METHODOLOGICAL FRAMEWORK FOR ASSESSMENT AND MAPPING OF ECOSYSTEM CONDITION
AND ECOSYSTEM SERVICES IN BULGARIA

PART C

GUIDE FOR *IN SITU* VERIFICATION OF THE ASSESSMENT AND MAPPING OF ECOSYSTEMS CONDITION AND SERVICES

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OF ECOSYSTEMS CONDITION AND SERVICES

PART C

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Contents

1. Beyond the ecosystem – the purpose of this Guide

This section provides an introduction to the *in situ* verification and explains the rationale, objectives and scope of the current document.

a. Landscape level verification of several linked ecosystems – introduction and relevance

Ecosystems are a key study area of ecology and have traditionally been used to define the boundaries of an organism community and its abiotic environment that act as a single system.

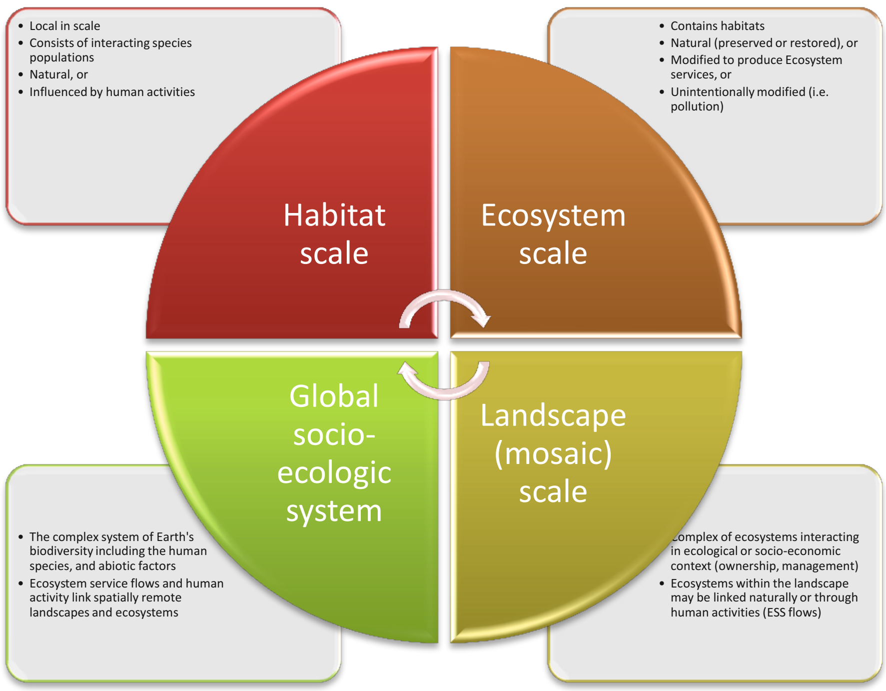
However, in most contexts of the socio-ecological system[1] the physical boundaries of a single ecosystem are not very important. Based on ownership or other social relations (such as spatial planning, nature management imposing restrictions on arbitrary land use, etc.), human activities tend to focus on landscapes. Landscapes may contain parts of a single ecosystem (i.e. ownership over a parcel of forest; a protected area within a bigger landscape), or contain several ecosystems in whole or part (i.e. ownership over a townhouse with a garden, and the adjacent cropland by the same person or company). In addition, landscape ecology is a relatively new but quickly developing branch of ecology which deals with the ecological links and interactions within spatial groupings of ecosystems – landscapes and landscape mosaics. The development of landscape ecology is being augmented and, in some ways, shaped by the global governance on the topics of sustainable landscape planning and conservation of biodiversity[i]. Landscape ecology is also closely related to the concepts of ecosystem services and natural capital; it studies the processes of interactions between ecosystems and is therefore useful for scaling up beyond the single ecosystem and studying ecosystem service generation, flows and consumption patterns[ii,iii]. For example, a field's natural ecosystems are removed and the new cropland ecosystem is optimized by the farming businesses to produce high crop yield; the crop is then harvested and transported to urban ecosystems. The process of rearing crops involves fertilization which in turn is accountable for diffuse nitrate pollution of the nearby water ecosystems, causing eutrophication and decline in their condition.

The link between the different scales of socio-ecologic interactions from habitat level to global, is presented in Fig. 1 below. Understanding these scales is important for ecosystem services research because the higher scale developments (such as global trade, international tourism, national and local policies on the landscape level) influence the ecosystems,

[1] A system consisting of ecosystems and humans that influence, manage and in some cases destroy them in order to replace them with other ecosystems and/or artificial objects. In the context of socio-ecological systems, the condition of an ecosystem and the services it provides may be influenced by human populations outside its location, for example the demand for food outside Bulgaria influences the land use and land grabbing to produce and export grain

habitats and species, and therefore impact the ecosystem conditions and ecosystem services production.

Fig. 1. Relation between ecosystems, ecosystem services and landscape mosaics



Understanding higher level interactions above the ecosystem scale is also important for the precise valuation of ecosystem services. For example, hunting tourism impacts terrestrial ecosystems (predominantly forest) but is motivated by the wish to attract (predominantly foreign) high-end paying customers. Without this economic motivation, keeping the stock of game species in forests would be much less important to the local population. Similar is the situation with the cultural ecosystem services in general[iv]. The landscape prospective is also important for other services such as pollination (pollinators may live in forest or shrubs ecosystems but enhance agricultural production in cropland ecosystems) and regulating services (i.e. a wetland used for flood retention and water purification, a forest providing avalanche protection to a resort's urban ecosystem).

In this context, mapping and assessing the diverse ecosystems on a given territory is important for a number of practical purposes, such as monitoring, ecosystem services biophysical assessment and monetary valuation, informing policy implementation and management decisions related to ecosystems and land use in general.

