

**Technical specifications
for the CORINE Land Cover (CLC)
pilot projects implemented in the
Eastern Partnership countries
(2017-2019)**

Prepared by the EEA and the
European Topic Centre on Urban, Land and Soil Systems (ETC/ULS)
as part of the ENI SEIS II East Project
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Implementation of the Shared Environmental Information System principles and practices in the Eastern Partnership Countries

1. Context

1.1 Overall context

The **ENI SEIS II East** project builds on the regional EU-funded project ‘Towards a Shared Environmental Information System (SEIS) in the European Neighbourhood’ (ENPI-SEIS¹ executed in the period December 2009 - March 2015), implemented by the European Environment Agency (EEA). The project supported the environmental and statistical authorities in the six Eastern Partnership countries (Armenia, Azerbaijan, Belarus, Georgia, Republic of Moldova and Ukraine) in gradually developing and extending their national environmental information systems in line with the SEIS principles in terms of institutional cooperation, content and infrastructure.

The second phase of SEIS cooperation through the ENI SEIS II East project² (February 2016 – January 2020) aims to help the countries find solutions to better respond to regional/international commitments related to environmental reporting; to improve their capacities to manage and use environmental statistics, data and information in support to decision-making; and prepare regular State of the Environment Reports (SoER) and indicator-based assessments. At national level, the project is coordinated by two National Focal Points (NFP), representing the Ministry of Environment and the National Bureau of Statistics respectively.

Activity 2.3 of the ENI SEIS II East Description of Action³ “**Pilots on extending CORINE Land Cover (CLC) methodology to areas of the partner countries**” is a step to facilitate the access to, and use of, some spatial data required for SEIS implementation at national level. This activity also allows direct links to related initiatives and programmes at the European level; namely the on-going work to produce the 2018 update of the CLC layers in the EEA39 countries, and services provided through the Copernicus Programme⁴, a joint European Union and European Space Agency initiative for a long term sustainable capacity building in Earth Observation from space.

The Copernicus Land Monitoring Service⁵ provides geographical information on land cover, land use, land cover-characteristics, and changes thereof via time-series. The three main components of the Land Monitoring Service are:

- A Global Component: Biophysical parameters to give a picture of the state of vegetation, the energy budget, water cycle, etc.
- A Pan-European Component: Data sets of land cover – land use and on land cover characteristics such as: artificial surfaces, forest areas, agricultural areas, wetlands, and water bodies.
- A Local Component: Focus on so called “hotspot areas”. These are areas requiring a specific focus, such as: urban areas (Urban Atlas), river networks (Riparian Zones) or Natura 2000 sites.

¹ <http://enpi-seis.pbe.eea.europa.eu/>

² <https://eni-seis.eionet.europa.eu/east>

³ Description of Action available at <https://eni-seis.eionet.europa.eu/east/governance/project-documents>

⁴ <http://www.copernicus.eu/>

⁵ <http://land.copernicus.eu/>



The Pan-European and the Local Components of Copernicus are managed by the EEA. The CLC (2012 version and future updates) is now embedded in the Copernicus programme⁶. All of the land monitoring products can be consulted (viewing), used (services) and downloaded (FTP) via: <http://land.copernicus.eu>

1.2 Methods of implementation

The ENI SEIS II East project is coordinated at the EEA by the Partnerships and Networks programme (PAN), group on European neighbourhood policy activities (PAN2).

Expert support and technical assistance for the implementation of pilot projects extending the CORINE Land Cover (CLC) methodology in the six Eastern Partnership countries will be provided by the **European Topic Centre on Urban, Land and Soil Systems (ETC/ULS)**⁷ under joint contracting with the Copernicus programme.

Under the ENI SEIS II East project, a variety of models may be considered to mobilise experts and provide technical assistance to the countries. These included for instance:

- Expert visits to the partner countries;
- Assistance to provide guidance on nationally-driven and/or regional processes (e.g. provision of guidelines, desk studies, and review of documents);
- Study tours and working visits to the EEA, Eionet⁸-related entity and/or in relevant national entity in Eionet countries;
- Through dedicated hands-on training.

