BIO_SOS

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COOPERATION

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Signatures

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1. Project Objectives

BIO_SOS (**Bio**diversity Multi-**S**ource M**O**nitoring **S**ystem: From Space To Species; www.biosos.eu) is a response to the Call for proposals FP7- SPACE-2010-1, addressing topic SPACE.2010.1.1-04 “Stimulating the development of GMES services in specific areas" with application to (B) BIODIVERSITY.

The main objective of BIO-SOS is the development of an operational ecological modelling system suitable for effective and timely multi-annual monitoring of NATURA 2000 sites and their surrounding areas particularly exposed to different and combined type of pressures. ***Its input data sources are satellite-based measurements and ancillary data collected in situ. Its seamless output products can support management decisions based on ecological status and trends according to National and EU obligations.*** *The proposed system, named EO Data for Habitat Monitoring (***EODHaM***), will be compliant with ongoing GEOSS, GMES and INSPIRE initiatives.*

Study areas in three Mediterranean and two Western Europe Countries are under way. To extrapolate from European test cases to a general use, additional areas are considered in two highly biodiverse, tropical countries (i.e., Brazil and India), where the Natura 2000 system does not exist, but the availability of advanced monitoring systems for supporting biodiversity conservation is particularly important. BIO_SOS is a pilot project which intends to develop:

1. Novel operational automatic high spatial resolution (HR), very high spatial resolution (VHR) and hyper-spectral resolution EO data pre-processing and understanding techniques for land cover (LC) map and LC change (LCC) map generation eligible for use in biodiversity monitoring.
2. A modeling framework to combine EO and *in-situ* data supporting automatic calculation of adequate indicators of biodiversity, assessment and prediction of the impacts of human-induced pressures on biodiversity using new and existing models that are able to evaluate and predict trends in biodiversity values.

The *objective of BIO-SOS has been elaborated in the following working objectives:*

1. The design of a service and system architecture, user driven by SLA;
2. The design and development of the full set of modules still required by the proposed EODHaM system. These include:
    a. A battery of context-sensitive modules for feature extraction and class-specific fuzzy rule-based classification required by the RS-IUS second stage, to generate an LC map from spaceborne imagery;
    b. Modelling modules for ecological knowledge base explicitation and scenario analysis at both: b.1) habitat level, for the automatic production of habitat maps from land cover maps and *in-situ* data; b.2) landscape level for indicators extraction (e.g. connectivity/fragmentation, status, pressure and threats);
    c. Stratified semantic nets for: c.1) automatic LCC detection useful for trend evaluation and *c.2)* warning signals for management authority.
3. Modules integration and system qualification;
4. Consolidation of already existing uses of satellite images devoted to biodiversity assessment and monitoring, developed within previous projects by liaison with ongoing projects (e.g. EBONE);
5. Identifying and promoting new utilisations of satellite imagery, linked to new and old modelling needs required for the adaptive conservation management of our NATURA 2000 sites by the direct involvement of Users in the partnership.

2. What policies the project relates to

After the adoption of the revised and updated Strategic Plan for Biodiversity (2011-2020), it is urgent that national and regional Biodiversity targets should be developed in the framework of the Aichi Biodiversity Targets [http://www.cbd.int/sp/]. The 20 Aichi Biodiversity targets are included within 5 Strategic goals, considered as measurable and realistic to be implemented in full for maximum effect.

In May of 2011, the European Union adopted a new strategy entitled “Our life insurance, our natural capital: an EU biodiversity strategy to 2020”; this new strategy is built around a limited number of measurable, ambitious, yet realistic sub-targets that focus on the main drivers of biodiversity loss in order to halt biodiversity loss in the EU, restore ecosystems where possible, and step up efforts to avert global biodiversity loss. The EU contribution to the implementation of the Aichi Targets is largely covered by the new strategy. In some respects, the EU is already ahead of the game when it comes to implementing the Aichi Targets. The six targets address different aspects of the challenge, each one accompanied by a corresponding set of actions. The first target is: full implementation of existing nature protection legislation. The EU has already a powerful legislation in place to protect its nature, but these laws need to be implemented. Efforts will also be made to improve and restore ecosystems and ecosystem services wherever possible, notably by greater recourse to “green infrastructure”. Other targets cover agriculture and forestry activities, and safeguarding and protecting EU fish stocks. A more comprehensive approach will also be taken to control invasive species, which are a growing cause of biodiversity loss in the EU. The final action area is increasing the EU contribution to action to avert global biodiversity loss. Reference is made to the high percentage (18 %) of the European territory covered by the ‘Natura 2000’ network of protected areas, although much still has to be done to ensure adequate protection of habitats and species.

In the European Union (EU) there is a legal obligation for EU Member States to report every 6 years on conservation status and trends of species and habitats of European importance, through the Habitats Directive (92/43/EEC) and the Birds Directive (79/409/EEC), following standardized assessments of conservation status and implementing monitoring schemes to show trends in status between the six-year reporting intervals.

