disciplines** (biology, psychology, sociology etc.) to indicators wherever it is possible. This allows the user to sharpen single indicators but also to complement the indicator system for a more integrative analysis by adding e.g. biodiversity aspects or qualitative data from satisfaction studies. The city of Padova did this exemplary during their pilots with the help of different University departments.

4. Implementation theory

In this chapter general instructions on how to use the model are given. There are no regional specifications mentioned as the model is designed for transnational transferability and applicability. Parts of the model will be tested and applied through pilot actions on local level and therefore are documented in the respective pilot concepts including chapters on data availability, calculation routines and specific implementation strategies. Based on the experiences of the pilot actions the following chapters will be adapted and completed and thus form the final version of the GIS model that will finally be integrated into the Smart Governance Manual. External best practice examples for applying the logical and technical workflow at hand to indicator-based green space assessments are presented in chapter 5.

a. Choice of indicators and pursuit of logical paths

Subsequent to the conceptualisation of indicators in chapter 2, the smart application of analytic paths within the indicator framework is described in the following. First and foremost, users of the model have to **define objectives** that they would like to achieve in their site based on local assets, strategies and stakeholder interests. Only by this step, it is possible to effectively contribute to planning and development goals. An example might be to reduce the urban heat island effect by making more use of the cooling effect of urban green belts and thus reducing the heat stress for inhabitants. Another use case can be to motivate residents to follow a healthier lifestyle by spending more time on moving outside. Attractive urban green spaces will contribute to that to a great extent. A more straightforward way of defining local goals would to completely work off one thematic pillar and examine for example the effort of maintenance of certain UGS types in one area. In each case, the **appropriate choice of indicators** and their **right application strategy** is essential for reaching the goals. The framework in chapter 3 supplies a set of indicators that is at least sufficient to completely analyse the five thematic pillars as well as some other key indicators, always provided that the particular required data are available and usable. The construction of logical analytic paths may **contribute to planning and development policies** from both sides. On the one hand, management and maintenance indicators and tools will support the monitoring and effective implementation of existing policies, while on the other hand key indicators or analyses on fair supply will show demand and need for new policies or strategies.

Anyhow, it is not necessarily required to implement all indicators within a thematic pillar, if there is for example a lack of data requirements or simply no demand or need for this kind in-depth analysis at local level. On the other hand, **cross-domain paths** that cover several thematic pillars can be of particular value in order to work on challenges like the above mentioned (climate regulations, increasing usage by residents, touristic marketing, etc.). Some of these are already depicted by the predefined key indicators but users of the model are free to follow their own logical paths through the thematic pillars and end up with an **adjusted meta-analysis**. In general, this concept is orientated at preserving the benefits of UGS for human beings and particularly the local residents. Nevertheless, users can set their own analytic topics by focusing more deeply on certain pillars or even expanding the recommended indicators (see chapter 3) by their own in order to analyse for example the habitat function for animals or the degree of extensive cultivation. An interesting approach in this context would be to **establish connections to the other thematic working groups** by deriving and testing (key) indicators in the pilot concepts and activities that include community involvement or capacity building issues. Potential is seen especially at attractiveness, usage and satisfaction studies (e.g. by gathering subjective data via interviews, questionnaires or round tables) or at demand and ranking studies (with correspondent indicators) that might be useful tools in the capacity building process. GIS-based approaches can also be interesting within public participation and community involvement referring to green space planning and green space governance, which is task of TWG 2 within the UGB project. E.g. information about the perception of the qualities and the lacks of existing UGS by citizens could be a valuable input for a GIS model for green space assessment.

b. Technical part: data, analysis and visualisation

Apart from the thematic structure of the GIS model the technical implementation has to be considered. The **availability of appropriate data and software** defines or at least influences the analytic options thematically and practically. Figure 12 depicts the generalized workflow on application side. This procedure consists of three steps: data collection and management, analytic routines and visualisation and communication strategies.

