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ENVIRONMENTAL SAFETY AND PROTECTION

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У навчальному посібнику для студентів ОС Магістр за спеціальністю 101 Екологія вперше англійською мовою ґрунтовно викладені теоретичні і практичні аспекти екологічного контролю та екологобезпечного використання природних ресурсів, наведені особливості організації різних рівнів моніторингу компонентів довкілля, розглянуто сучасні методи та засоби моніторингових досліджень, а також розроблено тлумачний словник термінів у галузі екологічної безпеки, контролю та охорони природи.

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INTRODUCTION

The problems of environmental protection and of sustainable development of material resources represent, at present, a common preoccupation of all the states of the world, a global-wide objective.

Environmental protection focuses on solving problems arising from the interaction between humans and environmental systems and includes issues related to conservation, pollution, loss of biodiversity, land degradation or environmental policy.

The key aim of environmental protection is to prevent the degradation of the natural environment which is affected by increasing population, technology and overconsumption, all of which have created a negative impact on the environment and continue to put humans and animals at risk.

Another element of environmental protection is environmental monitoring that can be described as a programme of recurring, systematic studies that reveals the state of the environment. The results of environmental monitoring are of fundamental importance to environmental management in general, as the drafting and prioritization of environmental policies is based on the findings of environmental monitoring.

Environmental monitoring is an important tool of effective management of environmental quality, timely warning of negative impacts on the natural environment and population, as well as provision of information to the public and decision-makers about the state of the environment. Environmental monitoring is a necessary component of environmental science and policy design.

The main objective of discipline “Environmental Safety and Protection” is formation the theoretical knowledge and practical skills on the problems of different components of the environment (surface and ground water, oceans and seas, atmospheric air, soils etc.), estimation of impact of anthropogenic stresses on them, prediction of changes in the state of environment as well as working out the scientifically-grounded recommendations for realization of nature protection measures.

This manual designed for graduate students in the specialty 101 Ecology and includes theoretical and practical aspects of environmental monitoring and ecologically safe nature use, modern methods of ecological control as well as glossary in the field of ecological compliance and natural environment protection.

1. FUNDAMENTALS OF ENVIRONMENTAL MONITORING AND ENVIRONMENTAL CONTROL

Basic concepts of environmental monitoring and control

The environment is all-encompassing. It is "the totality of surrounding conditions".

Trying to describe the state of the environment is a monumental task. Even assessing the health of a small part of it – a certain lake that become polluted, or air quality over a particular city – is fraught with difficulties.

This is because any part of the environment is a subset of a larger area and its state is not stable but in constant flux.

Furthermore, we still lack a complete picture of how ecosystems work.

Finally, the task is complicated by the blurred distinction between us and the environment.

It is not simply "out there" where we can get a good look at it from a distant and dispassionate vantage point. Humans are an integral part of the environment. To report on its conditions we have to observe and interpret a complex, dynamic system of which we are an interacting component.

The term "monitoring" has started up before the United Nations Conference on the Human Environment (1972).

The first proposals on the occasion of such a system have been developed by experts of the special commission SCOPE (the Scientific Committee on Problems of the Environment) in 1971.

The main elements of the monitoring as system were first described by the R. Munn[1] (1973).

A total system for environmental control includes three basic types of activity.

1) The first involves measurements and observations directed towards a description of the state of the environment and its changes.

2) The second activity is the evaluation and analysis of environmental data to determine possible trends and to develop a warning system related to pre-set criteria.

This specifically includes functions such as predictions of the environmental consequences of planned actions, descriptions of the budget of contaminants and the analysis of ecosystems, determination of environmental

[1] R. Munn was a Canadian climatologist and meteorologist. Among other things he was editor-in-chief of the SCOPE (The Scientific Committee on Problems of the Environment) series of 60 books relating to interdisciplinary environmental topics.

criteria for specific pollutants, and the formulation of recommendations for actions.

3) The third and final activity in the total system is that of action, designed to avoid environmental deterioration but in the overall context of achieving environmental management in the most beneficial way.

Global environmental monitoring or "monitoring" describes as activities of the first type listed above. Accordingly, ***monitoring is defined as, "a scientifically designed system of continuing measurements and observations."***

Environmental monitoring can be defined as the systematic sampling of air, water, soil, and biota in order to observe and study the environment, as well as to derive knowledge from this process (Artiola et al., 2004; Wiersma, 2004).

Monitoring can be conducted for a number of purposes, including to establish environmental “baselines, trends, and cumulative effects”, to test environmental modelling processes, to educate the public about environmental conditions, to inform policy design and decision-making, to ensure compliance with environmental regulations, to assess the effects of anthropogenic influences, or to conduct an inventory of natural resources (Mitchell, 2002).

Environmental monitoring is defined as "an activity undertaken to provide specific information on the characteristics and functions of environmental and social variables in space and time“.

The British Standard EN ISO 14031:1999 defines Environmental Performance Evaluation (EPE) as an internal management process and tool designed to provide environmental management with reliable and verifiable information on an ongoing basis to determine whether an organization’s environmental performance is meeting the criteria set by the management of the organisation.

Environmental monitoring may be defined according to DWAF’s Integrated Environmental Management Framework (IEMF)[2] as “the repetitive and continued observation, measurement and evaluation of environmental data to follow changes over a period of time to assess the efficiency of control measures”.

Environmental monitoring can be described as a programme of recurring, systematic studies that reveals the state of the environment.

The specific aspects of the environment to be studied are determined by environmental objectives and environmental legislation. ***The purpose*** of environmental monitoring is to assess the progress made to achieve given environmental objectives and to help detect new environmental issues.

[2] DWAF - Department of Water Affairs and Forestry South Africa

The results are of fundamental importance to environmental management in general, as the drafting and prioritization of environmental policies is based on the findings of environmental monitoring.

Environmental monitoring is analytical information system that covers the following main areas:

1) observation of the environment and the factors that affect the separate elements of the environment;

2) evaluation and analysis of the actual state of all components of the environment;

3) forecast (prediction) of the state of environment and evaluation of the environmental condition;

4) providing scientific information to support for management of decision making.

Classification of the monitoring system

Generalized classification of all possible systems (or subsystems) of monitoring can be seen in the table 1.1.

Table 1.1 − Generalized classification scheme of monitoring systems

The principle of classification	The current or long-term monitoring systems
By universality of the system	Global (including baseline and paleomonitoring). national, "international" (transboundary pollutants transport monitoring), regional
According to the reaction of the main components of the biosphere	Geophysical monitoring, biological monitoring (which includes genetic monitoring), environmental monitoring (including geophysical and biological monitoring)
By the main components of the biosphere	Monitoring of anthropogenic changes (man-made change of environment) in atmosphere, hydrosphere and lithosphere
By the influence sources	Monitoring of sources of pollution, ingredient monitoring (selected pollutants, ionizing radiation, noise, etc.)
By the influences (impact factors)	Biotic and abiotic monitoring
By the severity and globality	Monitoring of the ocean, climate monitoring, ozone layer monitoring, etc.
By the methods of observations	Aerospace monitoring (remote sensing methods) Monitoring of physical, chemical and biological parameters
By the complexity of approach	Biomedical or health-related monitoring, bioenvironmental monitoring, climate monitoring. Variants: biomonitoring, geoecological monitoring, monitoring of biosphere, monitoring of resources and others.

Table 1.2 − Classification of reactions of natural systems, sources and impact factors that need to be covered by the monitoring system

Section of observations	Classification
A. Local sources and impact factors	A.1. Sources of pollution and influence sources A.2. Impact factors (pollutants, radiation etc.)
B. State of the environment	B.1. State of the environment that is characterized by physical and physiographic data B.2. State of the environment that is characterized by geochemical data and pollution data
C. State of biotic component of biosphere	C.1. Challenge response - by species - by population - by communities and ecosystem
D. Response of a large scale systems and biosphere	D.1. Response of a large scale systems (weather and climate) D.2. Response of biosphere in whole
E. Public health and human wellbeing	E.1. Environmental influence on morbidity and public health E.2. Environmental influence on human wellbeing

Environmental Indicators

Environmental indicators are simple measures that tell us what is happening in the environment. Environmental indicators have been defined in different ways but common themes exist.

- An environmental indicator is a numerical value that helps provide insight into the state of the environment or human health. Indicators are developed based on quantitative measurements or statistics of environmental condition that are tracked over time. Environmental indicators can be developed and used at a wide variety of geographic scales, from local to regional to national levels (EPA)[3].

- A parameter or a value derived from parameters that describe the state of the environment and its impact on human beings, ecosystems and materials, the pressures on the environment, the driving forces and the responses steering that system. An indicator has gone through a selection and/or aggregation process to enable it to steer action (EEA).[4]

The goal of environmental indicators is to communicate information about the environment − and about human activities that affect it − in ways that highlight emerging problems and draw attention to the effectiveness of current policies.

[3] EPA - U.S. Environmental Protection Agency

[4] EEA - European Environment Agency

Environmental indicators are developed in order to:

- assist in the development of optimal environmental policy;
- compare countries and regions;
- ensure understanding of the problem;
- study of the relationship of industrial activity and cause-effect relationships.

The Global Environmental Outlook (GEO) Indicators by UNEP is a set of selected environmental trends, which are not assumed to be comprehensive. The selected indicators are a mix of environmental pressures, states, impacts and responses. But they do not intend, nor are they able, to capture all aspects of all global and regional environmental problems. The underlying data that are used to compile the indicators come from internationally recognised sources.

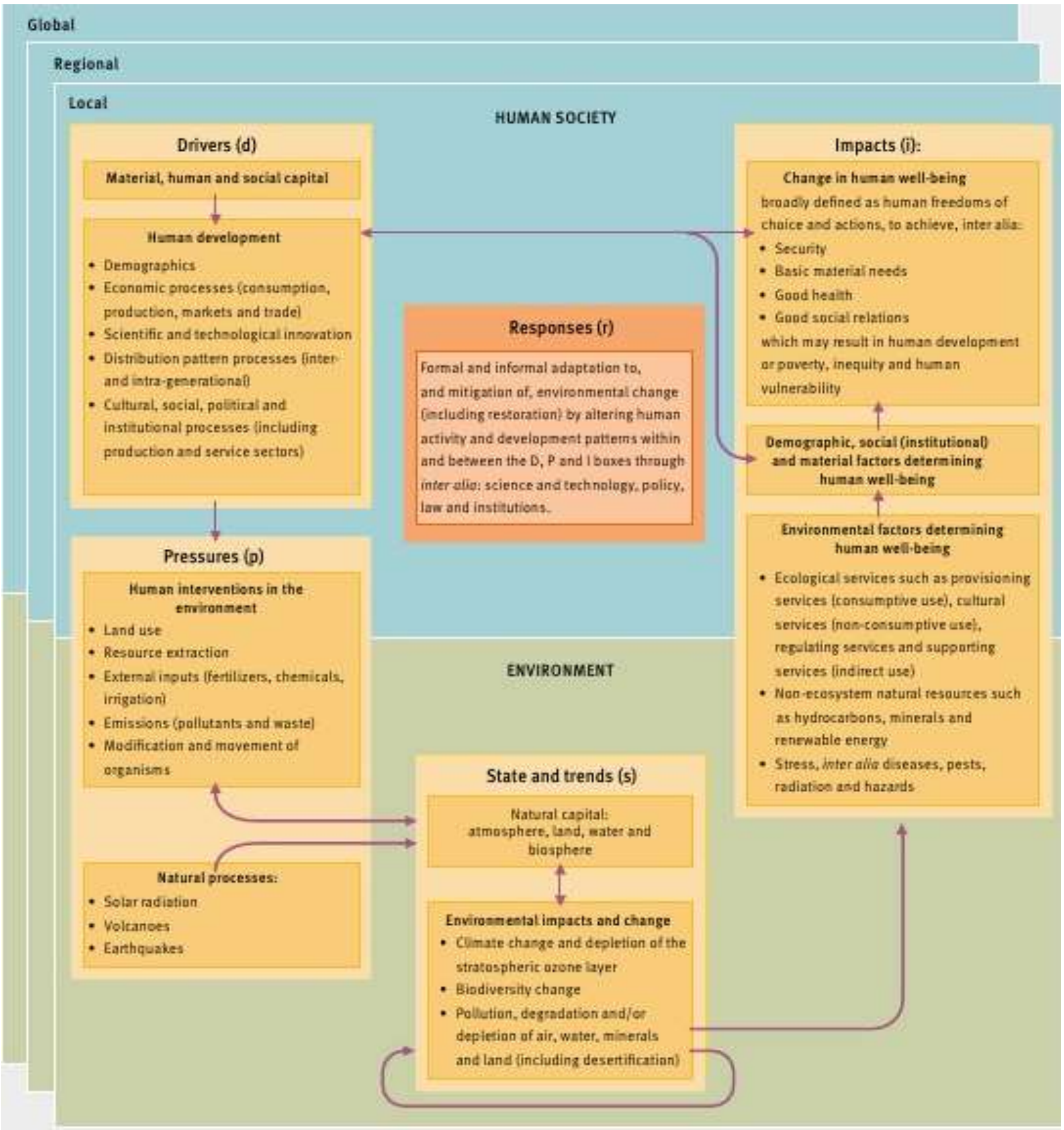

Figure 1.1 – GEO DPSIR conceptual framework

This infographic depicts the GEO indicators (see Fig. 1.2 below) used from 1990-2005 and charts the progress of the different indicators through the years in that period. For each issue, the single most important, suitable and reliable indicators currently available are presented. Every year, an updated selection of the Core Set of Indicators is included in the GEO Yearbook series as 'GEO Indicators'.

