# FINAL REPORT on

# implementation of the pilot project extending the CORINE Land Cover (CLC) methodology in Republic of Azerbaijan

*GEODESY AND CARTOGRAPHY LLC*

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## 1. Background

The European Commission started the CORINE Land Cover (CLC) project in the mid 80s in order to help harmonisation of the European environmental policy. The 1st inventory (realised between 1985 and 1995) is referred to as CLC1990. The 2nd land cover inventory – coordinated by the European Environment Agency – refers to 2000 ± 1 year, and is called CLC2000. Land cover changes between the two inventories were also mapped (CLC-Changes$_{1990\text{-}2000}$).The5th CLC inventory (CLC2018) has been completed in 2018.

Cooperation between the EEA and the six Eastern Partnership countries (**Armenia, Azerbaijan, Belarus, Georgia, Republic of Moldova and Ukraine**) is established through the EU-funded regional project "Implementation of the Shared Environmental Information System principles and practices in the Eastern Partnership countries" (the ENI SEIS II East Project). The period of implementation of the ENI SEIS II East project is 53 months, 1 February 2016 - 30June 2020.

"**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 recently completed 2018 update of the CLC layers in the EEA39 countries, and services provided through the Copernicus Programme (activities are to be implemented in close dialogue and cooperation with the Copernicus activities led by the EEA).

Coordination of country-level activities is ensured by the Ministry of Ecology and Natural Resources, while technical implementation was provided by "Geodesy and Cartography" Ltd. in the case of Azerbaijan. Pilot area of 2500 km² covering Absheron peninsula including Baku and its outskirts was chosen by mutual agreement between Ministry of Ecology and Natural Resources and European Technical Team Experts. Main goal was mapping the CLC status layer for 2018 and CLC changes on the pilot area for the 2000-2018 period.


Experts from the **ETC/ULS** conducted two CLC trainings in Baku on the 26-28 August 2019 and 26-27 November 2019. A training report from the ETC/ULS was shared with Azerbaijan colleagues shortly after, in which there were proposals on the overall project responsibilities among members of the Azerbaijan CLC team. The coordinating unit for the ETC/ULS is the **Environment Agency Austria**.

The CLC2018 database was produced by “Geodesy and Cartography”LLC. “Geodesy and Cartography” LLC was also responsible for the production of the database of changes between 2000 and 2018.

The present document is the final report accompanying the delivery of the CLC2018, CLC2000 and CLC-Change$_{2000\text{-}2018}$ databases.CLC2018 and CLC2000 have 25 ha resolution, while CLC Change database includes changes larger than 5 ha in land cover between the years 2000 and 2018. The databases are produced according to CLC nomenclature. Azerbaijan is expected to fulfil the following tasks:

- Producing land cover database for 2018
- Mapping CLC changes between 2000 and 2018
- Cretate land cover database for 2000.

The project has been financed by the Environment Agency Austria (representing ETC-ULS) under contract with Geodesy and Cartography LLC dated 16 September 2019. Project code: 10689-11.

## 2. Databases used in the project

The CLC2018 project is based primarily on the IMAGE2018 high-resolution (HR) satellite image coverage. The IMAGE2018 HR satellite image coverage, digital topographic maps and other ancillary data were used to map land cover changes between 2000 and 2018. An overview of the databases used in the project is shown in **Table 1.**

**Table 1** Overview of databases used in the project

| Name | Data type | Resolution | Reference year | Data source |
|---|---|---|---|---|
| **Aero ortho-photo** | Ortho-photo | 50cm | 2000 | Aerophoto |
| **Aero ortho-photo** | Ortho-photo | 15cm | 2008 | Aerophoto |
| **Aero ortho-photo** | Ortho-photo | 30 cm | 2016 | Aerophoto |
| **Pleiades** | Pleiades satellite images | 0.5 m | 2015 | Satellite image |
| **Spot6** | Azersky satellite images | 1.5 m | 2015-2018 | Satellite image |
| **Topographic maps** | Scanned topographic maps scale 1:50.000 | ~2.5m | 2000 | The State Enterprise on Aerogeodesy |
| **Maps** | CAD, GIS based topographic maps on 1:2.000 scale | digital data | 2000-2018 | The State Enterprise on Aerogeodesy |

### 2.1. IMAGE2018

CLC2018 project aims to provide a double (usually summer and spring or autumn) satellite data coverage for the area to be mapped in order to support high-quality photo-interpretation. Sentinel-2 images (10 m pixel size) selected by ETC-ULS and SPOT-6 Images (available locally) are used as a basis for mapping. Thus, an excellent multi-temporal coverage was available.

