Institutul Național de Cercetare-Dezvoltare pentru Protecția Mediului - INCDPM București

INCDPM

National Institute for Research and Development in Environmental Protection

Bucharest, 294 Splaiul Independentei, Romania

AI-BASED TECHNOLOGY USED TO DETERMINE PERFORMANCE IN ECOLOGICAL AGRICULTURE TO REDUCE GHG EMISSIONS

Authors: DEÁK György Eng. Ph.D Habil., **MATEI Monica** Ph.D, Eng., **LASLO Lucian** Ph.D, Eng., **SADÎCA Isabela** Eng., **ENACHE Natalia** Eng.

Patent no.: RO138721

The invention involves a complex technology based on artificial intelligence (AI) with the aim of determining both soil quality and climatic indicators for the study area, to determine and quantify performance in the field of agriculture, considering soil types, crops, and climate change, with the goal of reducing GHG emissions. The technology subject to this patent offers answers and solutions regarding the EU Missions on Soils (1) and Climate Change (2) and addresses the principles of Taxonomy, leading over time to the promulgation of feasible, Nature-based Solutions (NbS) with in situ applications, to support Romania in the process of transitioning to a sustainable agriculture.

In Romania, studies on GHG emissions/retention and the impact of climate change in agriculture are a relatively new field, thus far, methodologies for quantifying GHG emissions have been developed to identify the impact of climate change (3), as well as technologies for mitigating drought at national level through satellite products and climate parameter modeling (4). National studies on regional climate indicators (5) and the assessment of GHG effluxes from the terrestrial environment, including land used for agriculture (6), focus primarily on CO_2 analysis. To determine the best NbS for the transition to a sustainable agriculture, a holistic and multidisciplinary approach is required, to provide a comprehensive database regarding both climate and forecast indicators, soil performance indicators, considering soil type, microbiota, and the most suitable crop to enhance agricultural productivity.

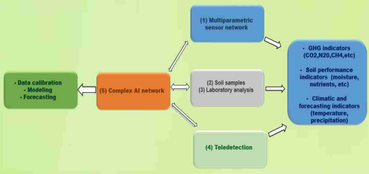

Figure 1 – Functional diagram of AI-based technology used to determine performance in the field of ecological agriculture to reduce GHG emissions

The AI-based technology used to determine performance in ecological agriculture to reduce GHG emissions, is comprised, according to the description and figures 1 and 2, of:
(1) A network of multiparameter sensors, which provide information regarding the GHG effluxes variation and climatic and soil performance indicators; (2) Soil samples sent further to (3) Laboratory analysis to obtain data on soil quality (moisture, pH, eH, microbiota, nutrients, etc.); (4) Remote sensing through the acquisition of satellite products and by obtaining digital images via drones (vegetation indicators, desertification, etc.); and (5) A complex AI network aimed at calibrating and corroborating the obtained information for modeling and developing climate forecasts and scenarios.

The **technical solution** that this patent addresses aims to reduce GHG emissions through a holistic approach by using an interconnected data set, obtaining a comprehensive overview with a high level of confidence in relation to the reality on the ground. The developed technology includes various interdependent stages:
1) Remote sensing (acquisition of satellite products and digital images obtained with drones), which provide information regarding humidity, vegetation indicators, desertification, etc.
2) Sampling for the analysis of soil quality indicators, which defines parameters such as soil texture, pH, Eh (redox potential), nutrients, organic carbon, microbiota, etc.
3) In situ data measurements through a complex network of sensors, which will provide information regarding GHG effluxes, humidity, temperature (both from air and soil), precipitation, etc. Data calibration will be performed through AI.
4) Weather data forecasting and climate scenarios supported by AI, in accordance with in situ reality based on data obtained through the initial stages of the technology.
5) Comparative statistical analysis of the information from the obtained databases and biogeochemical modeling based on AI.

