CONFERENCE SETOF PROJECT
SOIL EROSION AND TORRENTIAL FLOOD PREVENTION: CURRICULUM DEVELOPMENT AT THE UNIVERSITIES OF WESTERN BALKAN COUNTRIES

UNIVERSITY OF FORESTRY & FRI-BAS, 12-13 May, Sofia, Bulgaria

Ecosystem services provided by natural, urban and peri-urban forests – overview on the assessment and mapping in Bulgaria

Miglena Zhiyanski

Forest Research Institute – Bulgarian Academy of Sciences

Outline

1. Intro: MAES process in Bulgaria

2. Key questions

3. Mapping and assessments of ES concept and process

4. Forest ecosystems in natural, urban and peri-urban areas - UGI

5. Mapping of ES in natural, urban and peri-urban areas

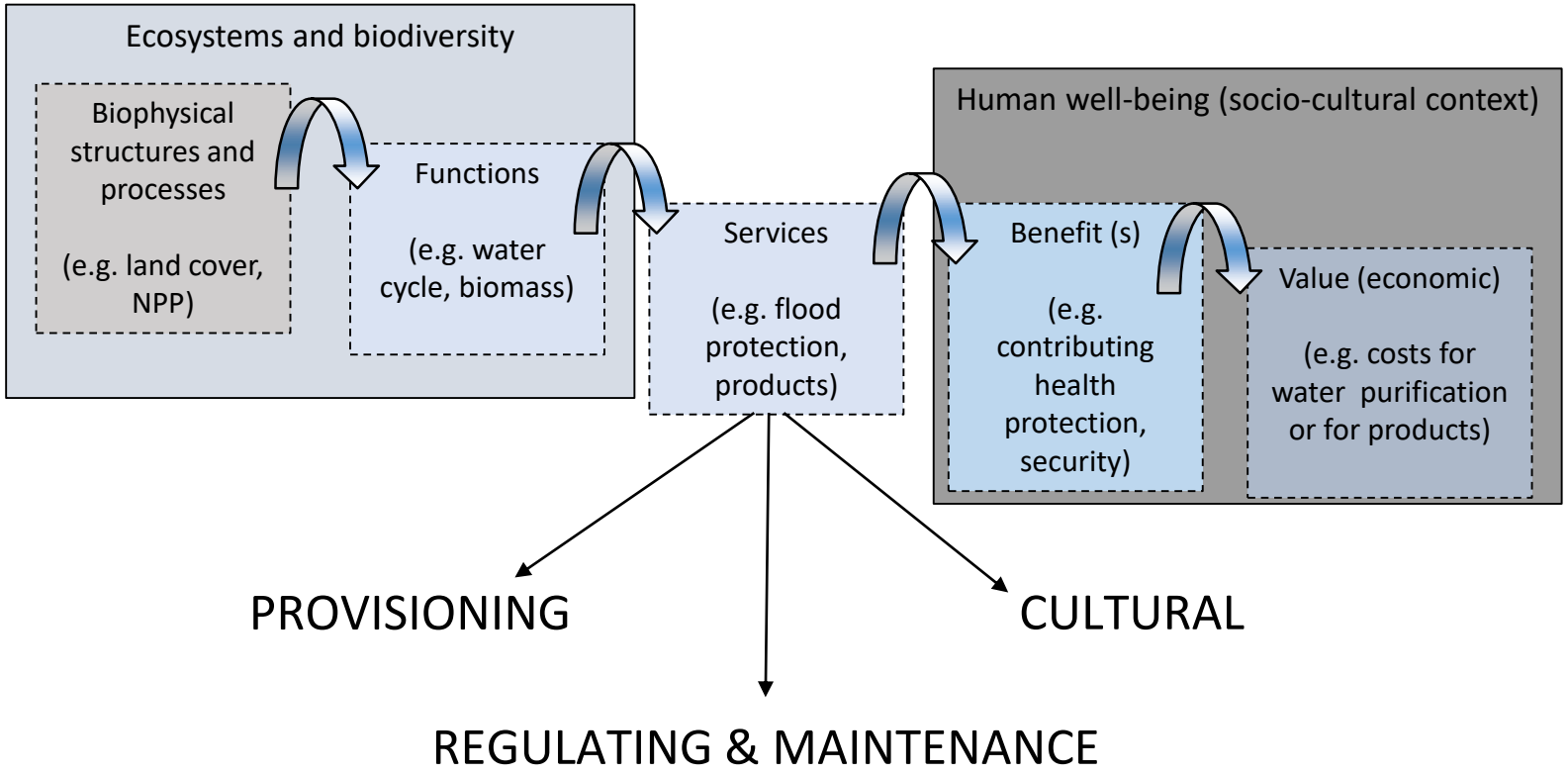
6. ES provisioning assessment and mapping– examples

7. Main findings

I. INTRO

Priority 4 for reinforcement of the existing networks so as to meet the requirements of the Directive 2016/2284: to align the monitoring networks with the analytical framework developed by the EU initiative on Mapping and Assessment of the state of the Ecosystems and their Services (MAES)

- **ECOSYSTEM SERVICES**
- – direct and indirect benefits people obtain from functioning of ecosystems incl. processes of creating ecosystem products



I. INTRO

MAES - an indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020 (Maes et al., 2016): **Target 2 - Action 5**

MAES initiative was set up in Bulgaria and the Methodological framework for MAES is elaborated within the project **MetEcosMap** (FM of EEA 2009-2014), FRI-BAS experts involved.

Mapping and assessment of ES **in all ecosystem types at national level is elaborated undertotally 9 projects** funded by the FM of EEA (2009-2014) Toward better UNderstanding the Ecosystem Services in URBan environments through assessment and mapping – TUNESinURB – FRI-BAS leader

EnRoute Project: Enhancing Resilience of urban ecosystems through green infrastructure. EnRoute is a project of the European Commission in the framework of the EU Biodiversity Strategy and the Green Infrastructure Strategy – leaded by JRC. FRI-BAS participant

www.oppla.eu/enroute

MAIA - MAPPING AND ASSESSMENT FOR INTEGRATED ECOSYSTEM ACCOUNTING

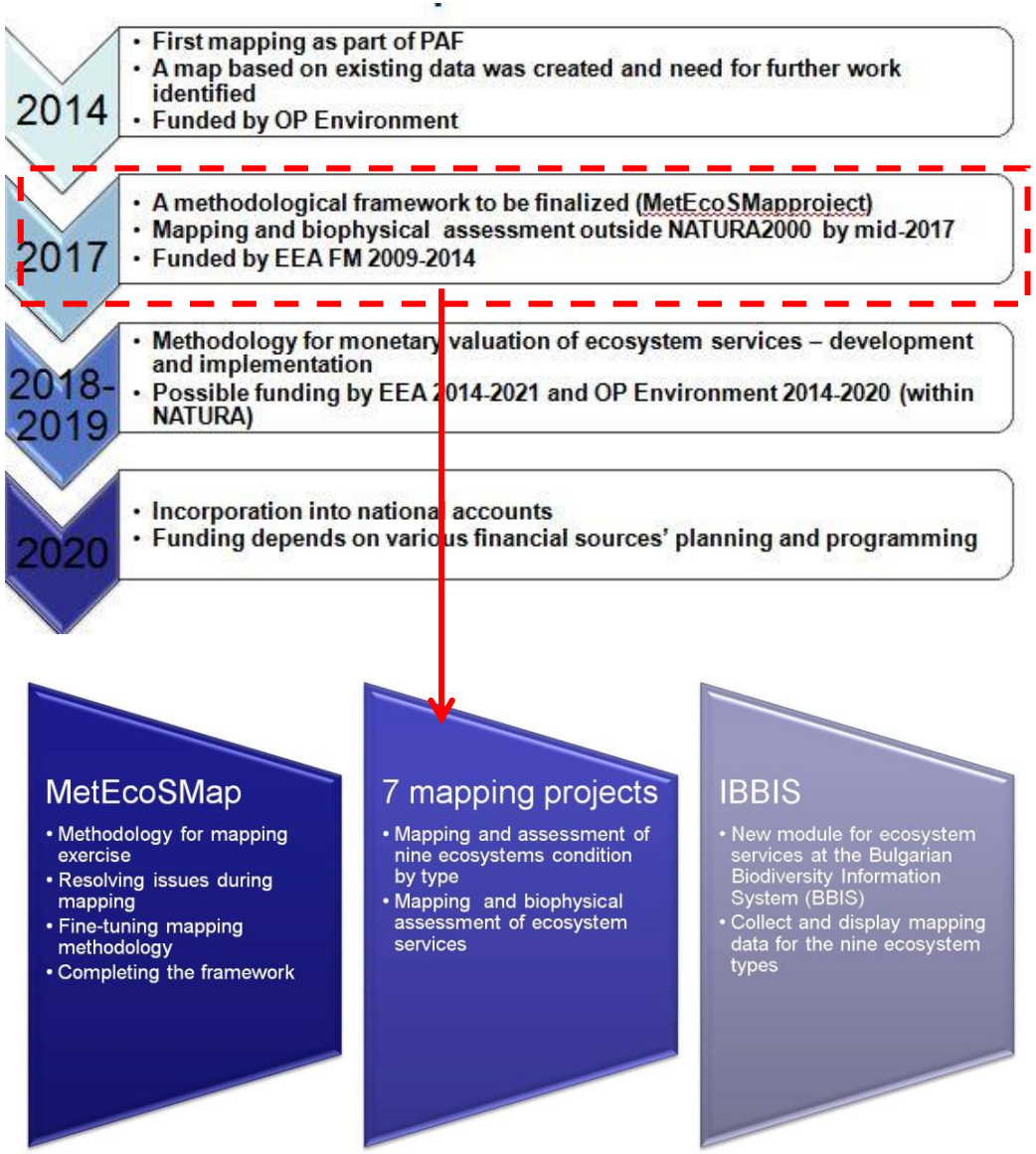
aims to mainstream natural capital and ecosystem accounting (NCA) in EU Member States (MS), ongoing H2020 project, https://maiaportal.eu/ , FRI-BAS experts involved

