CHAIN REACTIONS

THEMATIC BRIEF BIOECONOMY

BIG DATA – ARTIFICIAL INTELLIGENCE JULY 2020

ABOUT THEMATIC BRIEFS

CHAIN REACTIONS addresses the challenge for industrial regions to increase regional capacity to absorb new knowledge and turn it into competitiveness edge and business value. There is a strong need to help SMEs to overcome capacity shortages for innovation and integration into transnational value chains.

The project aims at empowering regional ecosystems with the knowledge and tools to help businesses overcome those barriers and generate sustained growth through value chain innovation.

CHAIN REACTIONS focuses thereby on modern approaches considering value chains and their complex developments rather than linear technology transfer approaches. The framework of value chain innovation builds on Porter's 5 forces framework (new entrants, substitutes, customers, suppliers and rivalry) and transversal innovation drivers: key enabling technologies, resource efficiency, digital transformation and service innovation.

During the project lifetime CHAIN REACTIONS will publish about every 6 month five thematic briefs presenting the rationale behind specific innovation deployment within selected business areas.

This new brief of the CHAIN REACTION project presents the big-data and Artificial Intelligence (AI) revolution in the bioeconomy and looks at the state of the art of big data technologies and their application in this area. The importance of a well-functioning bioeconomy is increasingly recognized in addressing challenges like climate change, natural resource scarcity and unsustainable consumption patterns. We already discussed specifically about these environmental challenges and related impacts in a previous thematic brief. This new brief is now focusing on the overall optimised bioeconomy management that Big Data approaches and technologies could allow.

Big data and artificial intelligence in the bioeconomy

Introduction

According to the European Commission, the bioeconomy comprises those parts of the economy that use renewable biological resources from land and sea – such as crops, forests, fish, animals and micro-organisms – to produce food, materials and energy [1]. This economy is based on the sustainable production and conversion of renewable biomass into a range of bio-based products, chemicals, and energy. Several strategies have been produced in Europe from different perspectives that outline the roadmap for the transition to a bioeconomy. The digitalisation using Big data, Artificial Intelligence (AI) and Machine Learning (ML) is one of the key transformation to support development of the European bioeconomy and the transition towards sustainable development. Artificial Intelligence is becoming able to support processing the bioeconomy data in a smart way and, more specifically, Machine Learning could give machines access to these data and let them learn for themselves.

Indeed, farm machines, fishing vessels, forestry machinery, and remote and proximal sensors can provide large quantities of data. This large-scale data collection and treatment can enhance knowledge and the efficiency of decision-making processes can then be improved to increase performance and productivity in a sustainable way. The quality and timeliness of decisions can be raised by giving various bioeconomy actors the opportunity to react more quickly to deviations from normal situations.

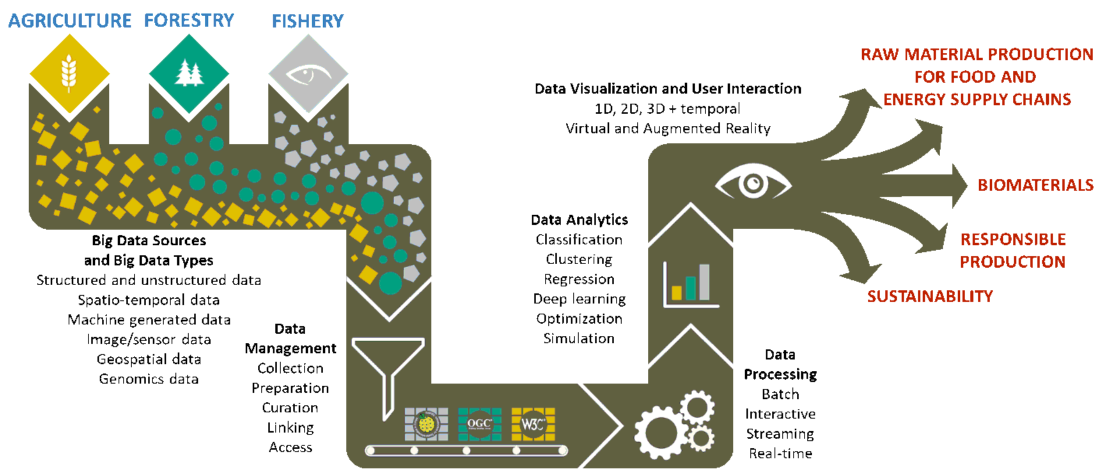

Figure 1 - Data-Driven Bioeconomy | DataBio Project | H2020 Cordis - Europa EU [2]