2. CORINE Land Cover (CLC)

CORINE Land Cover (CLC) was specified to standardize data collection on land in Europe to support environmental policy development. The reference year of first CLC inventory was 1990 (CLC1990), and the first update created in 2000. Later, the update cycle has become 6 years. The number of participating countries has increased over time – currently includes 33 European Environment Agency (EEA) member countries and six cooperating countries with a total area of over 5.8 Mkm². Ortho-corrected medium / high spatial resolution satellite images provide the geometrical and thematic basis for mapping. In-situ data (topographic maps, ortho-photos and ground survey data) are essential ancillary information. The project is implemented by national teams under the management and quality control (QC) of EEA. The basic technical parameters of CLC have not changed since the beginning, therefore the results of the different inventories are comparable.

⁶ <http://land.copernicus.eu/pan-european/corine-land-cover>

⁷ <https://www.eea.europa.eu/data-and-maps/data-providers-and-partners/european-topic-centre-on-urban>

⁸ Eionet stands for European environment information and observation network



Basic technical parameters of CORINE Land Cover

Minimum mapping unit (MMU) for mapping status layer= 25 hectares; smaller objects should be generalised to “most similar” neighbour

Minimum mapping unit for change mapping: 5 hectares; smaller changes should be generalised

Minimum mapping width (MMW) = 100 meters; narrower objects should be generalised

Geometric (localisation) accuracy: better than 100 m

Thematic accuracy: better than 85% (checked by independent validation)

Nomenclature: hierarchically structured. 44 classes on level-3 (see Annex). Level-1 classes:

- **Artificial surfaces**
- **Agriculture areas**
- **Forests and seminatural areas**
- **Wetlands**
- **Water**

Mapping methodology: computer assisted photointerpretation of satellite imagery (CAPI) by using reference data (topographic maps, orthophoto, field checking)

Result: vector database with polygon topology

The layer of **CORINE Land Cover Changes (CLC-Change)** is produced since the second CLC inventory (CLC2000). CLC-Change is derived from satellite imagery by direct mapping of changes taken place between two consecutive inventories, based on image-to-image comparison. Change mapping applies a 5 ha MMU to pick up more details in CLC-Change layer than in CLC status layer. Integration of national CLC and CLC-Change data includes some harmonization along national borders. Two European validation studies have shown that the achieved thematic accuracy is above the specified minimum (85 %). Primary CLC and CLC-Change data are in vector format with polygon topology. Derived products in raster format are also available. The seamless European CLC and CLC-Change time series data (CLC1990, CLC2000, CLC2006, CLC2012 and related CLC-Change data are distributed in the standard European Coordinate Reference System defined by the European Terrestrial Reference System 1989 (ETRS89) datum and Lambert Azimuthal Equal Area (LAEA) projection (EPSG: 3035). Results of the CLC inventories can be downloaded from Copernicus Land site free of charge for all users.

CLC data can contribute to a wide range of studies with European coverage, e.g.: ecosystem mapping, modelling the impacts of climate change, landscape fragmentation by roads, abandonment of farm land and major structural changes in agriculture, urban sprawl, water management.

3. CLC pilot projects in the Eastern Partnership countries

The main components of the pilot projects are:

- To set-up and train a National Team (NT) in each of the six Eastern Partnership countries to implement a CORINE Land Cover (CLC) pilot study in their own country.
- Select / agree on the area of the pilot project (e.g. about a 50 km x 50 km area in the capital region).



- Produce the **CLC status layer** for the pilot area by means of computer assisted photo-interpretation of satellite images and reference data.
- Produce the **CLC-Change map** for the pilot area (map CLC changes taken place in e.g. an 5-10-year period) by means of computer assisted photointerpretation of satellite images and reference data.
- Technical assistance (training, software support, quality control and remote support) will be provided by the European Topic Centre of Urban, Land and Soil Systems (ETC-ULS).

The workflow is presented on Figure 1. More detailed specification is provided in section 4 below.