**Table 2** Satellite images in the IMAGE2018 database covering pilot area

| **1st coverage** | | **2nd coverage** | |
|---|---|---|---|
| **Sensor** | **Acquisition date (d/m/y)** | **Sensor** | **Acquisition date (d/m/y)** |
| Azersky Spot-6 | 19/03/2018 | Azersky Spot-6 | 22/09/2017 |
| Azersky Spot-6 | 09/04/2017 | Sentinel-2 | 08/09/2018 |
| Azersky Spot-6 | 29/08/2018 | Sentinel-2 | 13/09/2017 |
| Sentinel-2 | 12/03/2019 | | |
| Sentinel-2 | 05/07/2019 | | |
| Sentinel-2 | 22/03/2018 | | |

The first coverage was to cover the summer months, which are optimal to map vegetation. The second coverage, with the aim to provide additional information for mapping was taken in spring or autumn.

**Figure 1 Azersky Spot-6 (19/03/2018)**


**Figure 2 Azersky Spot-6(29/08/2018)**

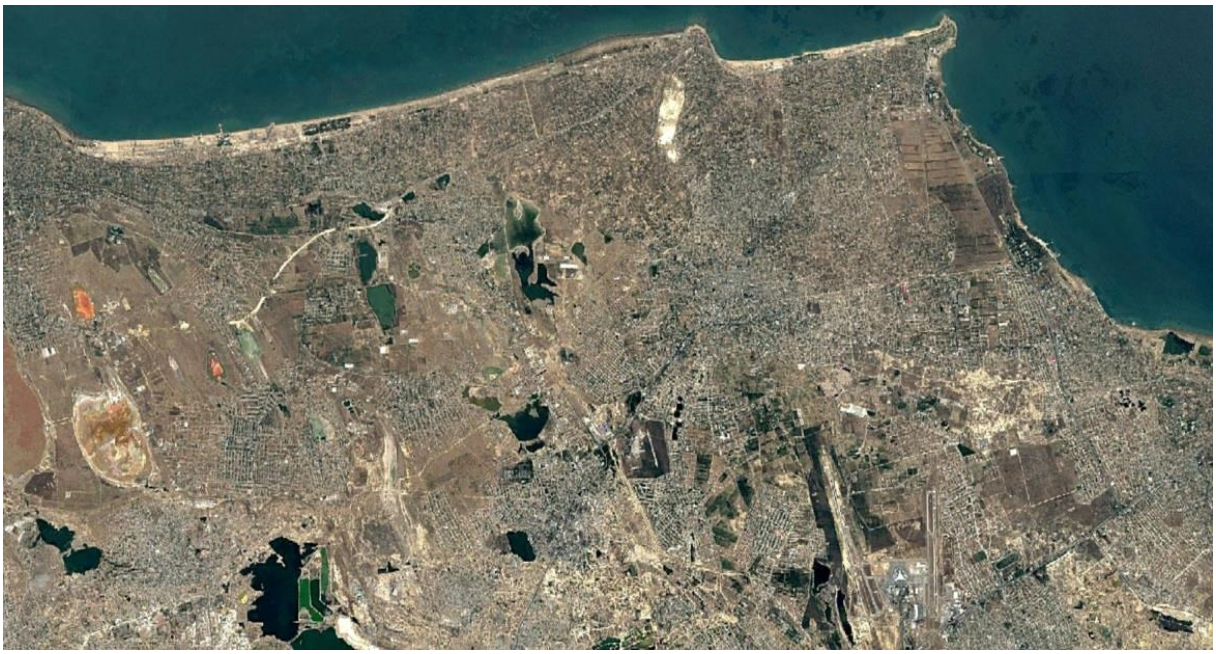


**Figure 3 Azersky Spot-6(20/12/2016)**

## 2.2. IMAGE 2000

Image 2000 (Landsat TM) date were selected by ETC-ULS. Like in the case of IMAGE2018 here also an excellent multi-temporal coverage was available, including early spring, spring, summer and early autumn data (Table 3).