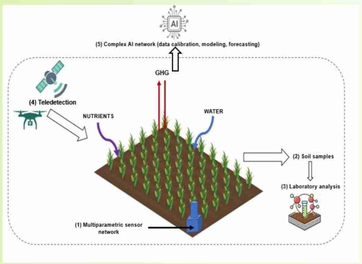

Figure 2 – Overview of the use of AI-based technology for determining performance in ecological agriculture to reduce GHG emissionsv

The technical problem that the invention solves is the possibility to simultaneously analyze all the important factors that influence crop productivity, the sustainability of agriculture in Romania, in compliance with the principles of Taxonomy and the EU Missions on Soils and Climate Change. Thus, through the AI based technology used for determining performance in the field of ecological agriculture aimed at reducing GHG emissions, raw data regarding soil quality indicators, climatic indicators, models, forecasts, and scenarios are calibrated using AI to provide a realistic overview of the analyzed factors. Therefore, all this information will support the implementation of optimal NbS to maintain and improve performance in Romanian agriculture.

The functionality of the technology is claimed, which offers the possibility of a simultaneous, and holistic analysis of factors that influence crop productivity, and sustainability of the agricultural sector in Romania. Through the AI based technology used for determining performance in the field of ecological agriculture aimed at GHG reduction, raw data regarding soil quality indicators, climatic indicators, models, forecasts, and scenarios are calibrated using AI to provide a realistic overview of the analyzed factors. Therefore, all this information will support the implementation of optimal, NbS to maintain and improve performance in Romanian agriculture.

ACKNOWLEDGEMENTS
This work was carried out through the Nucleu Program (44N/2023) within the National Plan for Research, Development and Innovation 2022-2027, supported by the Romanian Ministry of Research, Innovation and Digitization, project PN 23 31 04 02/2023.

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AUTONOMOUS MOBILE SYSTEM, MONITORED THROUGH IA, FOR THE TRANSPORTATION OF WILD STURGEON

Patent no. RO137990

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The invention intends to address an issue in the conservation and monitoring of wild sturgeons and relates to a technical concept for transporting wild sturgeons in a controlled environment to preserve their vital integrity. The autonomous mobile system is composed of a sturgeon storage basin, a compartment systems that ensure the constant maintenance of vital physical parameters of the water in the sturgeon storage basin, Monitoring and control compartment of the vital physical parameters of the water in the sturgeon storage basin, video monitoring and electricity supply, Danube water supply motor pump and an Electric current generator.

The system continuously monitors the state of the system (physical parameters of the water essential for survival and video images from the sturgeon storage basin) through a dedicated AI application, throughout the transport, and transmits real-time signals when their values exceed the set intervals or when errors occur in the operation of the equipment.

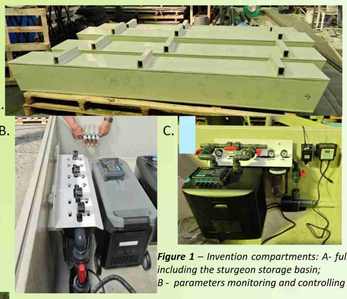

Figure 1 – Invention compartments: A- full assembly, including the sturgeon storage basin; B - parameters monitoring and controlling equipment

Figure 2 – Project implementation area for reconnecting the hystorical migration route for anadromous sturgeon species

The Mobile System is designed to provide functionality in a compact, thermally insulated container consisting of three compartments. The container, motor pump for water supply from the Danube and gasoline-electric current generator are mechanically fixed on a transport platform, which can be placed on a car trailer or a boat. The ccompartment consists of a basin with a volume of approximately 1500 liters, filled with water from the Danube. The tank is equipped with a watertight top cover for the introduction of sturgeons and an anti-wave system. An underwater video camera is placed in the lower part of the pool, protected by a double bottom, for air diffusion. The underwater video camera exits the pool through a sealed connection. Systems in compartment ensure constant maintenance of vital physical parameters of the water in the basin, while compartment monitors and controls these parameters.

The technical problem that the invention solves, in comparison to other previous systems, is the possibility of facilitating the transport of wild sturgeons in a controlled environment, which ensures the optimal state of vitality (avoiding injury, decreasing the level of dissolved oxygen, and respectively increasing the level of oxidative stress during the transport period), as well as the transmission of data in real-time regarding their health. The sturgeon transport system in a controlled environment is a national and international first, to facilitate the transport of sturgeons in optimal vitality conditions while ensuring a controlled environment, which makes it applicable in a wide range of directions and research applications, to restore the route of historical sturgeon migration.