Digital Agriculture

Big data and AI technologies are together expected to support the development of „precision farming” [3] and to improve a wide range of agriculture-related tasks in the entire food supply chain. The farming industry is starting to use AI technologies to help higher yielding crops, control pests, and monitor soil and growing. These technologies organize data for farmers and help with workload management. The use of geo-coded maps of agricultural fields and the real-time monitoring of activities on the farm can increase the efficiency of resource use and reduce the uncertainty of decisions [4]. Studies have shown that ICT infrastructure improvements, such as increased mobile coverage, information services, real-time pricing and weather data resulted in increased income of farmers [5] and lower market prices [6].

Each farm produce thousands of data points on the ground daily. AI allows farmers for analyzing numerous things in real time such as weather conditions, temperature, water usage or soil conditions collected from their farm to better inform their decisions. For example, AI technologies help farmers optimize planning to generate more prolific yields by determining crop choices, the best seed choices and resource utilization. Indeed, the precise selection and application of exact types and doses of agricultural inputs (crop, fertilizers, pesticides, herbicides, water) for optimum crop growth and development help to increase the yield. BASF Digital Farming, a unit of the BASF group, developed an application for smartphone that uses machine learning and artificial intelligence (AI) in weed identification. Farmers can upload photos of weeds in the app, which then matches the photo against a comprehensive Bayer database to recognize the species. With each new image from each subscriber, the system gets smarter[7].

Farmers can also use AI to create seasonal forecasting models to improve agricultural accuracy and increase productivity. These models are able to predict upcoming weather patterns months ahead to assist decisions of farmers. Seasonal forecasting is particularly valuable for small farms in developing countries as their data and knowledge can be limited.

Big data has already changed heavily the farming work. There has been an explosive growth in the use of Remote Sensing data in recent years both in terms of volume and velocity.

- Sensors on fields and crops provide data points on soil conditions, information on wind, fertilizer requirements, pest infestations and water availability. Precision agriculture is detecting diseases in plants, pests, and poor plant nutrition on farms. These sensors can detect and target weeds and then AI decide which herbicides to apply within the right buffer zone.
- Geolocalisation of tractors allows for agriculture machinery usage optimisation. Tracking the machinery fleet allows localization of farm vehicles in real time.
- Unmanned aerial drones patrol fields and can capture images of the entire farm, thus allowing for large farms to be monitored very frequently. Computer vision and deep learning algorithms process these data and can alert problem areas and potential improvements.
- RFID-based traceability systems are already used to provide a constant data stream on farm products as they move through the supply chain.

Purpose	Example
Camera	Provides pictures of leaf health, lighting brightness, chlorophyll measurement and ripeness level. Also used for measuring leaf area index (LAI) and measuring soil organic and carbon lmake-up.
Global positioning system (GPS)	Provides location for crop mapping, disease/pest location alerts, solar radiation predictions and fertilizing.
Microphone	Helps with predictive maintenance of machinery.
Accelerometer	Helps determine leaf angle index, and used as an equipment rollover alarm.
Sensors	Temperature, UV exposure and humidity in crops.Temperature, pressure, sound in equipment to predict upcoming failure.
Gyroscope	Detects equipment rollover.

Table 1 - Agricultural uses of tools and sensors [8]

Forest

In most European countries, traditional methods for forest management are based on “static” management plans, created at the planting stage and reviewed every 10 years. In recent years, these management plans have become a declaration of intentions, including objectives for multifunctional forests (non-wood products and services). However, these plans often lack effective implementation and monitoring methods that allow forest owners, managers and regulators to validate the progress in achieving the target objectives set out in the management plan.

Using satellite radar data, scientists have created a global map that quantifies the amount of wood in our forests - a key to understanding Earth's carbon cycle and, ultimately, climate change. To understand the carbon cycle better, scientists use forest carbon stock estimates from Earth observation data [11]. One of the parameters for these estimates is 'growing stock volume', which describes how many cubic metres of wood are estimated per hectare. Stock volume represents above-ground carbon and is thus one of the most important variables in the global carbon cycle. ESA's GlobBiomass project is paving the way for a synergistic Earth observation approach to the operational monitoring of carbon stocks globally. The project exploits archived radar and optical data - including data from the Sentinel fleet of satellites - to develop new algorithms in cooperation with expert teams from across the globe.

