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Information provision for monitoring the sustainable development of the land and biodiversity

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Abstract. The study is focused on gathering information to monitor sustainable land development and biodiversity. The article discusses the objectives and measures required to achieve Sustainable Development Goal 15 "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss". This paper shows the results of the analysis of key indicators and values for Ukraine. It also contains the developed conceptual diagram for managing the sustainable development of ecosystems and biodiversity. There were identified the main sources of statistical information, including traditional enterprise-level data and big data, and analyzed changes in indicators for monitoring the achievement of the Sustainable Development Goals at micro level under section "Environmental area". The study also identified potential sources of information for calculating the presented indicators and explored the use of big data to develop an information base for monitoring, evaluating, and policy development related to sustainable land development and biodiversity. Further research and studies are needed to determine the algorithms of data processing, modelling and constructing of integrated indicators.

1. Introduction

On September 25-27, 2015, the UN Summit was held in New York within the framework of the 70th session of the General Assembly of the United Nations. During the high-level meeting on sustainable development, 193 member states of the United Nations (UN) officially adopted a new program in the field of sustainable development, entitled "Transforming our world: The 2030 Agenda for Sustainable Development". The program officially entered into force on January 1, 2016 [1].

The term "sustainable development" was first used by the International Commission on Environment and Development in 1987 and was defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The concept of sustainable development was adopted at the UN Conference on Development and Environment in Rio de Janeiro in 1992 [1].

To achieve sustainable development, it is extremely important to coordinate three main components – economic growth, social integration and environmental protection. These components are interconnected and extremely important for well-being of individuals and society as a whole. Therefore, sustainable development is defined as development that meets the needs

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of the present generation without compromising the ability of future generations to meet their own needs.

UN member states have identified 17 sustainable development goals (SDGs) for the period up to 2030 and 169 tasks. These goals and objectives can be applied to any society. Achieving the SDGs requires all countries to integrate them into their national strategies and plans [1]. SDGs are not legally binding. It is assumed that governments of all countries take responsibility and create national mechanisms that will contribute to the achievement of the stated goals. In order to promote prosperity and protect the entire planet, the SDGs call for action by all countries without exception – poor, rich and middle-income countries. They are global in nature and universal in application, but at the same time take into account development specificities, national potential, as well as national strategies and priorities. Since they are interrelated, efforts to achieve them should be comprehensive.

At the global level, a set of indicators is used to monitor and review the process of implementing goals in the field of sustainable development and tasks of the new agenda [1]. Countries bear the primary responsibility for follow-up and review of progress in the implementation of goals, and for this it is necessary to ensure the collection of high-quality, accessible and relevant data.

Biodiversity is a key theme of the UN's 2030 Agenda for Sustainable Development which corresponds to SDG 14 and 15.

SDG 14 is dedicated to "Conserve and sustainably use the oceans, seas and marine resources".

SDG 15 is dedicated to "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss".

2. Aim and methodology

Aspects of information provision of sustainable development were reflected in the works of Ukrainian statisticians [2].

Issues related to biodiversity monitoring, aspects of the importance of ensuring the long-term preservation of and access to data are considered in the works of Hardisty et al [3], Alblas and van Zeben [4], Alkemade et al [5], Navarro et al [6], Barral and Guillet [7], Moersberger et al [8], Schmeller et al [9], Schmidt et al [10], Blanco-Zaitegi et al [11], Brörken et al [12], Xie et al [13], Lu et al [14], Cipullo [15], Estoque et al [16], Ren et al [17], Tóth et al [18], Kong et al [19], Li and Lei [20], White et al [21], Spangenberg [22].

Study of Hardisty et al [3] is devoted to the issues of Essential Biodiversity Variables (EBV) – the fundamental variables that can be used for assessing biodiversity change over time, for determining adherence to biodiversity policy, for monitoring progress towards sustainable development goals, and for tracking biodiversity responses to disturbances and management interventions.

The research of Navarro et al [6] contributes to deepening of the understanding of coordinated observing system adopted by GEO BON, focusing on two interconnected core components – the Essential Biodiversity Variables as a standard framework for biodiversity monitoring, and the Biodiversity Observation Networks that support harmonized observation systems – while highlighting their societal relevance.

Moersberger et al [8] presented two key clusters of needs in Europe over the next 5-10 years: 1) biodiversity data are needed to ensure integrated cross-sectoral policies; 2) biodiversity data are needed to increase policy impact and effectiveness to fulfil goals of the EU Biodiversity Strategy.

Schmeller et al [9] presented a globally coordinated approach is needed for biodiversity monitoring that is linked to environmental data and covers all biogeographic regions. They identified nine requirements that they believe are necessary for developing and implementing such a global terrestrial species monitoring program: 1)designing and implementing an integrated information chain from monitoring to policy reporting; 2) capacity-building to create a comprehensive spatial monitoring program; 3) implementing minimal data standards to capture EBVs; 4) implementing common monitoring protocols; 5) developing and optimizing semantics and ontologies for data interoperability; 6) integrating emerging technologies (monitoring, data management and analysis); 7) coordinating diverse but complementary local nodes; 8) facilitating and securing funding.

Schmidt et al [10] reviewed different sampling strategies, methods of data collections and analysis according to the monitoring of habitat distribution, species population, species trends, etc.

Tóth et al [18] proposed frameworks of soil-related sustainable development goals and related indicators which can be monitored in current monitoring schemes.