INES - INtegrated assessment and mapping of water-related Ecosystem Services for nature-based solutions in river basin management (INES), ongoing NSF project, https://inesproject.com/

MAPESMOUNT – Mapping ES in Mountain Areas, scientific project funded under the National Science Fund, ongoing

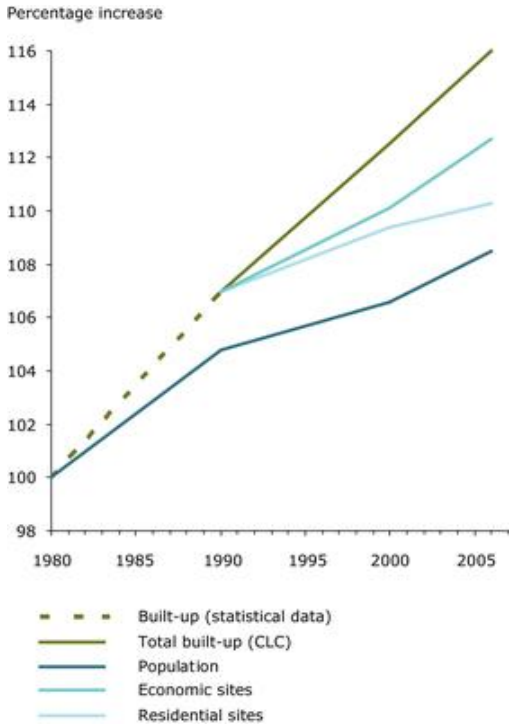
Conceptual framework of MAES process in Bulgaria under Action 5 of the EU Biodiversity Strategy to 2020

MAES process in Bulgaria

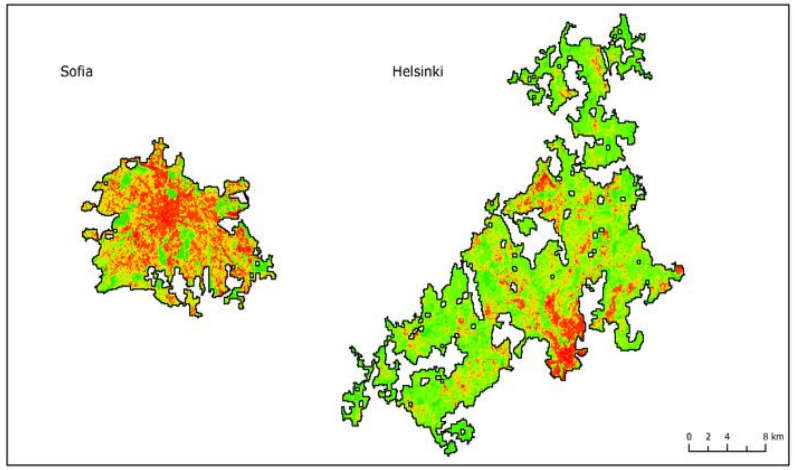


I. INTRO

Urbanization and urban ecosystems



NOW cities are expanding globally, while the area for nature is reduced.
HOW to ensure better human well-being in the settlements while preventing the increasing loss of biodiversity.



Degree of soil sealing (impermeability) in the Urban Morphological Zone (UMZ) of Sofia and Helsinki

Degree of soil sealing (%)
0 30 50 80 100

	Sofia	Helsinki
Population:	1 013 249	895 738
Area of UMZ (km^2):	172	413
Population density (inhabitants per km^2):	5 889	2 170
Average soil sealing degree (%):	58.4	29.4
Sealed surface per inhabitant (m^2):	99	135

WHAT urban areas represent mainly human habitats but characterized by high typological variability: urban ecosystems include urban and peri-urban, industrial, commercial, and transport areas, urban green areas, mines, dumping and construction sites, and artificial water structures.

Urban landscapes provide a number of benefits for the human society through Green Infrastructure in natural, urban and peri-urban areas.

http://www.eea.europa.eu/data-and-maps/figures

I. INTRO

Bulgarian cities

257 cities and towns

5 181 755 people

73.5% of the population

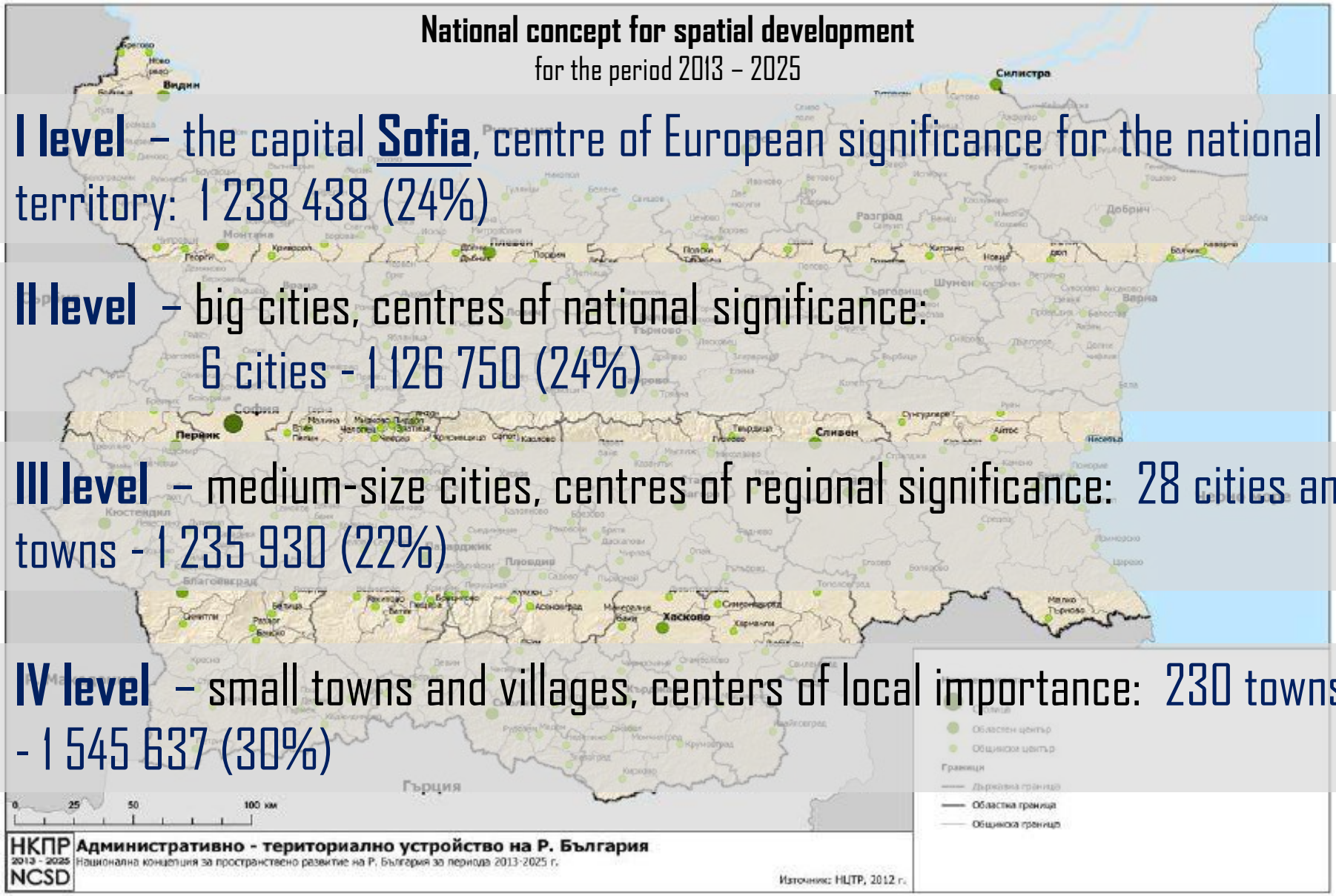
Sofia: 1 238 438 (24%)

Sofia, Plovdiv, Varna, Burgas:
2 122 199 (41%)

Most Bulgarian cities have well maintained urban green infrastructure (UGI)

The UGI is a source of vital ecosystem services

I. INTRO



I level – the capital **Sofia**, centre of European significance for the national territory: 1 238 438 (24%)

II level – big cities, centres of national significance:
6 cities - 1 126 750 (24%)

III level – medium-size cities, centres of regional significance: 28 cities and towns - 1 235 930 (22%)

IV level – small towns and villages, centers of local importance: 230 towns - 1 545 637 (30%)

I. INTRO

Forests have great adaptive potential and capacity to preserve biodiversity and to mitigate pollution and climatic change

What is ?

URBAN FORESTS & GREEN INFRASTRUCTURE

An interconnected network of green space and other environmental assets that conserves the functions of the natural ecosystem and provides associated benefits to people – FORESTS are elements of GI in natural, urban and peri-urban regions

What is "NOT" Green Infrastructure (GI)?

It is the opposite of "gray infrastructure" and most people have a pretty good idea of what that is.

http://fakti.bg/img/news2012/41205/ddf0cc55144d0ce5694c0ed4ba8a1d4d_big.jpg

EU COM (2013) 249 - 6.5.2013. Many **definitions of GI have been developed**. It is therefore difficult to cover all aspects in one short paragraph. The following working definition will however be used for the purposes of this Communication.