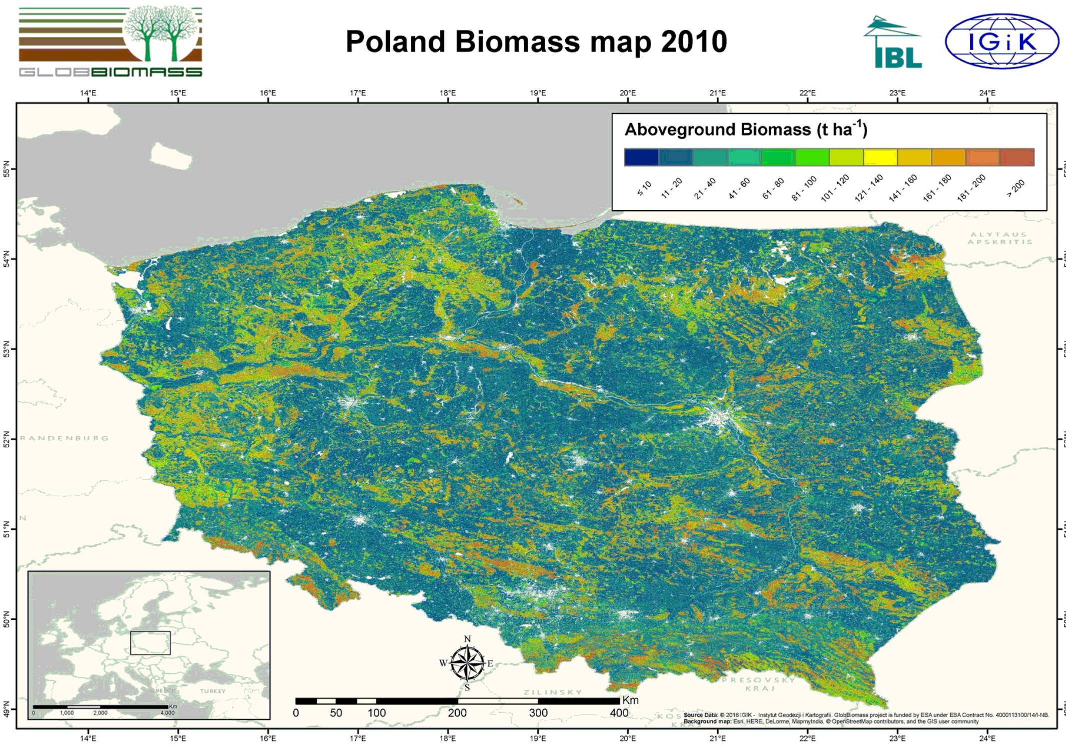

Figure 2 – GlobBiomass project [12]

Map biomass in Poland derived from satellite radar data in 2010. Orange represents areas of high above-ground biomass, while blue areas have very little.

Big data methods bring the possibility to both increase the value of the forests as well as to decrease the costs within sustainability limits set by natural growth and ecological aspects. The key technology is to gather more and more accurate information about the trees from a host of sensors including new generation of satellites, UAV images, laser scanning, mobile devices through crowdsourcing and machines operating in the forests. This enables a characterization of even single trees. Once accurate forest information has been gathered, the following step is to employ tools that mobile and cloud technology recently have made available and deposit the measured data onto digital platforms that can be accessed by a variety of user devices. The precise databases enable a sustainable growth of timber extraction, an optimized use of the tree raw material and a higher long-range growth of the biomass by precise support actions. At the same time, the costs for management, labour and timber transport can be significantly reduced, which gives gains also in the short run. There will be a variety of new services e.g. relating to timber sales, working and transport assignments, that create economic growth.

Fisheries

In the fisheries sector, companies are ramping up their digitalisation efforts to start harvesting the benefits from applying Big Data technology to optimize their business. Vessel monitoring systems (VMS) are the baseline for the deployment of big data and AI systems in this sector. Theses systems are used in commercial fishing to allow environmental and fisheries regulatory organizations to track and monitor the activities of fishing vessels both in a country's territorial waters and the Exclusive Economic Zone. Vessel equippers as well as manufacturers of fish finding and catch equipment are continuously increasing the capacity and functionality in their systems to store and collate data. But, rather than opening up their systems and sharing data , major industrial players are focusing on building their own Big Data platforms to gain a business edge for their products through more advanced analytics.

