EU4Environment in Eastern Partner Countries:
Water Resources and Environmental Data (ENI/2021/425-550)

REGIONAL REPORT ON OUTPUT 2.2:
LAND AND AGRICULTURAL MONITORING

PUBLIC REPORT

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EU4Environment
Water and Data in Eastern Partner Countries

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Water Resources and Environmental Data (ENI/2021/425-550)

ABOUT THIS REPORT

AUTHORS

STOCKHAMMER Katrin, Environment Agency Austria

ZAPPA Luca, Environment Agency Austria

REHBERGER Oliver, Environment Agency Austria

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Owner and Editor: EU4Environment-Water and Data Consortium

Umweltbundesamt GmbH	Office International de l'Eau (IOW)
Spittelauer Lände 5	21/23 rue de Madrid
1090 Vienna, Austria	75008 Paris, FRANCE

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ABOUT EU4ENVIRONMENT – WATER RESOURCES AND ENVIRONMENTAL DATA

This Programme aims at improving people's wellbeing in EU's Eastern Partner Countries and enabling their green transformation in line with the European Green Deal and the Sustainable Development Goals (SDGs). The programme's activities are clustered around two specific objectives: 1) support a more sustainable use of water resources and 2) improve the use of sound environmental data and their availability for policy-makers and citizens. It ensures continuity of the Shared Environmental Information System Phase II and the EU Water Initiative Plus for Eastern Partnership programmes.

The Programme is implemented by five Partner organisations: Environment Agency Austria (UBA), Austrian Development Agency (ADA), International Office for Water (OiEau) (France), Organisation for Economic Co-operation and Development (OECD), United Nations Economic Commission for Europe (UNECE). The action is co-funded by the European Union, the Austrian Development Cooperation and the French Artois-Picardie Water Agency based on a budget of EUR 12,75 million (EUR 12 million EU contribution). The implementation period is 2021-2024.

https://eu4waterdata.eu

CONTENTS

List of abbreviations

ADA ..... Austrian Development Agency
BQE ..... Biological Quality Elements
CDSE..... Copernicus Data Space Ecosystem
CLC ..... CORINE Land Cover
CLMS..... Copernicus Land Monitoring Service
CORINE ..... Coordination of Information on the Environment
DG NEAR ..... Directorate-General for Neighbourhood and Enlargement Negotiations of the European Commission
DoA ..... Description of Action
EaP ..... Eastern Partners
EC..... European Commission
EECCA ..... Eastern Europe, the Caucasus and Central Asia
EMBLAS..... Environmental Monitoring in the Black Sea
EPIRB..... Environmental Protection of International River Basins
ESCS ..... Ecological Status Classification Systems
EU ..... European Union
EUWI+..... European Union Water Initiative Plus
GEF..... Global Environmental Fund
HRVPP..... High Resolution Vegetation Phenology and Productivity
ICPDR ..... International Commission for the Protection of the Danube River
INBO..... International Network of Basin Organisations
IOW/OIEau ..... International Office for Water, France
IWRM ..... Integrated Water Resources Management
NESB ..... National Executive Steering Board
NFP ..... National Focal Point
NGOs..... Non-Governmental Organisations
NPD..... National Policy Dialogue
OECD..... Organisation for Economic Cooperation and Development
RBD ..... River Basin District
RBMP ..... River Basin Management Plan
Reps ..... Representatives (the local project staff in each country)
ROM..... Result Oriented Monitoring
SDG .....