Spangenberg [22] suggest simple ordinal scale index for monitoring of land use intensity changes. It is based on the hemeroby concept, measuring the human impact as deviation from naturalness. This makes it an information collection and presentation tool for those working in landscape planning and management.

Our research is devoted to information provision for monitoring the sustainable development of the land and biodiversity, which is primarily related to monitoring the achievement of the SDG 15.

Parties of the United Nations Convention on Biological Diversity are making efforts to ensure functioning of the global biodiversity conservation system for the period after 2020, the goal of which is to stabilize the loss of biodiversity by 2030 and fully restore natural ecosystems by 2050.

The purpose of sustainable development management ecosystems and biodiversity can be formulated as ensuring adaptability of society to preservation and improvement of the environment, responsible use of ecosystems and restoration of biodiversity.

3. Method

The use of statistical methods provides an opportunity to assess the level of achievement of the above-mentioned goal and outlines methods of accounting for aspects of sustainability.

Conceptual block diagram of information provision for the regulation of sustainable development of ecosystems and biodiversity which characterizes structure and sequence of operations aimed at justifying management decisions, is shown in figure 1.

A necessary condition for ensuring a systematic study of sustainable and responsible use of ecosystems and restoration of biodiversity is the formation of a single open database as an information source for ensuring management.

The content of analytical work consists of bringing disparate information to a logically constructed system of relationships, which makes it possible to give a reasonable assessment of both the entire set of facts and each of them separately, and to determine their role in solving the investigated problem.

The analysis of the dynamics of development components forms the basis of an objective assessment of the identification of trends and regularities.

The use of statistical methods makes it possible to translate many management problems into plane of accurate quantitative display with qualitative content, based on real information provision of calculations in accordance with user needs.

Appropriate software speeds up and improves information processing, significantly expanding the range of tasks that can be solved using statistical methods in the management process. This provides a creative approach to the performance of specific management tasks, the search for new ways to improve the quality and validity of management decisions, and the development of measures to improve efficiency in all areas of activity.

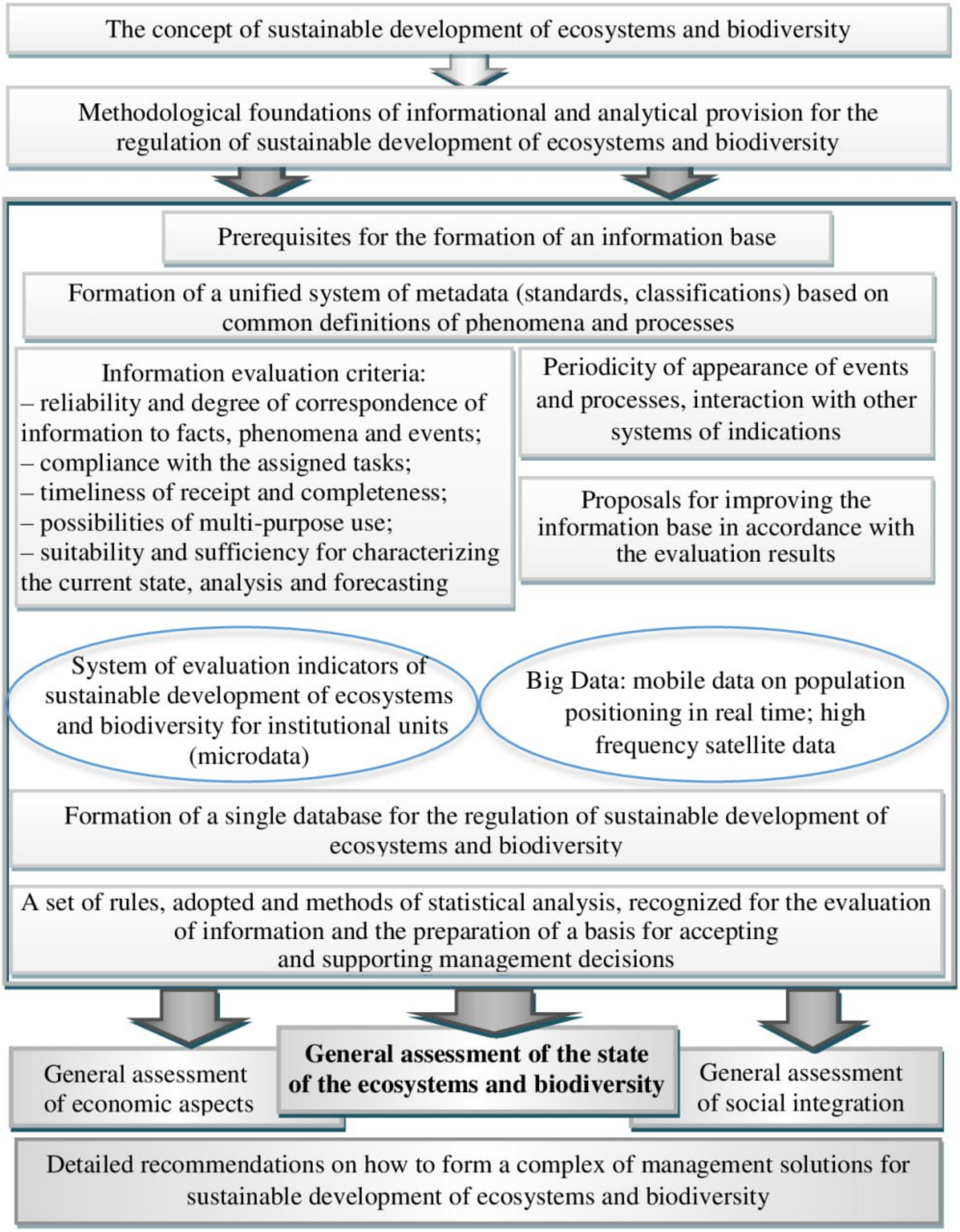

Figure 1. Conceptual block diagram of information provision for the regulation of sustainable development of ecosystems and biodiversity.