2. Purpose, methods, scope and audience of this Guide

The current document is part of the National Methodological Framework for assessment and mapping of ecosystem condition and ecosystem services in Bulgaria, which was produced with the financial support of the FM of the EEA, within the project **BG03.PDP2**

“Methodological Support for Ecosystem Services Mapping and Biophysical Valuation” (MetEcoSMap). The Framework provides practical guidance for mapping of ecosystems and biophysical valuation of services both in the field and in the context of mid- to long-term policy implementation and management. Its place in the data collection is to identify missing parts and resolve inconsistencies in data collected following the single ecosystem methodologies (parts B.1 to B.9 of the Framework) and/or in monitoring data (part D of the Framework). In this context, *in situ* verification can be performed both in parallel to the data collection in order to inform methodology development (as it was practiced in the MetEcoSMap project), or after the fact as a verification tool for already collected data.

Like in other parts of the Framework, this Guide contains guidance on the pre-processing the data, the actual fieldwork of the in-situ verification, and the follow-up evaluation. The first and third of these steps are subject of cameral work. Fieldwork, however, is subject to seasonal and weather conditions and therefore must utilize existing windows of opportunity.

Objectives

Its immediate practical objectives are to:

- **assist the performers of activities** related to the verification of the assessment of ecosystems condition, the quantity of the services provided by them and the mapping of ecosystems on the territory of the Republic of Bulgaria.

  The *in situ* verification of all ecosystems on selected territories within the MetEcoSMap project showed a good potential for cross-validation of the single ecosystem services methodologies because contradictions such as abrupt changes of ecosystem service conditions or service provision are much easier to detect and resolve within a landscape than it would be possible at larger scales (national or global). Therefore, the approach outlined below is suited to clarifying and ensuring the correct application of the texts of the Methodologies for mapping of ecosystems and ecosystem services;

- **assist the verification and approval of the results obtained** during the assessment of the ecosystem condition, the quantity of the services provided by them and the mapping of ecosystems on the territory of the Republic of Bulgaria by the responsible stakeholders.

  Selection of representative ecosystems for *in situ* verification in the landscape context is a necessary step for the verification of results obtained by ecosystem level assessment of other ecosystems similar to the representative ecosystems. Because the *in situ* verification is performed in the landscape context, its assessment includes cross-checked measurements and is less error prone. If, therefore, similar ecosystems are ass essed to have significantly different state or single parameters than the representative ecosystems, this may hint at errors made during their assessment. Also, stakeholders (such as monitoring authorities or their contractors, local authorities and volunteers) will be able to visit the reference ecosystem for educational or training purposes as preparation for the checking and approval of results from other ecosystem data collection.

- **ensure uniformity and comparability of the results obtained** during the verification of the assessment of ecosystems condition, the quantity of the services provided by them and the mapping of ecosystems on the territory of the Republic of Bulgaria.

  The *in situ* verification is an important part of the whole process of data collection using the same methods across the country. Its particular role is to support the quality assurance of national datasets by identifying and resolving inconsistencies between data for similar ecosystem types in different locations.

Scope and place within the Methodological framework

The *in situ* verification is a one-time activity limited to smaller areas in a single landscape. It does not replace the full-scale data collection such as the mapping and assessment of ecosystems and ecosystem services

Target audience

This document is for you if you are:

1. An official in an administration that is competent as regards the mapping, valuation and monitoring of ecosystems and ecosystem services;

2. An official of another administration, a representative of the scientific community, of local bodies or another interested party – you use the results from the mapping and valuation of the ecosystems and ecosystem servicesand you show interest in or identify a need of an *in situ* verification;

3. A volunteer who wants to support the *in situ* verification, or other stakeholder interested in ecosystems and ecosystems services mapping and assessment.

Contents of the Guide

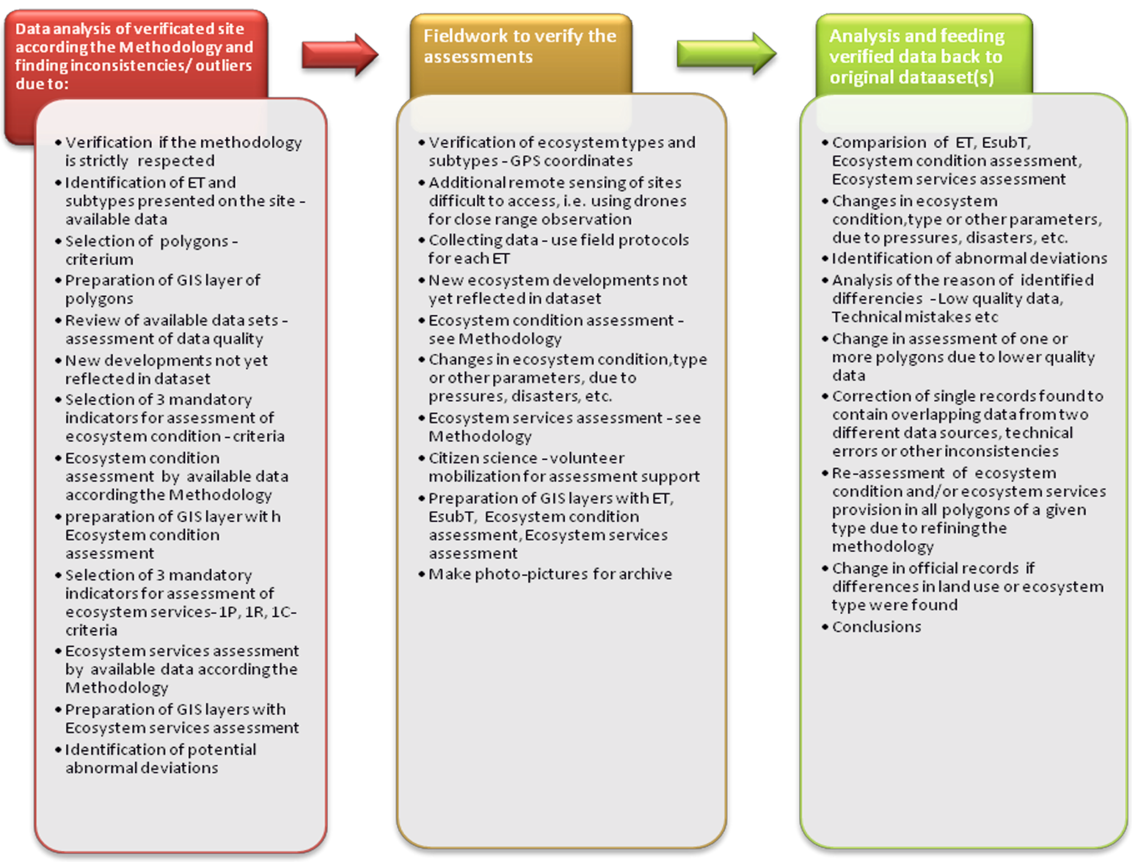
The Guide provides step-by-step instructions for the process of *in situ* verification, including consideration on the time and place of verification, specific verification points – mandatory and optional, checklists and instructions