ToR..... Terms of References
UBA..... Umweltbundesamt GmbH, Environment Agency Austria
UNDP ..... United Nations Development Programme
UNECE..... United Nations Economic Commission for Europe
WFD ..... Water Framework Directive

Country Specific Abbreviations Armenia

EMIC ..... Environmental Monitoring and Information Centre (until January 2020)
HMC..... Hydrogeological Monitoring Centre (since February 2020)
MNP..... Ministry of Nature Protection
SCWS..... State Committee on Water Systems
SWCIS..... State Water Cadastre Information System of Armenia
WRMA ..... Water Resources Management Agency

Country Specific Abbreviations Azerbaijan

Azersu JSC..... JSC Water Supply and Sanitation of Azerbaijan
MENR..... Ministry of Ecology and Natural Resources
WRSA ..... Water Resources State Agency of Ministry of Emergency Situations

Country Specific Abbreviations Georgia

MENRP..... Ministry of Environment and Natural Resources Protection
NEA ..... National Environment Agency
NWP..... National Water Partnership

Country Specific Abbreviations Moldova

AAM..... Agency “Apele Moldovei”
AGMR..... Agency for Geology and Mineral Resources
AMAC..... Association of Apacanals
ANRE..... National Agency for Economic Regulation of the Energy Sector (also regulates WSS)
EAM ..... Environment Agency Moldova
MoAgri..... Ministry of Agriculture (of the Republic of Moldova)
MoENV..... Ministry of Environment (of the Republic of Moldova)
Moldova..... Republic of Moldova
NSDI ..... National Spatial Data Infrastructure
SHS..... State Hydrometeorological Service

Country Specific Abbreviations Ukraine

MENR..... Ministry of Ecology and Natural Resources

NAAU ..... National Accreditation Agency of Ukraine

SAWR ..... State Agency of Water Resources

SEMS..... State Environment Monitoring System

UkrHMC ..... Ukrainian Hydrometeorological Center

1. Introduction

The EU4Environment Water and Data programme aimed to enhance land and agriculture monitoring through improved data collection, analysis, and collaboration among partner countries. One of its key objectives, **Component 2 – Output 2.2**, focused on expanding the use of advanced remote sensing technologies to support environmental decision-making. The Output consisted of two major activities:

1. **Capacity building** and case studies focusing on generating know how to use advanced **Copernicus products**, such as the High Resolution Vegetation Phenology and Productivity (HRVPP).
2. **Expansion of** CORINE **Land Cover (CLC)** in Armenia, Georgia, Moldova, and Ukraine

These activities were selected to help Armenia, Georgia, Ukraine, and Moldova (in 2022 Azerbaijan opted not to participate in this project task) **strengthen their use of Earth observation**, particularly **European Copernicus products**, as they offer complementary data that together provide **a more comprehensive view of land use, land cover, and vegetation health**, including:

- **Corine Land Cover (CLC)** maps provide **categorical land cover** information (e.g., forests, urban areas, water bodies, agricultural land). High resolution Copernicus products such as the **HRVPP** provides **dynamic, time-series vegetation** data (e.g., how vegetation changes over the seasons and years).

- Corine Land Cover is great for broad, **long-term land use analysis**, but it lacks high-frequency updates[1] and detailed vegetation health information. High resolution Copernicus products such as the HRVPP fill that gap by providing **daily vegetation monitoring**, making it essential for agriculture, deforestation, urban expansion, and land degradation.

- **Agricultural Planning and Food Security:** CLC identifies farmland, while high resolution Copernicus products such as HRVPP monitors crop productivity trends, drought stress, and seasonal variations. Together, they enhance yield forecasting and drought impact assessment.

- **Disaster Risk Reduction (Floods, Fires, Droughts)**: CLC identifies high-risk areas (e.g., forests, urban zones), while high resolution Copernicus products such as the HRVPP detect early warning signs of environmental stress, such as drought stress in crops, wildfire risks in dry forests, and flood risks based on vegetation moisture levels.

Understanding and utilizing Copernicus products also aligns with EU environmental and agricultural policies and thus enhances the integration with European standards.

[1] CLC is usually updated only every 6 years.