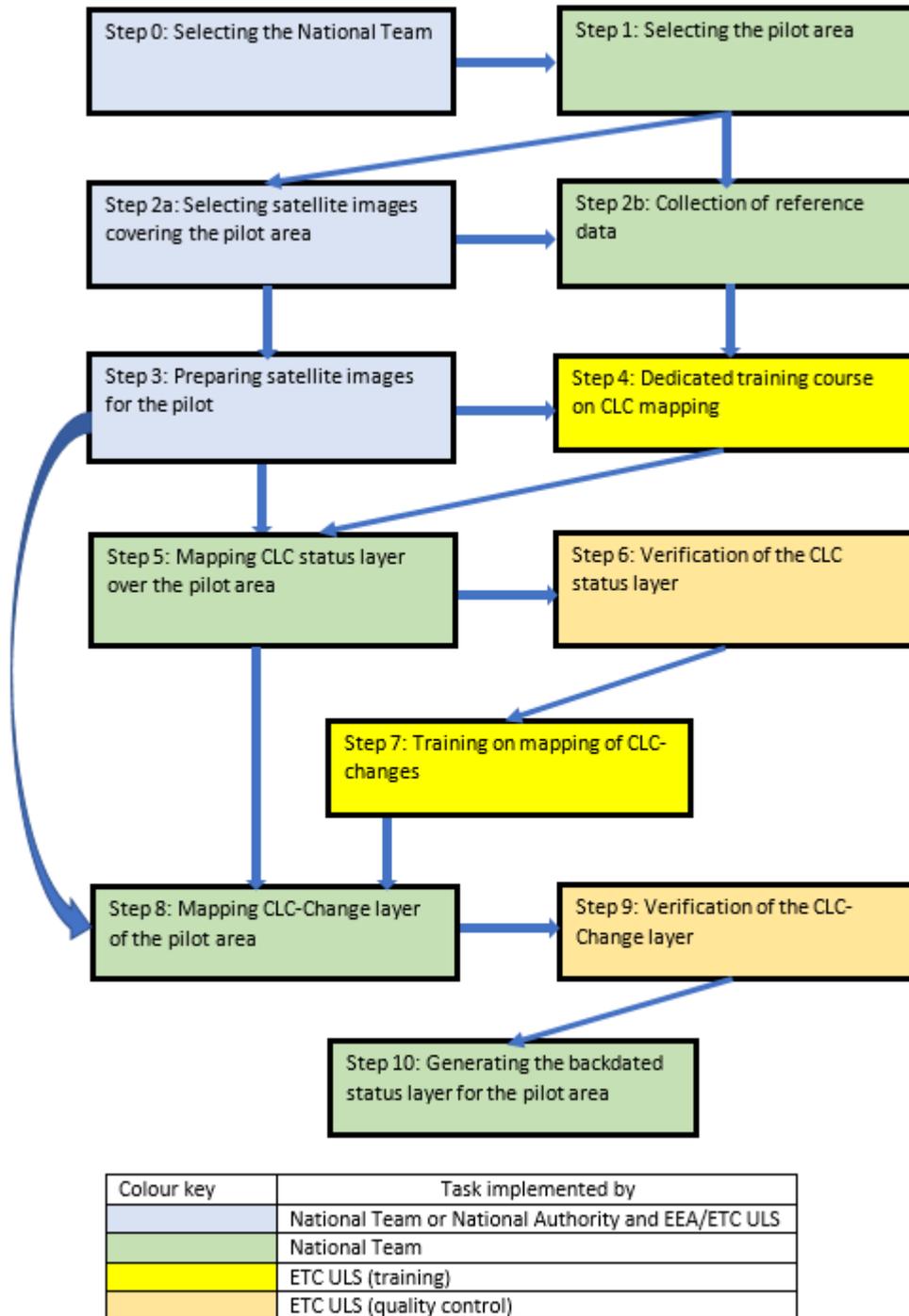


Figure 1: Workflow of CLC pilot projects



4. Technical specifications of the CLC pilots

Steps of implementation are discussed below together with the estimated work load for the National Team.