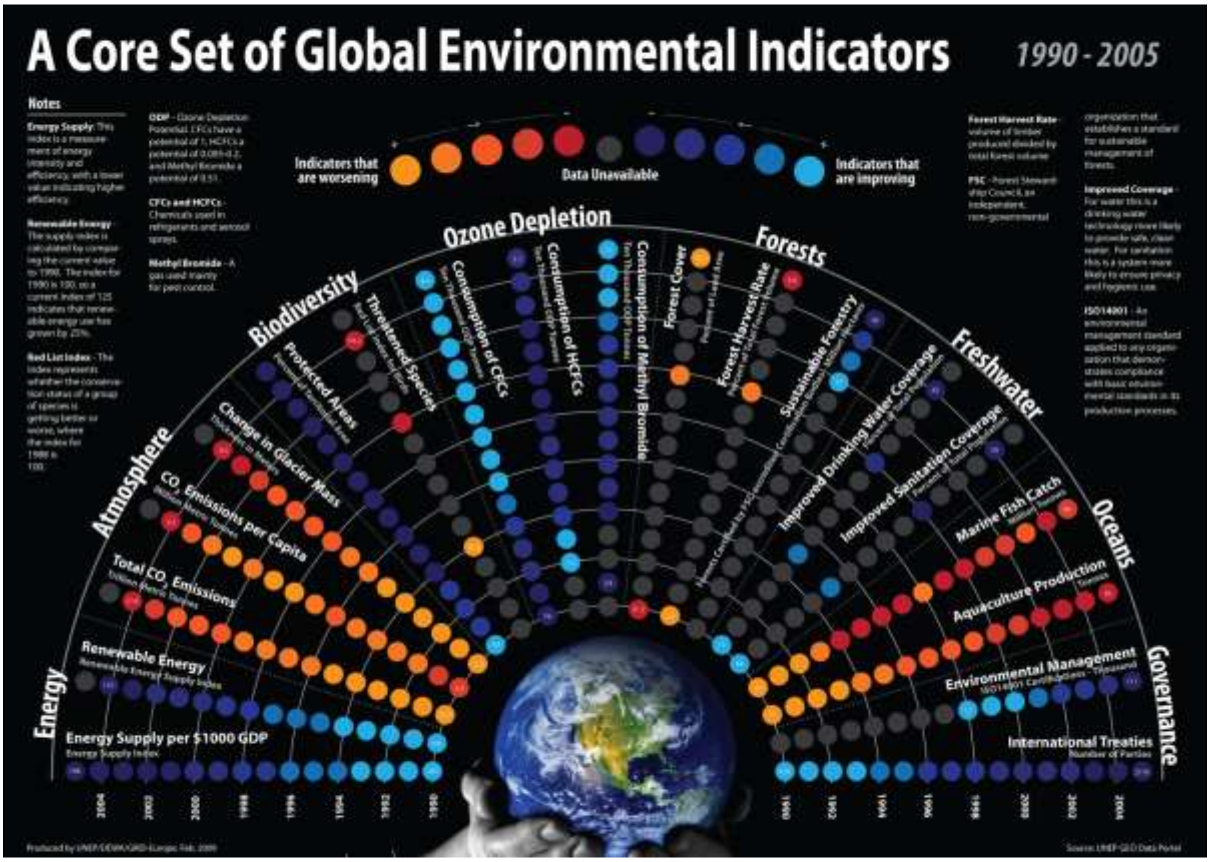

Figure 1.2 – A core set of Global Environmental Indicators

The OECD[5] has developed and published the first international sets of environmental indicators and uses them regularly in its country environmental performance reviews and other policy analysis work.

Central to the OECD work are core environmental indicators to measure environmental progress, complemented with several sets of sectoral environmental indicators to help integrate environmental concerns in sectoral policies.

Indicators are further derived from environmental accounting and work is done on indicators to measure the decoupling of environmental pressure from economic growth.

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[5] Organisation for Economic Co-operation and Development

In 2001 the OECD identified a shortlist of environmental indicators (key indicators). Their selection took into account: their policy relevance with respect to major challenges for the first decade of the 21st century, including pollution issues and issues related to natural resources and assets; their analytical soundness; and their measurability.

Pollution issues		**Available indicators***	**Medium term indicators****
Climate change	1.	CO2 emission intensities Index of greenhouse gas emissions	Index of greenhouse gas emissions
Ozone layer	2.	Indices of apparent consumption of ozone depleting substances (ODS)	Same, plus aggregation into one index of apparent consumption of ODS
Air quality	3.	SOx and NOx emission intensities	Population exposure to air pollution
Waste generation	4.	Municipal waste generation intensities	Total waste generation intensities, Indicators derived from material flow accounting
Freshwater quality	5.	Waste water treatment connection rates	Pollution loads to water bodies
Natural resources & assets			
Freshwater resources	6.	Intensity of use of water resources	Same plus sub-national breakdown
Forest resources	7.	Intensity of use of forest resources	Same
Fish resources	8.	Intensity of use of fish resources	Same plus closer link to available resources
Energy resources	9.	Intensity of energy use	Energy efficiency index
Biodiversity	10.	Threatened species	Species and habitat or ecosystem diversity Area of key ecosystems

** indicators for which data are available for a majority of OECD countries and that are presented in this report*

*** indicators that require further specification and development (availability of basic data sets, underlying concepts and definitions).*

Figure 1.3 – OECD set of key environmental indicators

The list of indicators hence is neither final, nor exhaustive; it will evolve as knowledge and data availability improve. Ultimately, the list is expected to also include key indicators for issues such as toxic contamination, land and soil resources, and urban environmental quality.

European Environment Agency (EEA) uses five types of integrated indicators.

(A). Descriptive indicators − for example the proportion of organic farming to all agricultural lands, %

(B) Performance indicators − they characterize the progress in achieving intended goals such as greenhouse gas emissions

(C) Efficiency indicators are indicators that characterize the ecological efficiency, for example, the level of emissions per unit of GDP (gross domestic product).

(D) Indicators of political efficiency − are indicators that characterize the relationship between changes in the environment and political measures (response).

(E) Aggregate welfare indicators – these indicators are characterizing the development of society, for example, indicators of sustainable development.

The establishment and development of the EEA core set of indicators has been guided by the need to identify a small number of policy-relevant indicators that are stable, but not static, and that give answers to selected priority policy questions. They should, however, be considered alongside other information if they are to be fully effective in environmental reporting.

The core set covers six environmental themes (air pollution and ozone depletion, climate change, waste, water, biodiversity and terrestrial environment) and four sectors (agriculture, energy, transport and fisheries).

Some other relevant priorities (chemicals, noise, industry, consumption, material flows) have not yet been included because indicators are insufficiently developed, but this will be the main focus for the future development of the core set (Table 1.3).

Table 3 – EEA core set of indicators

Theme	**CSI**	**Indicator title**
Air pollution and ozone depletion	1	Emissions of acidifying substances
	2	Emissions of ozone precursors
	3	Emissions of primary particulates and secondary particulate precursors
	4	Exceedance of air quality limit values in urban areas
	5	Exposure of ecosystems to acidification, eutrophication and ozone
	6	Consumption of ozone-depleting substances
Biodiversity	7	Threatened and protected species
	8	Designated areas
	9	Species diversity
Climate change	10	Greenhouse gas emissions and removals
	11	Projections of greenhouse gas emissions and removals and policies and measures
	12	Global and European temperature
	13	Atmospheric greenhouse gas concentrations
Terrestrial	14	Land take
	15	Progress in management of contaminated sites
Waste	16	Municipal waste generation
	17	Generation and recycling of packaging waste

Water	18	Use of freshwater resources
	19	Oxygen-consuming substances in rivers
	20	Nutrients in freshwater
	21	Nutrients in transitional, coastal and marine waters
	22	Bathing water quality
	23	Chlorophyll in transitional, coastal and marine waters
	24	Urban wastewater treatment
Agriculture	25	Gross nutrient balance
	26	Area under organic farming
Energy	27	Final energy consumption
	28	Total energy intensity
	29	Total energy consumption
	30	Renewable energy consumption
	31	Renewable electricity
Fisheries	32	Status of marine fish stocks
	33	Aquaculture production
	34	Fishing fleet capacity
Transport	35	Passenger transport demand
	36	Freight transport demand
	37	Use of cleaner and alternative fuels

Each indicator in the core set can be positioned in the DPSIR framework, (D = driving forces, P = pressures, S = states, I = impacts, R = responses) but they are not spread in a balanced and comprehensive way.

Table 1.4 – EEA core set of indicators in the DPSIR framework and by type

	D	P	S	I	R	A	B	C	D	E
Air quality and ozone depletion		4		2			6			
Biodiversity			1	1	1	3				
Climate change		2	2			1	3			
Terrestrial			1		1	2				
Waste		1.5			0.5	1.5	0.5			
Water		1	5		1	6	1			
Agriculture					1	2				
Energy	3				2	2	3			
Fishery	2		1			3				
Transport	2				1	2	1			
Total	7	9.5	10.5	3	7	22.5	14.5			

D = Driving force indicator
P = Pressure indicator
S = State indicator
I = Impact indicator
R = Response indicator

A = Descriptive indicator
B = Performance indicator
C = Efficiency indicator
D = Policy effectiveness indicators
E = Total welfare indicator

The indicators are also classified by type (A = descriptive indicator, B = performance indicator, C = eco-efficiency indicator, D = policy effectiveness indicator, E = total welfare indicator).

The United Nations Commission on Sustainable Development (CSD) was created in December 1992 to monitor and report on the implementation of the Earth Summit agreements. The CSD recognized an urgent need for global action to combine national and international information efforts and to promote comparability, accessibility, and quality of that information.

It began a work programme, with the goal of providing national decision-makers with a list of indicators to use in national policies and in reports to the CSD and other international agencies.

The proposed set of environmental indicators are not final or definitive, but can be adjusted to fit national conditions, priorities, and capabilities. Countries are encouraged to adopt and use this set as a starting point for their national indicator programmes. Wide adoption and use of the core set is meant to help improve information consistency at the international level.

Table 1.5 below shows the CSD's list of issues and associated environmental indicators.

Table 1.5 − CSD environmental indicators

Climate change	• Emissions of greenhouse gases
Ozone layer depletion	• Consumption of ozone-depleting substances
Air quality	• Ambient concentrations of air pollutants in urban areas
Agricultural land	• Arable and permanent crop land area • Use of fertilizers • Use of agricultural pesticides
Desertification	• Land affected by desertification
Forests	• Forest area as a per cent of land area • Wood harvesting intensity
Urban areas	• Area of formal and informal settlements
Oceans and marine	• Algae concentration in coastal waters • Per cent population living in coastal areas
Fisheries	• Annual catch by major species

Freshwater	• Annual withdrawal of ground- and surface water as a per cent of total available water • BOD in water bodies • Concentration of faecal coliform in freshwater • Per cent population w/ adequate sewage disposal facilities • Per cent population w/ access to safe drinking water
Biodiversity	• Area of selected key ecosystems • Protected area as a percentage of total area • Abundance of selected key species
Energy and consumption	• Per capita annual energy consumption • Material use intensity

At the Intergovernmental Meeting on Monitoring (Nairobi, 11-20 February 1974) was developed method, criteria and priorities of different pollutants. Found priorities were divided into eight classes (Table 6), with the definition of the environment and the type of measurement program («I» − impact, «R» − regional, «B» − baseline and «G» − global).

Monitoring priorities

If we speak about observations over areas the highest priority has cities and areas which are sources of drinking water.

The higher priority among the environments has air and water from fresh water bodies (especially lentic).

For air the most important ingredients are dust, sulfur oxides, carbon oxides and nitrogen oxides, heavy metals, benzo (a) pyrene and pesticides.

For water there will be biogenic products, phenols and oil products.

Among the sources of pollution the highest priority has motor transport, thermal power plants, and enterprises of non-ferrous metallurgy.

The occurrence of organized, community-based environmental monitoring has been increasing in the last decade owing to an emerging global emphasis on the importance of sustainable development.