2. Schedule of Implementation

Output 2.2 followed this **schedule of implementation,** which had been designed and implemented together with the main beneficiaries:

1. **Contracting of local experts (September – November 2022)**
2. **Workshop 1 – Scoping (November 2022 – March 2023):**
    - Official launch of the new CLC implementation project.
    - **Selection of a case study** for applying **High-Resolution Vegetation Phenology and Productivity (HRVPP) data** in national assessments
    - Pilot area selection to benefit from **HRVPP services**
3. **Workshop 2 – Progress and case studies (November 2023 – February 2024):**
    - Reviewing **progress in CLC mapping**
    - Guiding through case studies, such as:
        - Assessing wildfire impacts on forests
        - Understanding ecosystem responses to droughts
    - Completion of updated CLC maps, including:
        - **CLC 2018**
        - **CLC 2023**
        - **CLC Change Analysis (2018-2023)**
4. **Workshop 3 – Regional Workshop (May 2024):**
    - Reviewing CLC products and discussion of process
    - Summarising topics of the case studies

Table 1: Dates of held workshops

	Workshop 1	Workshop 2	Regional Workshop (Tbilisi)
Armenia (Yerevan)	30.11. – 01.12.2022	28. – 29.11.2023	21. – 22.05.2024
Georgia (Tbilisi)	06. – 07.03.2023	30.11. – 01.12.2023	
Moldova (Chișinău)	01. – 02.02.2023	12. – 13.12.2023	
Ukraine (Online)	13. – 14.03.2023	07. – 08.02.2024	

3. Capacity building and High Resolution Vegetation Phenology and Productivity (HRVPP)

3.1. Overview

Capacity building workshops in all countries included a general introduction to the Copernicus Data Space Ecosystem (CDSE) as well as QGIS, a freely available GIS software. The newly launched Copernicus Dataspace Ecosystem platform was introduced to workshop participants and its possible applications were tested through practical exercise based on predefined national interests. During these sessions, specific focus was given to data access, visualization, and downloading.

The HRVPP was introduced as a key tool for monitoring vegetation dynamics and ecosystem health. It offers detailed insights into seasonal vegetation changes, including the onset of growing seasons and variations in productivity. HRVPP is part of the **Copernicus Land Monitoring Service (CLMS)** and provides **10m resolution** data on vegetation cycles across **EEA39 countries**. This data can serve as a foundation for environmental assessments and strategies aimed at climate resilience by helping to track:

- **Start and end of the growing season**
- **Seasonal productivity levels**
- **Ecosystem responses to climatic and human-induced disturbances**

Result and Outcome: The integration of HRVPP analyses marks a significant step forward in the environmental monitoring framework of Armenia, Georgia, Moldova, and Ukraine. With high-resolution, standardized data now available, stakeholders—such as policymakers, researchers, and environmental agencies—can rely on accurate information to support sustainable land management efforts.

3.2. Cases Studies

A total of **six different case studies** were defined for the workshops adapted to national interests, which dealt with monitoring and analysing ecosystem dynamics with high resolution Copernicus products such as Sentinel-2 and HRVPP data.

Vegetation productivity: inter-annual changes in response to climate (Armenia, Georgia and Moldova)

This analysis examines inter-annual changes in vegetation productivity in response to climate variability from 2017 to 2022. By visually comparing productivity changes with meteorological data, the study interprets how climate factors such as temperature and precipitation influence vegetation dynamics over time.

Figure 1: Comparison of climate related indicators between 2017 and 2022

Impact of droughts on ecosystems (Ukraine)

This task explores the impact of climate-related datasets on various land cover types, focusing on how climate variables influence ecosystems. Specifically, it examines the differing responses of cropland and forests, and their productivity shifts due to climate change.