STEP 0: SELECTING THE NATIONAL TEAM

National Team (NT) responsible for technical implementation of CLC pilot should be established in each country. NT could include 4-5 experts with clear responsibilities inside the team:

- photointerpreters (computer assisted photointerpretation, good knowledge of the pilot area)
- GIS experts (working with vector and raster data, experience in datasets with topological structure; practice in using GIS software, e.g. ArcGIS)
- project manager (good understanding of the work to be done, day-to-day management of the work, communication with EEA/ETC-ULS, keeping deadlines, writing technical report).

To communicate smoothly with the ETC-ULS team all team members should possess a basic skill in English.

Estimated work load on behalf of National Team (discussions with National Authority e.g. Ministry of Environment, National Environment Agency): 2 man-days

STEP 1: SELECTING THE PILOT AREA

This is a mandatory step to be able to collect satellite images for photointerpretation and organise the dedicated CLC training course. The pilot areas(s) selected by the NT will be endorsed by EEA.

Recommendation regarding the location and size of the pilot area:

- It should be large enough, diverse and change-prone (regarding land cover) to support development of basic skills in mapping CLC and CLC-Changes layers.
- Being a pilot exercise, it should not be too large (or include several locations) not to overload the NT and complicate the overall implementation.
- Recommended size of the pilot corresponds to a single topographic map sheet at scale 1:100.000 (about 50 km x 50 km = 2500 km²). An administrative or geographic unit with arbitrary shape with similar size is also a good choice.
- An area including the capital (or part of the capital) is recommended, where
 - good quality reference data are usually available
 - field checking is easy
 - changes are expected (at the scale of CLC).

NT should communicate the location of the agreed pilot area to ETC-ULS to start selecting Sentinel-2 satellite images (see Step 2a) covering the area.

Estimated work load for the National Team: 2 man-days



STEP 2A: SELECTING SATELLITE IMAGES COVERING THE PILOT AREA

To produce the **CLC status layer** images acquired by the European Sentinel-2 satellite is proposed. The same satellite data are used by the 39 EEA member states (EEA39) in the CLC2018 project. Sentinel-2 is an ideal support for land cover mapping in Europe, because:

- good spatial resolution (10 / 20-meter pixel size in VIS, NIR and SWIR⁹ spectral bands)
- good spectral / radiometric resolution (includes SWIR spectral band)
- high repeat frequency (possibility to acquire several images of the same location)
- available for free of charge

ETC-ULS will check the availability of Sentinel-2 imagery over the selected pilot area. In an optimal case two images will be selected (acquired in 2016-2017 in different seasons, e.g. summer and spring). NT and ETC-ULS will discuss and agree, which two of the available images will be selected and used for the photointerpretation.

To produce the **CLC-changes layer** another satellite imagery is needed, taken 5-6 years¹⁰ (comparable with the update frequency of European CLC), before the recent Sentinel-2 images. NT is requested to check the available medium resolution satellite images in their archive:

- Landsat TM/ETM, IRS LISS III or SPOT 4/5 (two, multi-seasonal acquisitions, if available). Existence of SWIR band is mandatory, to be able to compare with Sentinel-2.
- Acquisition date: 2011-2012 (to be conform with CLC2012) or before

If no proper data are available, ETC-ULS will check the international archives (like in case of Sentinel-2). Step 3 includes more about pre-processing of these images.

Estimated work load on behalf of National Team: 3 man-days

STEP 2B: COLLECTION OF REFERENCE DATA

The purpose of reference (in-situ or ancillary) data is to provide support to photointerpretation of satellite images. The most important type of reference data is:

- Topographic maps. The most suitable scale, matching the details of CLC is: 1:50.000 or 1:25.000. Digital topographic maps are preferred over traditional paper maps, because digital maps can be overlaid and analysed easily with satellite imagery. The date of survey should be known.
- Orthophotos are important support materials to help photointerpretation in cases when interpretation of satellite imagery is questionable. In optimal case separate orthophoto coverages are available for interpreting the CLC status layer as well as the CLC change layer.
- Other thematic reference data (e.g. forest map, map of built-up areas, some objects of the topographic map) could be used directly to take over to the CLC map. This could be beneficial to keep consistency with relevant national datasets and might be faster than producing that CLC class with photointerpretation. However, the class taken over needs rigorous revision (to be conform with the basic technical parameters of CLC (see above)).