There is a global recognition that “environmental issues are best handled with the participation of all concerned citizens”, a principal first articulated in the United Nation’s Earth Summit Agenda 21 (UN, 1992). This principal was strengthened further in July, 2009, with the formal ratification of the Aarhus

Convention which mandates participation by the public in environmental decision-making and access to justice in environmental matters (UNECE, 2008)[6]

Table 1.6 − Classification of priority pollutants by priority classes (by Yu.A. Izrael, 1984)

Class	Polluting substance	Environment	Program Type
1	Sulfur dioxide, suspended solids, Radionuclides ($^{90}Sr + ^{137}Cs$)	Air Food	I, R, B I, R
2	Ozone DDT (dichlorodiphenyltrichloroethane) and other chloroorganics Cadmium and its compounds	- troposphere stratosphere Biota Food, water	G B I, R I
3	Nitrates, nitrites Nitrogen oxide	Freshwater, food Air	I I
4	Mercury and its compounds Lead Carbon dioxide	Food, water Air, food Air	I, R I B
5	Carbon oxide HC-hydrocarbon (petroleum)	Air Sea water	I R, B
6	Fluorides	Freshwater	I
7	Asbestos Arcenic	Air Drinking water	I I
8	Microtoxins Microbiological pollution Reactive pollution	Food Food Air	I, R I, R I

There are several global-scale organizations that are responsible for the collection and distribution of environmental data internationally. For example, there are multiple programs operated by the United Nations that participate in global environmental monitoring activities, such as the World Meteorological Organization (WMO), the Global Atmosphere Watch, and the World Conservation Monitoring Centre. The WMO, the World Weather Watch, and the World Health Organization collectively manage the Global Environment Monitoring System (GEMS), which is responsible for monitoring and reporting on the "global state of water, air, climate, atmosphere, and food contamination".

Through the administration of these programs, the United Nations is providing a valuable mechanism for data collection and dissemination on a

[6] The United Nations Economic Commission for Europe (UNECE or ECE) was established in 1947 to encourage economic cooperation among its member States.

global scale, making it possible to address global scale issues such as water security and climate change.

Environmental monitoring is an important tool of effective management of environmental quality, timely warning of negative impacts on the natural environment and population, as well as provision of information to the public and decision-makers about the state of the environment.

Environmental monitoring is a necessary component of environmental science and policy design. Despite criticisms that environmental monitoring can be ineffective and costly when programs are poorly planned, well-planned monitoring programs cost little in comparison to the resources that can be protected and the policy design that can be informed.

2. ORGANIZATION OF ENVIRONMENTAL MONITORING IN UKRAINE

Basic principles of environmental monitoring and control in Ukraine

The Law of Ukraine "On Protection of the Environment" (1991, articles 20 and 22) envisages establishment of the state environmental monitoring system (hereinafter – SEMS) to conduct observations of the state of the environment, the level of pollution, the collection, processing, transmission, storage and analysis of information about the environmental situation, forecasting its changes and development of scientifically based recommendations for decision-making on the prevention of negative changes of the environment and observance of requirements of ecological safety.

Implementation of these functions entrusted to the Ministry of Energy and Environmental Protection of Ukraine (Minecoenergo) and other central authorities that are parties of the SEMS, as well as to the enterprises, institutions and organizations whose activity leads or may lead to the deterioration of the environment.

The main principles of SEMS operation are defined in the Regulation of the Cabinet of Ministers of Ukraine № 391 dated 30.03.1998 "On Approval of Statement on the State Environmental Monitoring System" (as amended).

According to this Regulation, the State Environmental Monitoring System is an open information system, priority operations of which are:

- the protection of vital important ecological interests of human and society;
- preservation of natural ecosystems;
- prevention crisis changes in the ecological state of the environment; and
- prevention of emergency environmental situation.

The ***basic principles*** of SEMS operations are specified in the Resolution of the Cabinet of Ministers of Ukraine listed above, namely:

- coordination of regulatory legal and organizational and methodological implementation, interoperability of technical, information and software implementation of its parts;
- systematic character of observations on the environment and technogenic objects that influence it;
- timely obtaining, complexity of processing and use of ecological information that comes and stored in the monitoring system;
- objectivity of primary, analytical and forecasting ecological information and efficiency of its delate to the public authorities, local governments, public

organizations, media, population of Ukraine, interested international organizations and the international community.

The State system of environmental monitoring in Ukraine (SEMS) has ***three levels***:

1) local - territory of selected objects (enterprises, cities, plots of landscapes);

2) regional - within the administrative and territorial units, economic and natural regions;

3) national – the total territory of Ukraine.

Functions and objectives of monitoring bodies

Functions and objectives of observations and information provision (within SEMS) are carried out by:

1) the Ministry of Energy and Environmental Protection of Ukraine;

2) the Ministry of Economic Development, Trade and Agriculture of Ukraine;

3) the Ministry of Communities and Territories Development of Ukraine;

4) the State Agency of Ukraine on Exclusion Zone Management;

5) the State Service of Geology and Mineral Resources of Ukraine;

6) the State Space Agency of Ukraine;

7) the State Emergency Service of Ukraine (Ukrainian Hydrometeorological Center);

8) the State Agency of Forest Resources of Ukraine;

9) the State Agency of Water Resources of Ukraine;

10) the State Service of Ukraine on Geodesy, Cartography and Cadastre;

and their territorial bodies, enterprises, institutions and organizations belonging to the sphere of their management, oblast, Kyiv and Sevastopol city state administrations, as well as the executive authorities of the Autonomy Republic of Crimea on environmental protection issues.

Each body of SEMS monitors those objects of the environment that are defined by the Statement on the state system of monitoring and statements on the state monitoring of some natural components of the environment.

The current system of environmental monitoring comprises the sub-systems of state parties of monitoring and is based on the fulfillment of the distributed functions that are defined by the Statement on the state monitoring system.

Each sub-system (at the level of separate body of the monitoring system) has its own structural, organizational, scientific, methodological basis. However, each sub-system functions on the basis of single statutory, methodological and metrological provision.

The basic regulations governing the environmental objects of monitoring are:

- Regulation of the Cabinet of Ministers of Ukraine of 14.08.2019 No. 827 "On Approval of the Procedure for the Organization and Monitoring of Air Pollution";

- Regulation of the Cabinet of Ministers of Ukraine of 19.09.2018 № 758 "On Approval of the Procedure on State Monitoring of Water";

- Regulation of the Cabinet of Ministers of Ukraine of 20.08.1993 № 661 "On Approval of the Statement on Land Monitoring« (last updated 20.08.2019 №760);

- Order of the Ministry Agrarian Policy of Ukraine of 26.02.2004 № 51 "On Approval of the Statement on Soil Monitoring on Agricultural Land“;

and others.

Functions and objectives of *the Ministry of Energy and Environmental Protection of Ukraine* (Minecoenergo) in the sphere of environmental monitoring:

- Control of water objects in nature protected territories (background concentration of pollutants, including radionuclides);

- State of soils in nature protected territories (pollution content, including radionuclides);

- State Environmental mapping of the territory of Ukraine to assess its condition and its changes under the influence of economic activity;

- Control of surface and marine waters (background concentration of pollutants, including radionuclides);

- Endangered species of flora and fauna as well as and species under special protection

Implementation of these functions is based on long-term systematic observations of the integrated environmental network of monitoring points. The functions are carried out to assess, analyze and predict the state of natural environment to support managerial decisions.

Functions and objectives of *the State Emergency Service of Ukraine* (at the stations of the state system of hydrometeorological observations) in the sphere of environmental monitoring:

- Control of atmospheric air and precipitation (pollution content including radionuclides, transboundary pollutants transport);

- Snow cover;

- Monitoring of terrestrial (hydrochemical and hydrobiological indicators including radionuclides) and marine water (hydrochemical indicators) ecosystems;

- State of soils of various designation (pesticide residue and heavy metals pollution);

- Control of the radiation situation, hazardous nature events and disasters.

Functions and objectives of t*he State Agency of Ukraine on Exclusion Zone Management* (at the exclusion zone and evacuated part of the zone of unconditional (obligatory) resettlement) in the sphere of environmental monitoring:

- Control of atmospheric air (pollution content including radionuclides);

- Control of surface and ground waters (pollution content including radionuclides);

- Monitoring of terrestrial and water ecosystems (bioindicator identification);

- Control of soils and landscapes (pollution content including radionuclides, spatial distribution);

- Control of sources of emissions (pollution content, volume of emissions);

- Control of sources of sewage water discharge;

- Objects of storage and/or disposal of radioactive waste (radionuclide content, radiation situation.

Functions and objectives of *the Ministry of Economic Development, Trade and Agriculture of Ukraine* in the sphere of environmental monitoring:

- Control of agricultural soils (radiological, agrochemical and toxicological evaluations, residual quantity of pesticides, agrochemicals and heavy metals);

- Monitoring of agricultural plants and products produced out of them (toxicological and radiological evaluations, residual quantity of pesticides, agrochemicals and heavy metals);

- Monitoring of agricultural animals and products produced out of them (zootechnical, toxicological and radiological residual quantity of pesticides, agrochemicals and heavy metals);

- Control of surface waters of agricultural designation (toxicological and radiological evaluations, residual quantity of pesticides, agrochemicals and heavy metals).

Functions and objectives of *the State Agency of Forest Resources of Ukraine* in the sphere of environmental monitoring:

- Control of soils and lands of forest fund (radiological evaluations, residual quantity of pesticides, agrochemicals and heavy metals);

- Control of the state of forest vegetation (condition, productivity, damage by biotic and abiotic factors, biodiversity, radiological evaluations);

- Control of the state of game fauna (specific, quantitative and spatial characteristics).

Functions and objectives of *the State Agency of Water Resources of Ukraine* in the sphere of environmental monitoring:

- Control of the state of rivers, water reservoirs, canals, water areas within boundaries of water utilization systems; control of the state of water bodies in areas impacted by nuclear power stations (hydrochemical and radiological indicators);

- Monitoring of surface waters in border regions;

- Control of irrigated and drained lands (groundwater depth and mineralization, salinity level and soil alkalinity);

- Submergence area (rural settlements, coastal zones of reservoirs (re-shaping of coast and flooding of territories)).

Functions and objectives of *the State Service of Ukraine on Geodesy, Cartography and Cadastre* in the sphere of environmental monitoring:

- Control of soils and landscapes (pollution content, erosion and other exogenous processes, spatial pollution of land by industrial and agricultural production);

- Monitoring of irrigated and drained lands (secondary submergence and soil salination);

- Monitoring of coastal lines of the rivers, seas, lakes and water reservoirs as well as hydro-technical utilities (time history, damage of land resources).

Functions and objectives of *the Ministry of Communities and Territories Development of Ukraine* in the sphere of environmental monitoring:

- Control of drinking water quality of the centralized water supply system (pollution content, consumption);

- Control of sewage waters of the city sewage system and treatment facilities (pollution content, volume of sewage flow);

- Monitoring of green plantations in settlements (plant damage degree by harmful insects and plant diseases);

- Monitoring of submergence areas in settlements.

Functions and objectives of *the State Service of Geology and Mineral Resources of Ukraine* in the sphere of environmental monitoring:

- Monitoring of ground waters (resources, usage, levels and chemical composition);

- Monitoring of endogenic and exogenic geological processes;
- Control of geophysical fields (background and abnormal evaluations);
- Control of geochemical state of landscapes (the content and distribution of natural and technogenic chemical elements and compounds).

Functions and objectives of *the State Space Agency of Ukraine* in the sphere of environmental monitoring:

- Monitoring of the state of the territories according to the data of remote sensing of the Earth (keeping track of thermal anomalies, flood and flood situation, ice situation);
- Monitoring of seismic conditions and other geophysical phenomena in Ukraine and around the globe;
- Monitoring of the radiation situation at the home station of the units of special control; space situation in the near-Earth space (determining the of the impact locations of spacecrafts, carrier rockets and their parts).

The Ministry of Health of Ukraine was excluded from the list of subjects of SEMS, but… According to paragraph 22 of the Regulation of the Cabinet of Ministers of Ukraine № 391 dated 30.03.1998 "On Approval of Statement on the State Environmental Monitoring System" (last edition), the assessment of the impact of environmental pollution on the health of the population rests in the Ministry of Health and its territorial bodies (in the case of their formation), which should inform in a timely manner public authorities and local self-government bodies about negative trends or crisis changes in the state of health of the population due to the deterioration of the environmental situation.

The subjects of SEMS have created or are in process of developing their corporate database containing monitoring information. The existing system of information interaction between the corporate environmental monitoring subsystems provides for the exchange of information at the national and regional levels.

Organizational integration of subjects of environment monitoring at all levels is performed by the Ministry of Energy and Environmental Protection of Ukraine and its regional bodies.

Sources of statistical data and environmental information

Statistical observations about the protection of the environment in Ukraine are carried out by the bodies of state statistics as well as sector ministries and agencies. In the first case, the state statistics data is being collected, in the second – administrative data is collected.

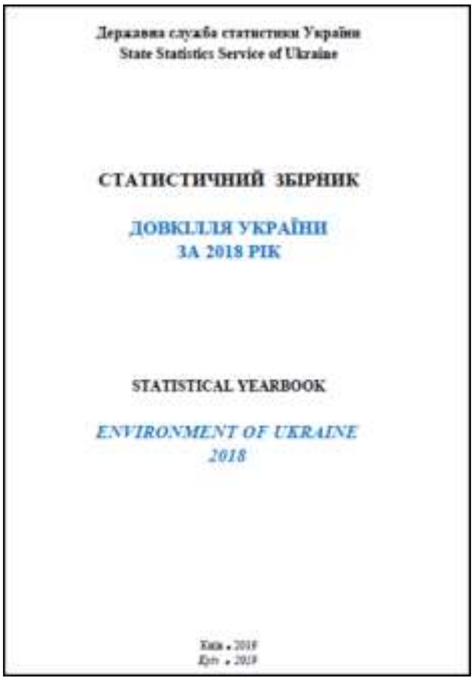
The main statements and principles of the statistical observations are determined by the Law of Ukraine "On State Statistics".