2. Mandatory points along which verification should be made

1. Main steps and methods

On the spot verification in the context of this Guide, refers to the systematic identification of outliers (inconsistent, lower quality or error prone data) using analytic techniques on database records, remote sensing/earth observation data, or other datasets available, and the improving of data quality by targeted fieldwork. The process could be represented as shown in Fig. 2:

Fig. 2. Steps and mandatory *in situ* verification points



To this end, the **following methods** may be applicable:

a. Checking the metadata of available datasets and establishing data accuracy based on criteria such as:

   i. Time of collecting
   ii. Exhaustiveness of the data
   iii. Source and scientific validity of the data

b. Using statistical analysis, GIS data review, machine learning or other appropriate techniques to assess the degree of dissimilarity to other data, incl. from reference ecosystems. The selection of processing methods depends on the nature of inconsistencies/outliers. For example:

   i. If polygons were not randomly selected during the mapping phase, the resulting assessment of ecosystems conditions may differ from real-world remote sensing observations. To identify such anomalies, the automated classification of ecosystems in the satellite/remote sensing imagery, ortophoto data or other georeferenced data source can be compared to the GIS layers of the ecosystem conditions assessment produced in the course of ecosystems condition mapping and assessment. Accordingly, after ground truth validation in step 2, such anomalies may result in re-assessing the ecosystems condition and ecosystem services provision capacity.

   ii. If data for the same ecosystem type varies significantly between polygons, the areas with very dissimilar data should be flagged for adding to the on-the-spot checks plan. Finding such an outlier, however, does not necessarily mean that data is incorrect – apart from the obvious possibilities of technical mistakes or low quality data, it might also be due to unknown factors such as new pressures on the ecosystem, unsolicited activities, disasters, change in land use not (yet) reflected in the database, etc. Depending on the validation in step 2., in such cases the modifications in the database may be very different and range from simple error correction to modifying official records, i.e. on changes in land use or in cases of ecosystems changes – reforestation of heathlands in the course of succession, destruction by fire, etc.

   iii. Downscaling of lesser resolution data could be a source of imprecision, especially for linear objects like rivers. Should for example the course of a river be different than the one estimated from satellite imagery, both a correction of the higher resolution GIS dataset and triggering of official modifications (i.e. changing the coordinates of the related NATURA 2000 area) may prove to be necessary.

Should the veracity of the outlier data be confirmed, inconsistencies with the predictions in the mapping and assessment methodology may also trigger a reassessment of the methodology itself. For example, a high ground pasture yielding, due to its location and climatic condition, much less hay than a lowland pasture of the same ecosystem type, may be found to be in the same or even better condition than the lowland pasture. This finding may lead to reassessing the biophysical assessment methodology for provisioning ecosystem services in grassland ecosystems.

2. The main points of verification

Summary of the techniques and methods to be used, and relation to part B

Due to its control nature, *in situ* verification has, in general, to be compatible to the ecosystem data collection. In particular, the indicators identified in Parts B.1 to B.9 can be:

1. Verified methodologically. To this end, sample ecosystems which are representative for a given ecosystem type with regard to biophysical conditions and typical in terms of land use and socio-economic relations, are verified and the results are used for intercalibration of the methodologies or their further development.

2. Verified for compliance control purposes. To this end, an independent verificator should visit a random sample of locations containing polygons that were mapped and assessed following Part B methodologies. Depending on the task at hand, they may perform a full verification of all ecosystem types and determine the correctness of the previous ecosystem assessment, or complement such verification with additional measurements such as the N/P ratio in soils, eDNA verification of species composition, etc.

3. Cross-checked for areas of interest, in particular where the methodologies are insufficiently conclusive due to borderline conditions, data discrepancies, inconsistencies between official data from different sources, etc. This cross-checking can be used for quality assurance of existing data.

4. Used for collecting additional data, for example if a new method or information source become available for measuring optional parameters that were not measured and evaluated during previous assessments.

The methodologies for assessment and mapping of ecosystems condition and their services (Part B) share a common structure and approach. They are applicable to the entire territory of Bulgaria, and provide a combination of information on relevant information sources and practical step-by-step guidance to:

1. Typology of the ecosystems (main types and subtypes)
2. Assessing the condition of the ecosystems;
3. Assessing the ecosystems' potential to deliver ecosystem services (biophysical valuation).

The Methodologies are detailed down to ecosystem subtypes (level 3) that occur through the country. Although the ecosystem subtypes are with accordance with largely used European classification systems (e.g. EUNIS) the Methodologies include detailed description of their characteristics for Bulgaria and relations with other classification systems.