⁹ VIS = visible part of the spectrum; NIR = near infrared; SWIR= short wave infrared

¹⁰5-6 years' time difference is the minimum recommended, longer time difference is also suitable



Also, its polygons must be compared with satellite images used in photo-interpretation (satellite image content has a preference over existing thematic data). If NT is willing to use this opportunity (to derive some of the CLC classes from an existing digital map) it should be investigated before the training (Step 3) in order to check with ETC-ULS if this strategy is realistic in the time frame of the pilot.

Estimated work load for the National Team: 3 - 6 man-days

STEP 3: PREPARING SATELLITE IMAGES FOR THE PILOT

Satellite images need some customisation (image pre-processing) to use them by the NT in the CLC pilot study.

- **Recent images (Sentinel-2):** these are orthorectified by the European Space Agency (ESA) and released in UTM projection (Level 1C product).
- ETC-ULS will download the selected Sentinel-2 images and pre-process them (exactly like for EEA39 within the CLC2018 project):
 - produce a so called **visual product** optimised for visual interpretation (10-meter pixel size, sharpened by synthetic panchromatic band);
 - transform the geometry (of the Level 1C product) to national projection (the same as the projection of available reference data).
- The cartographic projection of the country (EPSG number or prj file) should be made available for ETC-ULS to prepare the selected Sentinel-2 images for photointerpretation.

Pre-processed Sentinel-2 imagery is should be available to organise the CLC training course (Step 4).

- NT will check if the **second set of satellite images** (acquired around 2011-2012 or earlier) used in mapping the CLC-Change layer (see Step 2a) located in their archive
 - has been orthorectified, and
 - has proper cartographic projectionlike the Sentinel-2 images used to derive the CLC status layer.
- If not, an image-to-Sentinel-2 registration with ortho-rectification need to be carry out by the NT. Sub-pixel accuracy (compared to the Sentinel-2 image) is needed.
- ETC-ULS will check the quality of the registration accuracy of these images.

Estimated work load for the National Team: 1-5 man-days (depends on if orthorectification is to be done or not)

STEP 4: DEDICATED TRAINING COURSE ON CLC MAPPING

A 2-3-day long CLC training course (conducted by ETC-ULS in English at the premises of NT) will include the following components:

- Detailed discussion of the **CLC nomenclature** (with emphasis on the geography of the country and the pilot area)
- Demonstration of the use of the **InterChange** photointerpretation software to produce the status layer (mainly photointerpretation but also feasibility of taking over objects from existing database will be checked, if requested in advance (see Step 2b)); at the end of the course participants should be able to start working with InterChange.



- Short field trip (optional) - to be discussed and agreed with the ENI SEIS II East coordinating team.

Prerequisites of the training:

- setting up the NT completed (see Step 0)
- at least one Sentinel-2 image for the pilot is available (see Step 2a)
- reference data covering the pilot area are available (see Step 2b)
- main documents (nomenclature guidelines, InterChange manual) are available and studied in advance.

Some logistics issues:

- Location of the training should be decided (lecture room with projector, enough room for participants and trainers).
- Merging training courses of national teams is encouraged. Countries with similar geography might be trained together:
 - East-European region (Belarus, Moldova, Ukraine or any of these two), and
 - Caucasus region (Azerbaijan, Armenia and Georgia or any of these two).

Estimated work load for the National Team:

- preparations: 3 man-days
- participation: 4-5 experts for 3 days = 12 – 15 man-days

STEP 5: MAPPING CLC STATUS LAYER OVER THE PILOT AREA

The CLC status layer should be prepared by NT covering the pilot area, based on interpretation of Sentinel-2 imagery and reference data. The InterChange software (a CAPI tool developed by ETC-ULS to support CLC mapping in Europe) is proposed to be used. ETC-ULS provides remote support to NT. Controlled integration of digital reference data is allowed to replace partly the photointerpretation (see Step 2b) if discussed and agreed during the training course (Step 4).

Estimated work load for the national team: 20-30 man-days depending on the complexity of the area and level of experience of photointerpreter.