The State Statistics Service of Ukraine is not a body of environmental monitoring. Its work is focused on the collection and provision of statistical information related to technogenic impact on the environment.

Its functions and objectives in the sphere of information provision are:

- preparation and dissemination of statistical collections of environmental information for regions and Ukraine in total;

- accumulation and maintenance of information databases of statistical and administrative reporting.



In Ukraine statistical information is collected in relation to the natural environments (air, surface waters, soils, etc.). But absence of a single methodology for interpretation of data and exchange of environmental monitoring results makes it difficult to assess the quality of the environment.

The statistical yearbook contains information on the state of the environment, the impact of economic activity on it, the availability and use of natural resources, and the environmental protection expenditures for 2010-2018.

There is information for the whole country, by region and for the city of Kyiv. Some indicators are presented by selected localities and by type of economic activity. Most of the information provided is based on state statistical observations of the State Statistics Service of Ukraine.

The development of National state of the environment reports is ensured by the Ministry of Energy and Environmental Protection of Ukraine according to Article 25 of the Law of Ukraine “On Protection of the Environment”.

The national report is developed using information materials from more than 50 organizations – ministries, agencies, scientific and public organizations.

The developed report is forwarded to the Supreme Council of Ukraine for approval. Following that, the national report is printed publication and is uploaded on the website of the Ministry of Energy and Environmental Protection of Ukraine.

Generalized environmental information is also provided in a series of other reports that are published in Ukraine.

They include:

1. National report on the state of technogenic and natural safety in Ukraine;
2. National report on the state of drinking water and water supply,
3. National report on the state and perspectives of implementation of the state policy on energy efficiency;
4. National communication of Ukraine on climate change;
5. The Statistics books and other information documents.

Several groups of environmental indicators are traditionally used in the development of national state of the environment reports. They are:

- Air pollution and depletion of the ozone layer;
- Climate change;
- Water resources;
- Biodiversity,
- Land resources and soils;
- Waste;
- Agriculture;
- Efficiency indicators of the environmental policy implementation.

Since 2007, indicators on energy and transport have also been used in the reports. The main sets of indicators are presented in separate chapters of the national report.

The Ministry of Energy and Environmental Protection of Ukraine and bodies of SEMS have concluded multilateral and bilateral agreements on cooperation in the sphere of environmental monitoring that approve procedures on environmental information exchange.

This has been done to regulate information exchange on indicators and deadlines of information provision.

Ukraine is a party to more than 20 international environmental conventions, including the United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention on Biological Diversity (UNCBD), United Nations Convention to Combat Desertification (UNCCD). Ukraine has also joined some protocols to environmental conventions.

3. AIR POLLUTION AND AIR MONITORING

Notion about air pollution

High-quality air, along with water, is a crucial element for human life and all components of the biosphere. The high speed of mass movement within the atmospheric strata leads to air pollution migration across significant distances, within the ozone layer as well, and negative consequences, namely acid rain or acceleration of karstic processes. Envelope of air around the Earth forms the atmosphere with thickness up to 20 km.

Table 3.1 − The major components of dry clean air in ground atmospheric layer

Gas	Molecular mass	Relative amount in dry air, %	
		by volume	by weight
Nitrogen *(N_2)*	28,02	78,08	75,53
Oxygen *(O_2)*	32,0	20,95	23,14
Argon *(Ar)*	39,94	0,93	1,28
Carbon dioxide *(CO_2)*	44,01	0,033	0,05
Neon *(Ne)*	20,18	0,0018	0,001
Helium *(He)*	4,0	0,0005	0,00007
Krypton *(Kr)*	16,05	0,00015	0,00008
Xenon *(Xe)*	83,7	0,0001	0,00003
Nitrous oxide (N_2O)	44,02	0,00005	0,00008
Hydrogen (H_2)	2,02	0,00005	0,000003
Ozone (O_3)	48,0	0,00004	0,00007

Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere.

Air pollution includes all contaminants found in the atmosphere. These dangerous substances can be either in the form of gases or particles.

The sources of air pollution are both natural and human-based. As one might expect, humans have been producing increasing amounts of pollution as time has progressed, and they now account for the majority of pollutants released into the air.

Air pollution has been a problem throughout history. Even in Ancient Rome people complained about smoke put into the atmosphere.

Urban air quality worsened during the Industrial Revolution, as the widespread use of coal in factories in Britain, Germany, the United States and other nations ushered in an ‘age of smoke.’

In terms of their scale, the effects of coal smoke in the nineteenth and early twentieth centuries were mainly local and regional.

But after the Second World War a number of invisible threats began to emerge – acid rain, photochemical smog, ozone depletion and climate change – that were transnational and global in character.

The effects of air pollution are diverse and numerous. Air pollution can have serious consequences for the health of human beings, and also severely affects natural ecosystems.

Figure 3.1 − Smokey Mountain National Park - Acid Rain

Particulate matter and ground-level ozone are now generally recognized as the two pollutants that most significantly affect human health.

Long-term and peak exposures to these pollutants range in severity of impact, from impairing the respiratory system to premature death.

Particle pollution, also called particulate matter or PM, is a mixture of solids and liquid droplets floating in the air. Some particles are released directly from a specific source, while others form in complicated chemical reactions in the atmosphere.

Particles come in a wide range of sizes. Particles less than or equal to 10 micrometers in diameter are so small that they can get into the lungs, potentially causing serious health problems. Ten micrometers is less than the width of a single human hair.

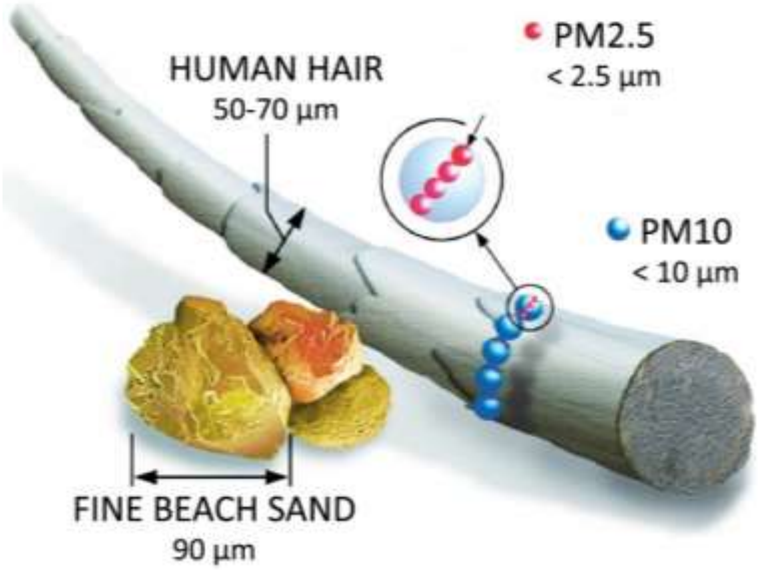


Figure 3.2 − Size comparisons for PM particles

Coarse dust particles (PM_{10}) are 2.5 to 10 micrometers in diameter. Sources include crushing or grinding operations and dust stirred up by vehicles on roads.

Fine particles ($PM_{2.5}$) are 2.5 micrometers in diameter or smaller, and can only be seen with an electron microscope. Fine particles are produced from all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes.

Ground-level ozone forms when heat and sunlight allow the reaction of two other pollutants: nitrogen oxides and volatile organic compounds (Fig. 3.3).

These chemicals come from industrial plants, electric utilities, vehicle exhaust, wildfire smoke, and oil and gas extraction. High heat can accelerate this process. The resulting ground-level ozone can build up to unhealthy levels − especially without wind or rain to mix up the air.

For instance, in recent years, up to 40 % of Europe’s urban population may have been exposed to ambient concentrations of coarse PM (PM_{10}) above the EU limit set to protect human health.

Fine particulate matter ($PM_{2.5}$) in air has been estimated to reduce life expectancy in the EU by more than eight months.

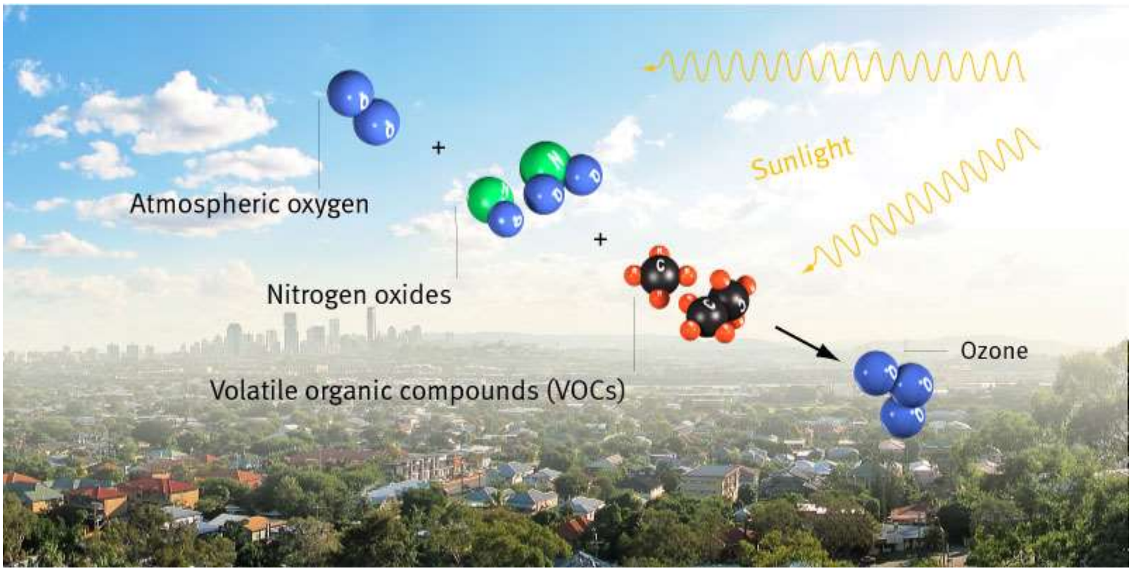


Figure 3.3 − Ground-level ozone formation

Up to 50 % of the population living in urban areas may have been exposed to levels of ozone that exceed the EU target value.

Air pollution also damages the environment:

Acidification is caused by acid deposition of excess sulphur and nitrogen compounds.

Eutrophication, is an environmental problem that caused by the input of excessive nutrients into ecosystems, in particular by excessive atmospheric nitrogen.

Crop damage is caused by exposure to high ozone concentrations.

Sources of air pollution

There are various sources of air pollution, both anthropogenic and of natural origin:

- burning of fossil fuels in electricity generation, transport, industry and households;
- industrial processes and solvent use, for example in chemical and mineral industries;
- agriculture;
- waste treatment;
- volcanic eruptions, windblown dust, sea-salt spray and emissions of volatile organic compounds from plants are examples of natural emission sources.

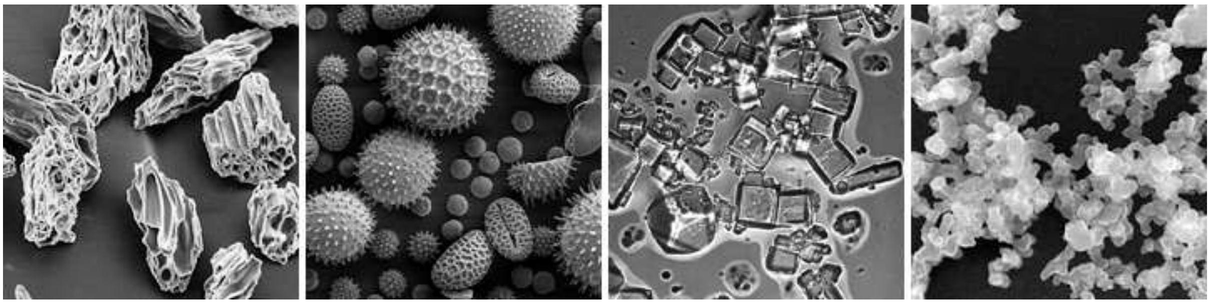


Figure 3.4 − These scanning electron microscope images (not at the same scale) show the wide variety of aerosol shapes. From left to right: volcanic ash, pollen, sea salt, and soot

Source: NASA

Table 3.2 − Comparative characteristics of emissions into the atmosphere of natural and anthropogenic pollutants

Pollutant	**Natural origin**	**Anthropogenic origin**
Carbon monoxide *(CO)*	—	$3{,}5 \cdot 10^{8}$
Sulphur dioxide (SO_2)	$1{,}4 \cdot 10^{8}$	$1{,}45 \cdot 10^{8}$
Nitrogen dioxide (NO_2)	$1{,}4 \cdot 10^{9}$	$(1{,}5 - 2{,}0) \cdot 10^{7}$
Particulate matters	$(7{,}7 - 22{,}0) \cdot 10^{10}$	$(9{,}6 - 26{,}0) \cdot 10^{10}$
Polyvinylchloride materials, freons	—	$2{,}0 \cdot 10^{6}$
Ozone (O_3)	$2{,}0 \cdot 10^{9}$	—
Hydrocarbons (C_nH_m)	$1{,}0 \cdot 10^{9}$	$1{,}0 \cdot 10^{6}$
Lead (*Pb*)	—	$2{,}0 \cdot 10^{5}$
Mercury (*Hg*)	—	$5{,}0 \cdot 10^{3}$

Air pollutants can be released directly into the atmosphere (primary emissions) or can form as a result of chemical interaction involving precursor substances.