**Table 3** Satellite images in the IMAGE2000 database covering pilot area

| Sensor | Acquisition date (d/m/y) |
|---|---|
| Landsat TM | 16/03/2000 |
| Landsat TM | 13/05/2000 |
| Landsat TM | 21/05/2000 |
| Landsat TM | 06/06/2000 |
| Landsat TM | 30/06/2000 |
| Landsat TM | 09/07/2000 |

## 2.3. Reference (in-situ) data

**Topographic maps**
1:50.000 and 1:100.000-scale scanned topographic maps (produced on the basis of Ortho-photo 2000 and 2008 databases) have been provided by the Geodesy and Cartography LLC.

**Ortho-photos**
Ortho-photos for CLC 2018 based on aerial photoghraphytaken in year 2008 by the Geodesy and Cartography LLC, with pixel size 0.11 m.

## 3. Organization of the work at national level

### 3.1. Milestones

Milestones of the project are presented in Table 4.

**Table 4** Milestones of the CLC2018- Azerbaijan

| No | Date (d/m/y) | Description |
|---|---|---|
| 1 | 16/09/2019 | Contract signed |
| 2 | 17/09/2019 | Technical part started |
| 3 | 28/10/2019 | Interpretation submitted for verification by ETC-ULS |
| 4 | 10/02/2019 | |
| 5 | 28/02/2020 | Delivery of final results |

### 3.2. Participating experts

Table 5 shows the experts participating in CLC2018-Azerbaijan.

**Table 5** Experts participating in CLC2018-Azerbaijan

| No. | Task | Subtask | Position / expertise | Responsible(s) |
|---|---|---|---|---|
| **1** | **Preparation of databases for the photo-interpretation** | | | |
| 1.1 | | Preparation of input raster and vector databases and sub-setting into two working units | Image processing / GIS experts | Ms. S. Jafarova<br>Ms. V. Kerimli<br>Ms. K. Osmanova |
| **2** | **Mapping land cover changes** | | | |
| 2.1 | | Interpretation of changes | Photo-interpreters | Ms. V. Kerimli<br>Ms. K. Osmanova |
| 2.2 | | Database integration (CLC2018, CLC Changes) | Photo-interpreters | Ms. V. Kerimli<br>Ms. K. Osmanova |
| **3** | **Quality control / quality assurance** | | | |
| 3.1 | | QA/QC of photo-interpretation sheets (thematic) | Leading photo-interpreters | Ms. V. Kerimli<br>Ms. K. Osmanova |
| 3.2 | | QC/QA of databases (technical) | Project Manager Technical Control | Mr. A. Baghirov<br>Ms. S. Jafarova<br>Mr. N. Bayramov |
| | | Final QC/QA | Project manager | Mr. A. Baghirov |
| **4** | **Management** | | | |
| 4.1 | | National project management | Project manager | Mr. A. Baghirov |

### 3.3. Processing methodology, software

#### 3.3.1. Methodology of mapping

The methodology consists of the following main steps:

- Preparing databases to support mapping CLC2018;
- Mapping CLC2018
- Delineation of land cover changes between 2000 and 2018, using satellite images and ancillary data in two working units;
- Producing seamless CLC2018 $_{revised}$ and CLC-Changes$_{2000-2018}$ databases;
- Producing the CLC2000database from revised CLC2018 and CLC-Changes$_{2000-2018}$ databases by means of semiautomatic generalisation;
- Final quality control of deliverables: CLC-Changes, CLC2018 and CLC2000.