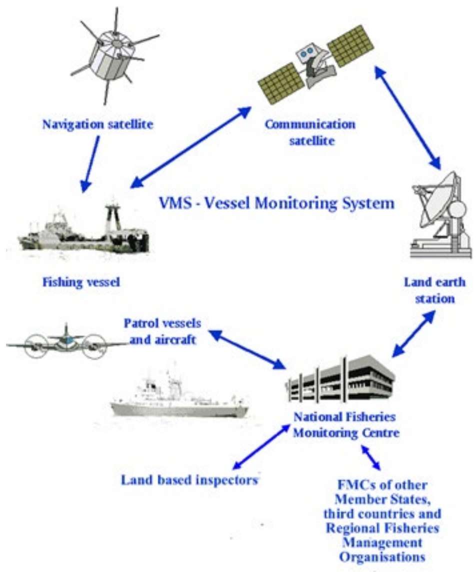

Figure 3 - Vessel monitoring systems (VMS) [14]

Machine learning based approaches using satellite data have already been successfully implemented in forecasting species recruitment and identifying new predictors [15][16]. Novel machine learning methods can even take advantage of suspected interactions between species. Recent advances in image analysis have also shown promising results for automated classification of marine samples.

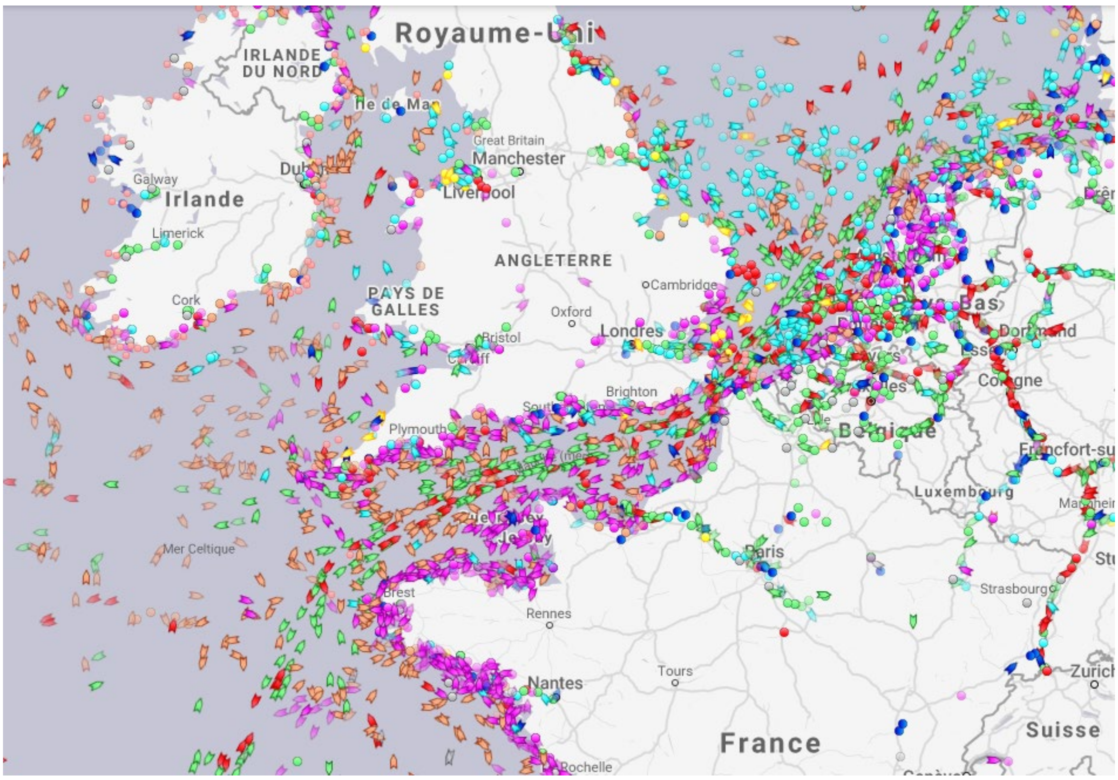

Figure 5 - Marine Traffic information portal [17]

BarentsWatch

BarentsWatch is a public monitoring and information system launched in 2012 and dealing with large parts of the northern seas. The “FishInfo” service is showing where fishing activity is ongoing and which areas have been closed or restricted for fishing [18]. Ice edge and concentration are also documented in real time as well as any king of sea danger (coral reefs, planned seismic activities, etc.).

Earth Observation data services

Earth observation have a key role in the European bioeconomy with extending data-collection possibilities.