STEP 6: VERIFICATION OF THE CLC STATUS LAYER

ETC-ULS experts will check (verify) the CLC status layer in the premises of the NT (using the same Sentinel-2 images and having access to the same reference data as NT). Remarks will be written into a GIS file which the NT will be able to recall in their project file to support implementing corrections. Findings of verification will be discussed with NT and a verification report will be provided. In case the results are not acceptable (e.g. serious systematic mistakes were found) the quality of the CLC map will need to be improved before continuing with change mapping (see Step 8).

Estimated work load for the National Team (providing working environment for ETC-ULS experts and discussing the results with NT): 3-5 man-days



STEP 7: TRAINING ON MAPPING OF CLC-CHANGES

A training course on mapping of CLC-Changes (conducted by ETC-ULS in English at the premises of NT, back-to back with Step 6) will include the following elements:

- Theory and practice of mapping CLC-Changes
- Demonstration of the use of the InterChange photointerpretation software to produce the CLC-Change layer by photointerpretation; at the end of the course participants should be able to start mapping CLC-Changes.

The following conditions should be fulfilled by the time of the training:

- satellite imagery taken in the past is available and co-registered to Sentinel-2 images (see Step 3)
- reference data covering the pilot area in two periods are available (see Step 2b)
- main documents (CLC2018 Technical Guide, Manual of CLC change mapping, InterChange manual) are available and studied by participants.

Estimated work load for the National Team:

- preparations: 2 man-days
- participation: 4-5 experts for 3 days = 12 – 15 man-days

STEP 8: MAPPING CLC-CHANGE LAYER OVER THE PILOT AREA

Having produced an acceptable CLC status layer by NT (as documented by ETC-ULS, see Step 6), preparing the CLC-Changes layer covering the pilot area can be started. Mapping CLC-Changes will be based on recent Sentinel-2 imagery, a second set of satellite images (taken in the past) and reference data. The InterChange software (a CAPI tool developed by ETC-ULS to support CLC mapping in Europe) is proposed to be used. Mistakes of the status layer discovered during mapping CLC-Changes should be corrected (a revised status layer is produced). ETC-ULS provides remote support to NT.

Estimated work load for the National Team: 10-15 man-days, depending on the complexity of the area (amount and type of changes) and level of experience of photointerpreter.

STEP 9: VERIFICATION OF THE CLC-CHANGE LAYER

ETC-ULS experts will check (verify) the layer of CLC-changes in the premises of the NT, using the same set of satellite images and having access to the same reference data as NT. Remarks will be written into a GIS file which the NT will be able to recall in their project file to support implementing corrections. Findings of verification will be discussed with NT and a verification report will be provided. In case the results are not acceptable (e.g. serious systematic misclassifications and/or omissions were found) the quality of the CLC-changes map will need to be improved before generating the 2nd (backdated) status layer in Step 10. The additional verification will be implemented remotely (meaning that data should be sent to ETC-ULS).

Estimated work load for the National Team (providing working environment for ETC-ULS experts and discussing the results with NT): 3-5 man-days



STEP 10: GENERATING THE BACKDATED STATUS LAYER FOR THE PILOT AREA

The backdated status layer (referring to 2011-2012 or earlier year) will be generated in GIS by subtracting CLC-Changes from the recent status layer. An ArcGIS programme will be provided by ETC-ULS.

Estimated work load for the National Team (providing working environment for ETC-ULS experts and discussing the results with NT): 2 man-days

5. Summary of total work load

No.	Activity	Estimated work load for the National team (man days)
STEP 0	SELECTING THE NATIONAL TEAM	2
STEP 1	SELECTING THE PILOT AREA	2
STEP 2A	SELECTING SATELLITE IMAGES COVERING THE PILOT AREA	3
STEP 2B	COLLECTION OF REFERENCE DATA	3 - 6
STEP 3	PREPARING SATELLITE IMAGES FOR THE PILOT	1 – 5
STEP 4	DEDICATED TRAINING COURSE ON CLC MAPPING	15 - 18
STEP 5	MAPPING CLC STATUS LAYER OVER THE PILOT AREA	20 – 30
STEP 6	VERIFICATION OF THE CLC STATUS LAYER	3 – 5
STEP 7	TRAINING ON MAPPING OF CLC-CHANGES	14 – 17
STEP 8	MAPPING CLC-CHANGE LAYER OF THE PILOT AREA	10 – 15
STEP 9	VERIFICATION OF THE CLC-CHANGE LAYER	3 - 5
STEP 10	GENERATING THE BACKDATED STATUS LAYER FOR THE PILOT AREA	2
	SUM OF ESTIMATED MAN-DAYS:	78 - 110