#### 3.3.2. Photointerpretation

InterChange 4.0 tool (provided by ETC-ULS) was used for mapping of CLC2018 and CLC-Change$_{2000-2018}$.

According to the European methodology, all changes larger than 5 ha have been delineated, not depending on their location. Efforts focused on mapping “real” changes concerning attributes and area.

CLC2018 was the first CLC project in Azerbaijan when photointerpreters had systematic access to digital orthophotos. This resulted many corrections in CLC2018, especially regarding transformation of pastures (231) and natural grassland (321) to discountinious urban fabric (112).

#### 3.3.3. Field checking

The field trip (organised at the time of the 1st training course) was organised to visit and discuss some of the locations that were problematic to classify during the interpretation exercise. It was also a good opportunity for the trainers to get acquainted a bit with the pilot area.

Main discussion points and stops of the field trip were:

- discontinuous urban area in Baku (112);
- road crossing (122) and industrial areas (121) in the suburb of Baku;
- steppe vegetation outside Baku: dominantly natural grassland (321) and sparsely vegetated areas (333);
- cemetery without vegetation (111);
- coastal area: dominantly discontinuous urban area (112) if the residence is permanent; sport and recreation (142) if the main purpose is recreation) and construction area (usually mixed with 112);
- sand dunes (331) if natural vegetation cover is max. 10% otherwise sparsely vegetated area (333);
- temporary water body (512) without water coverage in summer; the salt deposit was collected by a non-industrial way, which is not considered as mineral extraction;
- permanent agriculture plantation: vineyards (221);
- bare eruption area of a mud-volcano (332).

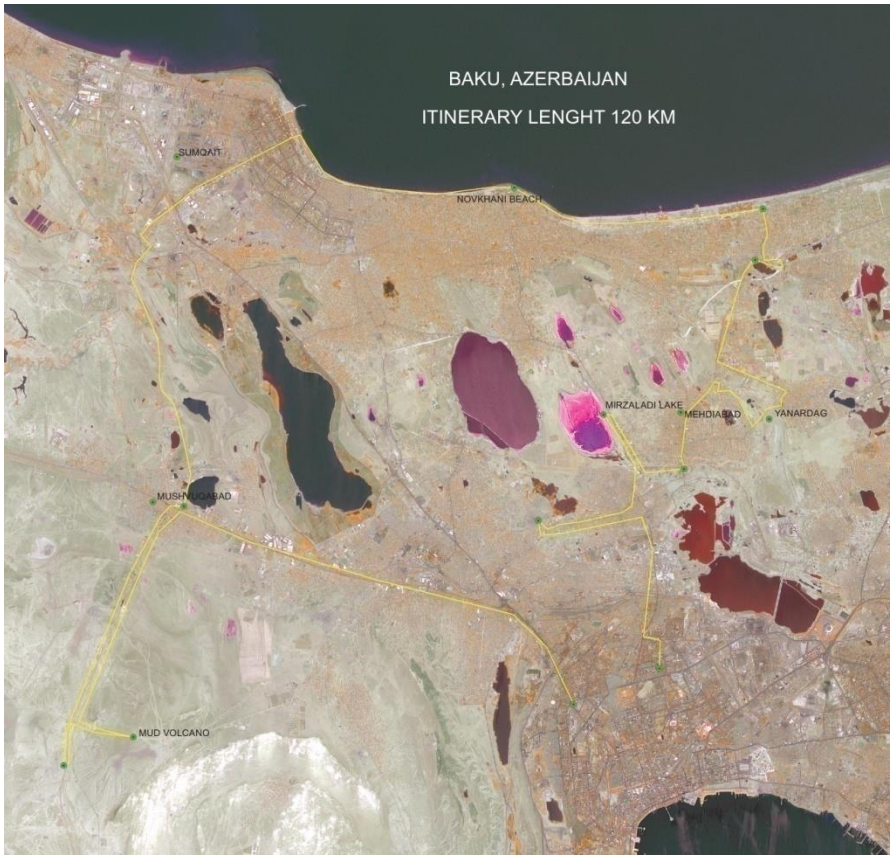



**Figure 4**
**Itinerary of the field trip around Baku**

Field check also been carried out by local surveyors in differen parts of pilot area.