Figure 3 – Sturgeons release after successful transportation

***Acknowledgment**: This work was carried out through the HORIZON-MISS-2021-OCEAN-02-02 Danube river basin lighthouse – restoration of fresh and transitional water ecosystems CALL, Action HORIZON - IA Innovation Action 2023-2026, Project DALIA, contract no. 101094070*

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SUBMERSIBLE PLATFORM FOR MONITORING ICHTHYOFAUNA, PARTICULARLY STURGEON SPECIES

Patent application no. A/00143/16.04.2025

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The present invention relates to a prototype for monitoring ichthyofauna, in particular wild sturgeons, by means of a durable submersible platform, which ensures both an optimal vital status of the captured specimens and the safety of the experts, ***considerably improving and streamlining research activities***. This invention is ***both a national and international first*** and is currently the ***only system of its kind developed specifically for research activities related to the capture, tag and release of fish species, in particular sturgeon***. There are much smaller platforms used in the identification and monitoring of spawning habitats by collecting biological samples from the substrate (1)(2), or large platforms for oceanographic study (3), but none of these fulfil the criteria of the present invention.

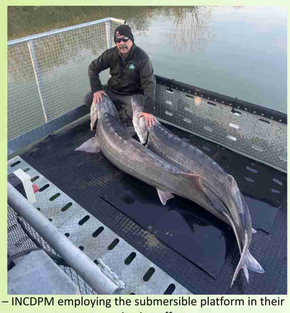

Figure 1 – INCDPM employing the submersible platform in their sturgeon monitoring efforts

The technical approach seeks to ***significantly reduce the necessity for human intervention in ichthyofauna research efforts***. The platform, constructed from robust, corrosion-resistant material and capable of supporting over 2 tons, is submersible via a hydraulically or electrically operated pulley system up to 0.5 m from the water's surface. It features two openings: one for access to the pontoon on which the platform is mounted (via swing gates) and a larger opening for the retrieval and release of specimens for marking purposes. The ***safety of the research team is guaranteed by a railing*** with a minimum height of 1 meter, featuring moveable sides along the length and fixed sides across the breadth to assure the ***stability and safety of the entire system***. The galvanized mesh bridge and the wire panel handrail ***provide rapid filling and drainage of water*** in the compartment through optimally sized meshes.

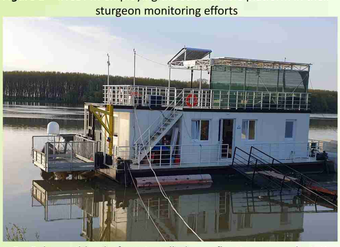

Figure 2 – Submersible platform installed on a floating research station

Figure 3 – Sturgeons release after tagging

The technical problem that the invention solves refers to the fact that the use of this , the specimen is not taken to the research team, but the experts will be introduced into the natural environment, submerged at a depth that does not jeopardize the integrity of the personnel. The lightweight metal structure, made of a durable and corrosion-resistant material; the galvanized mesh pod that can support a minimum weight of 2 T; and the ***automatic and rapid operation of the submersible platform make this the most optimal and sustainable solution developed for the capture, tagging, and release of ichthyofauna***..

Aknowledgement: *The work has been carried through the National Recovery and Resilience Plan 2020 - 2026, Pillar I "Green Transition", Component 2 "Forests and Biodiversity Protection", Investment 4.4., "Implementation of a monitoring system for wild sturgeons along the Lower Danube", Contract no. 6878/23.08.2022*

References:

1. Holban Elena; Deák György; Matache Răzvan; Danalache Tiberius; Boboc Mădălina; Raischi Marius; Prangate Raluca. ***PILOT VALIDATION SYSTEM OF BREEDING HABITATS OF STURGEON SPECIES*** International Journal of Conservation Science; Iasi Vol. 13, Iss. 3, (Jul-Sep 2022): 1079-1084.
2. Deák György; Matache Răzvan; Danalache Tiberius; Raischi Marius; Prangate, Raluca. Sistem pilot de validare a habitatelor de reproducere a speciilor de sturioni. Cerere brevet de invenție *A0 135422*
3. https://ocean.ucsd.edu/ship/Tio (accesat 14.04.2025)

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Assessing ecosystem vulnerability, monitoring adaptation measures, and estimating GHG emissions, in compliance with the objectives of the EU Mission - ClimGES

Authors: **DEÁK György** Eng. Ph.D Habil., **LASLO Lucian** Ph.D, Eng., **MATEI Monica** Ph.D, Eng., **ENACHE Natalia** Eng., **BOBOC Madalina** Ph.D, Eng. , **CHIRESCU Alexandra** Ec.