Statistical analysis should be used to determine the relationships between phenomena, the influence of the main factors on them, among which, in particular, those that arise as a result of the action of objective laws and cause the emergence of risks are distinguished. To do this, statistical models of various types of relationships are used – functional, stochastic, correlational.

On basis of the above directions of analysis, possibility of comprehensive usage of their results to reveal the mechanism of socio-economic phenomena and processes is determined. In particular, this refers to the economic efficiency of the information obtained based on the ratio of results and costs for obtaining it.

Based on the results of the statistical analysis, the main directions of management aimed at ensuring sustainable use of ecosystems and restoration of biodiversity are determined, taking into account objectively existing potential opportunities. At the same time, a list of tasks is formed, the sequence of their execution, methods of solving and mutual consistency of these tasks are determined. This creates a methodology for substantiating management decisions using statistical methods.

In this way, information provision of the system interconnection of target complex programs is formed: socio-economic, scientific-technical, digital, environmental, investment, regional, etc. in the system of ensuring sustainable use of ecosystems and restoration of biodiversity. It should be noted that in the process of developing and using information provision for sustainable development, it is necessary to use international standards, classifications and unified definitions (interpretations) of phenomena and processes that summarize modern world experience, as well as contribute to the prompt implementation of national analogues.

The problem of training modern specialists in statistics, who are able to perform the functions of analysts, experts and consultants in the field of management, is connected with the rapid development of the information society and the widespread introduction of information and communication technologies. Statisticians-analysts must be aware of availability of the necessary sources of statistical information in accordance with the formulated management tasks, systematize and classify it; apply the methods of its processing, generalization and drawing conclusions, as well as creatively use the obtained results of the analysis to prepare management decisions regarding sustainable local development and evaluate in real time the consequences of such management decisions.

4. Research results

4.1. Microdata

Company reporting is an important source of data for the Central Bank monitoring system. As the primary source of information on company performance, reporting can significantly improve SDGs monitoring mechanisms by providing stakeholders such as governments, investors and businessmen with instruments to assess the economic, environmental and social impact of companies on sustainable development. Accounting data for the formation of key indicators should be collected at the level of an institutional unit and aggregated by region.

Institutional units usually consist of several different units that produce different products/services and have different locations. In the system of national accounts, they are called establishments, and when tied to a certain territory – a local kind-of-activity units – LKAU [23]. This is especially true for large enterprises. The collection of data by individual institutions enables organizations with the necessary flexibility to meet a number of reporting requirements and facilitates compilation of environmental indicators.

For example, collection of data on environment at the level of individual objects will allow more detailed determination of areas of increased environmental danger. If an entity has facilities in different locations, it is likely that they operate under different conditions and have different environmental impacts. Therefore, it is useful to collect and compile environmental indicators for each facility first and then aggregate the reporting of institutional unit.

Development of a unified list of main indicators for reporting by institutional units to ensure monitoring of SDGs achievement was initiated by UNCTAD (United Nations Conference on Trade and Development) in 2016 and extended in 2017 and 2018 [24]. In 2022, guidelines were issued on the definition and calculation of the main indicators for monitoring the achievement of the SDGs at the micro level [25].

The results of a detailed analysis of the changes in the indicators presented in the guide for 2016-2022 at the level of the group “Environmental area” are shown in figure 2.

Based on the results of case studies, discussions at the Advisory Group meeting and taking into account key international developments in this area, UNCTAD revised the main indicators of the SDGs. As a result, in 2022 minor changes were made to the measurement methodology and normalization of indicators, as well as clarification and elimination of inconsistencies. However, the main result was the addition of the main indicators of the SDGs with an indicator on land and biodiversity.

In the group of indicators “Ecology” of the micro level was added subgroup B.6 “Land and biodiversity”, which includes indicator B.6.1 “Lands Used Near Biodiversity Sensitive Areas”. This indicator is defined as the number and area (in hectares) of plots owned, leased or managed in protected areas and/or key biodiversity areas (KBA) or adjacent to them, i.e. those areas on the planet, which are critical to the survival of unique plants and animals, as well as ecological communities.

Indicator B.6.1 measured in accordance with the proposal set forth in [26]: “KBAs provide a science-based and internationally recognized means of identifying sites that make a significant contribution to global biodiversity conservation, while protected areas indicate nationally (and often internationally) recognized areas of ecological or cultural importance, typically with special legal protection. Conducting operations in or near such areas indicates an increased risk of adverse impacts on biodiversity and an increased risk of associated legal or reputational risk.”

For reporting on this indicator B.6.1, the reporting entity must [25]:

- determine the location of surface and underground lands that may be owned, leased or managed by the organization;
- assess whether the land owned, leased or managed is located in protected areas/KBA and/or is adjacent to a protected area/KBA and/or contains parts of a protected area/KBA;
- determine amount and size of land owned, leased or managed, which is located in protected areas/KBA and/or is adjacent to a protected area/KBA and/or contains parts of a protected area/KBA, expressed in the number of hectares.

Among the potential sources of information, the following were identified.

(i) Information about the location of KBA (figure 3) can be found at [27].
As we can see that for Ukraine the information is presented for the year 2000.