### 3.4. Internal quality control, results

The revised CLC2018and CLC-Change (2000-2018) databases were 100% quality controlled by the leading photo-interpreters.

### 3.5. External quality control, results

The CLC Technical Team of the ETC-ULS verified the results of the photo-interpretation, first the CLC2018 database, then the revised CLC2018 and CLC-Change databases.Errors found were corrected by the Azeri Team and revised databases were produced.

### 3.6. Main difficulties

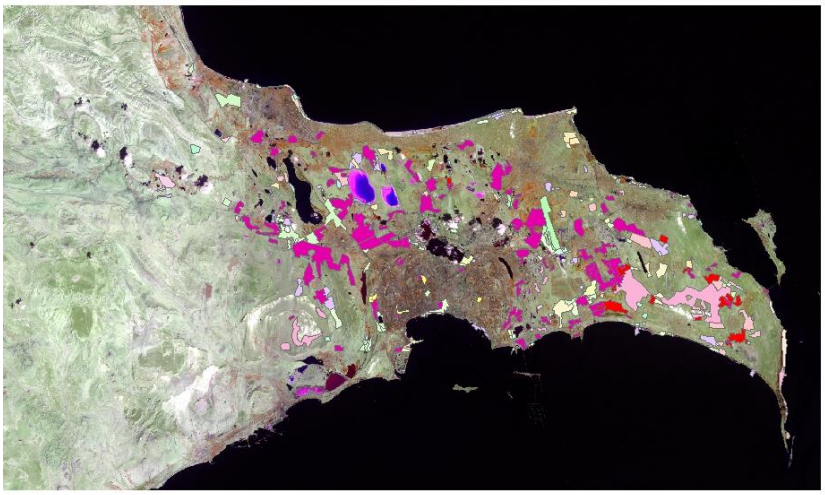
The main difficulty was that the pilot area faced many changes in the last 18 years. It was partly covered with non-accessable mud volcanoes and deserts. Presence of many construction sites, road infrustructure and abandoned oil fields polluted with black oil in Absheron peninsula, Baku city and Baku outskirts were the main obstacles in implementation the contract on time.

# 4. Results

## 4.1.CLC changes

The map of CLC changes (2000-2018) is shown on Figure 5. Altogether 349 CLC change polygons were delineated,10,6 % of  pilot area changed between 2000 and 2018 .