GI: a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in **rural and urban settings.**

2. Key questions

1. How to identify and map the ecosystems?

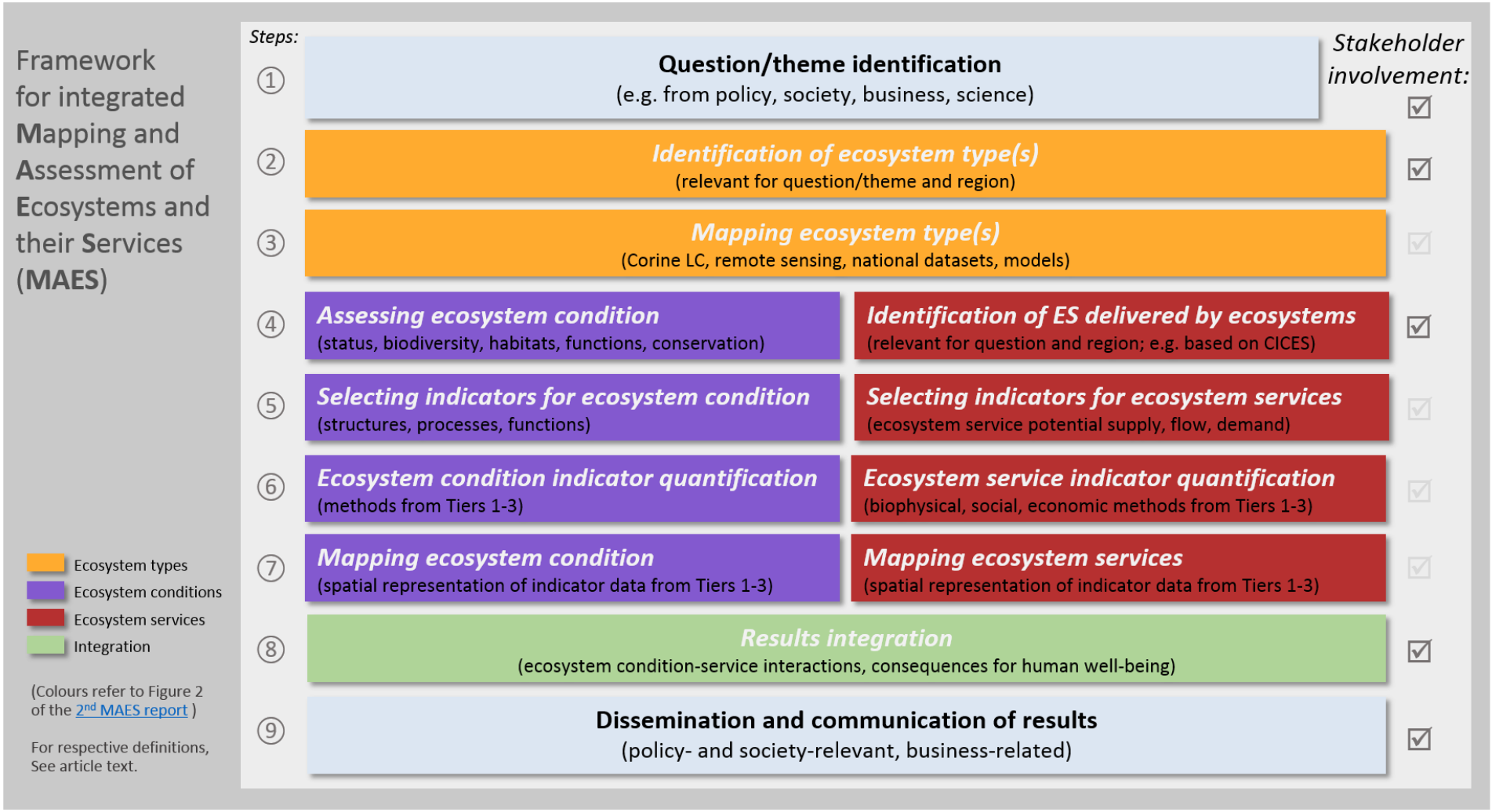
2. How to assess the condition of ecosystems?

3. How can we use the results to access the ecosystem services provided by ecosystems?

Examples – PHYTOSANITARY STATUS; SOIL-RELATED ES

4. How to integrate the concept and results in policy and decision making?

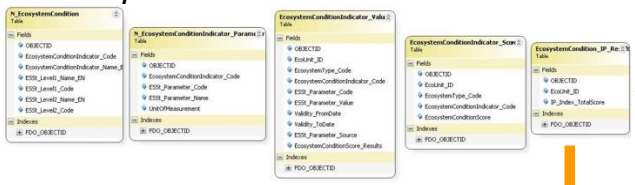
3. Mapping and assessment of ES concept and process



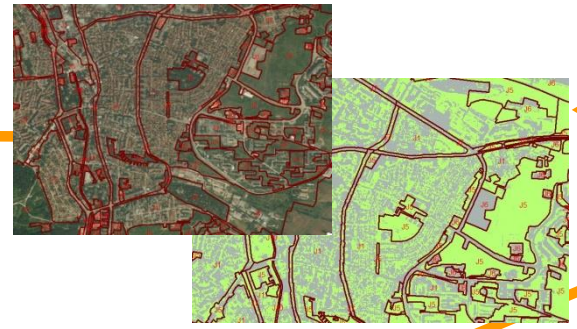
(Burkhard et al. 2018)

3. Mapping and assessment of ES

Ecosystems database



Ecosystems delineation

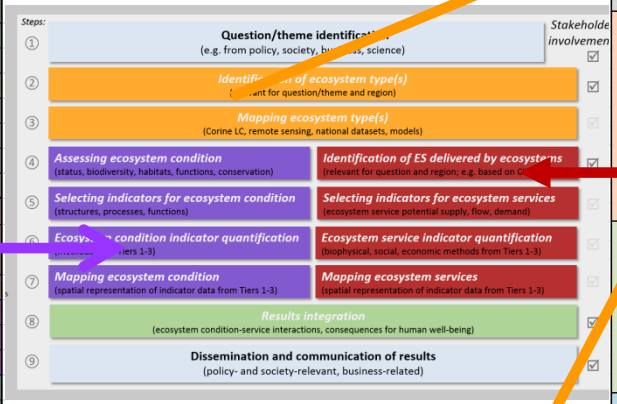


Urban typology

L.1	L. 2	Level 3
Terrestrial	Urban	J1. Residential and public areas of cities and towns
		J2. Sub-urban areas
		J3. Residential and public low density areas
		J4. Recreation area outside cities and towns
		J5. Urban green areas (incl. sport and leisure facilities)
		J6. Industrial sites (incl. commercial sites)
		J7. Transport networks and other constructed hard surfaced sites
		J8. Extractive industrial sites (incl. active underground mines and active opencast mineral extraction sites, and quarries)
		J9.Waste deposits
		J10.Highly artificial man made waters and associated structures

Ecosystems condition

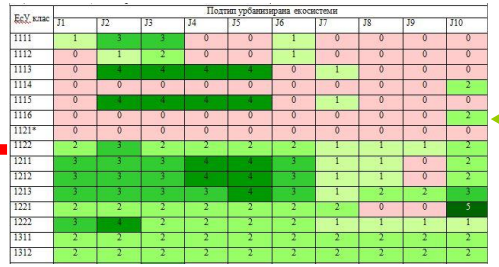
Ecosystem structure	Biotic Heterogeneity	Plant diversity
		Animal diversity
		Habitat diversity
		Invasive species
		Other biotic heterrogeity
	Abiotic heterogeneity	Soil heterogeneity
		Hydrological heterogeneity
		Air heterogeneity
		Geomorphological heterogeneity
		Other abiotic heterogeneity
Ecosystem processes	Energy budget	Energy balance (capture, storage)
		Entropy production
		Metabolic efficiency
		Other energy budget indicators
	Matter budget	Matter balance (input, output)
		Element concentrations
		Efficiency measures
	Water budget	Water balance (input, output)
		Water storage
		Other state indicators
		Efficiency measures



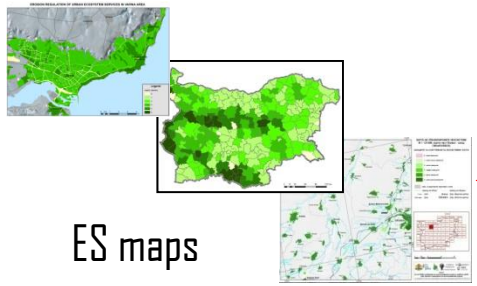
Ecosystem services

Section	Division	Group	Class (codes CICES)
Provisioning	Nutrition	Biomass	P1. Cultivated crops (1111)
			P2. Reared animals and their outputs (1112)
			P3. Wild plants, algae and their outputs (1113, 1115)
			P4. Wild animals and their outputs (1114, 1116)
	Materials	Water	P5. Ground water for drinking (1122)
			P6. Surface water for non-drinking purposes (1221)
			P7. Ground water for non-drinking purposes (1222)
		Material	P8. Fibres and other materials (1211, 1212)
			P9. Genetic materials from all biota (1213)
	Energy	Biomass-based energy sources	P10. Plant and animal-based resources for energy (1311,1312)
			P11. Animal-based mechanical energy (1321)
Regulating and maintenance	Mediation of flows	Mediation by ecos.	R1. Regulation of pollution and other impacts (2121,2122,2123)
		Mass flows	R2. Mitigation of erosion (2211,2212)
		Liquid flows	R3. Water flow maintenance and flood protection (2221,2222)
		Gaseous / air flows	R4. Regulation of air flows and atmospheric risks (2231,2232)
	Maintenance of physical, chemical, biological conditions	Lifecycle maint. etc	R5. Pollination and seed dispersal (2311)
		Pest and disease cntr	R6. Pest and disease control (2321,2322)
		Soil formation	R7. Regulation of soil formation and composition (2331,2332)
		Atmospheric and climate regulation	R8. Global climate regulation (2351)
			R9. Micro and regional climate regulation (2352)
Cultural	Physical and intellectual interactions	Physical interactions	C1. Recreation (3111,3112)
		Intellectual and representative	C2. Scientific and Educational (3121,3122)
			C3. Cultural heritage (3123)
	Spiritual, symbolic and other	Spiritual	C4. Aesthetic and spiritual (3125,3211,3212)
		Other cultural outputs	C5. Existence and bequest (3221,3222)