6. Deliverables

The following deliverables are expected covering the pilot area(s). All spatial data should be presented in ESRI ArcInfo shapefile format with polygon topology.

- Recent CLC dataset (with CLC code as attribute)
- CLC-Change dataset (with past CLC code and recent CLC code as separate attributes)
- CLC dataset for the past (with CLC code as attribute)
- Metadata* (note: this should be discussed further - this is part of deliverables for the EEA39 countries as part of the CLC2018 exercise, but may be simplified to "working-unit" metadata)
- A short technical report produced with the help of the ETC/ULS



Annex 1: CORINE Land Cover nomenclature

LEVEL 1	LEVEL 2	LEVEL 3
1. ARTIFICIAL SURFACES	1.1. Urban fabric	1.1.1. Continuous urban fabric 1.1.2. Discontinuous urban fabric
	1.2. Industrial, commercial and transport units	1.2.1. Industrial or commercial units 1.2.2. Road and rail networks and associated land 1.2.3. Port areas 1.2.4. Airports
	1.3. Mine, dump and construction sites	1.3.1. Mineral extraction sites 1.3.2. Dump sites 1.3.3. Construction sites
	1.4. Artificial, non-agricultural vegetated areas	1.4.1. Green urban areas 1.4.2. Sport and leisure facilities
2. AGRICULTURAL AREAS	2.1. Arable land	2.1.1. Non-irrigated arable land 2.1.2. Permanently irrigated land 2.1.3. Rice fields
	2.2. Permanent crops	2.2.1. Vineyards 2.2.2. Fruit trees and berry plantations 2.2.3. Olive groves
	2.3. Pastures	2.3.1. Pastures
	2.4. Heterogeneous agricultural areas	2.4.1. Annual crops associated with permanent crops 2.4.2. Complex cultivation patterns 2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation 2.4.4. Agro-forestry areas
3. FOREST AND SEMI-NATURAL AREAS	3.1. Forests	3.1.1. Broad-leaved forest 3.1.2. Coniferous forest 3.1.3. Mixed forest
	3.2. Scrub and/or herbaceous associations	3.2.1. Natural grassland 3.2.2. Moors and heathland 3.2.3. Sclerophyllous vegetation 3.2.4. Transitional woodland-scrub
	3.3. Open spaces with little or no vegetation	3.3.1. Beaches, dunes, sands 3.3.2. Bare rocks 3.3.3. Sparsely vegetated areas 3.3.4. Burnt areas 3.3.5. Glaciers and perpetual snow
4. WETLANDS	4.1. Inland wetlands	4.1.1. Inland marshes 4.1.2. Peat bogs
	4.2. Marine wetlands	4.2.1. Salt marshes 4.2.2. Salines 4.2.3. Intertidal flats
5. WATER BODIES	5.1. Inland waters	5.1.1. Water courses 5.1.2. Water bodies
	5.2. Marine waters	5.2.1. Coastal lagoons 5.2.2. Estuaries 5.2.3. Sea and ocean



Annex 2: Summary of technical documents to be provided

Subject / Title
CLC2018 Technical guidelines
Enhanced CORINE Land Cover nomenclature
Manual of CORINE Land Cover changes
ArcGIS programme to generate the 2nd (back-dated) status layer.
CLC2018 Support Package (software and user guide)

Note: These documents/resources are/will be uploaded in a password protected space in the Eionet Forum for the EEA/Eionet member of cooperating countries. They will be provided **directly** to ENI East experts as part of the implementation, in order to avoid the procedure to request/receive logins and passwords).