**Figure 5** CLC-Change$_{2000\text{-}2018}$ map of Absheron pilot area in Azerbaijan



Note: Change polygons coloured magenta

**Figure 6** CLC changes (2000-2018)

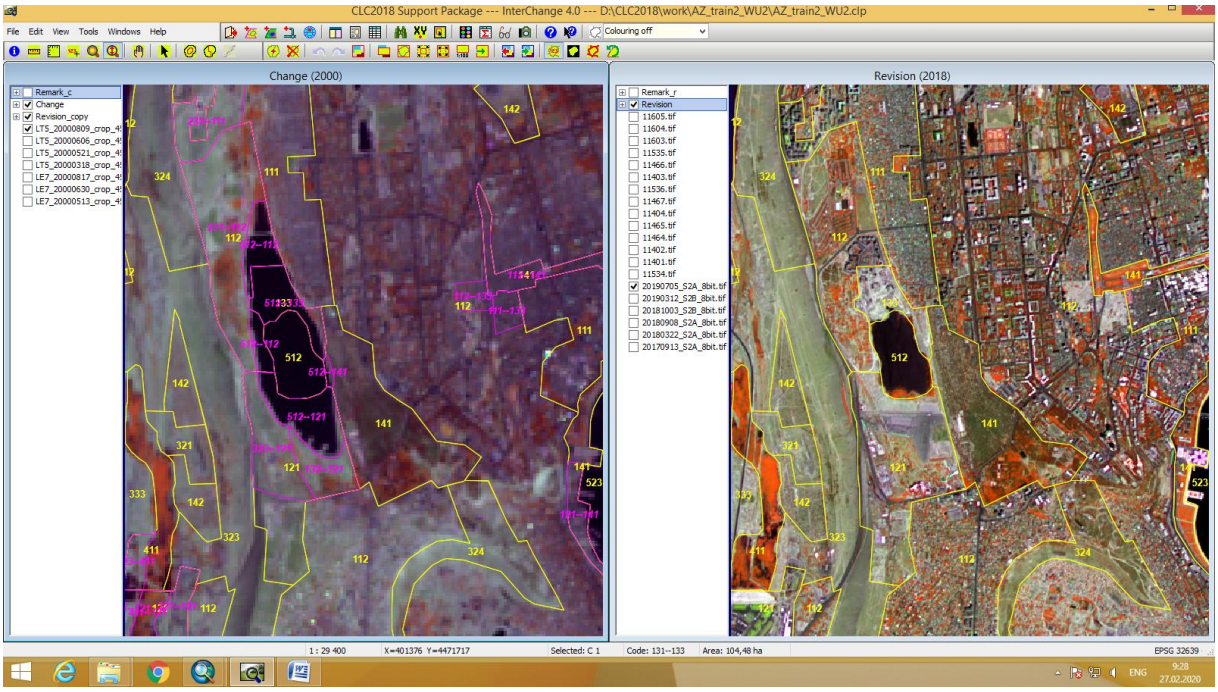


Figure 6 shows the extensive changes between 2000 and 2018: large part of Water body (512) changed to Discountinuous urban fabric (112),Commercial units (121), Green urban area (141), Construction site (133) in suburban area of Baku.