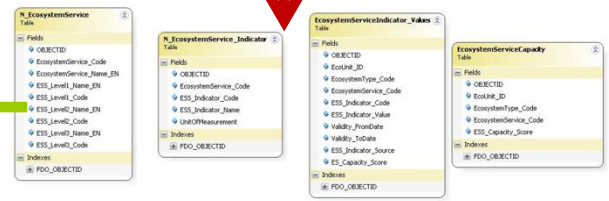
ES assessment



ES maps



ES database



3. Mapping and assessment of ES

Ecosystems' typology – urban ecosystems example

L.1	L. 2	Level 3
Terrestrial	Urban	J1. Residential and public areas of cities and towns
		J2. Sub-urban areas
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		J8. Extractive industrial sites (incl. active underground mines and active opencast mineral extraction sites, and quarries)
		J9.Waste deposits
		J10.Highly artificial man made waters and associated structures

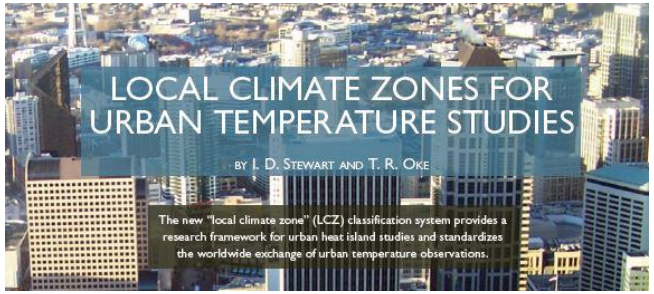
J5. Urban forests & green areas

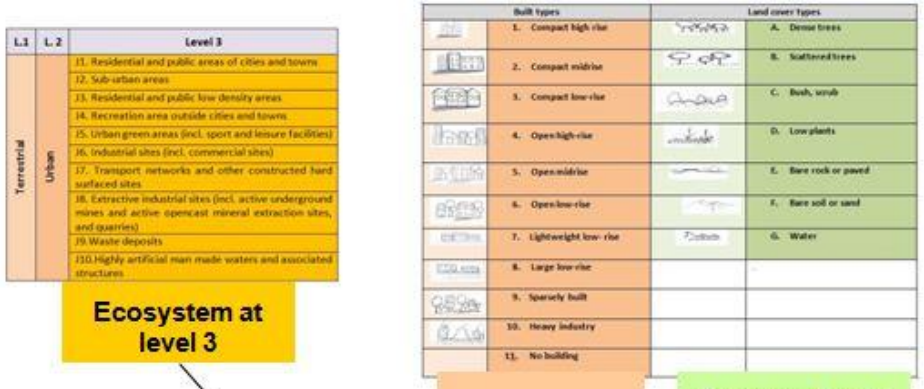
3. Mapping and assessment of ES

Integrated index of spatial structure of urban ecosystems

Built types	Definition	Land cover types	Definition
1. Compact high-rise	Dense mix of tall buildings to tens of stories. Few or no trees. Land cover mostly paved. Concrete, steel, stone, and glass construction materials.	A. Dense trees	Heavily wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural forest, tree cultivation, or urban park.
2. Compact midrise	Dense mix of midrise buildings (3–9 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.	B. Scattered trees	Lightly wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural forest, tree cultivation, or urban park.
3. Compact low-rise	Dense mix of low-rise buildings (1–3 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.	C. Bush, scrub	Open arrangement of bushes, shrubs, and short, woody trees. Land cover mostly pervious (bare soil or sand). Zone function is natural scrubland or agriculture.
4. Open high-rise	Open arrangement of tall buildings to tens of stories. Abundance of pervious land cover (low plants, scattered trees). Concrete, steel, stone, and glass construction materials.	D. Low plants	Featureless landscape of grass or herbaceous plants/crops. Few or no trees. Zone function is natural grassland, agriculture, or urban park.
5. Open midrise	Open arrangement of midrise buildings (3–9 stories). Abundance of pervious land cover (low plants, scattered trees). Concrete, steel, stone, and glass construction materials.	E. Bare rock or paved	Featureless landscape of rock or paved cover. Few or no trees or plants. Zone function is natural desert (rock) or urban transportation.
6. Open low-rise	Open arrangement of low-rise buildings (1–3 stories). Abundance of pervious land cover (low plants, scattered trees). Wood, brick, stone, tile, and concrete construction materials.	F. Bare soil or sand	Featureless landscape of soil or sand cover. Few or no trees or plants. Zone function is natural desert or agriculture.

Adapted after Steward and Oke, 2012



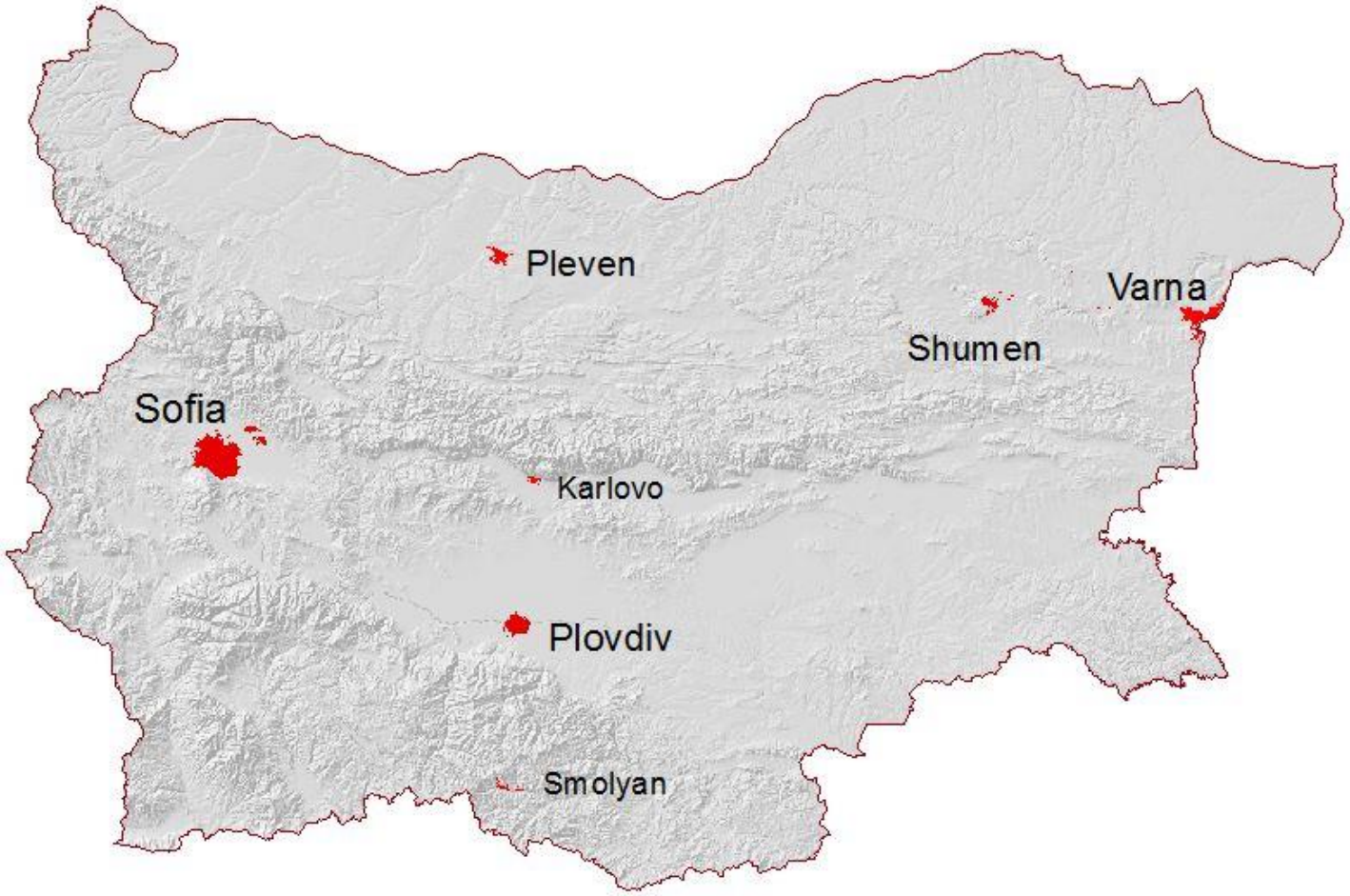


Ecosystem subtype	Built type	Land cover type	Integrated index of sp. Structure	Vegetation cover	Ecosystem subtype	Built type	Land cover type	integrated index of sp. Structure	Vegetation cover
J1	4	BE	J14BE	55	J6	8	DE	J68DE	50
		BDE	J14BDE	55			E	J68E	0
	5	BDE	J15BDE	55			BD	J69BD	90
	6	BDE	J16BDE	35		9	BDE	J69BDE	80
		BCE	J16BCE	55			EBD	J610EBD	15
		BE	J16BE	35		10	BDE	J610BDE	50
		E	J16E	0			BE	J610BE	35
J3	5	BDE	J35BDE	55			CE	J6 10 CE	35
	6	E	J36E	0			DE	J610DE	35
		BDE	J36BDE	60			E	J610E	0
	9	BDE	J39BDE	80	J7	11	BDE	J711BDE	15
		BCD	J39BCD	95			BE	J711BE	10
J5	9	BDE	J5 9 BDE	95			DE	J711DE	10
		BCD	J59BCD	95			E	J711E	0
	11	A	J511A	100	J8	11	BDF	J811BDF	40
		AE	J5 11 AE	90			E	J811E	0
		AD	J511AD	100		9	BDF	J89BDF	40
		BCD	J511BCD	100			E	J89E	0
		BD	J511BD	100	J9	11	E	J911E	0
		BDE	J511BDE	90			DF	J911DF	20
		BDG	J511BDG	90			D	J911D	15
		BE	J511BE	90			EG	J911EG	0
		CD	J511CD	100			G	J911G	0
		D	J511D	100	J10	11	G	J1011G	0
		DE	J511DE	90			EG	J1011EG	0
J6	8	EBD	J68EBD	15			DG	J1011DG	10
		BDE	J68BDE	55			BDG	J1011BDG	95
		ED	J68ED	15			BDEG	J1011BDEG	90

(Nedkov et al. 2017)