(ii) Information on protected areas (figure 4) can be found by searching the global database at [28].

A number of events at the international level have changed format and framework of reporting on sustainable development. Attention should be paid to the fact that in November 2021 at the twenty-sixth Conference of the Parties within the framework of the UN Conference of the Parties on Climate Change [29] the International Sustainability Standards Board (ISSB) was announced. This new international body is engaged in the creation and development of international financial reporting standards related to sustainable development, which should become mandatory for institutional units in many countries of the world. Therefore, Ukraine should accelerate national efforts to create, establish or strengthen the technical capacity that will ensure compliance with the new reporting standards [30].

Sub-Area	Indicators 2016	Indicators 2022	Measurements (2022)	Relevant SDG indicator
B.1. Sustainable use of water		B.1.1: water recycling and reuse	Total volume of water recycled and/or reused by a reporting entity during the reporting period in absolute amount and in % terms	6.3.1
	B.1: water consumption per net value added	B.1.2: water use efficiency	Net value added divided by the water use in the reporting period as well as change of net value added divided by the change of water use between two reporting periods	6.4.1
		B.1.3: water stress	Water withdrawn with a breakdown by sources and with reference to water-stressed or water-scarce areas in absolute amount and in % terms	6.4.2
B.2. Waste management		B. 2.1: waste generation	Change in the entity's waste generation per net value added in % terms, in terms of change and in absolute amount	12.5
	B.2: waste generated per net value added	B.2.2: waste reused, remanufactured and recycled	Total amount of waste reused, remanufactured and recycled in absolute amount, in % terms and in terms of change	12.5.1
		B.2.3: hazardous waste generation	Total amount of hazardous waste, in absolute terms, as well as proportion of hazardous waste treated, given total waste reported by the reporting entity	12.4.2
B.3. Greenhouse gas emissions	B.3: greenhouse gas emissions (scopes 1–2) per net value added	B.3.1: greenhouse gas emissions (scope 1)	Scope 1 contribution in absolute amount, in % terms and in terms of change	9.4.1
		B.3.2: greenhouse gas emissions (scopes 2)	Scope 2 contribution in absolute amount, in % terms and in terms of change	9.4.1
B.4. Chemicals, including pesticides and ozone-depleting substances		B.4.1: ozone-depleting substances and chemicals dependency	Total amount of ozone-depleting substances (ODS) (bulk chemicals/substances existing either as a pure substance or as a mixture) per net value added.	12.4.2
B.5. Energy consumption		B.5.1: share of renewable energy	Renewable energy consumption as percentage of total energy consumption in the reporting period	7.2.1
	B.5: energy consumption per net value added	B.5.2: energy efficiency	Energy consumption per net value added	7.3.1
B.6. Biodiversity		B.6.1: land use adjacent to biodiversity sensitive areas	Number and area (in hectares) of sites owned, leased or managed in or adjacent to protected areas and/or key biodiversity areas	

Figure 2. Core Sustainable Development Goal Indicators: Environmental area.

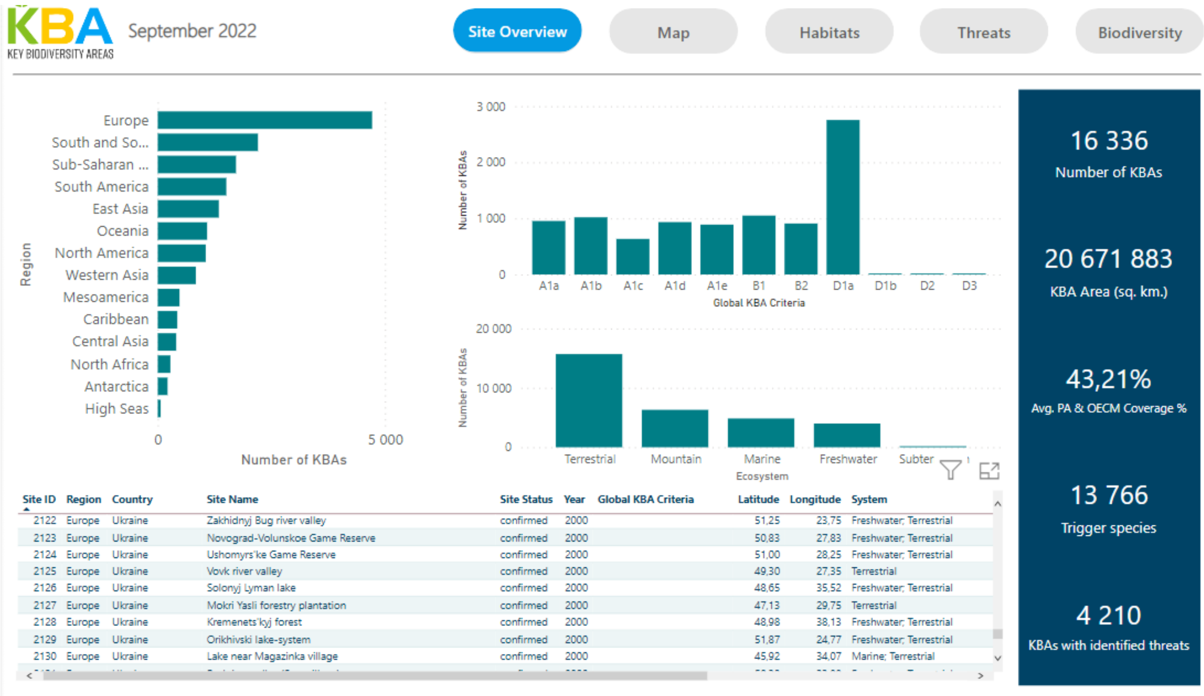

Figure 3. Key Biodiversity Areas (KBA) database.