Regarding the **data gathering** there are many different sources which have been already discussed in the framework concept. TWG 1 members basically use **administrative data** (proprietary or open source) but will enrich it with self-derived data based on remote sensing, questionnaires or field work. To make use of the benefits of the constantly growing **user-generated content** is also recommended and will be applied in this project's course in the form of an interactive app that allow to collect information, complement cadastres etc. with public and experts knowledge. Details are presented in the pilot concepts. On the analytic side users of the model will also have to precise their plans. It is essential to find appropriate software solutions for building up a **geodata infrastructure** (GDI) for managing and processing the relevant data and design innovative products to display the results. Best practice tools for are e.g. the PostGIS extension for PostGres (open source) or the Oracle Spatial Database.

Spatial analyses are mainly conducted via topological calculation routines within the database (e.g. spatial joins, routing), python scripting or user-friendly tools within GIS like QGIS (open source). They are also an important part of the indicator building process (cf. chapter 2c) and need to be referred there. The simplest operations are **arithmetic calculations** like shares of features within larger groups, for example percentage of children under 18 years amongst the whole population. If there is a spatial reference unit, users can easily calculate **areal shares** or **density maps** on different spatial scales, for example the green share per city district or the number of benches per hectare in an urban park. Related to this is a statistical evaluation where users summarize basic data or results on administrative level (e.g. community or district) to characterize and compare these units. A central GIS methodology in this model is the **weighted overlay** of spatial data since it is the foundation of calculating the key indicators presented in the previous chapter. It means the (weighted) calculation of multiple input data on harmonized scales to perform integrative analyses (e.g. recreational value). **Distance and network analyses** were also used to calculate certain indicators especially in the attractiveness and profitability pillar. Here the user calculates distances between objects (optionally based on a road network) to find the shortest path or generate service areas.

Another useful and heavily applied field of GI-based UGS assessment tools is **remote sensing** and **image analysis** which deals with the analysis, classification and interpretation of remotely sensed data (e.g. aerial photographs, multi-spectral/thermal images, radar and laser scanning products) to identify specific characteristics and structures of green space e.g. vegetation height and types of land cover or detect their changes in time.

On the **visualisation** side, web mapping libraries (OpenLayers, Mapbender, Leaflet etc.) are recommended. Some of the software systems cover more than one part of the implementation workflow. So do classic GIS like QGIS or the ESRI ArcGIS Suite where users can find solutions from data management to visualisation. However, with regard to **interactive Web-GIS applications** these products are not sufficient and need some upgrades. These can be web-mapping add-ons (e.g. ArcGIS Online, Web Viewers) or interfaces to databases (e.g. cadastres) to update and calculate data on the fly.