However, the 2009 summary report on Article 17 of the Habitats Directive concludes that data on species and especially habitats are collected in different ways, are unavailable or are insufficient in their spatial coverage [ETC-Biodiversity, 2009].

The reporting obligations for the European Directives are therefore difficult to implement with uncoordinated data. This is particularly the case in Mediterranean countries, where the systematic surveillance of habitats and species of Community Interest (Annexes I, II, IV) needs to be undertaken by the Users, and where the monitoring scheme is meant not only to show trends in conservation status between the six-year reporting intervals, but also to provide the data that are currently still lacking to assess conservation status of certain habitats and species.

To conduct monitoring of species and habitats, internationally accepted indicators need to be used. In particular, 22 biodiversity indicators were suggested by the Convention of Biological Diversity (CBD) in 2006. These have been reduced in number following the July 2009 workshop of the CBD and the UNEP WCMC [CBD, 2009]. At the tenth meeting of the Conference of the Parties (COP-10) to the Convention on Biological Diversity (CBD) held in Nagoya, Japan, 18–29 October 2010, these have been confirmed (www.cbd.int/doc/meetings/cop/cop-10/information/cop-10-inf-12-rev1-en.pdf). The twenty headline Aichi biodiversity targets are organized under five strategic goals. Subsequently the Executive Secretary of the CBD invited the Group on Earth Observations Biodiversity Observation Network (GEO BON) to prepare an evaluation of existing observation capabilities relevant to the twenty ‘Aichi targets’. Whilst the intention is to support conservation of biodiversity, differences in national and regional policies and funding occur and this has led, in part, to the lack of:

a) Long-term baseline data;

b) Standardized, rapid and cost-effective monitoring techniques;
c) Methods for assessing the significance of measured changes and evaluating trends;
d) Modelling techniques for evaluating the combined impact that different drivers affecting soils and/or vegetation may have on biodiversity in time;
e) Adequate communication to disparate, often contrasting, audiences corresponding to different groups of stakeholders.

A further issue is the lack of a centralized management of a biodiversity data and land cover change monitoring system, even at the same regional-local level [Strand et al., 2009] as well as very high spatial resolution(VHR) data to support such a system.

A key challenge for BIO SOS that needs to be developed is a cost effective and timely monitoring of changes in the land cover within and along the borders of protected areas to judge the effectiveness in protecting and conserving the regions from human impacts.

BIO-SOS will strongly support the reporting for the CBD, the European Biodiversity Strategy and the Habitat Directive by making the information directly compatible and so will become central to the whole process of managing biodiversity in Europe. By integrating in-situ data with reliable global land observations based on remote sensing, BIO_SOS will allow to unravel certain patterns and processes that were formerly not well understood, information that can then be used to adjust or fine- tune existing conservation objectives, especially in the Mediterranean Areas.

Moreover, the BIO_SOS proposes an ecological modelling system that can offer an important tool to monitor changes in the distribution and status of ecosystems. In particular, effective and timely monitoring of changes in the land cover and habitat within and along the borders of protected areas is needed to judge the effectiveness in protecting and conserving the regions from human impacts such as poaching, hunting, logging, urbanization, agriculture, mining, and road construction.

BIO-SOS will link with existing initiatives. Important in this respect is the INSPIRE Directive (Infrastructure for Spatial Information in Europe) that became in force in May 2008 and is being developed by the European Commission in collaboration with Member States. It aims at making available relevant, harmonised and quality geographic information to support formulation, implementation, monitoring and evaluation of Community policies with a territorial dimension or impact.

3. BIO_SOS output products

The BIO_SOS project will develop a modular system, named *EO Data for Habitat Monitoring (**EODHaM**), to provide the following* outputs:

- *Land cover (LC)/Land Use maps (LU)*
- *Habitat maps: General Habitat Categories (GHCs) and Annex 1 Habitat maps*
- *Land Cover/Land Use and Habitat change maps*
- *Biodiversity Indicators*
- *Biodiversity Indicator trends for Biodiversity pressure scenarios*

The outputs will be obtained by integrating high resolution (HR) and very high resolution (VHR) EO-derived products with “on site” data through ecological modelling. “On site” data include ancillary data/information which, by definition, is any data/information which cannot be inferred from EO image domain. The “on site” data will also include “in-situ” campaigns, which will be focused on the collection of data (flora, vegetation, fauna, soil) for both biodiversity and pressures/threats indicators extraction, as well as for GHCs identification.

Habitat maps, which are at the base of indicators extraction, can be obtained by interpreting land cover maps of sufficient detail with ancillary data and other EO derived products and also by re-labelling and, where appropriate, merging similar land cover classes according to the 92/43 EEC Directive and translating these to General Habitat Categories (GHCs) based on life forms as defined in previous BioHab project [Bunce et al. 2008]

Habitat Maps and Biodiversity status and trend indicators automatically extracted from multi-scale EO data are not standard products. These new products are composed by several innovative components: methodological, technological, procedural. The modularity of the proposed EODHaM system allows already provision of GHC and Annex I maps from pre-existing Land Cover/LU maps, once the class name is expressed in FAO_LCCS taxonomy.