Although different by ecosystem types, the indicators for assessing the ecosystem condition proposed in each methodology are divided into two groups: Primary and Optional. Primary indicators are mandatory and have to be verified during the *in situ* verification. Currently, there are no or limited data about the Optional indicators and additional investigations and/or case-studies are needed for their assessment (see Monitoring Guide). That is why Optional indicators are supposed to be *in situ* verified only if additional verification methods and/or data have become available since the mapping, and the optional indicator can be verified on site.

All indicators in each methodology are chosen to serve for a comprehensive assessment of the ecosystem condition and ecosystem services. For assessment of ecosystem condition the indicators are divided into Ecosystem structure section and Ecosystem processes section (see Annex 6 of the Methodology). For assessment of ecosystem services the indicators are grouped into: Provisioning section, Regulation & Maintenance section and Cultural section (for details see Annex 7 of the respective methodologies).

The typology of all methodologies in Part B is aligned to the typology developed by the EU Working group on mapping and assessment of ecosystem services (MAES). In addition, where feasible, methodologies are aligned to other policies, tools, methods and information. For example, the proposed typology of Urban ecosystems in Bulgaria corresponds to the classes at first and second levels, defined in MAES (2013) and at the third level the typology corresponds to the National concept for spatial development for the period 2013 – 2025. The latter model contains a hierarchic system of core-cities performed through assessment of their significance and role according to a number of criteria and indicators related to the population dynamics and the degree of development of their administrative, economic, transport functions etc.

Depending on the manner in which their assessment has been generated, indicators can be two types: off site and in site. Off-site measurements are those that - by definition - are carried out outside the monitoring urban site. They include collection of spatial, quantitative and qualitative data. Object of *in situ* verification are only the “in site” indicators, obligatory as well as optional.

Specific requirements for some ecosystem types

B1 Urban ecosystems

All urban ecosystem subtypes (J1, J2 …J10) must be included in the *in situ verification* procedure.

In the selected urban area corresponding to a certain urban ecosystem subtype a network approach should be applied. As mentioned before this is valid only for indicator which require in site assessment. The network in high urbanized and medium urbanized areas should be 3x3 km, while in low urbanized areas it should be 1,5 x 1,5 km. Each cross-point identifies the *in situ* verified polygon corresponding to a certain urban ecosystem's sub-type. For specific purposes (e.g. tree condition in urban parks, ground vegetation assessment) and to include all sub-types of urban ecosystems present in the monitoring urban area, one or more sub-sites may be necessary. A sub-site is an area of defined dimension and shape according to the polygon within which the assessment and measurements are carried out. To be representative for the area, the sub-sites must be selected according to a statistically sound procedure. If not, assessments and measurements carried out on the sub-site can be considered indicative for the site if experts provide the necessary statement.

Indicators for assessing of ecosystem condition and ecosystem services may be *in situ* verified in the same manner within all ecosystem subtypes, providing the considered timing of verification (see below).

The *in situ* verification has to be realized following the procedure described.

The verificator should take into account that some characteristics of ecosystems and services they provide are not directly visible on the field and/or required specific or additional techniques for assessment. For example plant species richness are relatively well determined in the field than animal species diversity, which depends of species characteristics, daily and seasonal activity of species, etc. and also of experts' knowledge and good identification skills.

B4 Woodland and forest ecosystems

The verification report has to detail:

1. *Forest stand data:*
    a. Forest unit;
    b. Compartment and sub-compartment;
    c. Type of sub-compartment according to forest function;
    d. Site location and altitude;
    e. Purpose;
    f. Area;
    g. Origin;
    h. Forest type;
    i. Ownership.

2. *Geospatial data:*
    a. Coordinates;
    b. Stand map;
    c. Changes of size and borders of the sub-compartment.

3. *Assessment of ecosystem condition*
    a. Application of the methodology for ecosystem condition (Annex 6);
    b. Comparison of assessment based on the existing forest inventory data and assessment made in the field (all indicators available in the field have to be compared;
    c. Comparison of the empirical model results used for assessment for the indicators "deadwood" and "grass cover" and the ground though results;

4. *Assessment of ecosystem services*
    a. Application of the methodology for ecosystem services (Annex 7);
    b. Selection of parameters according to forest functionality:
    Forest designated for wood supply:

    – Provisional ES – all parameters for assessment available in the field have to be selected.
    – Regulation and Cultural ES – the parameters are selected randomly by the verifier
    Special and Protective forests:

    – Provisional ES – the parameters are selected randomly by the verifier.
    – Regulating and Cultural ES – all parameters for assessment available in the field have to be selected

B8 Freshwater ecosystems

The verification report has to detail:

Ecosystem type	
Lake/Reservoir (standing waters)	txt/symbol*
River/Canal (running waters)	txt/symbol*
Artificial/Heavily Modified Water Body	txt/symbol*
Site location/name	
Name/Description	txt
Purpose (natural/modified/artificial)	txt
Ownership (public, concession, leasing/rent)	txt
Geospatial data	
Coordinates	number
Area (unit? - sq.m, ha, sq.km)/Length (km)	number
Stand map/list No	number
Changes of size/borders	txt
Assessment of ecosystem condition	
Methodology for ES Condition applied (Annex 6)	Y/N**
Number of missed/left out indicators	number+txt?
Level of completeness (required/applied ind's)	number/%
Level of confirmation of the assessments	number/%
Assessment of ecosystem services	
Methodology for ES Condition applied (Annex 7)	Y/N**
Number of missed/left out indicators	number+txt?
Level of completeness (required/applied ind's)	number/%
Level of confirmation of the assessments	number/%

Conclusions: txt/scores?