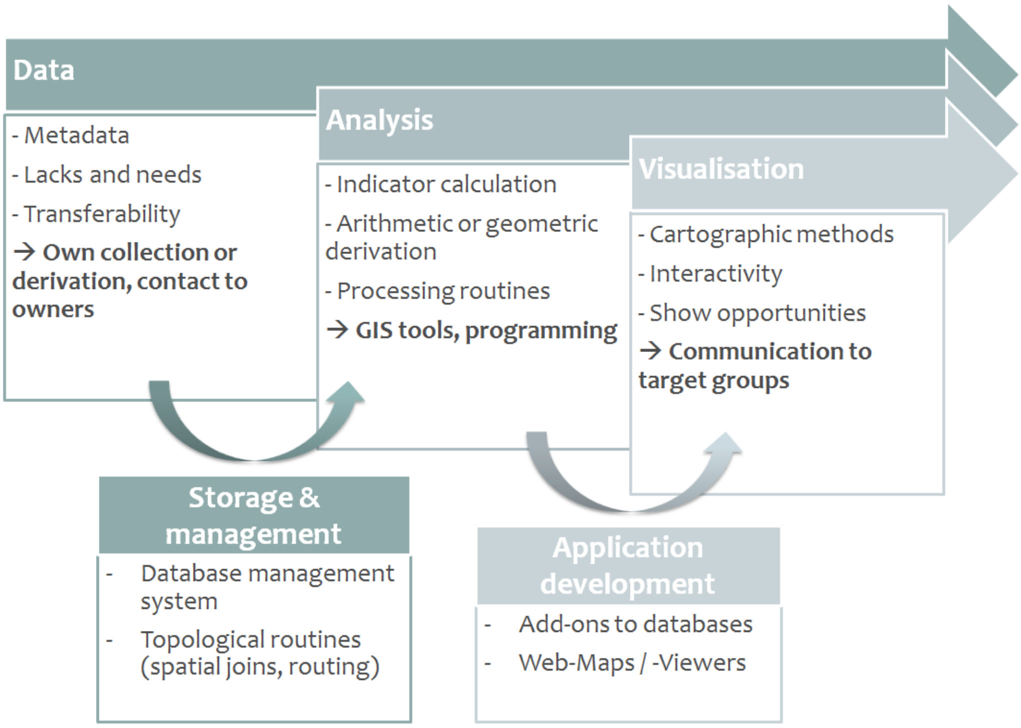

Figure 12: Standardised implementation workflow

Practical hint 3

There is obviously no best-practice solution for all challenges, but this GIS model collects several tools (indicators, routines etc.) to conduct specific analyses and support a long-term management and monitoring of urban green spaces. It is important that users precisely **document the data and processes used for their local actions in a harmonized way in order to follow a replicable and transferable approach**. This can take a couple of time in preparation and should contain the required data sources for each indicator including metadata (e.g. owner, format, currentness), the analytic routines for data processing and derivation of indicators and the application purposes in terms of visualisation and communication strategies. **The attached indicator tool helps to document the workflow.** Hereby, links to other disciplines (in case of UGB: thematic working groups) should be considered by assigning possible contributions to certain steps of the implementation process. Especially in the data collection and visualisation phase there is high potential for including community and stakeholder involvement or capacity building methodology.

The nature of the **implementation process very much depends on the starting position** (e.g. available data and resources) **and can be simpler or more complex according to the specific goals and target groups.** Only in few cases the whole process will be conducted. If it is planned to build an initial green cadastre, the user can focus on the data collection with storage and management procedures. If a cadastre is already in use, the user can focus on adding more complex data using high-level collection methods, merging distributed data sources or producing secondary data/indicators with the help of spatial analysis and processing routines. If desired information is available users can start with application building and the elaboration of communication strategies.

5. Practical applications

Chapter 5a has been elaborated before the beginning of the UGB pilot activities and therefore contains initial examples as a guideline for conducting the pilots as well as the concrete local implementation plans of the partners and how they intend to use the GIS model for doing this. We keep this information in the final model as a kind of documentation of the working progress. The chapters 5b and c give a short glimpse about the pilot implementations based on this model, but we absolutely recommend to **refer to the WP2-related project deliverables** (e.g. pilot concepts, pilot evaluation reports) to examine the local achievements and challenges of the UGB pilots. However, we want to shortly summarise the most important experiences and findings that TWG1 partners faces during their pilot work as a conclusion with a focus on the application of the GIS model at hand, i.e. in what terms was the model helpful to gain valuable results. Consequently, the shortcomings of the draft model that partners faced during its application were eliminated in this final version by sharpening some terms and indicators, adding several info boxes with practical hints and other amendments throughout the text. Supplementary to this model, we deliver an excel-based indicator tool which allows users to choose and define suitable indicators and document the implementation workflow in a standardized form as a transnationally transferable output.

a. Foundations and baseline examples

One specific goal for an analysis can be the evaluation of the recreational potential of green spaces. The recreational potential in this case can then be defined as the key indicator. CETIN & SEVIK (2016) describe some important values along with assigned properties that are important during such an evaluation process within their paper referring to the assessment of the recreational potential of a national park in Turkey. The following table shows these values and some examples of possible subordinate properties:

Values	Properties
Landscape value	Size of area, surface condition, flora, water bodies, visual quality, other properties (e.g. natural elements or historic textures)
Total climate value	Temperature, precipitation, sunshine, windiness
Accessibility	Region’s touristic importance, public transport, convenience of transportation
Total recreational facility	Picnic facilities, toilets, parking areas, guards and workers, sports facilities
Total negative factors	Air pollution, insecurity, water pollution, noise

Table 1: Values for the evaluation of the recreational potential of a national park in Turkey

Such an example from the literature can be a valuable basis for the development of an own evaluation approach for the pilot activities since it helps to determine, which indicators from the provided list are appropriate for a specific goal. In the case of recreational potential, mainly indicators belonging to the categories Maintenance and Attractiveness are suitable. It is also important to select the green space types that need to be considered within the evaluation process. For the assessment of the recreational value, parks and other recreational areas will be the most interesting ones. The list below shows an overview of some composite indicators that among others are important for this task and should be applied for all recreation grounds:

- Share of recreational areas in the FUA [%]
- Area of recreation grounds per capita [m^2]
- Number of residents within walking distance of recreational areas [n]
- Number of elements with positive influence on the quality of sojourn for single areas in relation to their size [n/ha]
- Tree density [n/grid cell]

For the implementation of these indicators, several basic figures/indicators are necessary as input for the calculation processes. In the case of the indicators mentioned above, these are:

- Area of recreation grounds [m^2]
- Population [n]
- Elements with positive influence on the sojourn quality (e.g. benches, sports facilities, playgrounds, picnic sites, etc.)
- Tree cadastre

In order to give some practical examples of potential application workflows the passages below present how indicators can be derived and displayed within a GIS. One example chosen for this task is tree density per defined grid cell (cf. German language instruction to derive a density map from a tree cadastre, available here). To calculate this density, a data set containing all trees within the area of interest as point features is necessary. Furthermore, a reference grid (e.g. 100 or 500m), which will be the basis for the density map, has to be created. For each of these grid cells the absolute number of trees needs to be determined by using the Spatial Join functionality for merging the grid and the tree locations. Afterwards, the result needs to be visualized (e.g. by using graduated colours). A possible outcome is represented in figure 13.

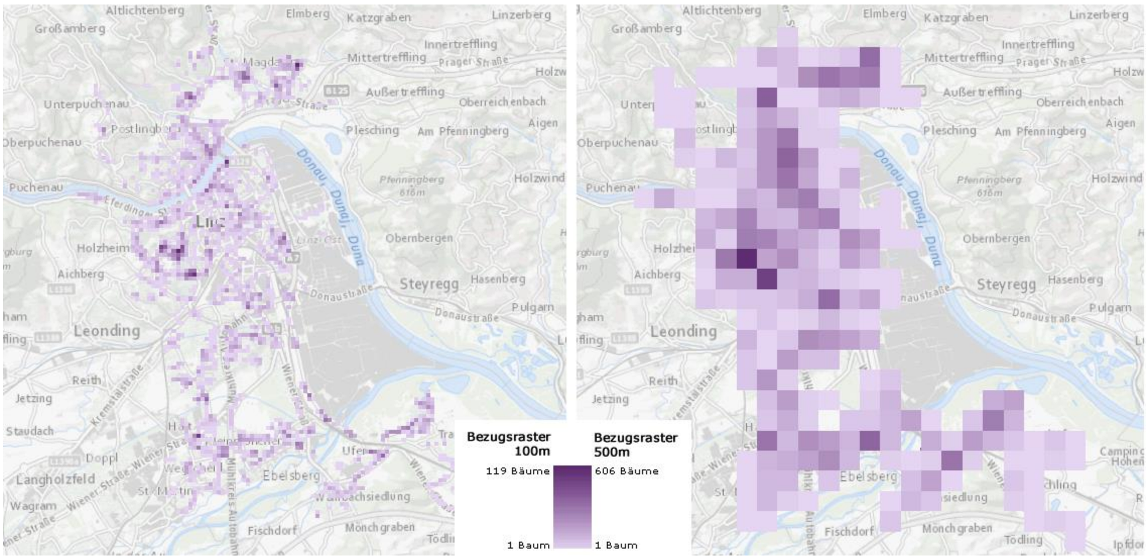

Figure 13: Possible results for tree density maps based on 100m and 500m reference grids

Additionally, the green index, which is a very common method for green space assessment providing information about the share of green per grid cell, shall be mentioned. It is usually derived with the help of aerial or satellite imagery. In the paper presented by SCHÖPFER et al. (2005), green spaces have been identified with the help of remote sensing techniques. The result layer includes a binary classification by distinguishing green and non-green areas and is displayed in figure 14.