Examples of Land Cover and GHC maps obtained for the Dyfi catchment in Wales using HR Landsat Thematic Mapper (TM) data are shown in Appendix 1, which also includes the BIO_SOS service chain diagram.

4. Expected relevance to policies.

The proposed EODHaM system will examine immediately (locally) recognizable pressures and their impact on habitats. As these pressures build up over time, trends can be extracted from multiple-time land cover/land use changes thereby allowing identification of potential pressure growth. This can be compared with induced modification in habitat destruction or modification of habitat connectivity.

In this framework, EO data are very useful for biodiversity inventories and monitoring for adaptive management on a regional and local scale since they can provide/extract information similar to field samplings, reducing the need for extensive, expensive and time intensive field surveys, as well as decreasing the time interval between updates. These data thus provide the opportunity for quicker and more effective management responses to changes and threats [Nagendra, 2001; Turner et al., 2003]. Furthermore:

- Land cover maps and land cover changes can be extracted by low to very high resolution (VHR) EO data, with cost/effective techniques.
- VHR LC and LCC maps can help to identify immediately (locally) recognizable pressures and their impact on habitats.
- VHR LC and LCC maps can help to identify hotspots and focus field campaigns
- Habitat and Habitat change maps can provide information on biodiversity indicators and their trends

The products and systems generated by the BIO_SOS project will be made available for policy decision making and planning (e.g., scenario building) and, more specifically, evaluating the consequences of changes within Natura 2000 sites and their surroundings. The project outputs will be used for:

- Compliance checking, for designing new policies.
- Following up impact of existing policy.
- Defining a buffer area for each Natura 2000 site and preventing habitat fragmentation in its surrounding area . When regional authorities elaborate and approve a plan for a protected area, a buffer zone needs to be defined around the protected area where rules different from the ones to be adopted within the site have to be defined. They do not have any scientific evidence of the impact of such rules within the areas and generally use a buffer area (ranging from 100m. to 5 km.). When they enter in negotiation with local authorities and local people, they need to support their decision with scientific evidence of the impacts that such rules may have on the areas and the importance of the buffer zone .
- Policy makers need a multi-scale approach, such as the one proposed in BIO_SOS for site monitoring. Protected areas cannot be managed as isolated islands. The sites should be

considered as laboratories of environmental rules interacting with the whole of the regional system.

- The use of BIO_SOS results is not limited to the management of Natura 2000 sites but to the integration of the sustainable management of the regional Natura 2000 network within the ordinary planning system. In Mediterranean areas, this is still based on local planning rules, with these mainly based on the expansion of urban areas.
- Innovative planning activity at a local level must try to modifying a static municipal planning system into a dynamic planning system. That means that they need indicators to establish whether the goals associated with the approved municipal plan were met during the implementation phase. So they need indicators that can provide a dynamic monitoring of the different planning processes and an evaluation of the effectiveness of the policies implemented.
- Outside Europe as well, in mega-diverse countries such as Brazil and India, the operational flexibility that is required given the diversity of environments, habitats, species and threats is supported by the BIO-SOS project in that the approach is multi-resolution and multi-scale for mapping out the land cover. This approach of the EODHaM system would enable managers to understand the pressure issues at multiple scales. Managers need to control the existing problem of agricultural encroachment and mining leases as well as invasive species detection and spread, which may have impacts on the study site.

5. References

Aichi Biodiversity Targets, http://www.cbd.int/sp/targets/

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Nagendra H., 2001. Using remote sensing to assess biodiversity, Int. J. Of Remote Sensing 22 (12): 2377-2400.

Strategic Plan for Biodiversity 2011-2020, http://www.cbd.int/sp/

Turner W., Spector S., Gardiner N, Fladeland M., Sterling E. and Steininger M., 2003. Remote Sensing for biodiversity science and conservation, TRENDS in Ecology and Evolution 18: 306-314.

6. Appendix 1.

Examples of Land Cover and GHC maps obtained for the Dyfi catchment in Wales using HR Landsat Thematic Mapper (TM) data are shown in Figure 1.a and Figure 1.b . A similar map of GHCs and Annex 1 habitats translated from a pre-existing Land Cover map of the Le Cesine Natural 2000 study area (as part of an Interreg project) and overlain on a QuickBird image is also shown in Figures 2.a to 2.c. Eunis habitats are also shown in Figure 2.c.