* Symbols as per nomenclature, see Table 1

B9 Marine ecosystems

The verification report has to detail:

Ecosystem type		
1.1	A1. Littoral rock and other hard substrate	txt/symbol*
1.2	A2. Littoral sediment	txt/symbol*
1.3	A3. Infralittoral rock and other hard substrate	txt/symbol*
1.4	A4. Circalittoral rock and other hard substrate	txt/symbol*
1.5	A5. Sub-littoral sediment	txt/symbol*
1.6	A6. Deep sea-bed	txt/symbol*
1.7	B3. Rock, cliffs, ledges and shores, inl. Supralittoral	txt/symbol*
Site location/name		
2.1	Name/Description	txt
2.2	Grid number	txt

Geospatial data		
3.1	Coordinates	number
3.2	Depth	
3.3	Area (unit? - sq.m, ha, sq.km)/Length (km)	number
3.4	Stand map/list No	number
3.5	Changes of size/borders	txt
Assessment of ecosystem condition		
4.1	Methodology for ES Condition applied (Annex 6)	Y/N**
4.2	Number of missed/left out indicators	number+txt?
4.3	Level of completeness (required/applied ind's)	number/%
4.4	Level of confirmation of the assessments	number/%
Assessment of ecosystem services		
5.1	Methodology for ES Condition applied (Annex 7)	Y/N**
5.2	Number of missed/left out indicators	number+txt?
5.3	Level of completeness (required/applied ind's)	number/%
5.4	Level of confirmation of the assessments	number/%

Conclusions: txt/scores?

* Symbols as per nomenclature, see Table 1

3. *Verification approach*

Indicators for assessing of ecosystem condition and ecosystem services may be *in situ* verified in the same manner within all ecosystem subtypes, provided the timing of verification is considered (see below).

When planning the *in situ* verification, the verificator should take into account specifics of the three steps – preparation, fieldwork and evaluation. In particular:

1. During preparation, all types of ecosystems expected to be found in site are to be listed and the respective off-site data collected as per the respective methodologies (Part B). An overlay of the existing ecosystem evaluation maps and other data is to be prepared and examined for gaps or inconsistencies (i.e. overlaps, discrepancies between data sources). In case of newly acquired data, it has to be added to the overlay and examined together with the existing data. If new measurement methods and tools have become available and collection of optional indicators data is possible, the respective resources (human, technological and financial) should be planned prior to the field trip.
2. Some characteristics of ecosystems and services they provide are not directly visible in the field and/or required specific or additional techniques and tools such as GPS,

other specific tools - soil augers, template to determine the density and coverage, ships to access marine sites, as well as specialized equipment for underwater observation, biota sampling and in-situ physical-chemical parameters measurements of the marine environment. Examples:

   a. plant species richness are relatively easier and better determined in the field than animal species diversity, which depends of species characteristics, daily and seasonal activity of species, etc. and also of experts' knowledge and good identification skills;
   b. the soil properties are not shown and are not visible above the ground - it is necessary to see and check them with soil auger or spade in deep;
   c. area of land cover or other land features is better to evaluate using of GPS devise, etc.
   d. the evaluation of the condition of benthic marine ecosystems cannot be done from the surface and requires special equipment and techniques in order to be observed and sampled e.g. sampling devices and cameras deployed from ships, scuba diving, remotely operated vehicles.

3. *In situ* verification data should be processed by ecosystem type and if a correction is needed, the administrator of the respective dataset is to be notified. This may require the development of new procedures and data sharing protocols between institutions, and the respective costs and time is to be planned for spending during the evaluation phase. New data obtained during the in situ verification is to be compatible to the unified database structure defined in this Framework, and made available to the administrator of the data – the Executive Environment Agency.
4. Landscape level analysis should be performed for cross-checking and cross-validation of borderline cases when discrepancies were identified on any of the previous stages. The discrepancies are to be resolved by expert assessment basing on the reliability of data for each ecosystem in the landscape (also called patch), and the data availability for the patches in the landscape that is being assessed. If the discrepancy persists but all methodologies were applied correctly, a re-alignment of methodology weights and borderline values for some parameters and indicators may

be proposed to the owner of the National Methodological Framework – the Ministry of Environment and Water. Examples of discrepancies include:

a. Inconsistency between data about a single ecosystem, such as significant divergence between measured ground truth and remote sensing imagery

b. Inconsistency between data about interconnected ecosystems, i.e. a water body in very good condition when heavy pollution is emitted into the water body from the the adjacent croplands (nitrate pollution) and urban zones (plastics and microplastics).

3. Step-by-step guidance for performing the *in situ* verification

This section provides detailed guidance on the procedures to be followed during the *in situ* verification. It contains verification report template and checklist for landscape level alignment and the verification of single ecosystem patches within the landscape, with specific points to be considered. In order to avoid or minimize any mistakes during the *in situ* verification process, field data collection must be carried out by personnel experienced in every group of indicators, within teams of the necessary expertise and equipped with the proper equipment.

1. Mandatory points along which verification should be made

Random selection of polygons for *in situ* verification from all ecosystem subtypes is recommended. From the above made random selection to be selected such ecosystem subtypes that are close and easy to reach. To make an exhaustive *in situ* verification of the Methodology the following points should be carefully reflected on field:

- geometry of the polygons (ecosystems);
- area of the polygons (ecosystems);
- ecosystem subtype;
- ecosystem condition indicators;
- ecosystem services indicators.

It should be noted that some condition and ecosystem services indicators are not presented or could not be observed at any time in every ecosystem polygon.

2. *In situ* verification data

Time of collecting

With the purpose of obtaining the best results, it is preferably to execute the *in situ* verification in regard with the vegetation maximum of every ecosystem subtype. The *in situ* verification should be done as follows:

B1 Urban

For all urban ecosystem subtypes the whole year is possible for *in situ* verification, but preferably the period for monitoring is during the period of vegetation growth in order to assess the specifics of green land cover.

B2 Croplands

During the vegetation period (if the study included cereals - time monitoring must comply with the pre-harvesting or during the harvest periods, if there are permanent crops surveyed - the observation period must comply with the periods and phenological stages of any species).

Selecting the fieldwork period within the *in situ* verification plan should be done in advance to ensure it is conducted at the right time depending on the selected culture and selected parameter/ indicator type.