CONTEXT

Human activities, especially after the Industrial Revolution, have drastically transformed land use, leading to the reduction of forested areas and the increase of agricultural land. These changes significantly contribute to climate change, as terrestrial ecosystems are vital for gas effluxes between the atmosphere and the Earth's surface. Agricultural, forestry, and other land use (AFOLU) sectors play a key role in GHG emissions, being responsible for 23% of anthropogenic emissions. Net emissions from land regarding non-anthropogenic activities account for 29% of CO_2 emitted from all anthropogenic activities. Among these, land management has a high potential for climate change mitigation and could contribute to approximately 6 to 7 Gt of CO_2 equivalent per year to global mitigation efforts by 2050. This represents a significant effort in reducing GHG emissions to meet international climate goals. Thus, depending on their use and management, lands can store greenhouse gases (GHGs) and provide multiple other services (including climate adaptation). A set of Nature-based Solutions (NbS) can contribute to climate adaptation and mitigation by harnessing natural processes and improving land management.

PILOT STUDIES

Experimental research on GHG effluxes and NbS integration in different land use scenarios, outline the impact of NbS on various types of land, using soil samples from forests, wetlands, agricultural lands, and abandoned lands, to present the methodology used to simulate different land use scenarios in a laboratory environment. CO_2 fluxes were measured using two techniques based on the closed chamber method for precise data at a given moment on the soil. Complementary mesocosms were created in the laboratory to simulate and evaluate carbon dynamics under controlled experimental conditions to determine the ecological causes and consequences of management practices and the effects of climate change at the local level, as well as to simulate conditions for sustainable land management through controlled tests.

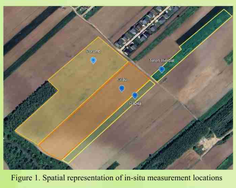


Figure 1. Spatial representation of in-situ measurement locations

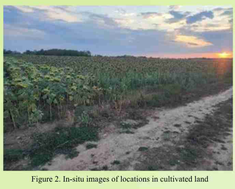


Figure 2. In-situ images of locations in cultivated land

Figure 3. Closed chamber method for measuring CO_2 fluxes used in the laboratory with Terra5000

LABORATORY MEASUREMENTS

The results of the microcosm measurements revealed a discrepancy between the laboratory and field values for vessels A and C during period 0. Because of the absence of humidity and the resulting near-zero fluxes in vessels A and C, the ratios between these values are more than 15 times in favour of the field results. Higher values for the laboratory experiments were suggested by the remaining ratios, which reported values below 1.

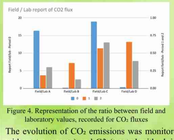


Figure 4. Representation of the ratio between field and laboratory values, recorded for CO_2 fluxes

Table 1. Ratio between field and laboratory values

Field/Lab report	PERIOD		
	0	1	2
Land (abandoned) / Lab A	16.39	0.18	0.30
Land (abandoned)/ Lab B	0.23	0.35	0.12
Land (agricultural)/ Lab C	18.93	0.57	0.65
Land (agricultural)/ Lab D	0.16	0.65	0.38

The evolution of CO_2 emissions was monitored on two experimental samples: G1 (control, without treatments) and G3 (treated with alginate). Both were irrigated simultaneously with 500 ml of water to ensure comparable conditions. At the beginning of the period, CO_2 concentrations were almost zero, indicating low emissions in the absence of stimuli. Subsequently, the application of alginate on G3 generated a significant increase in CO_2 emissions, unlike G1, where the variations were minimal. This difference suggests a stimulating effect of microbial activity by alginate. Subsequent irrigations accentuated this effect on G3, indicating an increased potential for CO_2 release in treated soils, relevant for emission management strategies in agroecosystems.