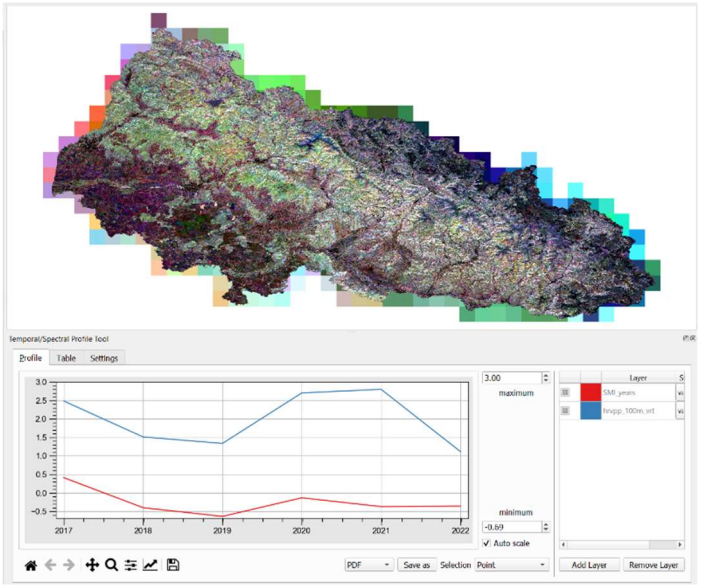

Figure 2: Trend of Soil Moisture Index (SMI) compared to total productivity

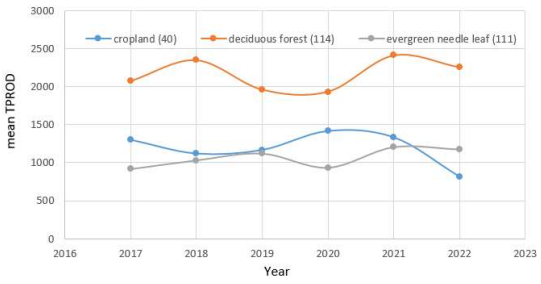

Figure 3: Mean total productivity over time of different land cover types

Soil moisture indices and HRVPP layers were temporally aggregated and compared across multiple years. A more detailed analysis was conducted for different land cover classes.

Land cover classification using HRVPP data and calculation of agricultural productivity (Armenia)

The analysis focuses on classifying cropland, calculating the area and share of different classes, and assessing productivity trends over multiple time steps. It examines variations in productivity within the classified dataset, identifies temporal trends and tracks changes in agricultural classes.

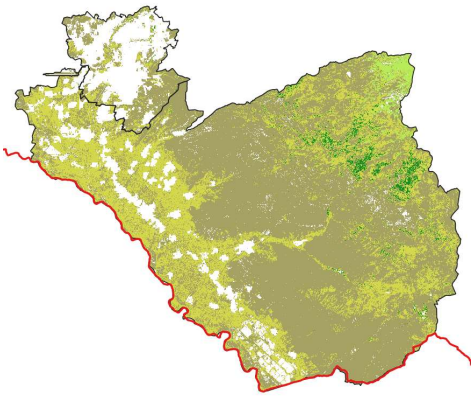

Figure 5: Land use classification in selected regions

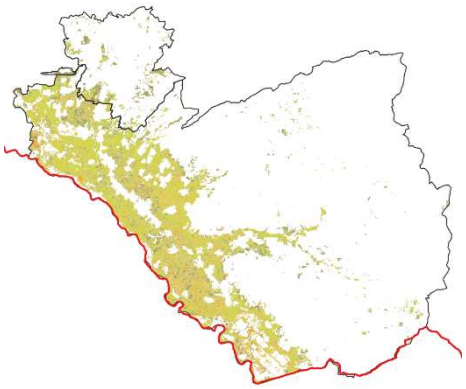

Figure 4: Crop classification in selected regions

Information on crop phenology and productivity was extracted from various HRVPP layers and combined to derive a land use classification, which is illustrated in the figure above

Forest changes: insights from satellite observations (Georgia and Moldova)

Using satellite observations, a forest mask was created from the CLMS Forest Fraction layer to assess productivity differences between two years. This approach enables the detection of forest growth and deforestation, offering valuable insights into landscape dynamics and environmental changes.