B3 Grasslands

- Dry grasslands – from middle June to middle July;
- Mesic grasslands – during July;
- Wet and seasonally wet grasslands – from middle July to middle August;
- Sub-alpine and alpine grasslands – during August;
- Inland salt meadows – during August

B4 Woodland and forest

For all forests ecosystems the *in situ* verification have to be done during the vegetation period – May to October

B5 Heathland and shrub

- Arctic, alpine and subalpine scrub – from July to August;
- Temperate and Mediterranean-mountain shrub – from May to July;
- Riverine and fen shrub – from May to June.

B6: Sparsely vegetated lands

- Coastal dunes and sandy shores: from middle June to middle July;
- Coastal shingle: July and August;
- Costal rock cliffs, ledges and shores, including the supralittoral: from middle June to middle July;
- Screes: July and August;
- Inland cliffs, rock pavements and outcrops: July and August;

B7 Wetlands

For all wetland subtypes optimum period for monitoring is from middle July to middle August

B8 Freshwater

For ecosystems of the standing waters (lakes, marshes, ponds, reservoirs) the optimal season for collecting the materials *in situ* is the period of summer stratification (July-September); for running waters (rivers, brooks, canals) the optimal is the period of low water levels (July-October, even November) but outside the summer diapause of invertebrates.

B9 Marine ecosystems

The selected methodologies for the evaluation of the ecosystem state require that measurements of water column parameters and sampling of zoo- and phytobenthic communities is carried out in the spring (April-June) and/or summer maritime seasons (July-September). Water column parameters usually require more than one sampling (usually once per month for three months).

Exhaustiveness of the data

When the results of *in situ* verification are used by other administrations or stakeholders to validate their data, the valuator from these other bodies should check:

- ✓ if the *in situ* verification has provided data for all obligatory indicators for ecosystem condition and services of target ecosystem type.
- ✓ are there clear explanation how the data has been collected and processed
- ✓ is the most actual, full and precise data for each indicator (parameter(s)) and whether it was used
- ✓ is there any new data available and whether it was used.

Source and scientific validity of the data

Data sources for necessary indicators are listed in Annex 5 of the Methodology for assessment and mapping of ecosystems. Some indicators for ecosystem condition and services lack of data and the relevant information is to be collected on field by the verification team. The verificator should check if a scientifically sound approach (references for example) has been used by the *in situ* verification team to describe the accuracy reached for each indicator.

Similarity to other data, incl. from reference ecosystems

Although a lot of indicators between different ecosystem types are common or at least similar, actually every ecosystem type has its individuality and transferring of data, with or without additional modeling; from one ecosystem type to another may result in undesirable mistakes. It is advisable *in situ* verification to be focused and processed ecosystem subtype specifically, no matter if field collected or modeled data is used.

Site selection (where applicable)

Site selection may not always be necessary during the *in situ* verification. In particular, when the purpose of the *in situ* validation exercise is to perform verification on a given site with identified and georeferenced discrepancies, the verification team has to visit a specific location and has no discretion over its itinerary.

There are, however, cases when the verification team may be free to decide, in part or in whole, on the site selection. This is the case, for example, when in Stage 1 of the *in situ* verification representative ecosystems are pre-selected on the basis of cameral data study, and are being verified through fieldwork. In such cases, the experts performing cameral work have the full discretion over the selection of sites to visit; the site verification team may also decide to make changes in the itinerary if the ground truth is vastly different from expectations – for example when the expected representative ecosystems are not in a good condition or have been replaced by other ecosystem types. Another example of non-fixed itinerary that requires site selection is the need to calibrate one or more mapping and assessment methodologies from Parts B1 – B9 of the Methodological framework in order to adjust the rating and weights in the methodology/methodologies.

Where site selection is necessary, the following is to be considered:

1. The data sampling techniques described in the Monitoring guide should be applicable to the selected site(s)

2. Selection of polygons for verification – ecosystem specific considerations
The *in situ* verification of ecosystems is based on random selection of polygons. All subtypes

should be considered. The following additional criteria should be applied:

a. representativeness - each ecosystem subtype should be presented taking into account any specific spatial, biogeographical, economic and other distribution regions.

b. representativeness of marine ecosystems polygons – polygons for verification should include quadrants from the different maritime regions – coastal zone, shelf, and open seas

c. polygon area – advanced rating should be applicable in three classes by area – small, medium and large; for forest ecosystems the polygon level I has to correspond to the level of forest sub-compartment according to forest inventory

d. IP index score for condition – advanced rating should be applicable in three classes by score – low, medium and high.

e. change frequency - polygons with frequent changes (such as polygons occupied with cereals) and such with relatively constant ground cover (permanent crops - orchards, vineyards) or with active urbanization should be presented when cropland ecosystems are verified *in situ*.

3. Selection of polygons for verification – other task specific considerations

Apart from considerations related to the ecosystems themselves, the objective of verification may also impose additional requirements on site selection. For example, if an analysis during the preparation phase reveals in which polygons mistakes most often occur, the number of such polygons may be increased within the number of sites to visit; therefore, the random selection may be limited to such polygons in order to ensure better error correction.

An analysis of the mistake types may also reveal a corrective course of action and inform the selection of sites for *in situ* verification. For example, if previously collected data was shown to be incorrect, the verification may concentrate on polygons where such data mistakes are known or suspected to occur.

If a bias was detected in the selection of polygons for the initial mapping and assessment, the type of bias may inform the selection of additional polygons that would allow for rectifying it. In this manner, the initial and *in situ* verification data may form a statistically correct dataset and allow for the re-assessment of the ecosystem condition and/or services.

During the preparation of the *in situ* verification, previous mistakes may be found also on the landscape or ecosystem level within a single polygon, especially if such polygon covers a big area with variations in the ecosystems present. In such cases, polygons with known or suspected mistakes may be selected for re-assessment.