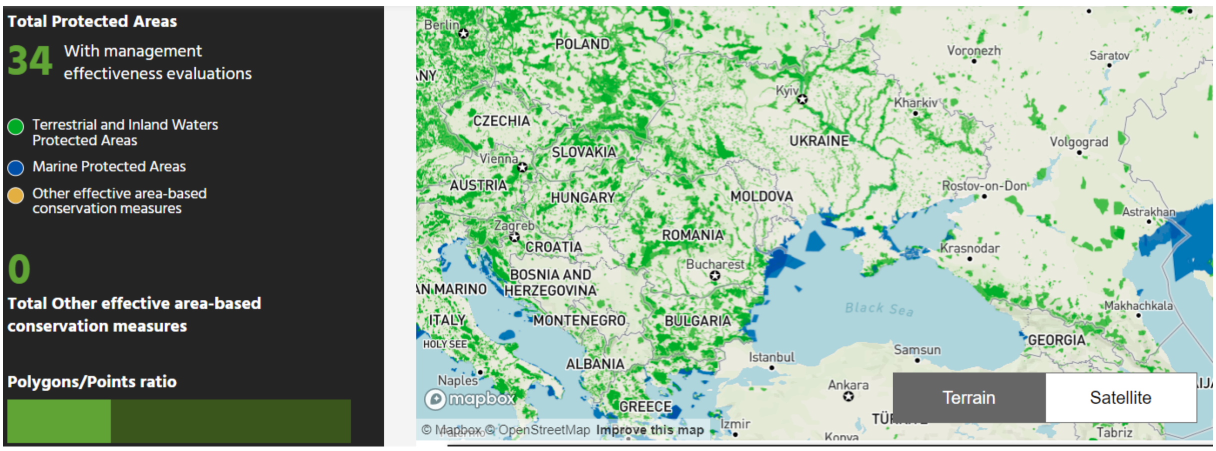

Figure 4. Protected areas from the Protected Planet global database.

Recent world events have reinforced the need for guidelines to support policymakers in building a robust national sustainability reporting infrastructure. This would ensure high quality reporting and support the implementation of future ISSB standards. All of the above confirms the relevance and importance of transparent measurement and disclosure, as well as comparability and reliability of information on sustainable development.

But it should be taken into account that placing an excessive burden on institutional units may harm the involvement of the private sector in obtaining quality information necessary to monitor the achievement of the SDGs. Therefore, it is recommended to apply a step-by-step approach, according to which, for the selected indicators, first the problems that the institutional unit controls and for which it collects relevant data are identified, or situations in which the company has unimpeded access to relevant sources of information.

4.2. Big data

The emergence of "big" data is closely related to the development of information and communication technologies. In today's hyper-connected digital world, people and things leave "digital footprints" in many different forms, creating ever-increasing streams of data, including commercial transactions, private and public records that companies and governments collect and store, created by users online materials such as photos, videos, tweets and other messages, as well as traces left by the Internet of Things (IoT), i.e. those uniquely identifiable objects that can be tracked.

There is no single, unique definition of this relatively new phenomenon known as "big data". At the most basic level, big data refers to data sets whose volume, velocity, or diversity are very high compared to the types of data sets that have traditionally been used. It is appropriate to refer to such definitions of the essence of this concept, with which most scientists agree. The first definition was proposed by Marv Adrian in 2011 in an article for Teradata Magazine: "Big data is data that cannot be collected, managed and processed with the help of the most commonly used hardware environments and software tools within the time allowed by the user" [31].

The data revolution, which includes the open data movement, new ICTs for data collection and the availability of big data, together with the emergence of artificial intelligence and the Internet of Things, has led to a radical transformation of society. Recently, "big data" began to be processed and analyzed in order to find relationships in economic and social systems, which was previously carried out with the help of surveys, experiments and other types of data collection, on the basis of which solutions were developed and forecasts were built.

Real-time mobile population positioning data and high-frequency satellite data are just main examples of big data that can be used to monitor the achievement of SDG 15.

Fixed and mobile telecommunications network operators, including Internet service providers, are an important source of data, and all forms of telecommunications big data (volume, speed or diversity) are considered for analysis purposes. Most telecommunications data can be considered as the result of an action (for example, making a call, sending an SMS, accessing the Internet or recharging a prepaid card).

An example of how mobile network data can track population movements is the 2010 Haiti earthquake. Figure 5 shows the number of people estimated to be in Port-au-Prince (PaP) on the day of the 2010 Haiti earthquake and outside the capital 19 days later [31].

One of the main projects aimed at integrating the development of big data for monitoring, evaluation and policy development within Group on Earth Observations Biodiversity Observation Network (GEO BON) is UN Biodiversity Lab [32], a geospatial information platform that maps natural resources and monitors environmental risks in real time using existing data and new digital technologies.

As part of the above-mentioned project, in 2022 the calculated data sets and indicators were included in the existing decision support system based on the UN Biodiversity Laboratory. Project data and indicators will be regularly updated until 2030 through the UN Biodiversity Lab [32]. The project is also a demonstration of the Observations for Sustainable Development Goals initiative [33]. The results of the project are expected to provide modern digital foundation for scaling up this forecasting methodology to more countries around the world working to monitor progress towards SDG 15. The project envisages widespread use in 170 UNDP partner countries of datasets, a brief the characteristics of which are presented in figure 6.