- Operative aerial Remote Sensing allow for mapping fields at high spatial resolution but with low frequency (also known as temporal resolution). The aim is for instance to prepare prescription maps for applications of fertilizers and pesticides or to control forest health. Aerial imaging is usually carried out using a multispectral camera by an external provider of photogrammetric services. Analyses may be then performed through interpretative algorithms after pre-processing of the acquired images, i.e. radiometric and geometric corrections.
- Periodic satellite Remote Sensing can be used for the wide-ranging identification of spatial variability and for the simultaneous capturing of the dynamics of vegetation growth.

The importance of Open Data for the bioeconomy

Open Data is also a powerful tool for long term sustainable development of AI and Machine Learning solutions by improving economic opportunity for farmers, fishers and the whole wood industry. Open access to data is even vital for nutritional security. Open data will play a crucial role in helping the agriculture, forest and fisheries sector navigate and thrive through Industry 4.0. It has the potential to transform these sectors and facilitate food security and overall resources management around the world. These datasets include weather data, data on seed genetics, data on environmental and sea conditions, and soil and forest data. To elaborate on how datasets can impact these sectors, take the example of weather data for farmers: if weather data from weather records are made open, it will be possible for farmers to plan their planting season and increase their yield by reducing the risk of frost or drought damaging their crops. In addition, if weather data is made open, farmers can optimize their water irrigation system to prepare for rainy or dry days and not over water or neglect watering their crops.

There are already several ongoing initiatives around the world that focus on data and agriculture. For example, the Technical Center for Agricultural and Rural Cooperation (CTA) is a joint international institution of the African, Caribbean and Pacific (ACP) Group of States and the European Union (EU) that supports other institutions in their goal to promote sharing agriculture data. Many national or regional agencies are also providing open data regarding local forests that can be used in Geographic Information Systems (GIS), like Forestry European Commission’s Open Data Site for spatial data [19] or Office National des Forêts in France [20].

In the fisheries sector, Global Fishing Watch is committed to making as much of its data and code publicly available as possible. Their web site provides many links to datasets for download, dealing with fishing effort, fishing vessels, transhipment, anchorages and other data [21]. But, although large efforts have been done to make scientific marine data sets available, e.g. EMODnet, NOAA, Copernicus, the problem is still that much of the industrial data in fisheries is either not recorded or is considered as business sensitive and therefore not shared or openly available.

Innovative SMEs – examples from the CHAIN REACTIONs' regions

Scanway sp. z o.o.

Scanway imaging space

www.scanway.pl/en

The company

Scanway is a Polish SME specializing in vision systems, remote sensing, image processing and 3D measurements. In terrestrial applications we focus mainly on vision systems for quality controlling. Currently developing own product – HyperEye – which will use smart IoT multispectral system for food&pharma quality control. Different activities of the company include development of optical payloads for Polish small satellites designated for Earth Observation.

Poduct / Service

Scanway is right now developing HyperEye system, which is a smart vision system for quality control in food&pharma sector. Due to the use of multispectral camera, we can see more shades of colours of the inspected element than regular cameras do. HyperEye will consist of camera, special illumination system and what is the most innovative aspect of this product – special electronic systems for data processing, which will allow the use of machine learning algorithms.

Cameras which will be used in HyperEye can see more than human naked eye, which means that they also produce a lot more data. Such information must be somehow processed into the end results, which will give a unequivocal result of quality inspection. Due to the small dimensions of the system, its modularity and smart features, it is necessary to use machine learning algorithms in order to process this amount of data.

All the information that are normally processed by HyperEye's FPGAs will have a possibility to be stored on external server, which means that this product will be also related to the big data itself. In conventional industry there is a need to store data for a long period of time (e.g. due to the guarantee issues), so proper data structure and its processing is also a key feature.

Processing electronics will be based on newest FPGA processors, which allow to process the spectral signatures in CUDA technology.

Possible applications for food sector include sorting and quality control – segregation of different products on one line, detection of foreign elements and pathogens or separation of edible and inedible plants.
Possible applications for pharma sector are mainly related to non-contact composition analysis (e.g. defective composition of pills in the package).

AGB GROUP s.r.o.

https://www.agbgroup.sk/

The company

AGB GROUP is Slovak innovative cooperative focused on research and provision of services in the area of agriculture, horticulture and forestry. New generation of farmers with IT background has acquired the cooperative few years ago and since then, it has gone through transformation process and become a modern facility, which takes into account innovative business practices and trends in agriculture. When proposing solutions in precision farming, the company uses its professional experience in the field of analysis and research of agrotechnological practices in Slovak agricultural holdings.

Poduct / Service

The cooperative is managed by new generation of farmers with IT background, therefore applying new business model to agricultural production in Slovakia. It is focused on the optimization of processes and on the development of new products and services.