The BIO_SOS service chain is indicated in Figure 3

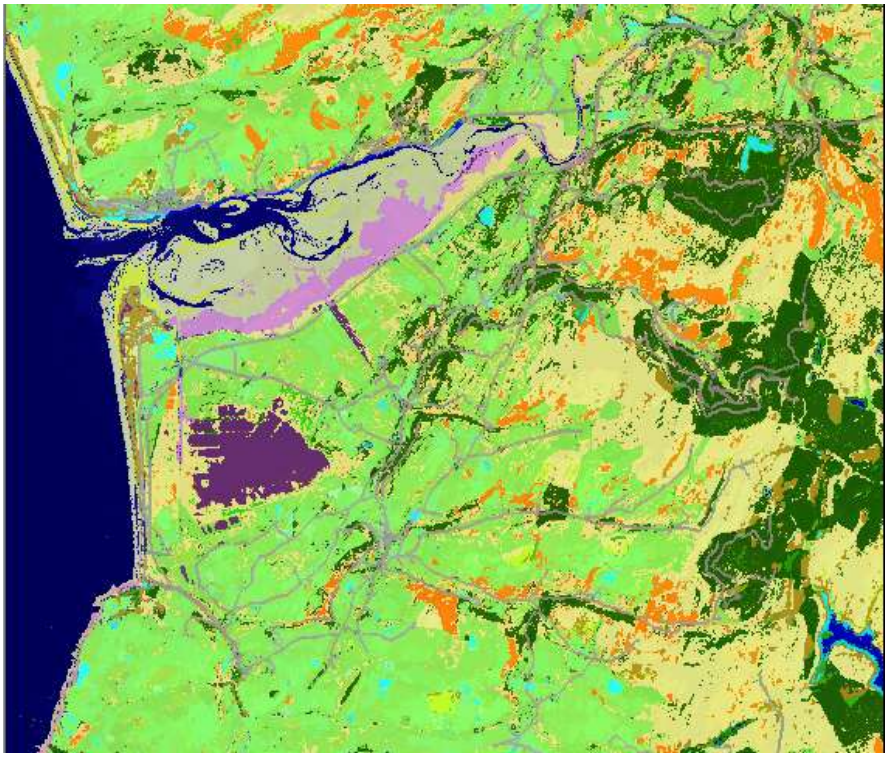

Figure 1.a LC map in LCCS taxonomy based on Landsat TM data from July, 2006.

LCCS		LCCS Code_Modifier	LC class description in LCCS taxonomy
A11		A3.A4.B1.B5.C1.D1.D9.B4	Permanently cropped area: Graminoid crops
A11		A1.B1.B5.C1.D1.D9.A8.B4-W7	Permanently cropped needleleaved trees
A11		A1.B1.B5.C1.D1.D9.A7.B4-W7	Permanently cropped broadleaved trees
A12		A1.A3.A10.B2.C2.D1.E2.B5	Broadleaved deciduous trees
A12		A1.A4.A11.B3.C2.D1.E2.B14	Broadleaved shrubland
A12		A1.A4.A11.B3.C2.D1.E1	Broadleaved evergreen shrubland (heath)
A12		A2.A6.A10.B4.C1.E5.B12.E6	Closed perennial medium tall grassland
A12		A2.A6.A11.B4.XX.E5.A12.B12.E6	Open medium tall grassland
A12		A2.A6.A10.B4.C2.E5.B13	Closed short grassland
A12		A2.A5.A10.B4.B12/B13	Closed medium tall forbs (3.0-0.8/0.8-0.3 m)
A24		A1.A4.A20.B3.C1.D1.E1.F2. F4.F7.G4.C4	Broadleaved evergreen shrubs flooded (bog)

A24	A2.A6.A12.B4.C1.E5.B11.C4.E6	Perennial closed tall grassland on permanently flooded land (persistent)
A24	A2.A6.A13.B4.C1.B13.C5	Open short grassland (saltmarsh)
B15	A3.A8	Paved road(s)
B15	A3.A10	Railway(s)
B15	A4.A13	Urban areas
B16	A3.A7	Bare rock
B16	A6.B6	Shifting Sands. Saturated Parabolic Dunes
B16	A6.A12	Stony loose and shifting sands
B16	A5.A13	Very stony and unconsolidated material(s)
B27	A1.B1.C2.D1.A5	Clear shallow artificial waterbody (standing)
B27	A1.B1.C1.A4	Turbid artificial waterbody(flowing)
B27	A1.B1.C1.A5	Deep/medium artificial waterbody (standing)
B28	A1.B1.C1.A5	Deep/medium natural waterbody (standing)
B28	A1.B3.A4.B6	Tidal area (flowing); surface aspect (sand)
B28	A1.A4	Natural waterbody, flowing (ocean/sea)