4. Forest ecosystems in natural, urban and peri-urban areas

UGI - selected cities for testing the results for vegetation cover



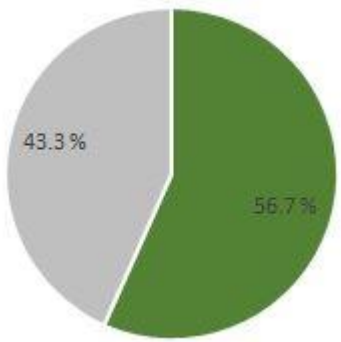
Sofia – 1 202 761

Plovdiv – 338153
Varna – 334870

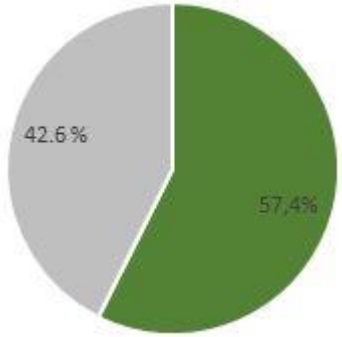
Pleven – 104 954
Shumen – 80 855

Smolyan – 30 642
Karlovo – 23075

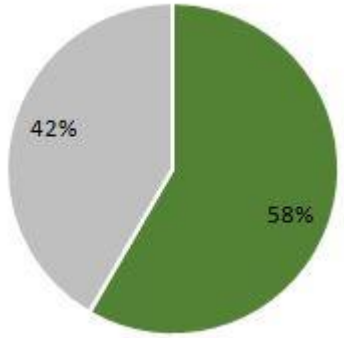
4. Forest ecosystems in natural, urban and peri-urban areas



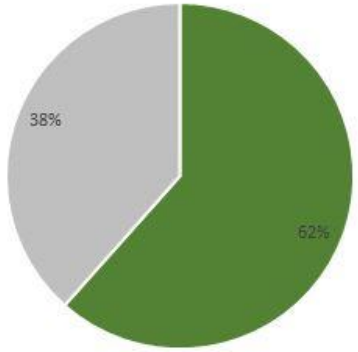
Sofia



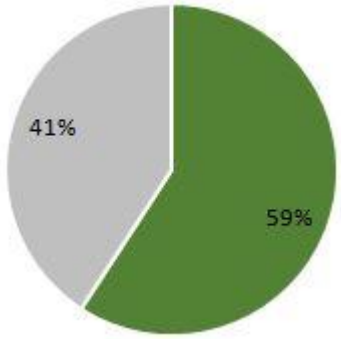
Varna



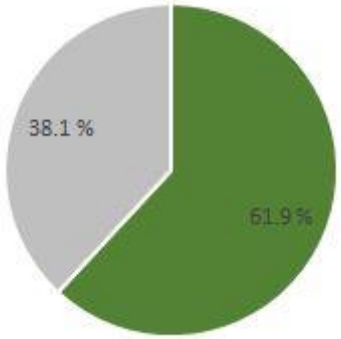
Shumen



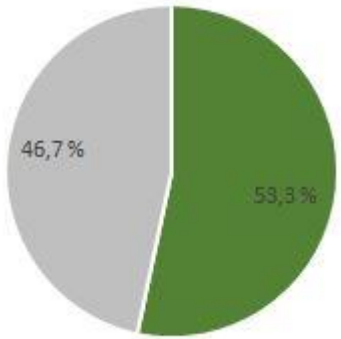
Karlovo



Plovdiv



Pleven



Smolyan

Green

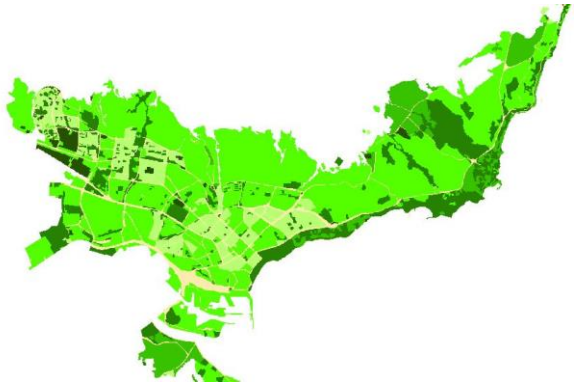
Gray (Paved)