Within the framework of this study, the available statistical data on the considered data sets, included in the existing decision support system, using the electronic database of the UN Biodiversity Lab [32]. Below, for example, the results for several main blocks are presented.

Global Forest Change. Many organizations deal with forest change issues, so the

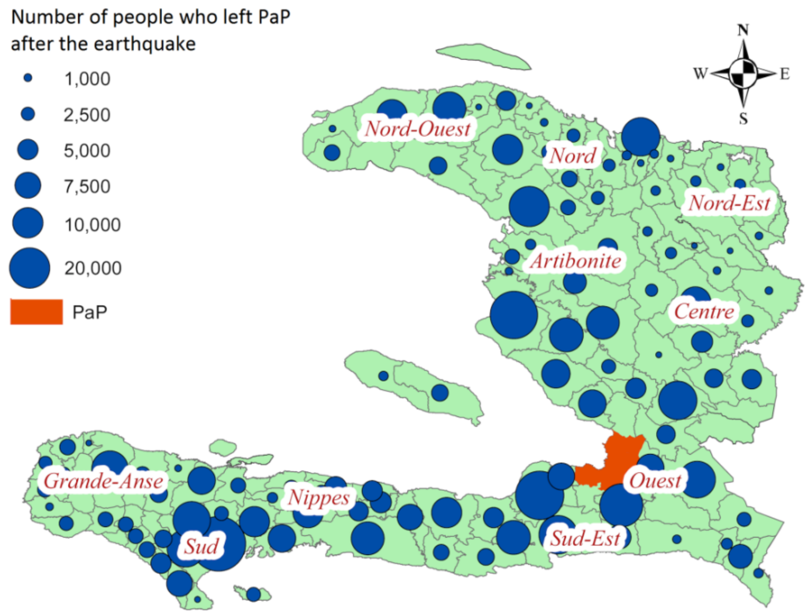

Figure 5. Tracking the mobility of the population in emergency situations using mobile phones (circles are shown for communes that received at least 500 persons).

definitions related to this concept are important and should be unified during the information provision of the study. Below are the definitions used by the FAO Forestry Department:

- Forests are lands of more than 0.5 hectares, with a tree canopy cover of more than 10 percent, which are not primarily under agricultural or urban land use.
- "Deforestation" is conversion of forest to another land use or long-term reduction of tree canopy cover below the 10% threshold.
- "Afforestation" is the conversion from other land uses into forest, or the increase of the canopy cover above the 10% threshold.
- "Reforestation" is re-establishment of forest formations after a temporary condition with less than 10% canopy cover due to human-induced or natural disturbances.
- "Forest degradation" is a reduction of the canopy cover or stocking within a forest.
- "Forest improvement" is the increase of the canopy cover or stocking within a forest.

Figure 7 shows changes in forest cover in Ukraine for 2001–2020.

Over the past twenty years (2001–2020), Ukraine lost 10.8 thousand square km, which was 1.8% of the forest cover in 2000.

Biodiversity Intactness Index. Biodiversity intactness index reflects the results of modeling the average number of originally present biological species, expressed as a percentage of their total number in a pristine ecosystem. Initially, the data was only available for 2015, but is now available in a time series covering the period 2000-2015.

Figure 8 shows value of the index for Ukraine in 2015.

Enhanced Vegetation Index (EVI). The Extended Vegetation Index (EVI) reflects the state of the vegetation during one year. High values of this index (closest to 1) represent dense and stably productive vegetation. Conversely, low values (close to 0) represent sparse vegetation with low productivity.