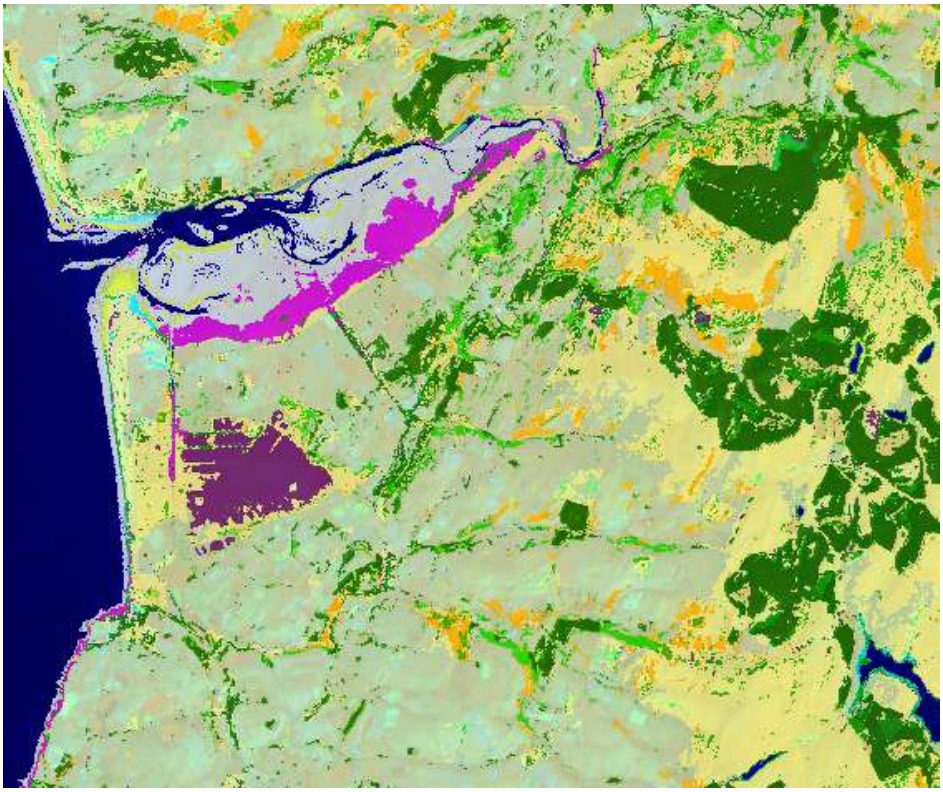

Figure 1.b. Classifications of GHCs based on the combinationa of Landsat TM data (July) and Landsat ETM+ data (April) LC maps in LCCS taxonomy.

LCCS		LCCS Code_Modifier	GHC Description
A11		A3.A4.B1.B5.C1.D1.D9.B4	CRO/GRA
A11		A1.B1.B5.C1.D1.D9.A8.B4	WOC/ TRE/TPH/FPH-CON(EVR/DEC)
A11		A1.B1.B5.C1.D1.D9.A7.B4	WOC(DEC)
A12		A1.A3.A10.B2.C2.D1.E2	TRE/TPH/FPH-DEC
A12		A1.A4.A11.B3.C2.D1.E2.B14	VEG/TRE/MPH/TPH
A12		A1.A4.A11.B3.C2.D1.E1	SCH/DEC/EVR
A12		A2.A6.A10.B4.C1.E5.B12.E6	CHE
A12		A2.A6.A11.B4.XX.E5.A12.B12.E6	CHE
A12		A2.A6.A10.B4.C2.E5.B13	CHE
A12		A2.A5.A10.B4.B12/B13	LHE
A24		A1.A4.A20.B3.C1.D1.E1.F2. F4.F7.G4.C4	TRS(DCH/SCH/LPH/MPH) HER(SHY/EHY/HEL/LEA) HER(EHY-FLO)
A24		A2.A6.A12.B4.C1.E5.B11.C4.E6	HEL(EHY)
A24		A2.A6.A13.B4.C1.B13.C5	HEL
B15		A3.A8	ART
B15		A3.A10	ART
B15		A4.A13	ART/NON
B16		A3.A7	ROC
B16		A6.B6	SAN
B16		A6.A12	STO
B16		A5.A13	STO/GRV
B27		A1.B1.C2.D1.A5	AQU
B27		A1.B1.C1.A4	AQU
B27		A1.B1.C1.A5	AQU
B28		A1.B1.C1.A5	AQU
B28		A1.B3.A4.B6	AQU(TID)
B28		A1.A4	AQU(SEA)