4. Forest ecosystems in natural, urban and peri-urban areas

Vegetation cover in selected cities

Sofia

Varna

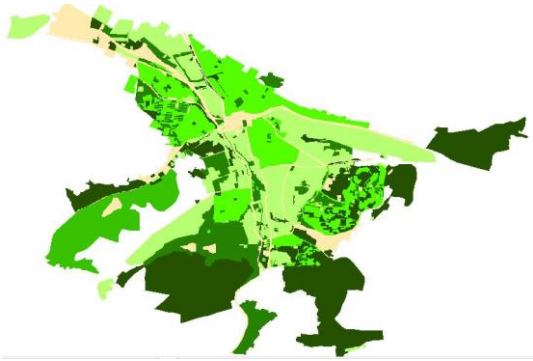


Karlovo

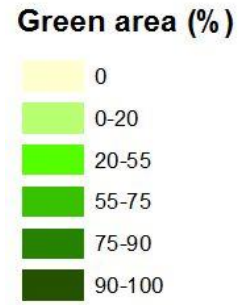
Shumen

Plovdiv

Pleven

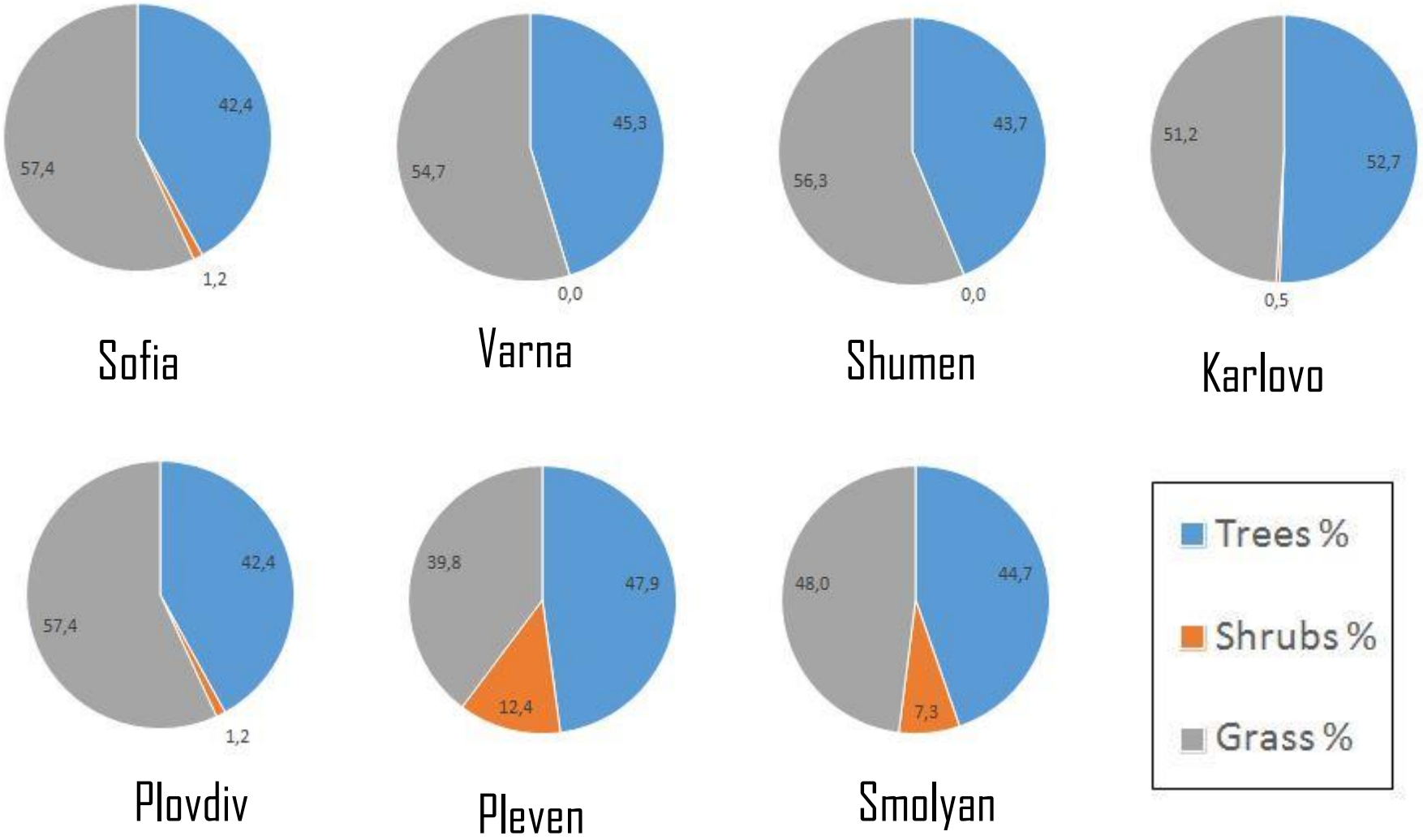


Smolyan



4. Forest ecosystems in natural, urban and peri-urban areas

Vegetation cover in selected cities



4. Forest ecosystems in natural, urban and peri-urban areas

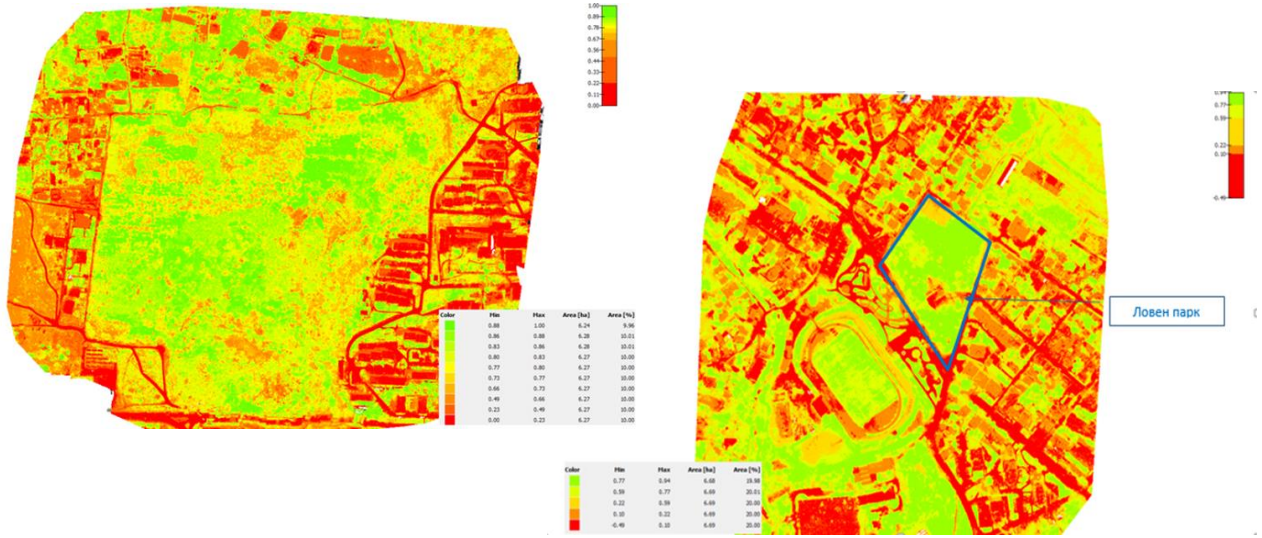
UGI in urban ecosystems

Multispectral camera 'Parrot SEQUOIA', integrated with an UAV system 'Flying Wing'; Standard RGB channel; camera equipped with a solar radiation sensor.

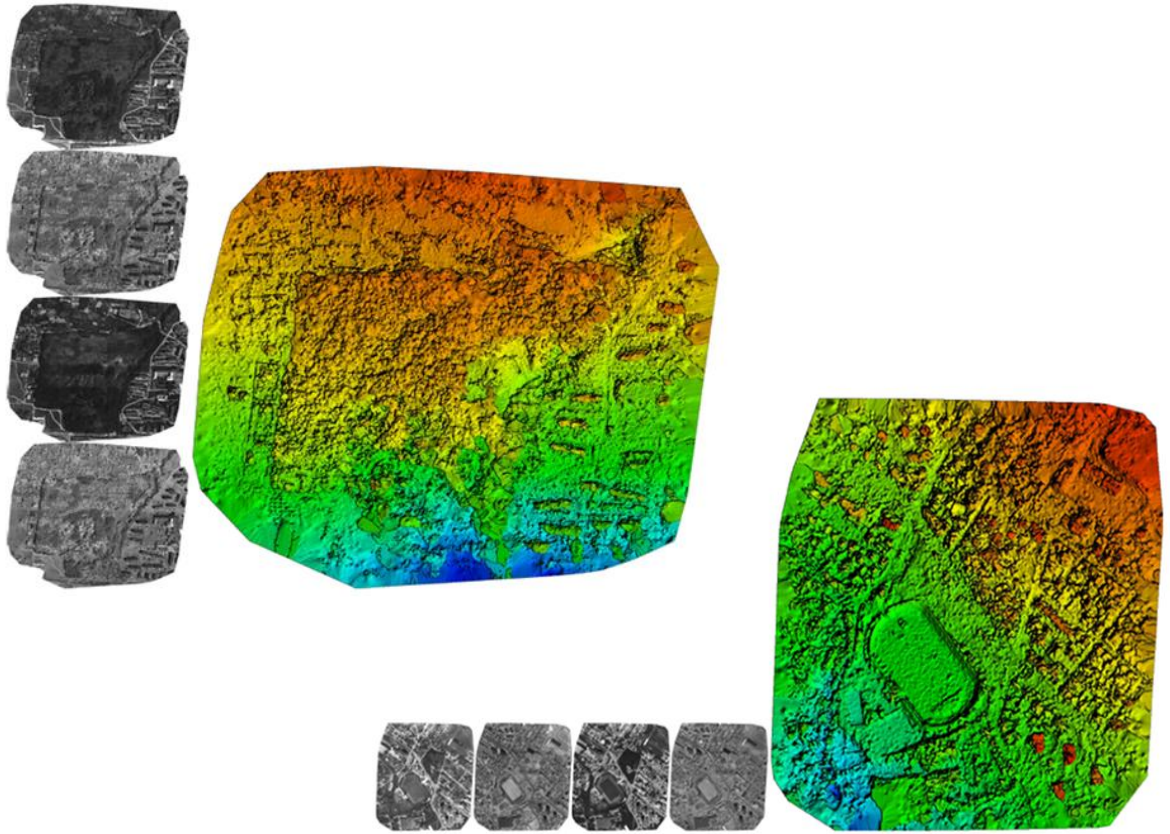
NDVI (Normalized Difference Vegetation Index)

Missions' planning was performed using SenseFly-E-motion specialized platform.

Imaging - UAV system eBee that utilizes photogrammetric and multispectral cameras.



In this local example are presented the results of the assessment of urban GI in Karlovo by application of remote sensing Unmanned aerial vehicle (UAV) technology.



4. Forest ecosystems in natural, urban and peri-urban areas

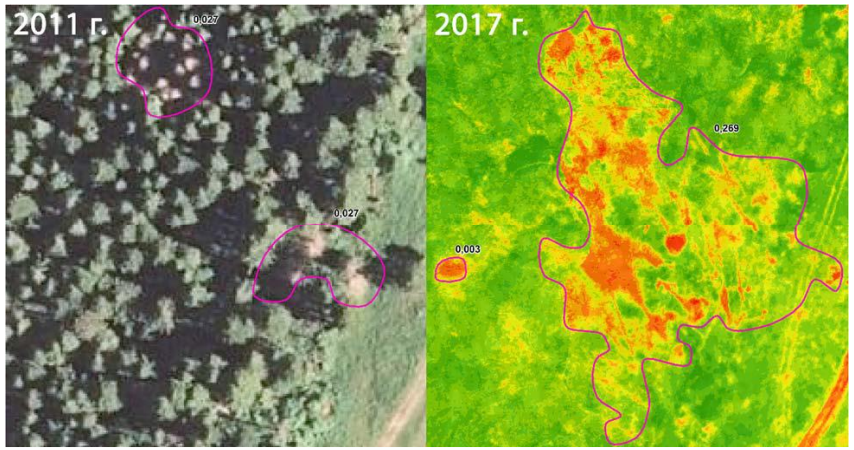
Forests in natural environments

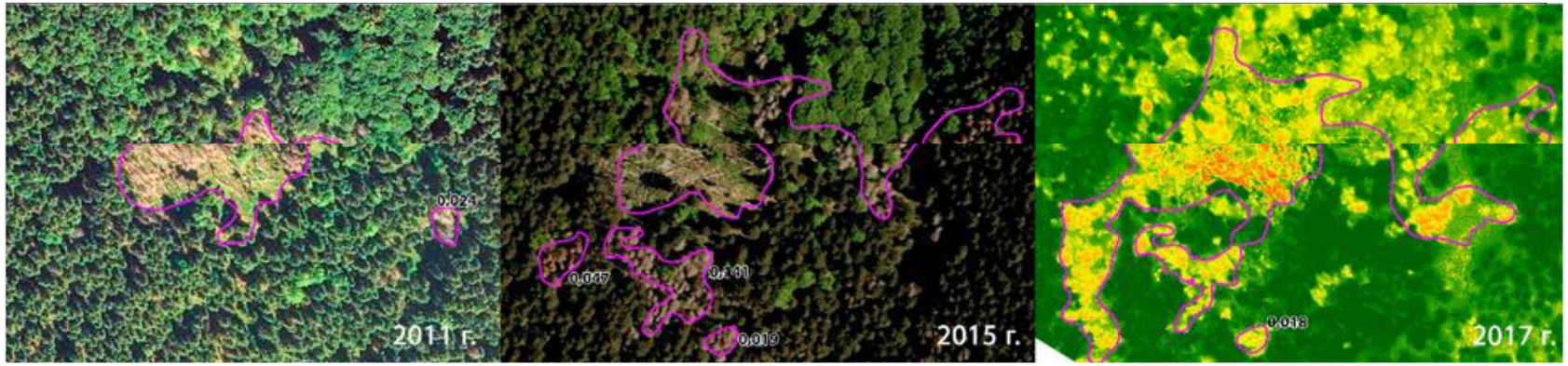
- Risks in forest territories – forest dieback (coniferous plantations & stands, some broadleaved stands) worse phytosanitary status, degradation processes (erosion, sealing…), flooding etc.
- The knowledge about conditions of natural forests and urban green infrastructure (UGI) is important for maintaining the quality of life in all regions.

The perspective of rapid changes of ecosystems' condition generates a need of establishment and use of adequate system for monitoring the damages in natural and urban territories.

Multispectral camera 'Parrot SEQUOIA', integrated with an UAV system 'Flying Wing'; Standard RGB channel; camera equipped with a solar radiation sensor.
NDVI (Normalized Difference Vegetation Index)
Missions' planning was performed using SenseFly-E-motion specialized platform.
Imaging - UAV system eBee that utilizes photogrammetric and multispectral cameras.

In this local example are presented the results of the assessment of forests in Natural reserves "Gornata koria" & "Chuprene" by application of remote sensing Unmanned aerial vehicle (UAV) technology.