The air pollutant emissions cause air pollution, however, reductions in emissions do not always automatically result in similar cuts in concentrations.

There are complex links between air pollutant emissions and air quality. These include emission heights, chemical transformations, reactions to sunlight, additional natural and hemispheric contributions and the impact of weather and topography.

Significant cuts in emissions are essential for improving air quality.

The state of air pollution in Ukraine

Not so long ago, Ukraine was among those countries with high absolute and weighted air pollution levels. The tendency toward reduced pollution emissions witnessed during 1992-2000, has ended. Today, pollution is again rising.

In 2000, fuel and energy complex enterprises released 35 percent of pollution emissions into the atmospheric air, particularly 55.6 percent of the atmosphere's mechanical pollution, 75 percent of sulfur dioxide emissions, 58 percent of nitrogen oxide pollution and 5.4 percent of carbon oxide pollution.

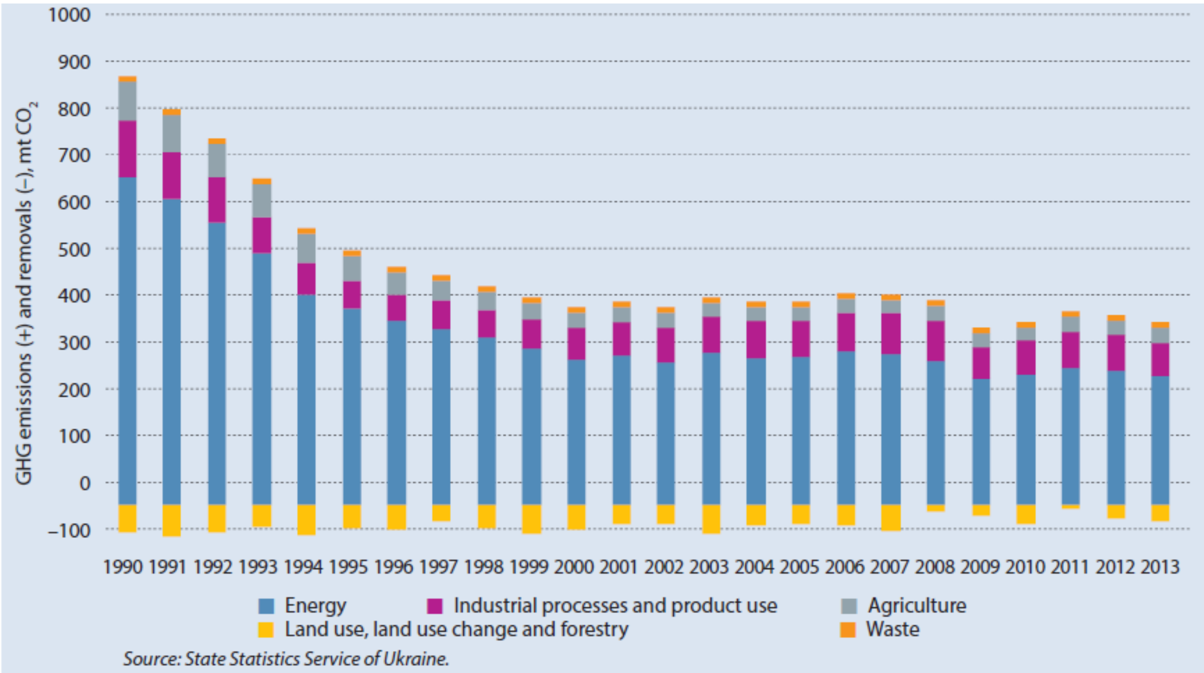


Figure 3.5 − Anthropogenic GHG emissions by source and removal by sinks in Ukraine, 1990–2013

Dust content exceeded specifications in 23 Ukrainian cities, particularly increasing in Kamianske (Dniprodzerzhinsk) (50 percent), Kremenchug (33 percent), Jani Kapu (Krasnoperekopsk) (36 percent), Poltava and Yalta (25 percent). The atmospheric air of Ukraine's industrial regions contains such harmful substances as formaldehyde, benz(a)pyrene, hydrogen fluoride, carbon oxide, and from time to time, they exceed their permissible levels.

In 2017, 3.97 million tons of pollutants were released into the atmosphere. Among them, 2.6 million are from stationary sources and 1.4 million are from mobile sources. Besides pollutants, 148.2 million tons of carbon dioxide was released into the atmosphere.

In 2015, there were 11303 enterprises that released pollutants into the atmosphere from stationary sources.

The emissions content is dominated by sulfur compounds (31.7%), carbon monoxide (26.7%), methane (18.0%), substances in the form of suspended solids (12.2%), nitrogen (9.2%), and other pollutants (2.1%).

The main air polluters in Ukraine are enterprises that produce electricity, gas and water (41.1%), processing industry (32.9%), mining industry and quarry development (17.2%).

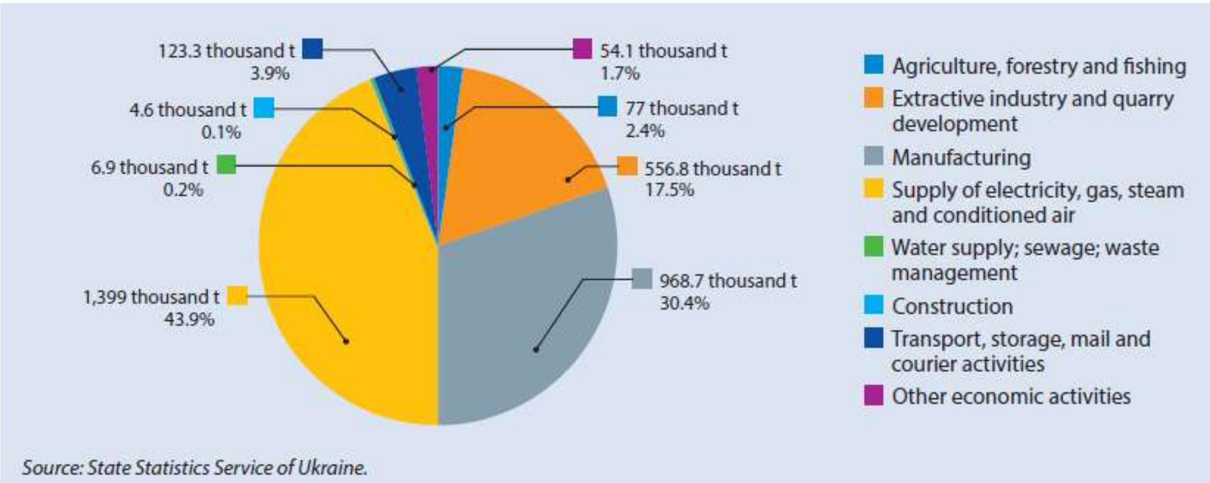


Figure 3.6 − Emissions of pollutants into the atmosphere in Ukraine by economic activity, 2014

Among human settlements of the Ukraine, the atmosphere of 6 cities (Burshtyn, Kamianske, Kurakhove, Energodar, Kryviy Rih, Mariupol) suffers from the highest anthropogenic load from stationary sources of emissions (over 100 thousand tons of emissions per year). Mainly these cities have power plants and enterprises of metallurgy and coke.

The majority of PE (Pollutant Emissions) from mobile sources is from automobile transport (88.7% of all emissions) and mobile production equipment (8.7%). In Ukraine, statistical data on emissions from mobile sources are collected since 2007. They take into account road, rail, aviation and water transport, as well as production equipment.

The emissions structure of the main chemical substances that came into the air during the exploitation of vehicles and production equipment was dominated by carbon monoxide (72.9%), nitrogen dioxide (13.2%), light non-methane organic compounds (10.7%), soot (1.7%) and sulfur dioxide (1.5%).

If data are compared with WHO (World Health Organization) recommendations on air quality in Europe, air quality improves regarding typical polluting substances, except for nitrogen oxide.

But when the question is about specific and toxic substances, even WHO standards are exceeded in almost all of Ukraine's large cities.

The worst air pollution is in Kiev, Kherson, Dnipro, Kryvyi Rih, Kamianske, Mariupol, Odessa, and Kramatorsk. Industrial regions produce greater ecological hazards, with emissions densities exceeding average country indicators. In general, emission volumes per person exceed indicators for developed countries by several times.

Close to 20% of elements that enter the atmosphere from stationary sources, meanwhile, are mutagenic. The growing number of automobiles has resulted in an increase of atmospheric air pollution, in the nation's big cities primarily. The quantity of automobile transportation will probably grow, and accordingly, the volume of air pollution from automobile sources will grow as well.

Monitoring of atmospheric air in Ukraine

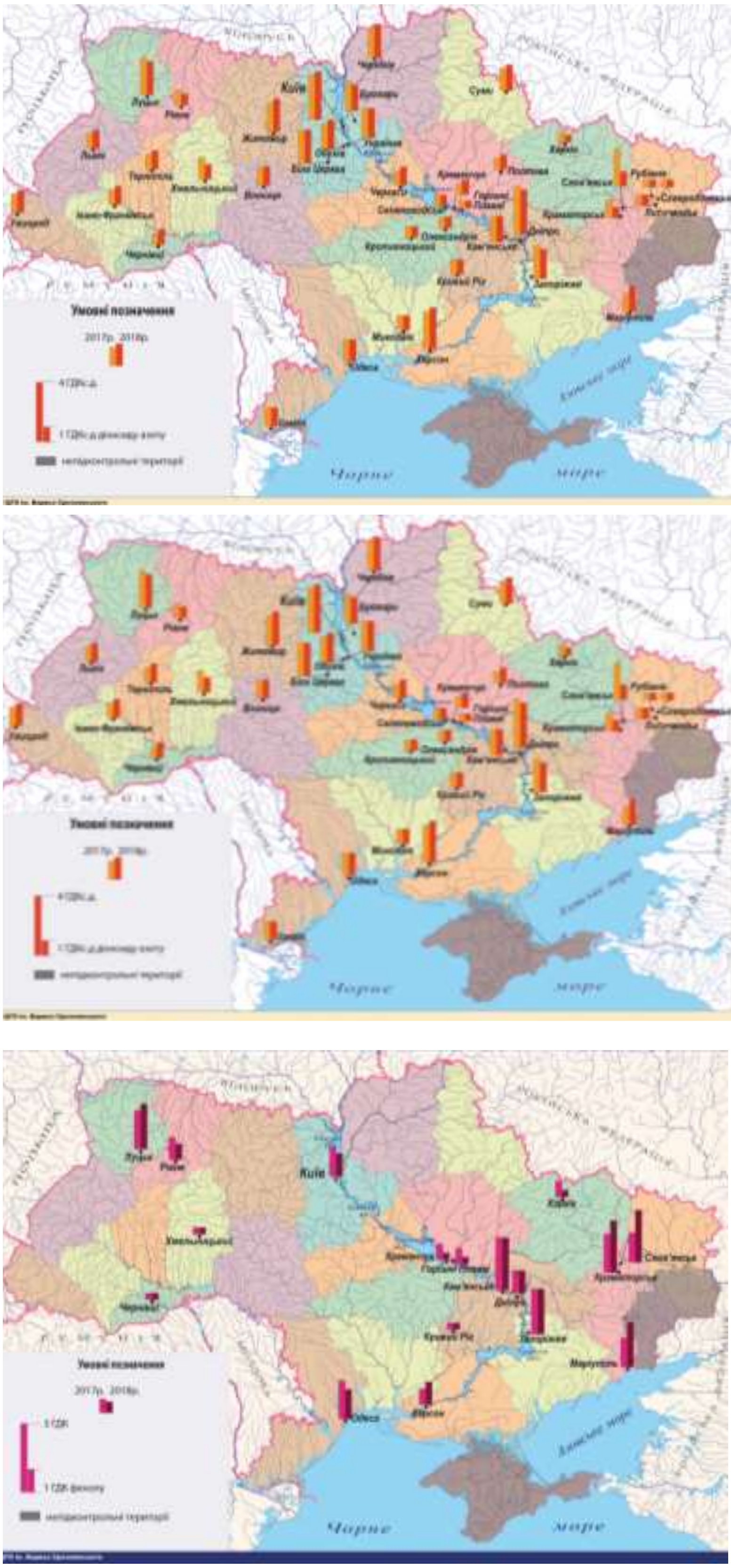
Monitoring of atmospheric air − is an informational and technical system of observation, evaluation and prediction of the air pollution level and providing on this basis recommendations for measures to protect air quality.