This modern Slovak farm is working on a concept of “robotic farm” with maximum animal welfare. This especially includes robotic milking and feeding (precisely mixed dose of feed, which is fed robotically - in the exact quantity - at the right time), thus aiming for better waste management, protection of the environment and animal welfare, less spread of diseases, etc. The instruments and tools applied within the robotic farm offer farmers a more complex picture of their livestock: animal health & welfare, fertility and the quality of milk they produce.

It is active in the area of smart and innovative precision farming and it is working on efficient data management system based on the exploitation of drones, unmanned aerial vehicles and information technologies to traditional agricultural production. The cooperative has a registered drone, which allows them to perform multispectral scanning and mapping of agricultural land, to monitor crops, or even to analyse the amount of biomass on the field / in forest. The cooperative is working with numerous partners on improving the processing and exploitation of collected data in order to monitor and manage the legal property, to measure crop damages, to predict and evaluate the crop maturity as well as to detect crop diseases. It is continuously developing smart farm management system in order to achieve optimization of processes and elimination of inefficiencies in the whole production chain.

Conclusion

The use of big data technologies and AI services in the bioeconomy offer significant benefits and can address challenges of heterogeneity and incompleteness of data, need for processing of large and rapidly increasing volumes, timeliness requirements, and privacy concerns among others.

Big data and AI also drive use of new technologies in the bioeconomy sector such as cloud computing, blockchain, and the Internet of things (IoT). Various IoT-based applications are going in the very next future to improve bioeconomy processes and make farms, fisheries and wood industry smarter, such as precision farming, fishing and forest management, driverless tractors and machines, agricultural drones/robots, monitoring and smart irrigation.

Literature

[1] European Commission, Research and Innovation, Bioeconomy. http://ec.europa.eu/research/bioeconomy/index.cfm

[2] DataBio Project, https://www.databio.eu/fr/

[3] Schriber, S. no date. Smart agriculture sensors: helping farmers and positively impacting global issues, too [online] United States of America. [Cited 23 April 2019]. https://www.mouser.ch/applications/smart-agriculturesensors/

[4] Se garra E, 2002. Precision agriculture initiative for Texas high plains. Annual Comprehensive Report. Lubbock, Texas, Texas A&M University Research and Extension Center.

[5] Mittal, Surabhi and Gaurav Tripathi. „Role of mobile phone technology in improving small farm productivity“ Agricultural Economic Research Review 22, 2009

[6] Waverman, Leaonard Meloria Meschi and Melvyn Fuss. „The impact if telecoms on economic growth in developping countries“ The vodaphone policy paper series 2, 2005.

[7] Xarvio web site, https://www.xarvio.com/

[8] Sch ellberga J, Hill MJ, Gerhards R et al., 2008. Precision agriculture on grassland: Applications, perspectives and constraints. Europ. J. Agronomy 29: 59-71.

[9] NEUROPUBLIC S.A.'s website, https://www.neuropublic.gr/

[10] Adamides, G.; Kalatzis, N.; Stylianou, A.; Marianos, N.; Chatzipapadopoulos, F.; Giannakopoulou, M.; Papadavid, G.; Vassiliou, V.; Neocleous, D. Smart Farming Techniques for Climate Change Adaptation in Cyprus. Atmosphere 2020, 11, 557.

[11] European Space Agency (ESA), „Mapping the world's forests“, http://www.esa.int/Applications/Observing_the_Earth/Mapping_the_world_s_forests

[12] ESA DUE Globbiomass project, https://globbiomass.org/

[13] Wuudis Solutions Oy, https://www.wuudis.com/

[14] European Commission, Vessel monitoring system (VMS), https://ec.europa.eu/fisheries/cfp/control/technologies/vms_en

[15] Fernandes, J. A. and all "Fish recruitment prediction, using robust supervised classification methods". Ecological Modelling, 221(2), 338-352.

[16] Fernandes, J. A. and all "Supervised pre-processing approaches in multiple class variables classification for fish recruitment forecasting. Environmental modelling &software", 40, 245-254, 2013.

[17] Marine Traffic Portal, Exmile Solutions Limited, https://www.marinetraffic.com

[18] www.barentswatch.no

[19] Forestry Commission, http://data-forestry.opendata.arcgis.com/

[20] Office national des forêts, Open Data sets, https://www.data.gouv.fr/fr/organizations/office-national-des-forets/

[21] Global Fishing Watch, Inc., https://globalfishingwatch.org/datasets-and-code/