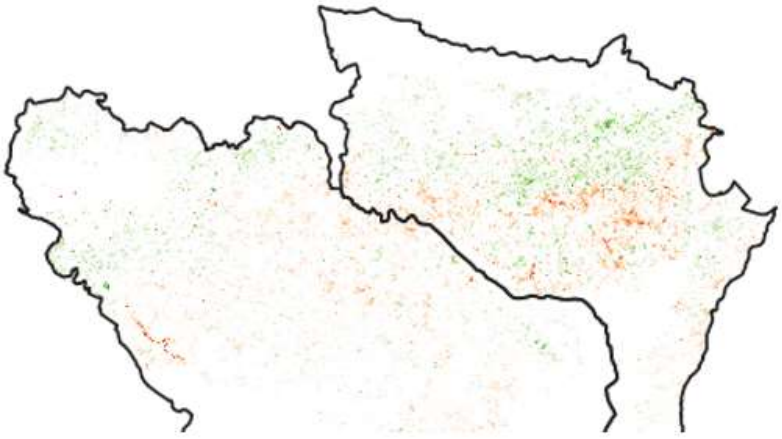

Figure 6: Gain (green) and loss (red) of vegetation productivity in forested areas

Monitoring lake shrinkage with satellite data (Moldova)

Satellite data was used to monitor the shrinkage of a reservoir (impounded river) by extracting relevant Sentinel-2 bands and analyzing a time series over several months. An NDWI mask was applied to track changes in water extent, providing insights into the lake's dynamics and potential environmental drivers.

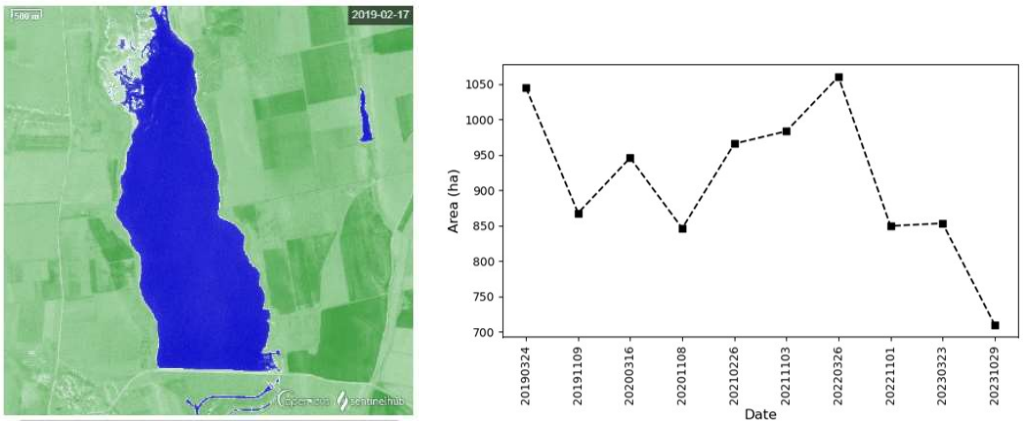

Figure 7: Masked water body of lake Taraclia and trend of covered water area over

Satellite data in support of wildfire monitoring and damage assessment (Ukraine)

This task utilizes satellite data for wildfire monitoring and damage assessment by analyzing biophysical parameters such as LAI and FAPAR to detect active forest fires. NDVI differences were used to determine the affected area, providing valuable insights into fire impact and vegetation loss.

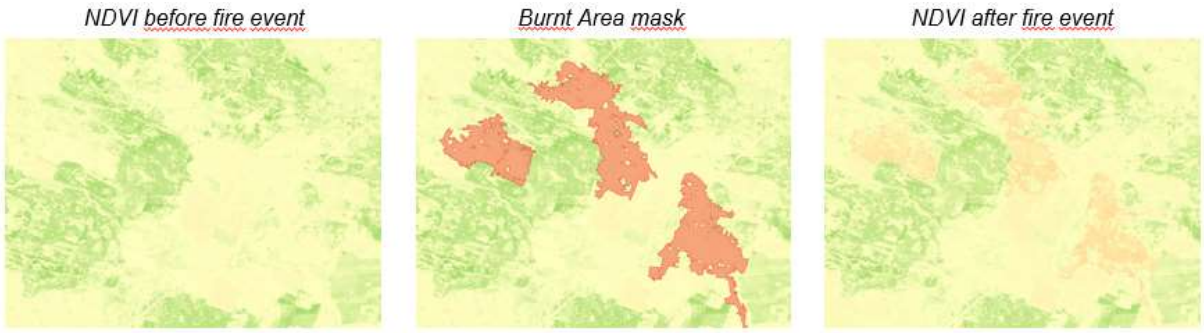

Figure 8: NDVI values before and after the fire event (high values in green, low values in red)

4. Identified Main Areas of Interest

During the workshops, participants in all countries were asked to provide information on their priority needs for Earth observation. The table below summarises the identified main areas of interest.