**Figure 7** CLC changes (2000-2018)

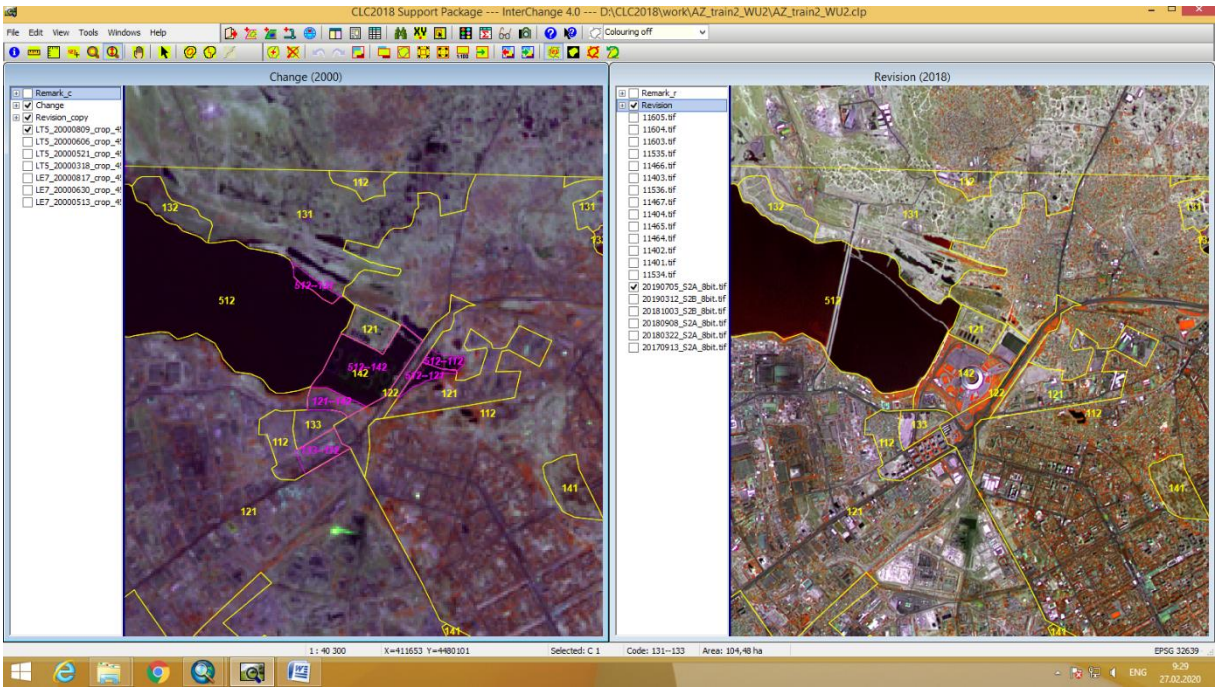



Figure 7 shows yet another sample of changes between 2000-2018 where part of Water body (512) changed to Sport and recreational area (142) in Central Baku.

**Table 6** Dominant CLC-changes between 2000 and 2018

| Change 2000-2018 | CLC change type | Counts | Area (ha) | Evolution process |
|---|---|---|---|---|
| 131-112 | Mineral extraction sites to discontinuous urban fabric | 9 | 545,79 | residential sprawl |
| 231-112 | Pastures to discontinuous urban fabric | 34 | 4250,99 | |
| 321-112 | Natural grassland to discontinuous urban fabric | 14 | 2130 | |
| 333-112 | Sparsely vegetated areas to discontinuous urban fabric | 6 | 599,86 | |
| 512-112 | Water bodies to discontinuous urban fabric | 5 | 139,15 | |
| 523-112 | Sea to discontinuous urban fabric | 3 | 28,9 | |
| 231-121 | Pastures to industrial or commercial units | 9 | 1085,35 | sprawl of industrial and mining sites |
| 321-121 | Natural grassland to commercial units | 5 | 188,09 | |

| | | | | |
|---|---|---|---|---|
| 321-131 | Natural grassland to mineral extraction sites | 5 | 1484,75 | |
| 231-212 | Pastures to permanently irrigated arable land | 8 | 970,92 | increase of irrigated arable land |
| 321-212 | Natural grassland to permanently irrigated arable land | 5 | 292,86 | |
| 231-222 | Pastures to orchards, fruit-tree plantations | 7 | 777,14 | increase of agriculture plantations |
| 231-223 | Pastures to olive groves | 4 | 561,31 | |
| | | | | |
| 333-223 | Sparsely vegetated area to olive groves | 1 | 222 | |
| 523-331 | Sea to beaches, dunes and sand plains | 10 | 592,8 | development of recreation areas |
| 523-123 | Sea to port areas | 3 | 105,44 | increase of ports |
| 121-142 | Commercial units to sport and recreational areas | 4 | 126,74 | greening of settlements |

**Existing classes on the pilot area and used codes**

Artificial surfaces....

- Continuous urban fabric class (111)
- Discontinuous urban fabric (112)
- Road and rail network (122)
- Ports 123)
- Airports (124)
- Mineral extraction sites (131)
- Dumpsites (132)
- Construction sites (133)
- Green urban area (141)
- Sport and recreational areas (142)

Agriculture areas….

- Non-irrigated arable land (211)
- Irrigated arable land (212)
- Vineyards (221)
- Fruit trees, orchards (222)
- Olive groves (223)
- Pastures (231)
- Complex cultivation patterns (242)

- Land principally occupied by agriculture with significant areas of natural vegetation (243)

Forests and semi-natural areas

- Natural grassland (321)
- Sclerophyllous vegetation (323)
- Transitional woodland-shrub (324)
- Beaches, dunes, and sand plains (331)
- Bare rock (332)
- Sparsely vegetated areas (333)