In accordance with the Resolution of the Cabinet of Ministers of Ukraine of March 9 1999, No. 343 "On Approval of the Procedure for the Organization and Monitoring of Air Pollution“ monitoring of air quality in Ukraine is performed by three bodies of the State Environmental Monitoring System:

1. The State Emergency Service of Ukraine (Ukrainian Hydrometeorological Center) carries out monitoring of air pollution in 39 cities of Ukraine by 129 stationary sites and 2 cross-border transfer stations (Svityaz, Rava-Ruska).

At the stationary posts, observations are carried out 4 times a day except Sundays and public holidays. Sampling is performed with the absorption filters within 20 minutes with subsequent determination of substance concentration.

In accordance with the Resolution listed above, mandatory air quality monitoring at the national level ("List A") covered seven pollutants: dust, nitrogen dioxide, sulfur dioxide, carbon monoxide, formaldehyde, lead and benzo(a)pyrene.



a)

b)

c)

Figure 3.7 − Maps of atmospheric air pollution in 2017 by the most widespread impurities, according to observations of the Ukrainian Hydrometeorological Center: a) suspended solids; b) nitrogen dioxide; c) phenol

According to new Resolution of the Cabinet of Ministers of Ukraine of 14.08.2019 No. 827 "On Approval of the Procedure for the Organization and Monitoring of Air Pollution" now List A includes:

Table 3.3 − The mandatory air quality monitoring at the national level (List A)

Pollutants in outdoor air	**Indicators and components of precipitation**
1. Sulfur dioxide	1. Ammonium ions
2. Nitrogen dioxide and nitrogen oxides	2. Hydrocarbonate ions
3. Benzene	3. Potassium ions
4. Carbon monoxide	4. Calcium ions
5. Lead	5. Total acidity
6. Particulate matter (PM_{10})	6. Magnesium ions
7. Particulate matter ($PM_{2,5}$)	7. Sodium ions
8. Arsenic	8. Nitrate ions
9. Cadmium	9. Sulfate ions
10. Mercury	10. Chloride ions
11. Nickel	11. pH
12. Benz (a) pyrene	
13. Ozone	

It should be noted that in Ukraine, concentrations of ozone, $PM_{2,5}$ and PM_{10} are not controlled in human settlements (except only 1 observation post of SI “O.M. Marzeiev Institute for Public Health of National Academy of Medical Sciences of Ukraine” and 6 stations of monitoring of the atmospheric air quality of the Automated Environmental Monitoring System of Donetsk Regional State Administration).

Concentrations of arsenic and mercury are controlled by the Ministry of Health of Ukraine when the need arises.

Some stations also control other pollutants. In accordance with the above-mentioned Procedure, monitoring of other 29 pollutants ("List B" - substances whose presence in the air is additionally determined by the decision of local executive authorities or local authorities) is carried out only at the regional level in accordance with the regional programs.

From List B, by the observation network of the Ukrainian Hydrometeorological Center determines ammonia, aniline, nickel, nitrogen oxide, hydrogen chloride, iron, soot, hydrogen sulfide, cadmium, phenol, hydrogen fluoride, manganese, chromium, copper, zinc; but don’t monitor such substances as benzene, ozone, hydrogen cyanide, mercury and its compounds, ethylbenzene, carbon disulfide, toluene, nitric acid, sulfuric acid, xylene, chlorine, chloranilin, arsenic and its compounds (as arsenic).

In total, 22 polluting impurities are determined in samples.

In addition, the analysis of pollutant presence is carried out in precipitation (41 weather stations) and snow cover (54 weather stations); hydro-meteorological parameters are also observed. The sulfate-hydrocarbonate type of precipitation remained as the dominant type on the greater part of the territory of Ukraine.

Up to now the observations are carried out in accordance with the requirements of the GD 52.04.186-89 "Guidelines for atmospheric pollution control".

In keeping with new Resolution about air monitoring system in Ukraine, List B now includes:

1. Ammonia;
2. Aniline;
3. Hydrogen chloride;
4. Hydrogen cyanide;
5. Iron and its compounds (in terms of iron);
6. Nitric acid;
7. Sulfuric acid;
8. Xylene;
9. Volatile organic compounds;
10. Manganese and its compounds (in terms of manganese dioxide);
11. Copper and its compounds (in terms of copper);
12. Soot;
13. Hydrogen sulfide;
14. Carbon sulfide;
15. Phenol;
16. Hydrogen fluoride;
17. Chlorine;
18. Chloroniline;
19. Chromium and its compounds (in terms of chromium);
20. Zinc and its compounds (in terms of zinc).

2. The Ministry of Health of Ukraine (State Sanitary and Epidemiological Survey, SES) (organization was disbanded in 2017) conducts periodic monitoring of air quality in residential and recreational areas, particularly near major roads, sanitary protection zones and residential buildings, on the territory of schools, preschool and medical institutions in urban areas.

In addition, the analysis of air quality is carried out in residential areas upon inhabitants’ complaints. The flare observations are also carried out near the sources of emissions.

Usually observations are carried out accordingly to the various social and health monitoring programs (5-15 air pollutants). The SES air quality monitoring programs are approved for each city and major settlement.

Monitoring of air quality performs on mobile or stationary control posts. Observations on the stationary posts conduct by sampling with absorption filters during 24 hours with subsequent determination of daily average concentrations by laboratory methods.

3) State Ecological Inspection of Ukraine (SEI) provides selective sampling at the emission sources. It measures over 65 parameters at more than 3,000 major sources of emissions, which belong to more than 1,500 enterprises.

Governance of state ecological monitoring of the Minecoenergo, as well as Regional governances of ecology and natural resources collected data from monitoring entities. Minecoenergo does not have its own network of air quality monitoring.

Current situation with national system of air monitoring

The state air monitoring has got new legal framework on August 14, 2019. The Procedure is based on Directive No. 2008/50/EC and Directive No. 2004/107/EC, which define the requirements for the monitoring of atmospheric air and air quality.

The Government's decision completely revised the old monitoring system, changed the approach to the formation of a network of observations and assessment of atmospheric air quality, clearly defined functions of the monitoring entities, revised mandatory indicators and regimes, introduced a mechanism for mandatory regular information and development long-term action plans.

But does adoption of the new framework mean Ukraine can start practical air monitoring in line with the European standards? In fact, there are several factors which will postpone or prevent effective implementation of the new air monitoring framework.

- The first factor is part of the new framework itself: it lacks necessary subordinate legislation. Effective implementation requires adoption by relevant ministry a number of decisions, setting clear requirements for each monitoring regime (fixed measurements, combination, modelling or objective estimation), development and approval of air quality management plans, action plans, new state air monitoring programs forms. Since the key ministry is under merging process, adoption of these new acts is likely to be delayed.

- A number of responsible institutions are yet to be defined or established: who is going to be responsible for air quality management, advisory and coordination bodies are lacking (such as Intergovernmental commission for state air quality monitoring). In turn, their absence delays development of relevant measures since they are supposed to be part of the process. This is true for air quality management plans and short-term action plans.

- Current level of institutional capacity of air monitoring authorities is also an important factor. There are serious doubts as to their capacity to install necessary and sufficient number of monitoring stations. The new air monitoring framework lacks any requirements as to the number of monitoring stations (as required by 2008/50 Air Quality directive). These requirements are yet to be set by the decision of the State Emergency Services. Rural monitoring stations are not addressed by the new framework. For instance the State Emergency Services reported its conclusions as compliance of current monitoring network with the Air Quality Directive. Their conclusions are clear: current network is insufficient to meet monitoring requirements set by the directive. No legal framework is in place.

- There's a need for technical modernization of monitoring stations and new monitoring organized for PM_{10} and $PM_{2.5}$, benzol and ozone. Overall costs needed for modernizing air monitoring network as estimated of 9.870−10.000 thousand Euros (about 10M).

Disadvantages of the Ukrainian monitoring system

The organization and methodology of atmospheric air quality monitoring in Ukraine does not meet EU standards.

- Requirements for the number of observation posts in settlements in Ukraine exceed similar EU standards;

- The list of substances monitored in Ukraine does not meet current needs;

- The use of indicative measurement or modelling is a poorly regulated by legal framework of Ukraine;

- Another disadvantage of the existing monitoring system is that measurements are taken at set time intervals;

- Hygienic air quality standards used in Ukraine are also imperfect;

- Ukraine lacks a legal framework for informing the public about the quality of atmospheric air.

Organization of the monitoring of atmospheric air

The existing network of air pollution survey includes:

- stationary sites,
- route sites,
- mobile sites (under plume sites).

<u>Site (or observation post)</u> is the selected location (point of detail), where the pavilion or car equipped with the appropriate instruments is located.

Stationary site is intended to provide for a regular air sampling to identify and register pollution content.

Route site is intended to provide for a regular air sampling in areas where impossible or impractical to set a stationary site.

Mobile site (under plume site) is designed for sampling in smoke (gas) plume to identify zone of influence of a particular source of industrial emissions.

Selecting of site location depends on: 1) the level of air pollution, which is representative of the respective region or 2) concentration of contaminants in a particular point that is influenced by emissions of certain industrial enterprise, highway or other source.

The most cities in the CIS[7] have 3−6 stationary sites, the largest of them – 6−20 (Kyiv − 16), most cities in Western Europe have 1−3 stationary sites.

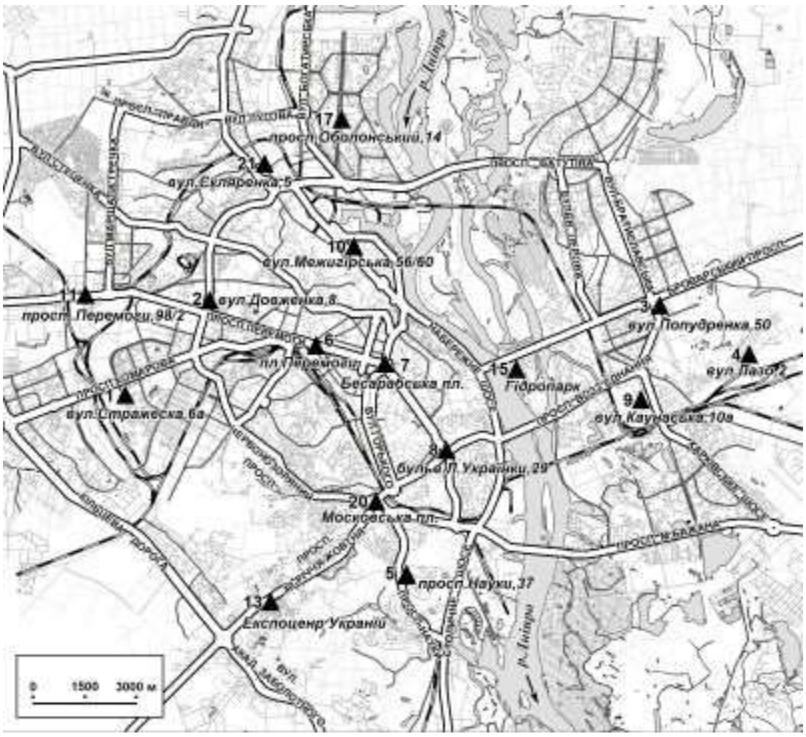


Figure 3.8 − Layout of stationary sites of observations in Kyiv

[7] CIS – The Commonwealth of Independent States

Now regular observations at stationary sites held by one of the four monitoring programs:

- complete monitoring program;
- incomplete monitoring program;
- reduced monitoring program;
- daily monitoring program.

Simultaneously with air sampling such meteorological parameters are determined: wind speed and wind direction, air temperature, weather conditions and the underlying surface conditions.

Air Quality Index (AQI)

An air quality index (AQI) is used by government agencies to communicate to the public how polluted the air currently is or how polluted it is forecast to become. Public health risks increase as the AQI rises.

Different countries have their own air quality indices, corresponding to different national air quality standards.

EPA (U.S. Environmental Protection Agency) calculates the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, EPA has established national air quality standards to protect public health.

To make it easier to understand, the AQI is divided into six categories:

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*..air quality conditions are:*	*...as symbolized by this color:*
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

Each category corresponds to a different level of health concern. The six levels of health concern and what they mean are:

- "Good" − AQI is 0 to 50. Air quality is considered satisfactory, and air pollution poses little or no risk.

- "Moderate" − AQI is 51 to 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.

- "Unhealthy for Sensitive Groups" − AQI is 101 to 150. Although general public is not likely to be affected at this AQI range, people with lung disease, older adults and children are at a greater risk from exposure to ozone, whereas persons with heart and lung disease, older adults and children are at greater risk from the presence of particles in the air.

- "Unhealthy" − AQI is 151 to 200. Everyone may begin to experience some adverse health effects, and members of the sensitive groups may experience more serious effects.

- "Very Unhealthy" − AQI is 201 to 300. This would trigger a health alert signifying that everyone may experience more serious health effects.