Area	**Preferences/needs**
Land degradation	Historical dynamics, post-disaster mapping
	Monitoring degradation of pastures, forests, land-slides, soil erosion etc.
Forest	Reforestation, deforestation
	Damages from wild fires, illegal logging, etc.
Agriculture	Yield forecast of agricultural crops, identify different crops
	Irrigated/non irrigated areas detection
	Soil moisture, drought monitoring
	Use of fertilizers
	Impact of pests on agriculture
Climate change	Estimate carbon sequestration
	Estimate evapotranspiration
	Changes of snow cover; size and movement of glaziers
Water quality	Pollution / chemical composition of surface water bodies
Urban Management	Urbanization
	Urban heat islands
Biodiversity	Identify vegetation zones

5. CORINE Land Cover (CLC)

5.1. Introduction

In the early 1980s, the European Commission identified the need for a unified, detailed, and harmonized **dataset on land cover and land use across Europe**. At that time, national land cover maps were often inconsistent and difficult to compare across borders, making it almost impossible to monitor the European environment on a continental scale. In response, the European Commission launched the CORINE (Coordination of Information on the Environment) program to develop a standardized methodology for creating land use and land cover maps. The first CORINE Land Cover dataset was produced in 1990. Since then, it has become a key component of the European Environment Agency's Copernicus Land Monitoring Service, providing essential information on European land cover and land use for over three decades.

Today, the CORINE Land Cover (CLC) product offers a comprehensive pan-European land cover and land use inventory with **44 thematic classes**, ranging from broad forested areas to individual vineyards. The product is updated every six years, with the most recent update in 2018 and the 2024 update currently in progress. CLC serves a wide range of users and has numerous potential and actual applications, including environmental monitoring, land use planning, climate change assessments, and emergency management.

5.2. Scaling up CLC in Armenia, Georgia, Moldova, and Ukraine

Under the previous ENI SEIS II East Programme (2017-2020), **pilot studies** were conducted to produce CORINE Land Cover maps for key areas in Armenia, Georgia, Moldova, and Ukraine. These maps, covering **regions surrounding national capitals**, provided valuable insights into land use changes over time and laid the foundation for further development.

Building on this progress, the **EU4Environment Water and Data programme strengthened its collaboration with national partners**, including ministerial and technical teams, to expand these efforts using the standardized CLC approach to ensure data consistency and reliability. This approach features a spatial resolution of approximately 25 hectares and a thematic classification encompassing 44 land cover classes within a three-level hierarchical system. On invitation of the UBA experts, Lechner Non-profit Ltd led this initiative, leveraging its expertise in regularly supporting CLC updates across the 39 member states of the EEA. Proven quality control measures were implemented to ensure the validation of results.

The **key objectives** included:

- Expanding the spatial coverage of CLC mapping:
    - **Armenia:** Lori and Tavush provinces in the **Northern River Basin District** (~20% of the country).
    - **Georgia:** Kvemo Kartli and Kakheti (~20% of the country).
    - **Moldova:** full national coverage.
    - **Ukraine:** Carpathian Convention Region.

- Increasing temporal coverage, with new datasets for 2018, 2023/2024, and a CLC Change Layer ($CLC_{2018-2024}$) to track land cover and land use changes.
- Integrating additional environmental data from Copernicus Earth Observation and national monitoring frameworks, as well as advanced software tools for data analysis and visualization ensuring a more comprehensive data basis and analyses.