In all cases when site selection is influenced by considerations that require a non-random site selection, the reasons should be detailed in the verification report with sufficient level of detail to inform on the analysis and proposed correction measures that led to the final itinerary for the *in situ* verification.

Selection of the indicators

The indicators to be observed during the *in situ* verification are to be selected across the landscape in such a manner that they would be measurable in adjacent patches within the landscape where fieldwork is to be performed. Such selection will allow for the same indicator to be cross-checked in some or all ecosystem types present in the landscape. For example, the same plant diversity indicators (such as Nr. protected species) may be selected for cropland, grassland and urban ecosystem patches in a given polygon or polygon group containing a landscape. For each ecosystem type, they would be measured following the respective methodology. Once such measurements are made, the rating for Nr. of protected species should be compared across the three ecosystem types and any inconsistencies should be explained (i.e. if the biggest number protected species is observed in the grassland, the reason may be an error, or the disturbances caused by agriculture and urban spatial planning or light/noise pollution may indeed be harmful to some of the protected species and crowd them out into the grassland patch. The findings of the experts performing the *in situ* observations and result evaluation should be entered in the verification report.

In terms of ecosystem service indicators, the discrepancies between ecosystem type may or may not be easy to observe and quantify. For example, in the same landscape containing cropland, grassland and urban ecosystem patches, it is logical to expect the cropland patch to provide the highest yield of biomass because this ecosystem was modified to optimize provisioning services. In terms of cultural services, however, the relative merits of intrinsic value attributed to rural tourism in the cropland area, cultural tourism in a city park containing a unique ancient church, and recreational/bird watching tourism to view rare grassland bird species is much harder to assess in a consistent manner.

The same selection principles apply to the indicators for ecosystem condition and indicators for ecosystem services, as follows:

- The indicators for ecosystem condition and ecosystem services could be **selected randomly**, regarding the availability on field and also availability of source data from national database

- At least three indicators for condition and three for services should be checked.
- For each indicator verified **data should be cross-checked** with the *in situ* verification team with regard to actual parameter value as well as the relevant scoring system applied.
- Explanation if more **than 20% discrepancy** has been established.
- **Validation using third party assessments** (i.e. available models, remote sensing methods, etc.): **In case of third party data** exists, it could also be used for validation.

Conflict resolution between different surveys, by a third party through on-the-spot visit and study/ analysis (where applicable)

In case discrepancies are found between two or more official datasets (national or regional), or disputes arise on the veracity of discrepant datasets, a third party (such as monitoring company) may be selected to establish the ground truth. In this case, such third party may apply other models and techniques or recommend them to the commissioning entities. Such applicable models and techniques may, for example, include:

- risk assessment;
- biodiversity, pollution and/or climatic modeling using the newly gained *in situ* verification data;
- identifying specific, georeferenced needs for further verification or/and data collection
- drafting and communicating mitigation or adaptation plans if biodiversity loss occurs;
- creating an adequate audit trail for follow-up of the verification with all concerned parties, and to inform further verification.

3. Verification report

The template presented in Table 1 below is prepared for reflecting the in-situ verification results in an unified manner. Filling in the report reflects all steps of performing *in situ* verification, as presented in the previous and this chapter. It creates the necessary audit trail for documenting the *in situ* verification on a given territory. Filling the complete template ensures that information is collected consistently across all patches in the landscape and across multiple landscapes. While filling it, the team has to aim at achieving a balance between creating a concise representation and reflecting all relevant facts and observations.

Table 1. ***In situ*** **verification report template**

Assignment name, ID: ***(i.e. project, contract name, or other similar identifier)***
Verification area(s) ID: (i.e. name of the locality, list of selected polygons with ID and coordinates) *Ecosystem types and subtypes present in the verification area* **Ecosystem types (select all applicable):** ☐**Cropland** ☐**Grassland** ☐**Heathland and shrubs** ☐**Marine** ☐**Rivers and lakes** ☐**Sparsely vegetated** ☐**Urban** ☐**Wetland** ☐**Woodland and forest** **Ecosystem subtypes present:** (For all ecosystem types listed above, list all subtypes presented in the verification area, as per methodologies from Parts B.1 – B.9 of the Methodological framework) **Part I Preparation phase** **Reasons for selecting the verification area (select all applicable):** ☐Representative types/subtypes ☐Representative landscape structure ☐Discrepancy between existing and/or new data (please describe sources, type of discrepancy, is there new or old data, etc.): ………………………. ☐Methodological verification needed (please specify which methodology, issues to be certified): ………………………. ☐Data verification needed (describe dataset) ………………………. ☐Model verification needed (please state model name, level of detail, modeling details, specify verification need) ………………………. ☐Other (please detail) ………………………. **Other relevant information** Available data – sources, ownership, level of detail, data formats, etc. Is there a map of the verification area from previous assessments, or was it prepared for this verification?

If evaluation methodology for one or more ecosystem types in the landscape is not applicable, describe why. If any new data or approaches were used, describe sources, format, ownership, representativeness, spatial properties, etc.; for approaches/models, describe parameters as relevant.

Assessment of the new data/approaches' influence on the preliminary assessment and expected verification score

Selection of indicators to be verified (at least 3 state and 3 service indicators, one each for provisioning, regulation, cultural services)

List indicators and describe reasons for their selection

Part II Fieldwork

Surveyor(s)

1. Name Date, time: Signature:
2. Name Date, time: Signature:
3. **…………**

Site description:

Site ID: ………………… Map/list/grid №: ……………….

Other official ID(s), such as forest or cadastral unit, for each polygon in the site: …….

(Use methodology specific nomenclatures, i.e. for freshwater: purpose – natural/modified/artificial. Where feasible, use legally mandated nomenclatures, i.e. for forests: forest unit, compartment and sub-compartment according to forest function, forest type)

Coordinates: …………….. Elevation: ………………………

Area: ………………… Settlement: ……………..