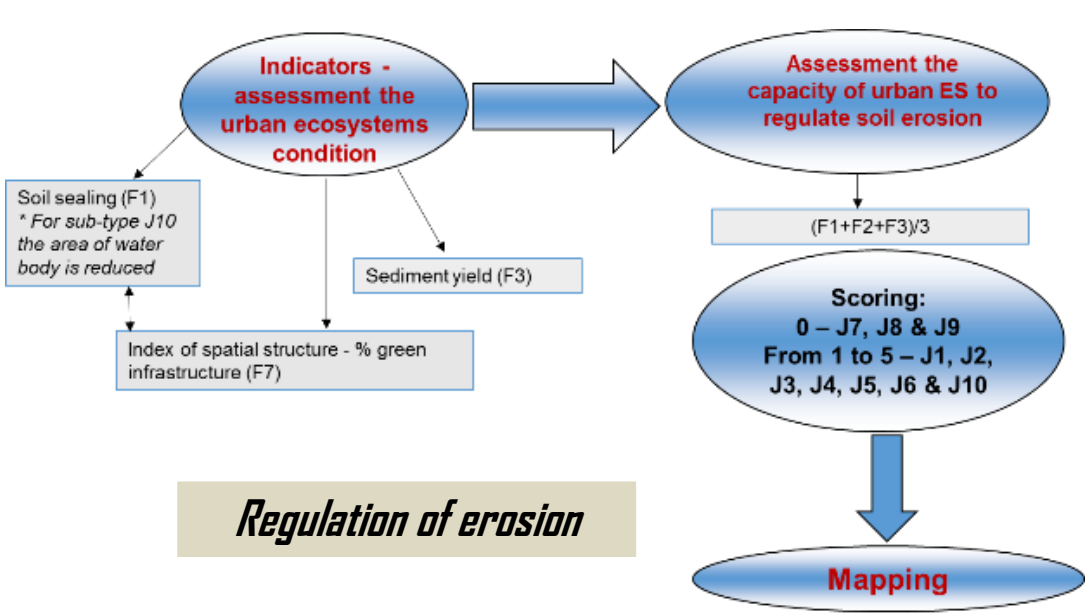
6. ES provisioning assessment and mapping – examples

Urban soils, in addition to their slow formation due to long-term natural processes are decisively modified by urbanization. High levels of soil disturbance and new substrates added to the soil due to human activities change the morphology of the soil profile and the overall soil processes and functions. This is important because soils play an essential role in sustaining the provisioning of ecosystem services (ES). Urban soils are the main basis for creation and existence of urban green infrastructure (UGI) - designed and managed to deliver ES and protect biodiversity in urban settings.

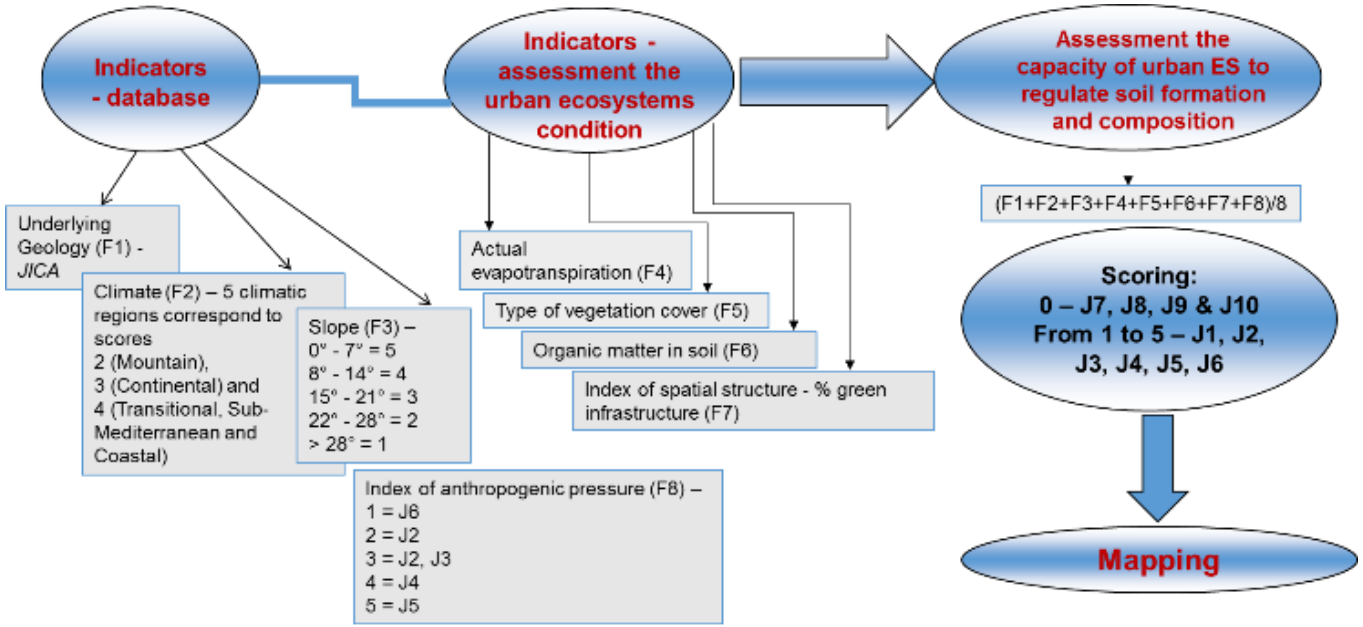
Studied soil-related ES: **erosion regulation & regulation of soil formation and composition**

Methodological approach is based on analysis of complex indicators associated with soil system functioning is applied for assessment and mapping of soil-related ecosystem services in three case-study regions.

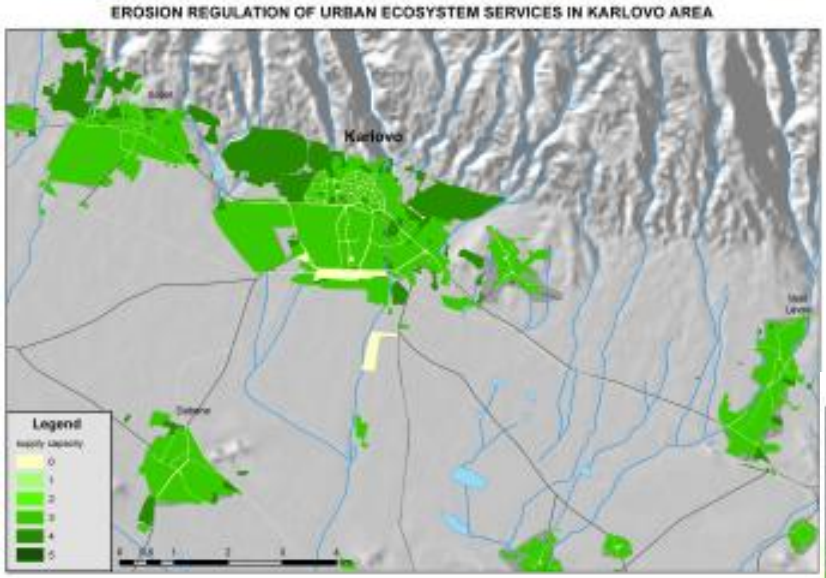
Regulation of soil formation and composition