- "Hazardous" − AQI greater than 300. This would trigger a health warnings of emergency conditions. The entire population is more likely to be affected.

The European Air Quality Index. The Index is based on concentration values for up to five key pollutants, including:

- particulate matter (PM_{10});
- fine particulate matter ($PM_{2.5}$);
- ozone (O_3);
- nitrogen dioxide (NO_2);
- sulphur dioxide (SO_2).

The index is calculated hourly for more than two thousand air quality monitoring stations across Europe, using up-to-date data reported by EEA member countries. These data are not formally verified by the countries.

The Index indicates the short-term air quality situation. It does not reflect the long-term (annual) air quality situation, which may differ significantly.

The air quality index is not a tool for checking compliance with air quality standards and cannot be used for this purpose.

United Kingdom. The most commonly used air quality index in the UK is the Daily Air Quality Index.

This index has ten points, which are further grouped into four bands: low, moderate, high and very high. Each of the bands comes with advice for at-risk groups and the general population.

4. MONITORING OF SURFACE WATER. WATER QUALITY INDICATORS

Meaning of water

Without water our planet Earth would be a gigantic dead desert. According to present knowledge the Earth is the only planet of our solar system with water in all three phases: solid, liquid and gas.

The Earth's surface is clearly dominated by water: 70.8% of it (361.2 million km^2) is covered by the oceans, about 3.16% (more than 16.1 million km^2) by ice on land. Lakes cover approx. 2 million km^2 (0.39%). Including rivers and wetlands, with approx. 2.7 million km^2 (0.53%), the total water-covered surface of our planet is above 75%.

This is without considering the surface that are constantly covered with snow. In the troposphere water also occurs in liquid, gaseous and solid form, and very small amounts of water from the troposphere can even reach the stratosphere by means of turbulence.

Water has very important functions in the world. It plays a central role for the climate and for the co-evolution of the life on Earth[8].

Water is a scarce and incredibly valuable resource, necessary for maintaining life and agricultural and industrial development.

Protection and the ecological rehabilitation of water resources is a priority in ecological policy.

During the second part of the last century and the beginning of this one, the number of unresolved problems related to water resources continuously grew. Every year, water consumption increases, and its declining quality significantly influences human health.

Water resources in Ukraine

Ukraine has 63119 rivers, including 9 big ones (water catchment areas above 50 thous. km^2), 81 medium ones (from 2 to 50 thous. km^2), and 63029 small ones (less than 2 thous. km^2).

Their total length is 206.4 thous. km, 90 % of which fall on small rivers. Geographically almost all river basins (except South Bug) belong to international water basins − the fact that stipulates activity of transboundary water-environmental relations and need for accelerated development of the basin water resources management.

[8] Lozán, José L., S. Meyer & L. Karbe (2007): Water as the basis of life. In: Lozán, J. L., H. Grassl, P. Hupfer, L.Menzel & C.-D. Schönwiese. Global Change: Enough water for all?. Wissenschaftliche Auswertungen, Hamburg.

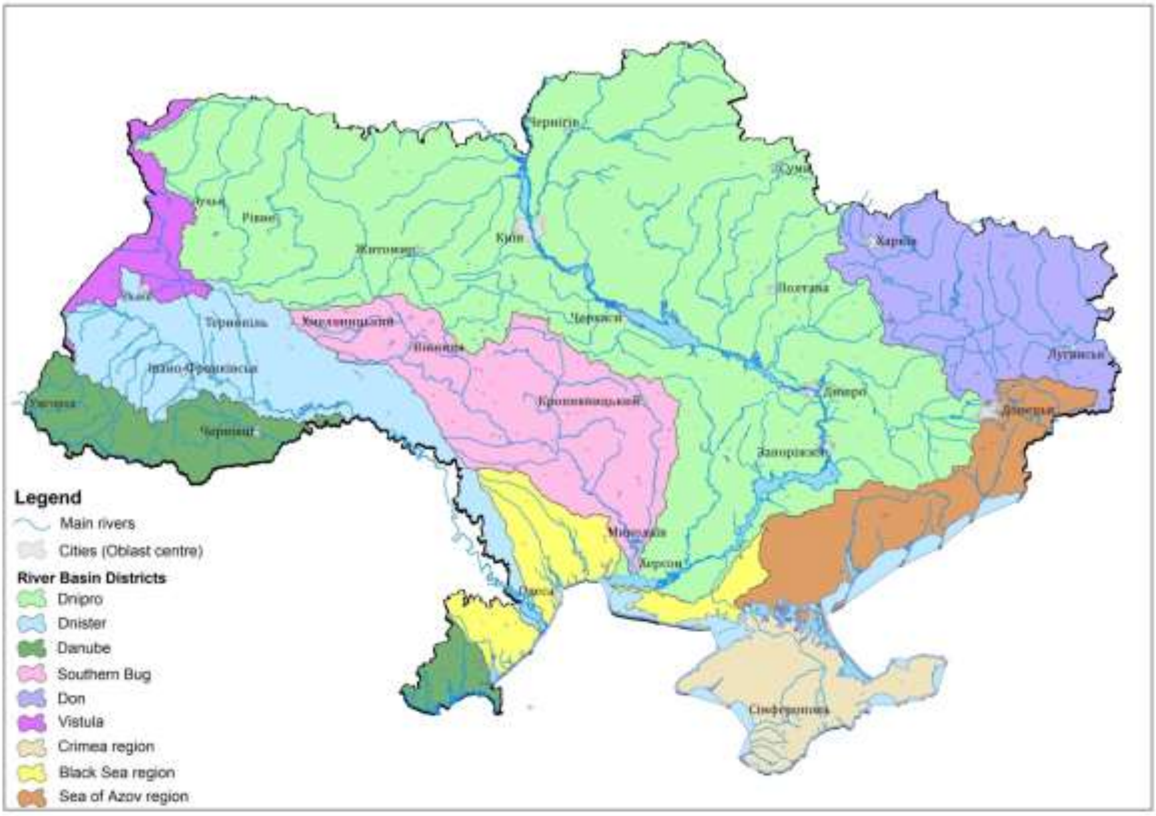


Figure 4.1 − Schematic map of hydrographical zoning of the territory of Ukraine by the basin principle (according to the State Agency of Water Resources)

Water stock of Ukraine includes about 8073 lakes and firths; the total water table area of which is 4021.5 km^2, the water table area of firths is 1073 km^2.

The number of water bodies that have water volumes of 1 million km^3 and more is 944. A relatively small part of the territory is occupied by the swamps, swampy terrain and excessively humidified lands − 3.6 million ha, but they play a significant resources stabilizing role.

Ukraine belongs to the least provided with water resources European countries. Its main component is river run-off.

Local water resources − those that are formed within Ukraine − amount to 52.4 km^3 in an average water-volume year.

Water resources are distributed in a very unequal way within the country's territory. Resources are higher in the north and less in the south, where the bigger water-consumers are located.

Ukraine also has underground water reserves. The general amount of forecasted exploitable subterranean water resources on the country's territory comes to 57.2 million cubic meters per day. The territorial division of subterranean water is uneven.

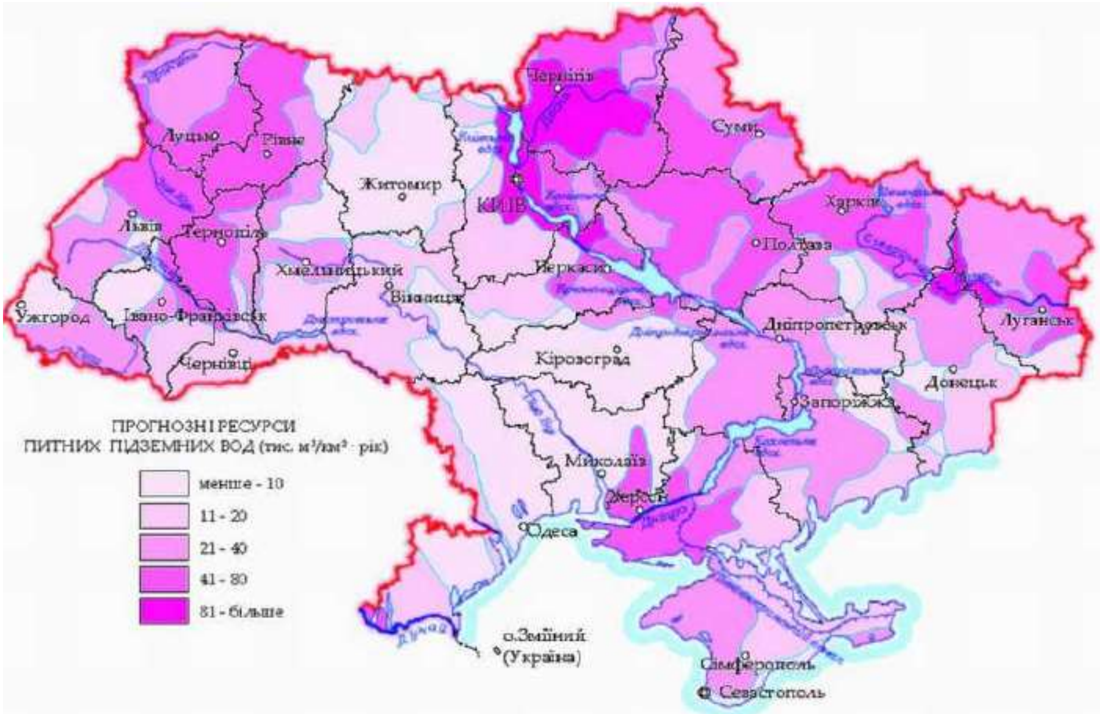


Figure 4.2 − Estimated resources of potable ground water in Ukraine

Judging by the amount of water per Ukrainian citizen, Ukraine, according to international standards, is among those countries insufficiently supplied with water resources. Among the 152 countries of the world Ukraine is 111th in terms of internal resources fresh water per capita.

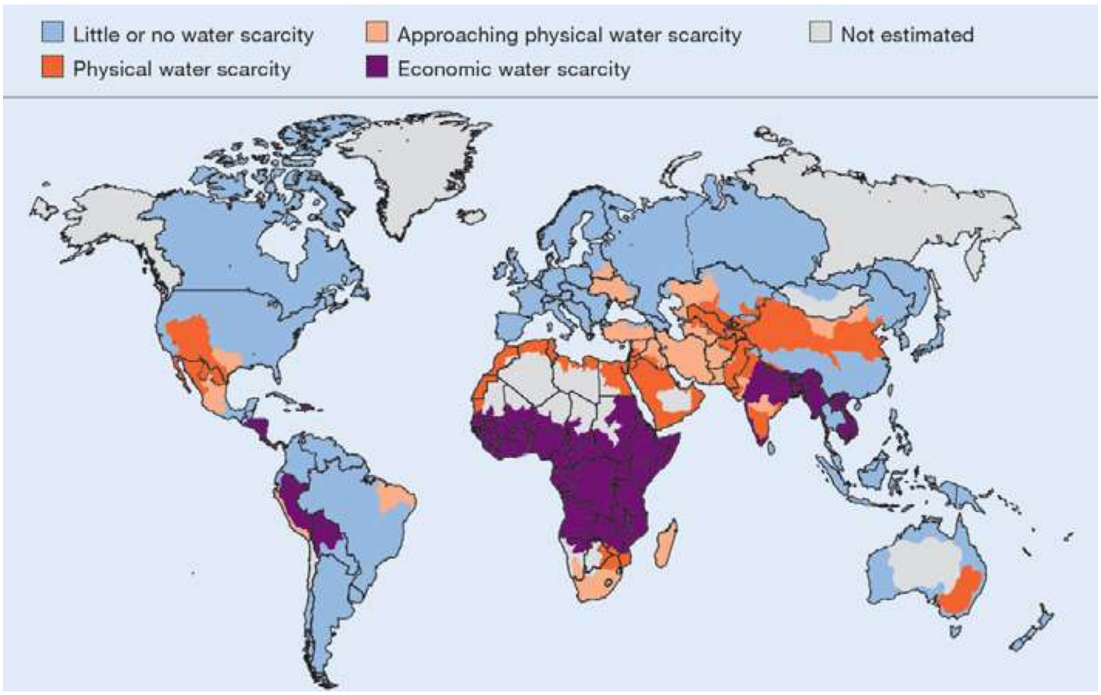


Figure 4.3 − Global water scarcity map

Source: Comprehensive Assessment of Water Management in Agriculture

As a result of limited water resources and the way they are distributed, river flow is widely regulated.

Reservoirs and ponds, in aggregate, hold close to 58 billion cubic meters, which exceeds the local river flow of all the country's rivers. Regulating the flow of the majority of rivers has reached, and even exceeded, the top-end economic- and ecology-based permissible limits.

Such regulation has drastically decreased and often completely destroyed rivers' capacity to purify themselves. In addition, many reservoirs (over 1100) and ponds (around 28 thousand) have caused increases in underground water levels in large areas, and changes in underground water systems.

Water use in Ukraine

Water use in Ukraine has multi-plan approach to water resource use. The consumer properties of water resources predetermine the possibilities for their complex and multipurpose use by many economic branches.