District: …………………….. Land cover, land use: ……………..

Water depth: ………………… Ownership: ………………….

Other specifics (i.e. protected area, specifics of land use, etc.): …………….

Findings on the ground – general description

Ecosystem types and subtypes on the ground (list as per methodologies, area of each subtype; species, habitats, other site specifics)

Land cover and land use in the vicinity:

North: ……..

East: …………

South: ……………

West: …………

Changes in patch size, discrepancies between polygon(s) description in preliminary maps/official data sources and on the ground: …………………….

Ecosystem conditions parameters verified on the ground:

(for each patch, use nomenclatures of ES types and subtypes and rating of ecosystem condition/services as per the applicable methodology, part B)

ES type	ES subtype	Name of parameter	Indications for availability on the ground (yes/no, short description)	Conformity to preliminary evaluation expectations (yes/no, describe any differences found)	New status assessment, number	New status assessment, description*

* Use the following nomenclature for describing the reasons for re-assessment:

Internal reasons - In

- **Not satisfied methodologies and guidelines –** In1
- **Unreliable data –** In2
- **Insufficient data –** In3
- **Incorrect GIS processing performed -** In4
- **Incorrect assessments –** In5

External reasons - Ex

- **Land use changes –** Ex1
- **Climate change –** Ex2
- **Anthropogenic pressure - Ex**3
- **Extreme natural events –** Ex4
- **Fires –** Ex5

- **Invasive species – new –** Ex6
- **Others – please, specify –** Ex7

Part III Evaluation of verification results

General description of verification results

Qualitative evaluation of the assessment for the patches in the verification area, interactions between patches and other landscapes outside the verification area, implementation results of policies in the area, etc. Include attachments, such as photographs, remote sensing data and new/corrected maps as needed.

Discrepancies found, discussion

Discuss all discrepancies found between the assessed situation on the ground and: projected condition/service assessment, official datasets, other preliminary information

Consider discrepancies within the landscape of the verification site, such as very big differences of assessment between patches, between assessment and pressures from adjacent areas, between the values of linked indicators, etc. For example, relate the expert assessment to available soil N/P ratio data and look for explanation if correlation is not as expected.

Recommendations

Based on findings, make specific recommendations, such as: recommended additional evaluations (specify methods and expected results); which authority is to be addressed in case of incorrect data found during the verification; methodological issues to be addressed, etc.

Analysis of common mistakes and recommendation for the best way to perform future verification.

A list for checking the sequence of the actions during verification

Main questions for verifiers are summarized in the following checklist which has to be filled for each verified territory:

Controls performed	Yes/No/Not applicable	Comment reference
I. Preparation stage		
Verification area correctly and completely identified in the report		
Data availability and quality described in the report		
New maps and other field documents prepared as needed		
The new data, approaches or methods used are described in the report and accounted for in creating working hypotheses, identifying areas of interest and planning the fieldwork (if applicable)		
Objectives of the verification set clearly		
Verification team has received all necessary facilities (evaluation forms, GPS, other equipment) for performing the verification		
II. Fieldwork		
Has the evaluation methodology been applied for all patches within the verification area's landscape? If no, state reasons in comment		
Are all ecosystem subtypes subjected to assessment and mapping procedure?		
Are all ecosystem subtypes correctly identified?		
Are all ***in site*** indicators for ecosystem condition assessment subjected to assessment and mapping procedure?		
Are the most actual, full and precise data used for each indicator (parameter(s)) and entered in the verification report?		
Are the best techniques used for indicator (parameter(s)) assessment and mapping?		
Verification report contains location of ecosystem types and subtypes - GPS coordinates		

Additional remote sensing of sites difficult to access, i.e. using drones for close range observation; data is attached to the report		
Is it necessary to correct the Ecosystem types and Ecosystem subtypes borders?		
Field data entered for each ecosystem type and subtype and each evaluated indicator per ecosystem type (for condition and services)		
New ecosystem developments are described in the verification report (if applicable)		
Verification of ecosystem condition and services assessment filled in the report and contains score projection form data as well as field score obtained during verification		
III. Evaluation of verification results		
Are the chosen indicators well justified in the term of assessment and mapping procedure goals?		
Are similar values of selected indicators (parameter(s)) obtained in validation procedure?		
Are the real values of target indicator (parameter (s)) correctly transformed to condition assessment scale and if there are any differences, are they well justified?		
Evaluation contains assessment of the exactness, suitability and effectiveness of the expenses during the process of data collection.		
Changes in ecosystem condition, type or other parameters, due to pressures, disasters, etc. are described in the report		
New dumpsites, signs of extreme events and fires are reflected in the report		
Newly found invasive alien species are reflected in the report GIS requirements of the Methodology are respected		
The report's conclusions and recommendations part details any major deviations and contains specific recommendations, including on whether a reassessment is needed		
Comments to the checks performed (references see above)		

4. Conclusions and next steps

The present document is work in progress, both because of the evolving nature of the methodologies that lay at its foundations, and due to the fact that landscape ecology is a rapidly developing branch of ecology and new findings in this area may lead to improving the *in situ* verification approach.

In addition, *in situ* verification may be used in many different contexts which will naturally require different scope and type of verification work. The proposed approach in this document is open to include specific checks and procedures as required by the tasks at hand.

It is expected that the verification approach and its specific procedures, including reports and checklist, will be improved over time to reflect the changes in the overall approach used in the Methodological framework. Areas of improvement are likely to include the ore specific use of *in situ* verification for ensuring dataset correctness and interoperability as ecosystem monitoring is put in place. Furthermore, the natural capital and ecosystem services' stock and flows components verification is likely to change once the monetary valuation is added to the Methodological framework.

All of these developments will complement the present Guide and allow it to become an even more versatile control instrument.

5. References

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