Figure 14: Binary classification of green and non-green areas

Afterwards, this layer has been aggregated to a grid cell raster (1 grid cell = 1 ha). The distribution of green area per grid cell by using four different classes is represented in figure 15. Figure 16 on the other hand shows the weighted green quality per grid cell, which is an aggregated measure. It is derived with the help of a combination of three different weighting factors:

- Percentage of green (green index): high green index = high green quality (60% weight)
- Percentage of multi-storey buildings: low percentage = high green quality (20% weight)

- Distance between buildings: high distance = high green quality (20% weight)

Figure 15: Green index

Figure 16: Weighted green quality

b. TWG 1 pilots as best practice examples

Padova Pilot has been organised around 4 pillars, contributing to a successful action. The joint elaboration of the GIS model and the Pilot Action has been propaedeutic to a systemic software upgrade, which also represent the very starting point of our Pilot. A second pillar, strictly linked to the previous, concerns the development of dedicated software, namely an APP, designed for different target users: professional or public oriented. A third pillar, concerns the communication and training activities, planned with a twofold goal: to enable targeted users to get acquainted and eventually use in a proper way the new tools developed, on the one hand, to disseminate the work done by the Municipality within UGB project activities and the results both expected and achieved so far, on the other. During this phase, a professional Video Tutorial will be produced and posted on the official UGB webpage (http://www.padovanet.it/informazione/progetto-europeo-ugb-urban-green-belts), clearly explaining how to use the APP in view of the territorial gaming. Besides, the Team will be taking advantage, for dissemination purposes, of two national fairs, the first one held in Padova and the second in Rimini. Two more planned events, the Trees Festival in November, the other to be defined, will also represent a great opportunity to reach residents in the Pilot Area and promote the initiative. A fourth pillar concerns the joint activity with the well-established SP and the new constituted Basso Isonzo work group. The right involvement of both, should ensure a motivated participation to the territorial gaming activity, in fact the core of the Pilot. The territorial gaming, the last pillar, concerns both data acquisition and assessment. During this phase, citizens and SP members will collect data, especially on private owned UGS and trees. The SIT dept. will then analyse and elaborate data.

ZADRA NOVA's main focus is on creation of Green Cadastre as an administrative resource and modern geodetic equipment which should accelerate and facilitate the performance of decision making processes in the greenery sector. The development of the Cadastre will take place in several phases: preparation, field work, data entry and analysis. Preparatory work is related to database preparation, exploration of existing documentation, definition of spatial objects, and elaboration of work plan. After carrying out inventory and assessments, it will be possible to manage all public green areas more responsible and have a continuous insight into the condition that will be available to everyone. The Green Cadastre created in the GIS will be able to overlap with other infrastructure layers, which will help in future urban development planning and all green operations. There will be in total, about 18,000 m^2 of green areas with about 600 trees covered with this Cadastre which will be fully accessible to the public.

ISPACE focuses on the evaluation of the recreational value of green spaces (especially parks, playgrounds, and other recreational areas) and on the fulfilment of the demand of various UGS functions, which aims at the detection of green space supply and areas with shortcomings. For both identified key indicators mainly composite indicators belonging to the category “attractiveness” are important, but will be supplemented by indicators from the other pillars and some basic figures in order to achieve a more in depth analysis. A major part of the pilot activities will be carried out with the help of the software ArcGIS. The results include different static maps, but also an additional web-based map.

c. Findings and conclusions from pilot activities

All partners consider the concept of thematic pillars and corresponding indicators useful for facilitating a better assessment and management of urban green spaces. The **presented GIS-based methods have been widely used and turned out to be valuable for the pursuit of the local goals** although there have been different starting points. Zadar put many efforts in data collection and the building of an initial green cadastre and thus focused more on basic indicators of the maintenance pillar, but thus created valuable foundations for future green assessment and management systems along with a remarkable rise of consciousness of green value with citizens. The latter applies also to the cities of Padova and Salzburg. The analytic focus however was slightly different, since both regions can build on large public datasets and thus choose a more complex approach by calculating various indicators across the thematic pillars. Padova also developed a data collection app for citizens following the concepts of GIS-based implementation design and offers the technology to interested partners in the UGB consortium. The **importance of including qualitative data** on people’s expectations, perceptions and satisfaction with green spaces has become evident during the pilot activities, particularly the green fests and the synergy workshop. Therefore, we recommend to always include sociological or psychological expertise and methodology in the indicator building and implementation workflow. Some related methods and indicators are mentioned in this document, but we aim at including other TWG competences to the local roadmaps and smart governance manual design. It is absolutely required to include the UGS users into assessment studies and local action plans for ensuring a long-term acceptance.

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