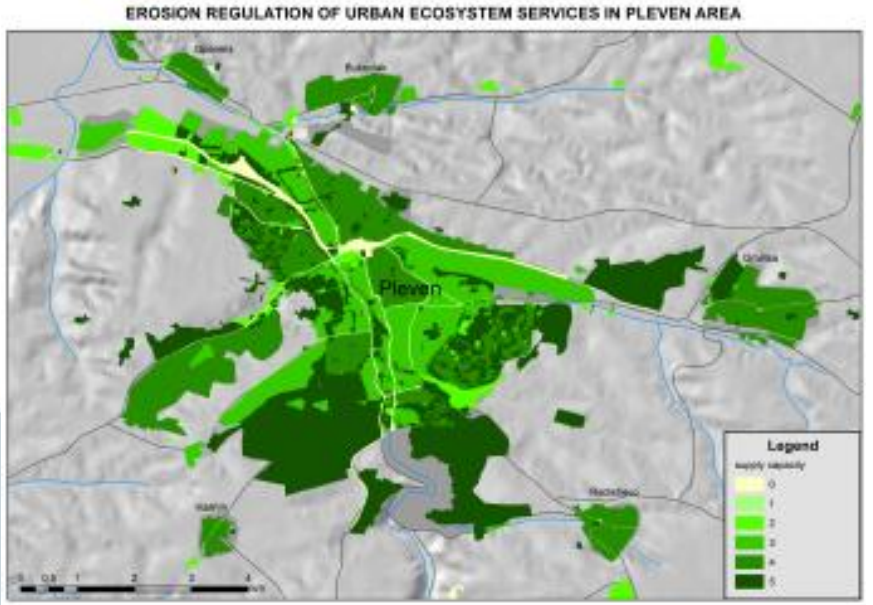
Regulation of erosion



6. ES provisioning assessment and mapping – soil-related



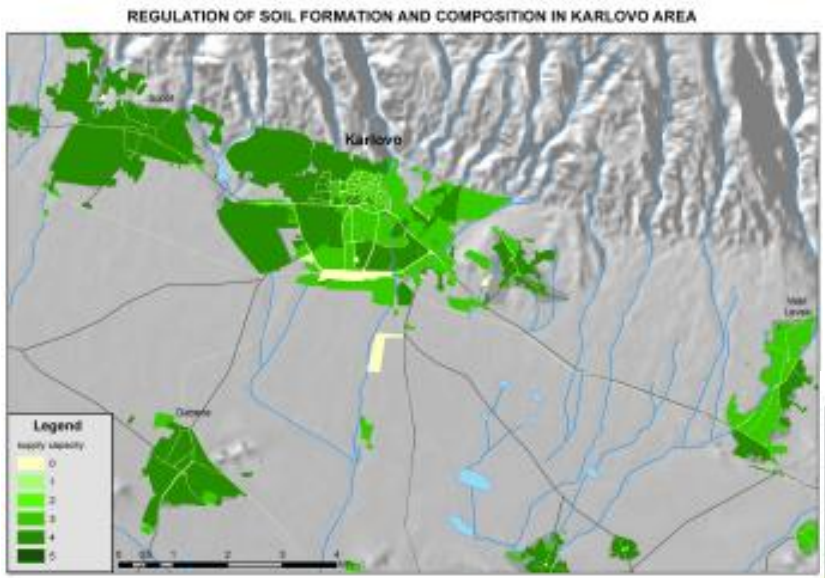
Regulation of soil erosion



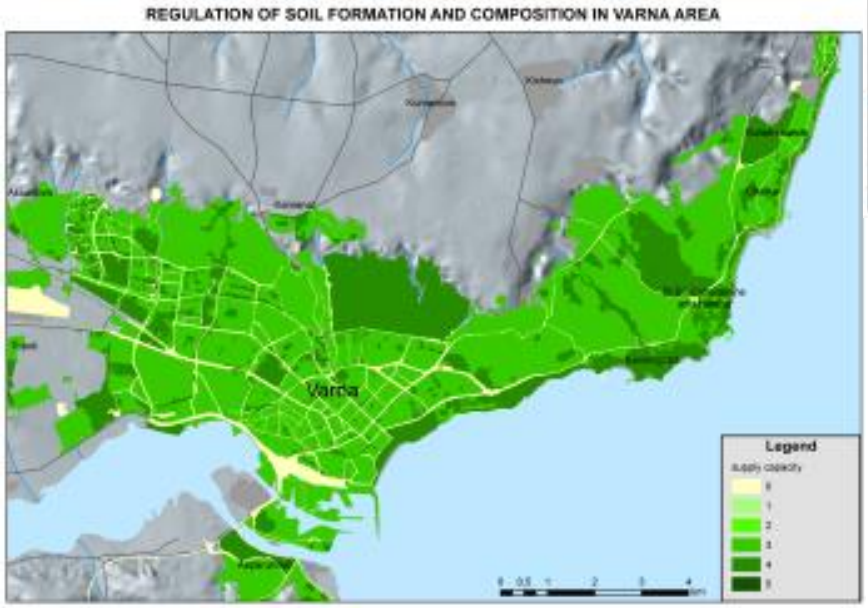
Capacity & Vulnerable zones:
Low capacity and high vulnerability – scores 1 and 2
Medium capacity and medium vulnerability – scores 3 and 4
High capacity and low vulnerability – score 5

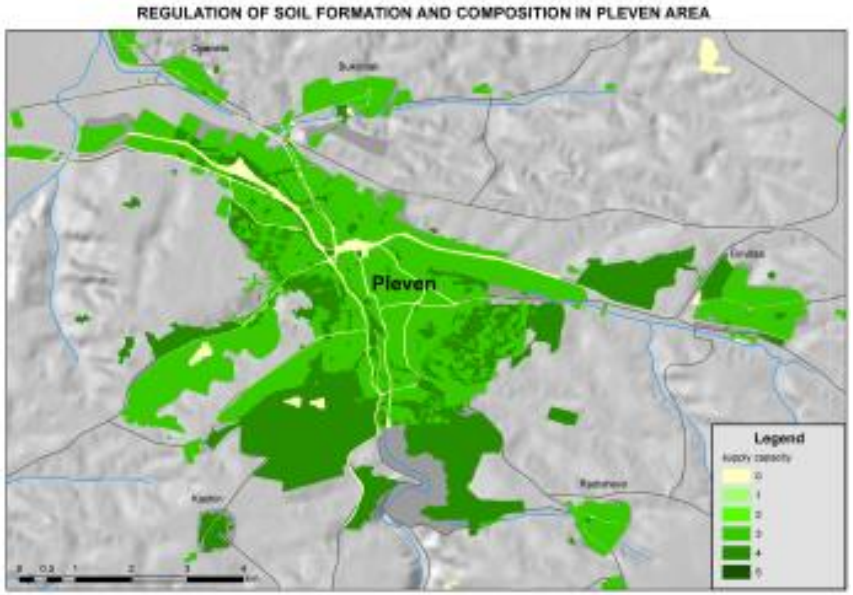
Applicable at local level decision making

6. ES provisioning assessment and mapping – soil-related



Regulation of soil formation and composition

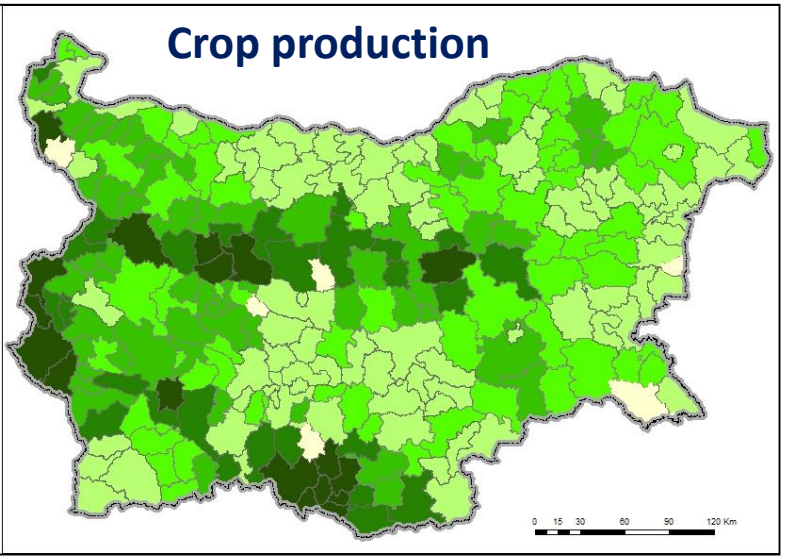




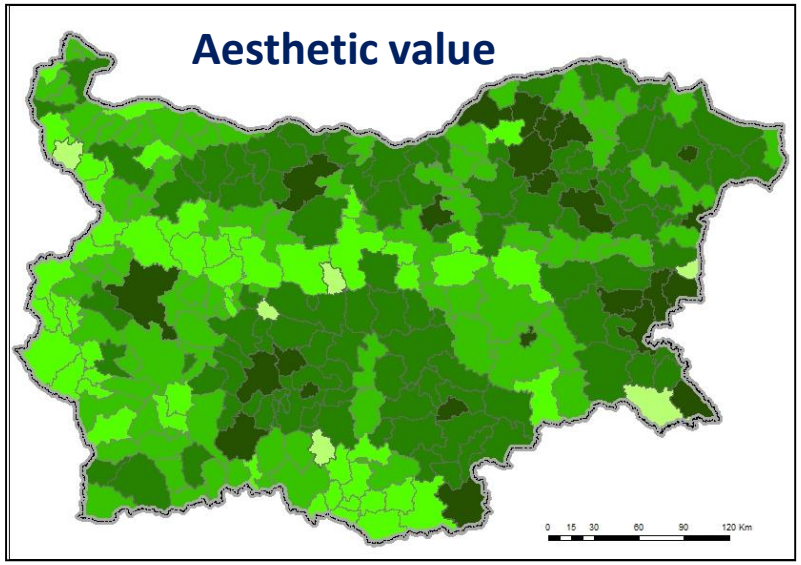
Capacity & Vulnerable zones:
Low capacity and high vulnerability – scores 1 and 2
Medium capacity and medium vulnerability – scores 3 and 4
High capacity and low vulnerability – score 5

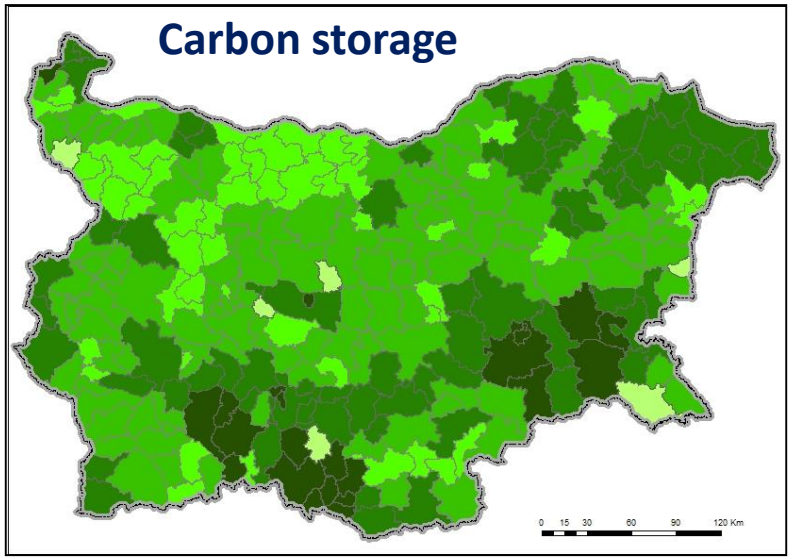
Applicable at local level decision making

6. ES provisioning assessment and mapping



Large scale ES maps





1 = low relevant capacity

2 = relevant capacity

3 = medium relevant capacity

4 = high relevant capacity

5 = very high relevant capacity

Applicable at national level decision making

7. Main findings

- The general conclusions are linked to the outlined vulnerable zones and recommendations for sustainable management of soil resources in urban ecosystems are proposed following regional approach. Most of the urban areas in Bulgaria characterize with medium capacity to regulate erosion rates and low to medium capacity to regulate soil formation and composition.

- UGI is the main factor, which increases the capacity of urban ecosystems to provide fundamental soil-related ES.

- The results showed that the implementation of the approach, which combines UAV and in-situ verification, could be used extensively for remote monitoring of natural forests, urban and peri-urban green infrastructure with subsequent detailed investigation of solitary trees for assessment of their condition which could be an EFFECTIVE SUPPORT TOOL for decision-makers and risk managers.

7. Main findings

- The MAES framework gives appropriate basis for mapping of ecosystem services at national level
- The delineation of ecosystem types ensures the spatial units for ES assessment, although not all services could be successfully quantified within such a frame
- The developed geospatial approach ensures proxies for ES with lack of measured data which increased the number of individual services that can be studied
- ES maps should be arranged according to the specific needs of the decision makers
- The GIS database of ES gives the opportunity to arrange the results at different levels and prepare different types of maps according to the specific needs of decision-making process
- The maps of ES provide appropriate information for decision making at national level but at local level more detailed data are needed

THANK you for your attention!

Prof. Dr. Miglena Zhiyanski
miglena.zhiyanski@gmail.com