Wetlands

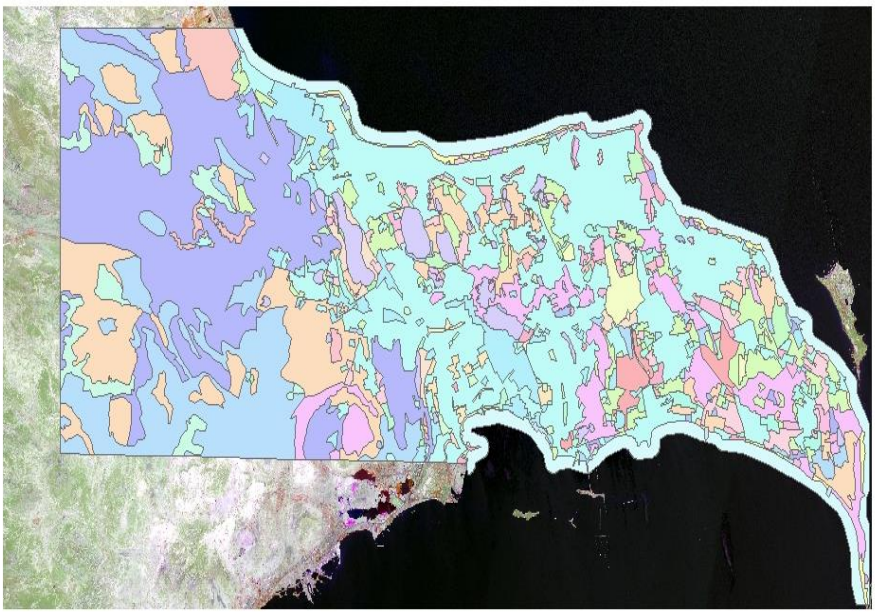
- Inland marshes (411)
- Salt marshes (421)

Water bodies

- Water bodies (512)
- Coastal lagoons (521)
- Sea and ocean (523)

### 4.2. CLC2018

**Figure 8** CLC2018 map of the Absheron peninsula



### 4.3. Back-dated CLC2000

**Table 7** CLC2000 statistics

| CLC code | No of polygons | Total area | Average polygon size |
|---|---|---|---|
| 111 | 9 | 843 | 94 |
| 112 | 37 | 46939 | 1269 |
| 121 | 36 | 7903 | 220 |
| 122 | 10 | 472 | 47 |
| 124 | 3 | 1052 | 351 |
| 131 | 19 | 10875 | 572 |
| 132 | 8 | 507 | 63 |
| 133 | 7 | 336 | 48 |
| 141 | 15 | 873 | 58 |
| 142 | 7 | 446 | 64 |
| 211 | 17 | 1742 | 102 |
| 212 | 18 | 2171 | 121 |
| 221 | 3 | 831 | 277 |
| 222 | 9 | 1385 | 154 |
| 223 | 3 | 2009 | 670 |
| 231 | 47 | 32042 | 682 |
| 242 | 32 | 4333 | 135 |
| 243 | 8 | 3784 | 473 |
| 321 | 34 | 22202 | 653 |
| 323 | 12 | 46380 | 3865 |
| 324 | 8 | 1616 | 202 |
| 331 | 13 | 1442 | 111 |
| 332 | 11 | 5631 | 512 |
| 333 | 40 | 29984 | 750 |
| 411 | 12 | 539 | 45 |
| 421 | 4 | 249 | 62 |
| 512 | 38 | 6567 | 173 |
| 521 | 1 | 33 | 33 |
| 523 | 3 | 17712 | 5904 |

## 5. Deliverables

The following data, covering the 252.708 ha of Absheron Pilot Area of Azerbaijan are delivered:

- CLC-Change$_{2000\text{-}2018;}$
- CLC2000
- CLC2018

## 6. Conclusions

Based on the difference of CLC2018 and CLC2000 statistics the dominant (largest) changes in Absheron pilot area in Azerbaijan are:

- Pastures have decreased;
- Sparsely vegetated (natural) areas has decreased
- Residential areas (discontinuous urban fabric) have increased
- Industrial and mining areas have increased.

If we consider relative changes (change area divided by the area of the class in 2000).

- More than 25% area increase can be seen in the following classes:
    - ports, construction sites, sport and recreation areas, airports and dumpsites
    - agriculture plantations (wineyards, fruit-trees, olives) and irrigated arable land
- More than 25% area decrease can be seen in the following classes:
    - non-irrigated arable land and pastures
    - wetland (inland and coastal)