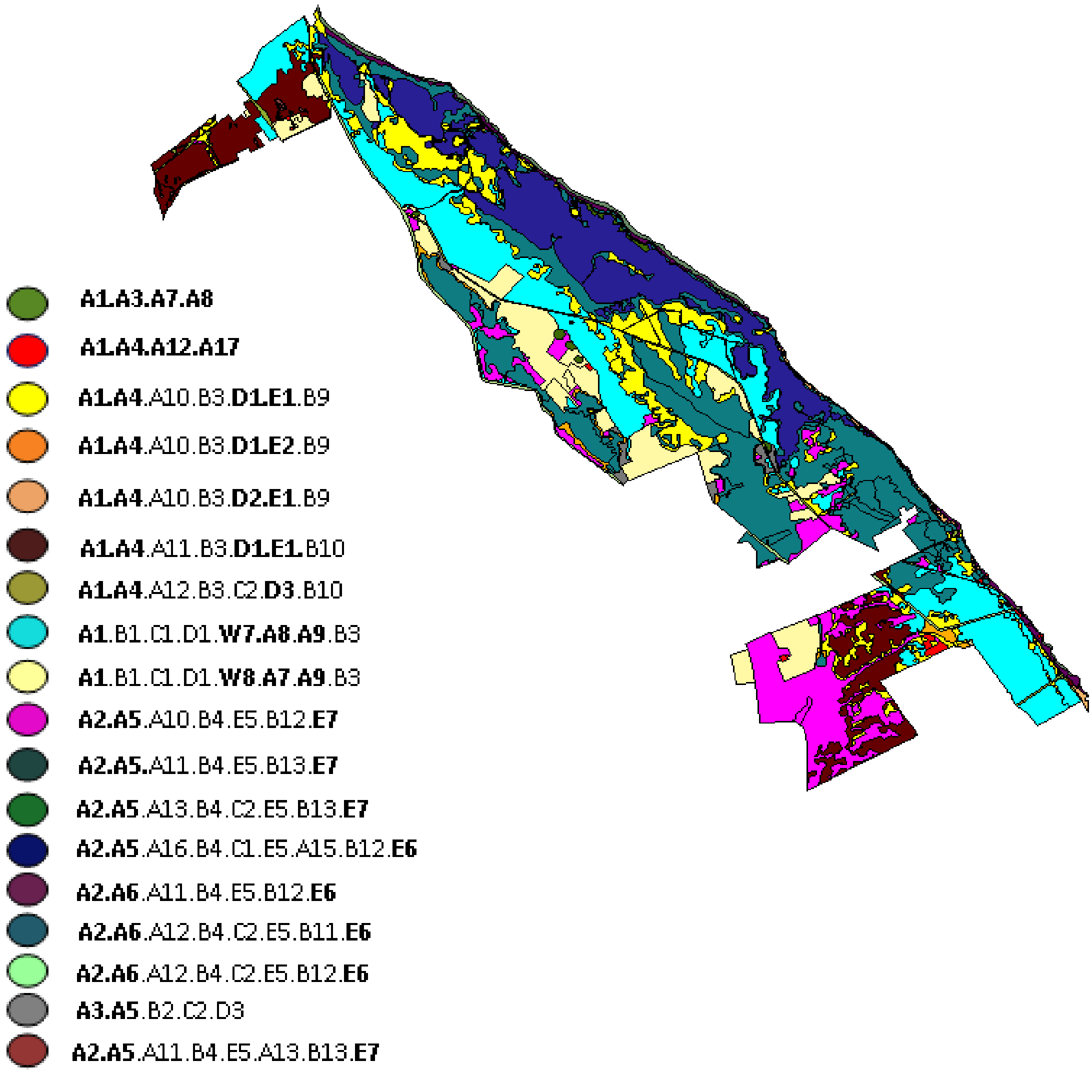

Figure 2.a A pre-existing Land Cover map, in CORINE taxonomy, was converted in LCCS taxonomy. The alphanumeric codes useful for GHC discrimination in LCCS to GHC mapping are evidenced in bold.