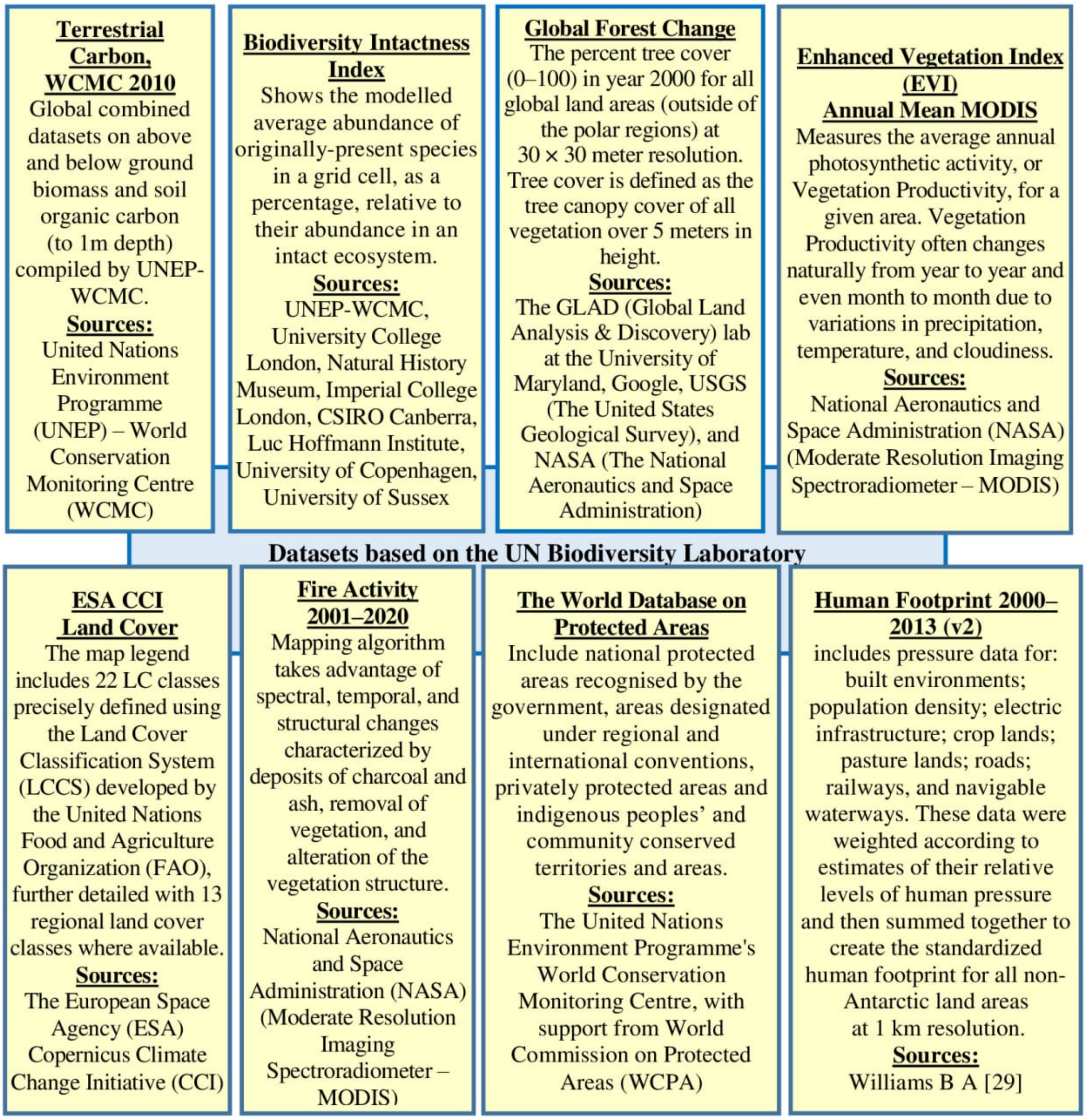

Figure 6. Datasets, included in the existing decision support system based on the UN Biodiversity Laboratory.

Average annual EVI values characterize the average annual photosynthetic activity, or vegetation productivity, for a certain area.

Vegetation productivity often varies naturally from year to year and even from month to month due to fluctuations in precipitation, temperature, and cloudiness.

With long-term observations, such assessments allow inferences about abnormal conditions, such as changes in land use or drought.

Figure 9 shows changes of Enhanced Vegetation Index in Ukraine in 2000-2021.

ESA CCI Land Cover. The European Space Agency and Copernicus Climate Change produced global land cover (LC) maps from 1992 to 2020 at 0.002778° (approximately 300 m)

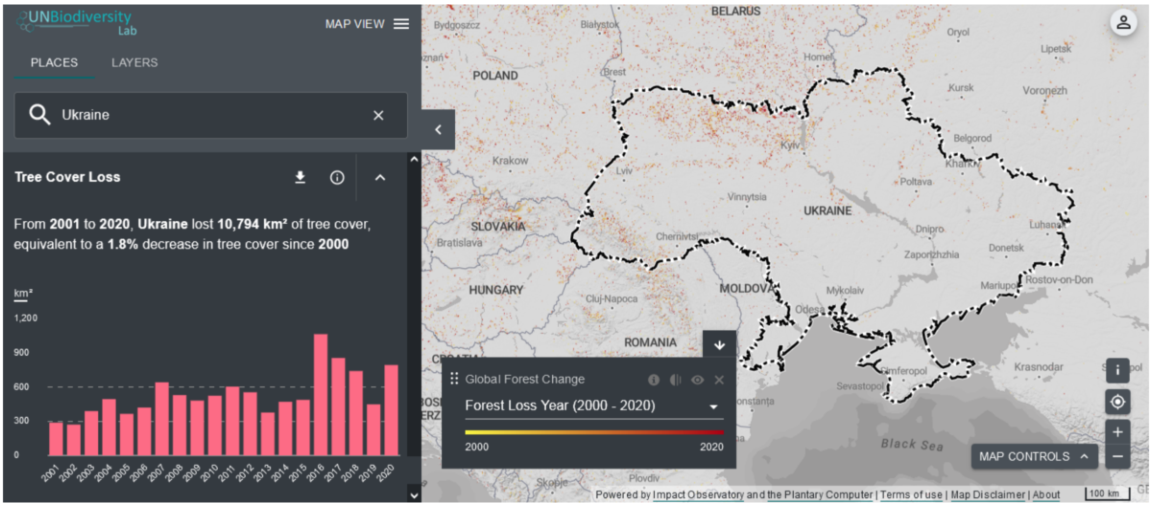

Figure 7. Forest change in Ukraine in 2001–2020.