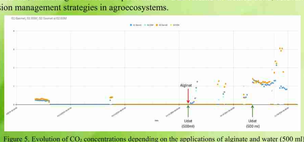


Figure 5. Evolution of CO_2 concentrations depending on the applications of alginate and water (500 ml)

BIOGEOCHEMICAL SCENARIOS

Wetlands - example of input data

The daily values of atmospheric temperature and precipitation were taken from Bănească weather station. Soil parameters were based on the results of field studies. The cultivation period was designated between March 1 and October 30 for the SC vegetation soil and between April 15 and September 30 for the SP vegetation soil. The fraction of leaves and stems remaining in the field was considered to be 100%.

Table 2. Input data for the model predictions

Data type	Sub-Type	Unit	Model predictions	
			SC	SP
Climate	Temperature	°C	Daily values for the baseline year and RCP 8.5 for 2050, 2100	
	Precipitation	cm		
Land Management practices	Fertiliser	kg N ha^{-1}	Auto-fertilising	
	Tillage	cm	N/A	
Soil	Bulk density	g cm^{-3}	1.07191	1.5078
	Clay	%	14	63
	Initial SOC	kg C/kg soil	0.00274	0.00638
	pH		7.42	6.21

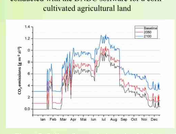
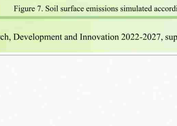


Figure 6. Output of the biogeochemical analysis conducted with the DNDC software for a corn-cultivated agricultural land

The result generated by the DNDC model for corn cultivation by month, show variations in emissions throughout the crop's life cycle. The graphic include data on soil conditions, such as moisture, temperature, organic carbon content, and crop-specific variables, such as growth stage or yield. These values validate the accuracy of the model, ensuring the alignment with the growth patterns for the crop.



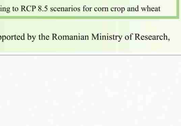


Figure 7. Soil surface emissions simulated according to RCP 8.5 scenarios for corn crop and wheat

ACKNOWLEDGEMENTS

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Funded by the European Union

DALIA

Danube Region Water Lighthouse Action

Pilot Site 6 Sturgeon migration by-pass Iron Gate I and II

Project implementation progress

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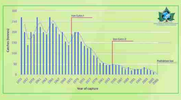
Among other R&I Missions, the European Commission has designated the '***Restore our Ocean, seas and waters by 2030***' **Mission** in order to provide a systemic approach for the restoration, protection and preservation of our ocean, seas, and freshwaters.2022 - 2025 comprises a *development and piloting phase* **-** Danube River Basin region Lighthouse with the **primary objective** of **protecting** and **regenerating** this water bodies' ecosystems and their biodiversity,

Implemented by a consortium of **22 expert organizations** from **8** different **Danube EU** and **Associated countries** (Hungary, Czechia, Romania, Slovakia, Germany, Serbia, Bulgaria and Ireland), ***DALIA*** **innovation actions** are supported by **9 Demonstration Pilot Sites (DPS)** from the **6 Danube River basin area countries** in that cover the specific outcomes in the project action and will serve as an input to forthcoming Horizon Europe projects and Missions.

INCDPM Bucharest implements the activities of ***DPS 6 - Sturgeon migration by-pass Iron Gates I and II*** that tackle the challenge to provide a technical & scientific solution in order to ensure the ***connectivity of the historical migration routes for the ultrasonic tagged sturgeon specimens*** upstream of the Hydropower System.

IMPLEMENTATION PROGRESS

✓ *Detailed analysis of the presence of sturgeon species* in the Lower Danube River, both historically and in their current situation, using the unique international database obtained from INCDPM's monitoring of ultrasonic tagged sturgeon specimens for over 12 years.



✓ *Scientific fishing* and *ultrasonic tagged sturgeons monitoring* activities have been carried out on the downstream sector of the Iron Gates II hydropower plant for the 2023 and 2024 Spring and Autumn seasons and in Spring 2025.

✓ Development of the general *GIS database with the Danube sectors* where the categories of activities within the project are carried out.

✓ The *design for the innovative solution* for the special transport of sturgeon specimens and the *by-pass strategies adapted for each hydropower plant of the Iron Gates I and II System* have been optimized in order to ensure both upstream and downstream crossing with minimized risk of injury of the ultrasonic tagged sturgeon specimens.