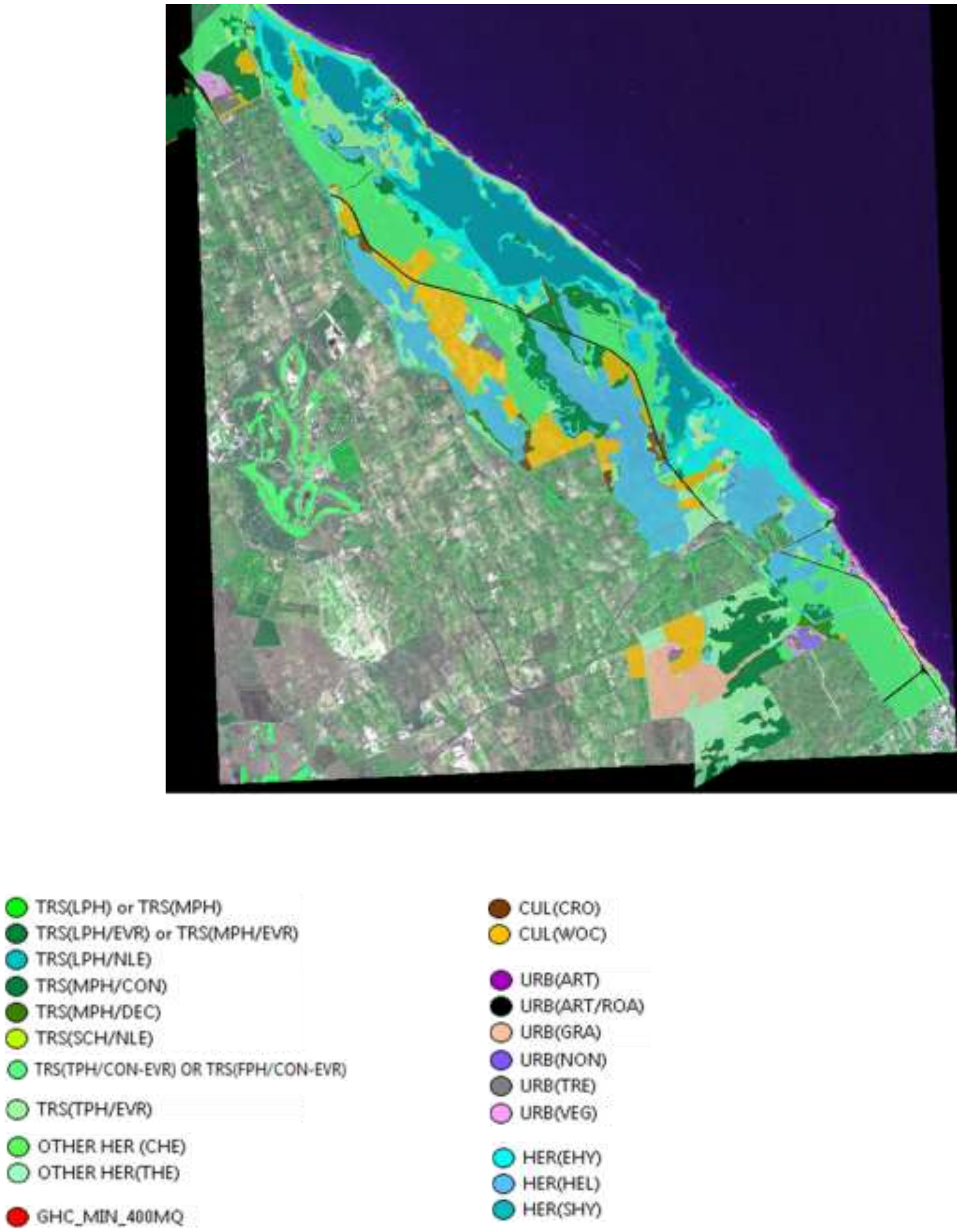

Figure 2.b. Final output GHC map obtained from the pre-existing LC/LU map in LCCS taxonomy. The GHC map is overlaid to the EO July QuickBird calibrated MS image, which was used to extract both texture information and *fRatioWaterIndex,* the latter as SIAM^{TM} output.