The finalized CLC maps are **publicly available at the EEA website** and can be downloaded here. National webpages that provide these data include:

- Armenia: Ecoportal of Armenia
- Moldova: National Spatial Data Infrastructure (NSDI) in the Republic of Moldova

Unfortunately, data for Georgia and Ukraine were not available on any national platform by the end of the project.

All **national reports summarizing the production of CLC** in Armenia, Georgia, Moldova, and Ukraine are **provided in the Annex**.

6. Outcomes of the workshops

After the kickoff of the CLC process and the **definition of case studies** in the first workshop, a **review of the CLC process** and the organization and **implementation of case studies** followed in the second workshop.

Then a regional workshop was conducted with the participation of representatives and experts from Armenia, Moldova, Ukraine, and Georgia. The primary goal of the workshop was to **review the progress and achievements** under Output 2.1 “Water Accounting” and Output 2.2 “Land Monitoring,” and to **provide a platform for cross-country dialogue and collaboration** across sectors.

The workshop served as an opportunity to:

- Share accomplishments and practical experiences in implementing water accounting and land monitoring activities.
- Facilitate open discussions among country representatives and experts from various sectors to foster knowledge exchange.
- Identify common objectives and challenges relevant to all participating countries.
- Explore concrete steps for future actions and cooperation.

A **follow-up project was presented**, highlighting specific outcomes and potential areas of regional synergy. In particular, the **role of remote sensing in supporting water accounting** was discussed. Despite data uncertainties, remote sensing offers significant value by providing globally consistent, climate-relevant data, especially related to precipitation, evapotranspiration and irrigation, supporting national efforts in environmental monitoring.

The session dedicated to Output 2.2 focused on the CORINE Land Cover (CLC) methodology. Key objectives included:

- Presenting the purpose and significance of CLC for consistent land cover monitoring.
- Reviewing the CLC process and its application across countries.
- Discussing the challenges faced during implementation and the results achieved.
- Evaluating the availability and access of CLC data.
- Exploring the potential extension of the High Resolution Vegetation Phenology and Productivity (HRVPP) dataset, supported by examples from various case studies introduced during the workshop.

Overall, the workshop reinforced the importance of continued regional collaboration and knowledge sharing to enhance environmental monitoring systems through harmonized approaches and innovative solutions.

7. Conclusions

The goals outlined in the introduction have been successfully accomplished across the four countries involved in the project. Local environmental experts and GIS users are now equipped to use the Corine Land Cover (CLC) and HRVPP data for their respective purposes, which has significantly enhanced their ability to monitor and manage environmental changes. This accomplishment reflects the project's positive impact on local capacities and the integration of advanced environmental tools.

However, there is still much work to be done. In particular, there remains a substantial gap in the coverage of CLC mapping in Ukraine, Armenia, and Georgia. These countries require further expansion and refinement of their mapping efforts to ensure that the environmental data is comprehensive and up-to-date, providing a more accurate foundation for decision-making.

Furthermore, while local experts and GIS users have made strides in utilizing the available tools, there is an ongoing need for more technical expertise across all four countries. Strengthening the capacity to handle increasingly complex environmental data is crucial for the long-term sustainability and effectiveness of the project. This could involve additional training, as well as ongoing technical support to help users fully leverage the potential of Copernicus Services.

In addition, Azerbaijan, which has not been part of these efforts so far, should receive a new and tailored offer of support. The country’s specific needs, particularly in relation to environmental monitoring and Earth Observation capabilities, should be addressed with a comprehensive plan that ensures continued development and the application of best practices in data usage and environmental management.

In summary, while significant progress has been made in introducing CLC and HRVPP in four countries, it is clear that continued efforts are necessary. Expanding the scope of mapping, increasing technical expertise, and providing tailored support to countries, including Azerbaijan, will be essential for achieving the EU support’s long-term goals.

8. Annexes

Final report CLC Armenia

Final report CLC Georgia

Final report CLC Moldova

Final report CLC Ukraine

Report Regional Workshop

9. Figures and Tables

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