✓ *Behavioral analysis* was carried out for 9 ultrasonically tagged specimens and the optimal male vs female ratio (4 to 1) was determined to be used in the by-pass solution implementation.

✓ During 2024, in-situ *high-resolution multibeam* and *single-beam ADCP measurement campaigns* were carried out in order to build the databases with morphological (3D bathymetry and 2D bathymetric profiles) and hydrodynamic (water flow and velocity vectors). Those parameters are needed to accurately determine the optimal location for DKMR systems for monitoring ultrasonically tagged sturgeon specimens.

✓ There are determined 2 options for the configuration and placement of the *ultrasonic tagged sturgeons monitoring system in the Bazias area*, dependent on the involvement of the Serbian DALIA project partners.

Bazias – Iron Gates I Danube sector

Option A – monitoring stations placement on both RO and RS Danube sectors

Option B – monitoring stations placement only on RO Danube sector

ACKNOWLEDGEMENTS

This work was carried out through the HORIZON-MISS-2021-OCEAN-02-02 Danube river bazin lighthouse – restoration of fresh and transitional water ecosystems CALL, Action HORIZON - IA Innovation Action 2023-2026, Project DALIA, contract no. 101094070

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily express those of the European Union or European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

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Finanțat de Uniunea Europeană NextGenerationEU

"PNRR: Funds for modern and reformed Romania!"

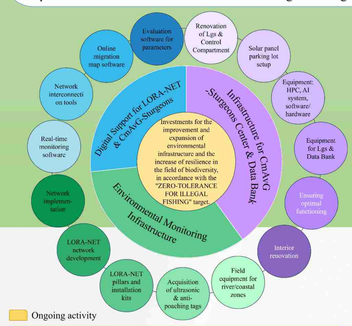
Planul Național de Redresare și Reziliență

IMPLEMENTATION OF A MONITORING SYSTEM FOR WILD STURGEONS ALONG THE LOWER DANUBE

Authors: ***DEÁK*** *György Eng. Ph.D Habil,* ***BOBOC*** *Mădalina Georgiana Eng. Ph.D,* ***MATEI*** *Monica Eng. Ph.D,* ***HOLBAN*** *Elena Ecol. Ph.D,* ***RAISCHI*** *Constantin-Marius Eng. Ph.D,* ***GHEORGHE*** *Petrache-Ionuț Eng.*

The project, with code number C2/I4.4., is financed by the National Recovery and Resilience Plan "PNRR: Funds for modern and reformed Romania!", Investment 4. Integrated investments for ecological reconstruction of habitats and species conservation related to grasslands, aquatic and water-dependent areas, Component 2: Forests and biodiversity protection, Milestone 39 - Operationalized network for monitoring, communication and data transmission of wild sturgeons.

The **general objective** refers to investments for the improvement and expansion of environmental infrastructure and the increase of resilience in the field of biodiversity through the development of a monitoring system for wild sturgeons along the Lower Danube (1500 km), combined with Artificial Intelligence (AI), in order to implement a recovery reform against poaching in accordance with the **"ZERO-TOLERANCE FOR ILLEGAL FISHING"** target set by the European Commission (EC) in the European Green Deal and the effects of climate change affecting the sturgeon population.



Ongoing activity

Acquisition of ultrasonic tags, acoustic monitoring receivers, and mobile monitoring equipment for ultrasonic tagged wild sturgeons

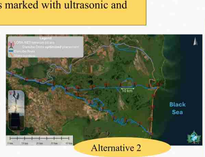
Acquisition of anti-poaching alarm tags

Acquisition of communication nodes and poles with installation kits (min. 150 pcs) for the LORA-NET network and field installation

Acquisition of sturgeon species and marking/release/monitoring services, and auxiliary materials for preserving DNA samples, isolation kits, nucleic acids, etc.

Execution according to the technical specifications of the monitoring stations - type DKMR/ DKTB (upgraded to be interconnected with the LORA-NET network) and their installation over a length of 1500 km for the scientific monitoring of wild sturgeons marked with ultrasonic and alarm tags

Alternative 1



Alternative 2

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