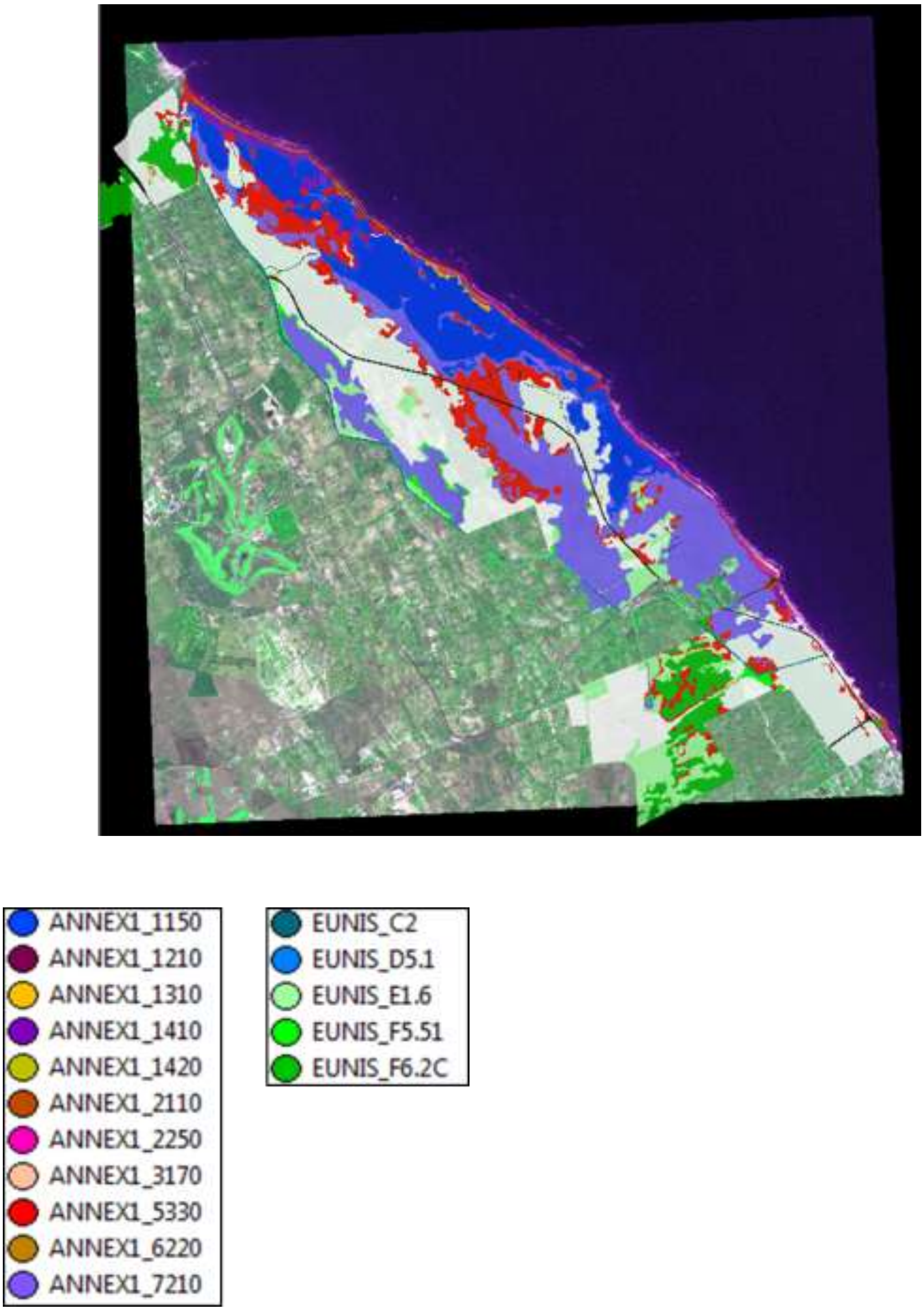

Figure 2.c. Final Habitat map including both Annex 1 and EUNIS habitats. GHC super categories were used to mask for URB, SPV, CUL GHC habitat areas (in white).

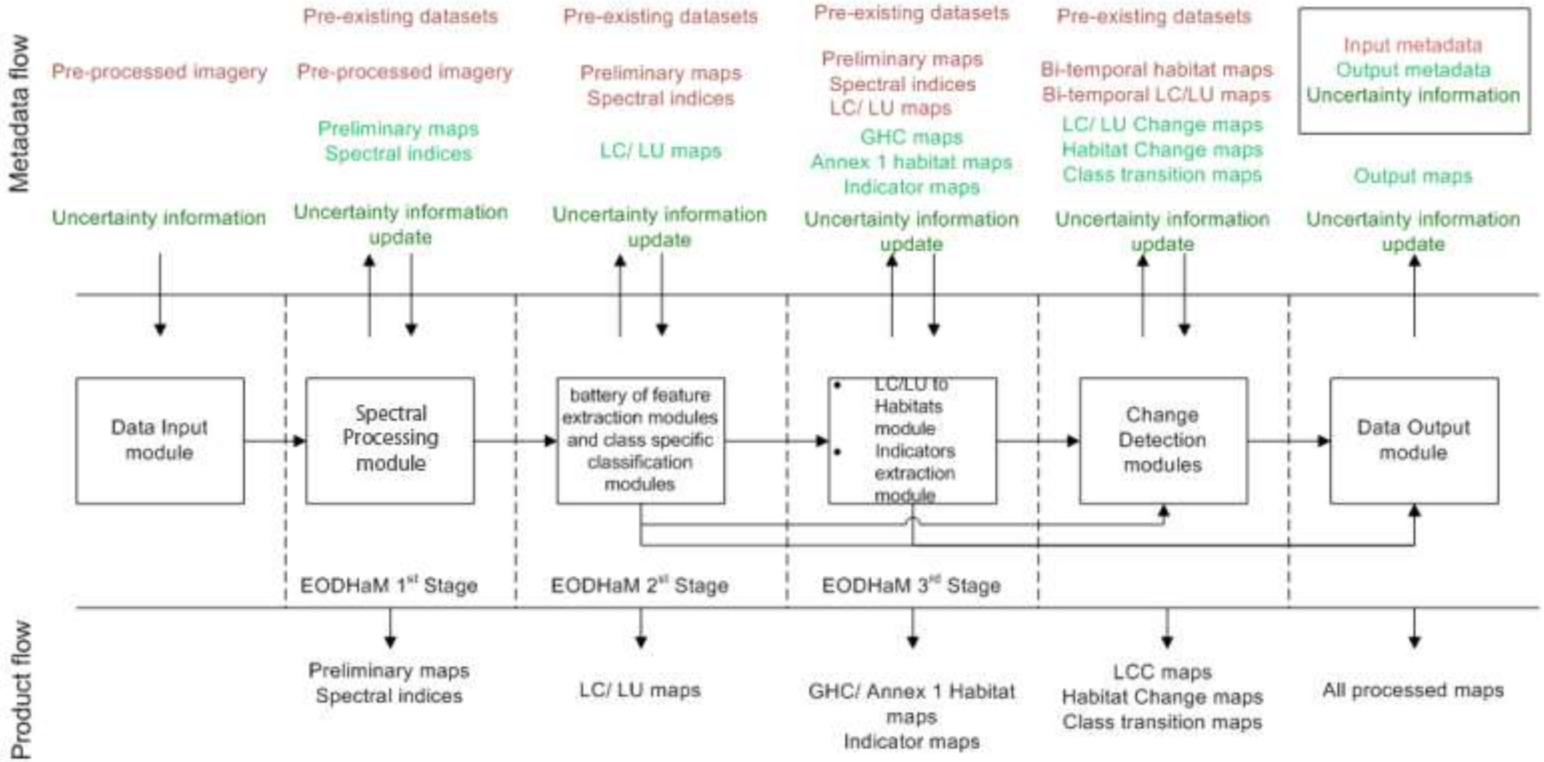

Figure 3. EODHaM's generic service chain (taken from D3.1)