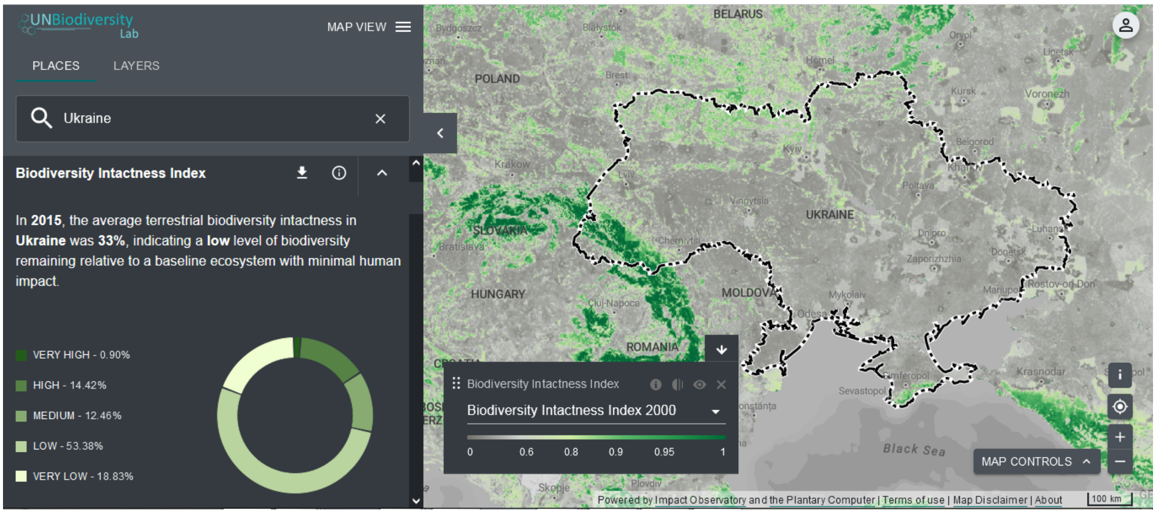

Figure 8. Biodiversity Intactness Index in Ukraine in 2015.

from the complete 300 m and 1 km multi-mission Earth observation (EO) archives. The map legend contains 22 LC classes that are precisely defined using the Land Cover Classification System (LCCS) developed by the Food and Agriculture Organization of the United Nations (FAO). 13 regional soil cover classes are detailed.

Figure 10 shows Ukraine's Land Cover in 2020.

Methodological decoupling of LC classification and LC change detection (LCC) ensures temporal and spatial consistency between successive maps. A new land cover map is created every year 9 months after the start of the year and is reviewed within a maximum of 3 months after publication. A user tool was developed to convert the LCCS nomenclature into plant functional type distributions used in various climate models.

5. Conclusions

Information provision for monitoring the sustainable development of land and biodiversity should be based on an understanding of the integrated use of statistical, administrative data sources,

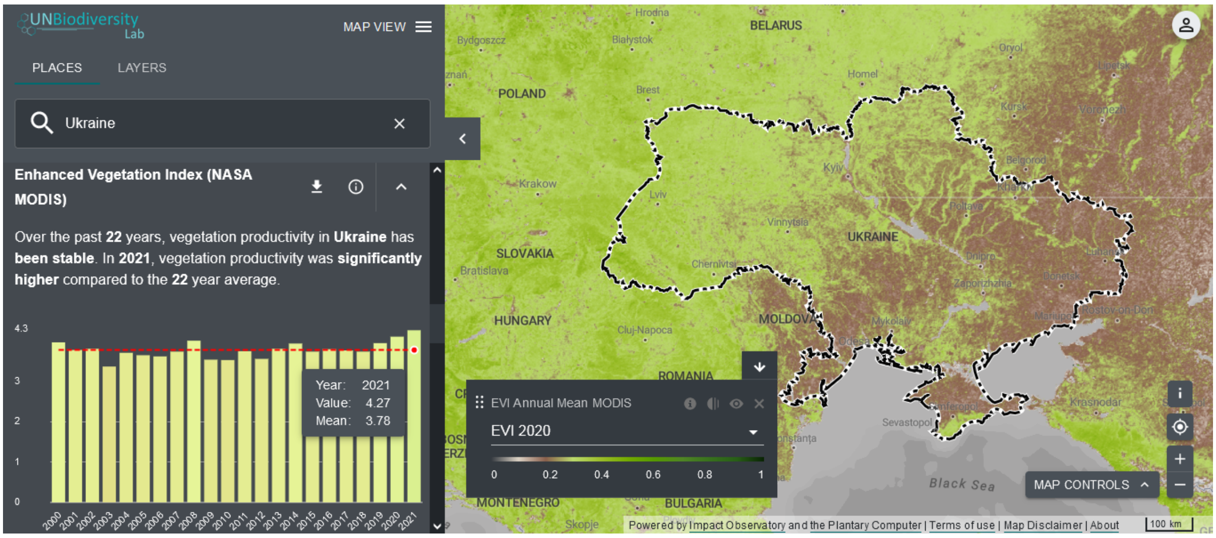

Figure 9. Enhanced Vegetation Index (NASA MODIS) in Ukraine in 2000-2021.

Figure 10. Ukraine's Land Cover in 2020.

metadata for their qualitative use, as well as a combination with big data, such as satellite images and data from mobile operators.

Recently, special attention should be paid to the collection of information on impacts on biodiversity in a specific place. Understanding the local context where an organization interacts with biodiversity is necessary to assess its impact, as well as to identify key drivers of biodiversity loss (overexploitation of resources, pollution, land-use change and climate change, etc.). It is also necessary to develop a program of actions that the organization needs to take to manage its impact on biodiversity.

Advances in computing and data science make it possible to process and analyze big data in real time. Integrating big data with traditional data should yield high-quality information that is more detailed, timely, and relevant. New insights derived from such data analysis can complement official statistics and survey data, adding depth and nuance to information in the course of monitoring the achievement of the Sustainable Development Goals.

Analysis of relevant trends over the long term can help maximize efforts to ensure sustainable land development and biodiversity conservation, and minimize environmental degradation and other potential negative consequences of increasing human impact on ecosystems.

The algorithms of data processing, modelling and constructing of integrated indicators would be the future research subject.

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