The main water consumers in Ukraine are industrial, agricultural and utility enterprises.

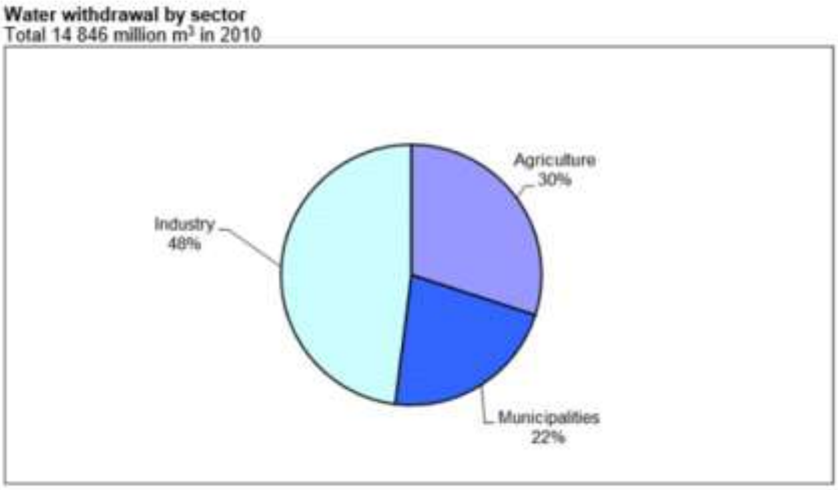


Figure 4.4 – Water withdrawal by sector in Ukraine

Source: FAO

Water consumption structure data analysis and the water supply and drainage system basic parameters dynamics, as well as the data on water quality dynamics, have shown that water use structure does not address the peculiarities of forming and territorial-time dividing the country's water resources and causes the creation of catastrophic situations within the population's water supply and economic entities for quantitative and qualitative indicators.

The water use situation is an intense one, and further developing it will be impossible if new stresses are added.

Ecological state of waters in Ukraine

Surface waters are much polluted, with the chief pollutants being poisonous chemicals, oil products, heavy metallic salts, phenols, and biogenic elements.

The connection of surface water pollution with economic activity in the past 10-15 years breaks down as follows:

- 60-65% is due to industry;
- 16-20% to agriculture;
- 18-20% to communal activity;

and around 1% to various spread-out contamination sources.

Low forestation and a high degree of tilled landscapes in small and medium rivers' sub-watershed systems provide ideal conditions for a stable surface water resource pollution level. With an average 70 percent of Ukraine's territory tilled, the indicators concerning reservoirs of some rivers vary between 58 and 78 percent, and the level of their agricultural cultivation reaches between 72 and 84 percent and more.

As a result of rapid anthropogenic element changes, pollution of surface water resources varies drastically, within a large range – from "mildly polluted" to "very polluted" (that is, from class II to VI, according to the current Ukrainian water quality classification system).

Calculations based on this classification show that 88% of tested rivers in Ukraine (and their basins) have ecological conditions ranging from "bad" to "catastrophic."

In the current structure of the processes of underground water pollution of Ukraine's territories, two levels are distinguished:

• almost complete pollution of subsoil waters (first from the day's surface water horizon), by remnants of mineral fertilizers, pesticides, heavy metals, oils, etc.;

• local pollution of the first urgent and deeper horizons of the active water cycle zone as a result of accelerated pollution migration under the influence of operating water off takes, mines, etc.

Water security

Water security is ensured access to sufficient quantity and acceptable quality water for all: for people, the economy and nature.

According to UN-Water, ***water security is defined as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water*** for:

• sustaining livelihoods, human well-being, and socioeconomic development,

• ensuring protection against water-borne pollution and water-related disasters, and

• for preserving ecosystems in a climate of peace and political stability.

The key challenges to ensure water security for people in Ukraine are:

1) challenges of water availability because of:

- natural water scarcity (lack of local surface or groundwater resources in 13 regions and Crimea; officially less than 1500 cubic meters per capita per year), climate change and extreme weather events (floods, droughts, heat waves, etc.) that affect both the water availability (in particular, lack of access to water during the drought due to drying and/or decreasing of water level in the springs, shallow wells, small rivers) and water quality (deterioration of water quality during a) drought – through evaporation and increase in the concentrations of substances in water sources, lack of surface water resources, particularly river flow for dilution of wastewater discharges from wastewater treatment plants (WWTP) or directly from sewer; and b) during floods or flesh-floods due to flooding of sources of drinking water supply and washing out a variety of contaminants from flooded areas, etc.);

- anthropogenic impacts or inefficient management of available water resources, leading to depletion and contamination of water resources (excessive water abstraction, inefficient water use, water losses in networks and irretrievable losses of water in technological processes, releases/discharges and emissions of pollutants into the environment);

2) problems of equal access to drinking water and sanitation for the population: the growing geographical, social and economic inequalities of different groups of consumers (inequality between rural and urban populations, between regions and within individual settlements regarding access to improved sources of drinking water and sanitation), social (children, internally displaced persons, population and military staff in the military conflict zone, patients in hospitals, people in prisons) and economic (large families, families with low income, other) inequalities of different groups of consumers.

3) problems regarding the quality of drinking water due to:

- poor quality of water in the sources (surface water, mainly, Dnipro River is a source of drinking water for 80 % of population of Ukraine, rivers flow regulated by dams, contaminated by organic compounds, nutrients and pollutants, sediments and eutrophication);

- outdated technology of water treatment and wastewater treatment;
- insufficient technical condition of the infrastructure and networks;
- a significant weakening of state control over the quality of water sources and drinking water.

4) affordability of water supply and sanitation services is now becoming the most critical. In a country where, according to experts assessments, more than 70 % of households unable to pay communal services bills, including water supply and sanitation, there is a real threat to ensure the human right to water and sanitation and to destroy water supplies and sanitation service provision.

Monitoring of surface waters in Ukraine

In Ukraine the national activity in the field of water quantity and water quality monitoring is regulated by Water Code of Ukraine, Law on Environmental Protection, Law on Hydrometeorological Activity, and a number of Regulations of the Cabinet of Ministers of Ukraine. The institutional activities in this field are undertaken by a number of governmental bodies. Basically, until recent times surface water quantity and water quality monitoring systems in Ukraine were inherited from the former Soviet Union.

Ukrainian Hydrometeorological Center of the State Emergency Service of Ukraine.

Observations of surface water quality are carried out on 103 rivers, 9 reservoirs, 7 lakes, 1 channel, 1 liman in 204 points on 327 sites (stream gauges) (See Fig. 4.5 below). 48 indicators of composition and properties of water as well as pollutants are determined. Samples are analyzed in 11 laboratories.

Hydrobiological observations and measurements of chronic toxicity of water are carried out on 49 water objects, at 88 points together with hydrochemical observations and are consistent with the specific phases of the water regime.

Hydrobiological samples collection is carried out by field research (by specialists of laboratories and personnel of hydrological stations) or directly by observers of hydrological sites. The water quality is determined directly by the state of the communities which live in water bodies.

Assessment of the state of hydrobiocenoses and ecosystems of controlled water bodies is determined by the results of evaluation of species composition and dynamics in abundance of phytoplankton, zooplankton, zoobenthos, periphyton, and higher aquatic vegetation and is provided by:

- bioindication − water quality assessment according to hydrobiological indicators;

- biotesting - an experimental determination of the toxicity of water.

Figure 4.5 – Sites for observation of surface water quality by hydrochemical indicators of the hydrometeorological service network in Ukraine (2016)

State Ecological Inspection of Ukraine collects water samples in the framework of planned and unplanned inspections of environmental compliance and takes individual samples at more than 2200 sites and receives data on 60 parameters that are being measured.

The State Agency of Water Resources of Ukraine monitors the state of rivers, water reservoirs, channels, irrigation systems within multi-purpose water economy systems, water supply systems, transboundary watercourses and reservoirs, in areas affected by nuclear power plants.

Water quality is controlled according to physical and chemical parameters at 72 water reservoirs, 164 rivers, 14 irrigation systems, 1 bay and 5 multi-purpose canals. Level of radionuclides in the surface waters is controlled by the water management organizations as part of radiation monitoring.

Number of observation sites – 435, quantity of parameters controlled – 16, frequency of observations – once a month.

The State Sanitary and Epidemiological Survey monitors centralized and de-centralized sources of supply of drinking water, recreation areas along rivers and water reservoirs. Observations are of selective seasonal character and reflect the state of water objects in summer period only as it is the most complicated from the environmental point of view.

Sanitary and epidemiological service controls chemical composition of ground waters that are designated for drinking purposes.

According to the monitoring results of the Laboratory Center of the Ministry of Health of Ukraine due to the lack or unsatisfactory status of sanitary protection zones of water supply sources, 46.7% of communal sources and 84.1% of rural water supply sources do not meet sanitary norms.

The State Service of Geology and Mineral Resources of Ukraine monitors the state of ground waters. The depths of ground waters and their natural geochemical composition are assessed twice a year at the monitoring sites. Twenty two parameters, including concentration of heavy metals and pesticides, are being measured.

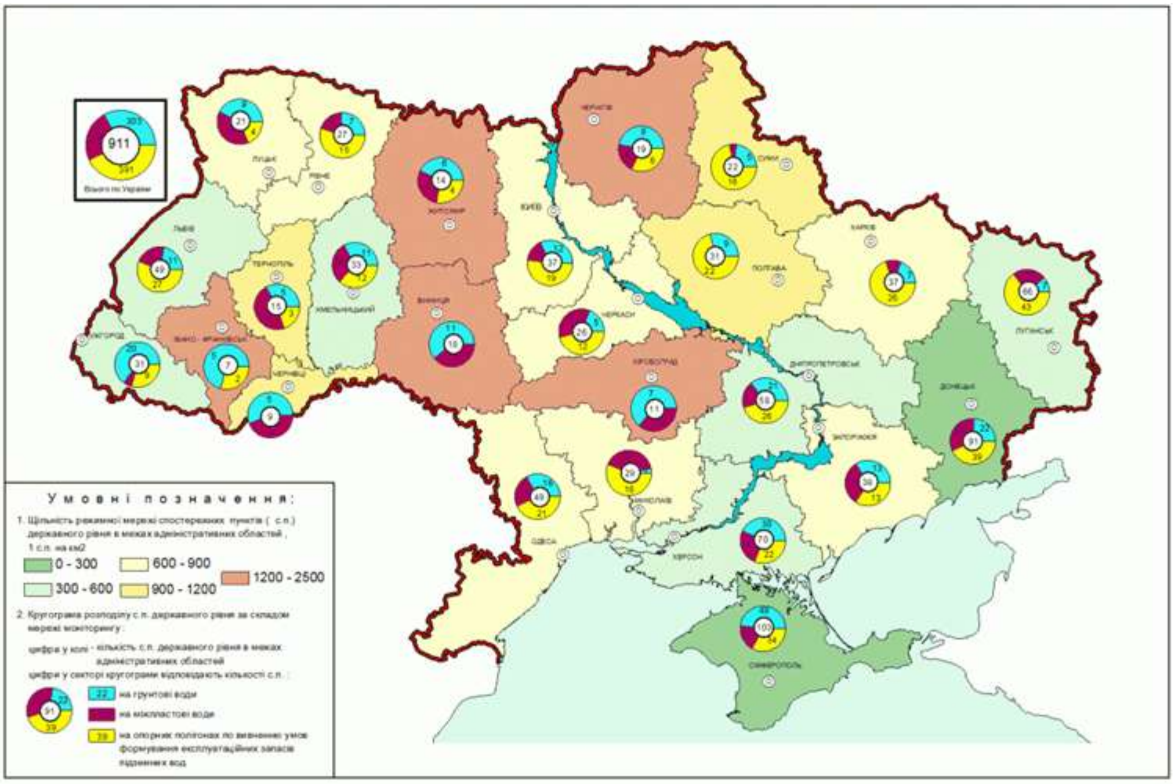


Figure 4.6 – Schematic map of the density of state-level observation points and their distribution by the composition of the groundwater monitoring network within administrative areas

The Ministry of Energy and Environmental Protection of Ukraine coordinates of water quality monitoring activities of different governmental bodies. It is also responsible for organization of monitoring of sources of anthropogenic impact and zones of their direct influence, and organization of the services for special inspections of analytical control.

Each governmental body involved in water quality monitoring uses its own software and data bank. As a result, the water quality data are distributed over various sources, unintegrated, and not comparable. There is no harmonized methodology for water quality monitoring.

The new approaches to monitoring of surface water in Ukraine

In 2014, Ukraine signed the Ukraine-European Union Association Agreement. According to this Agreement Ukraine has to make approximation of the Ukrainian "water" legislation to six EU Directives:

- Directive 2000/60/EC establishing a framework for the Community action of water policy (Water Framework Directive);
- Directive 2008/56/EC establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive);
- Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources (Nitrates Directive);
- Directive 98/83/EC on the quality of water intended for human consumption (Drinking Water Directive);
- Directive 91/271/EEC concerning urban waste-water treatment (Urban Waste Water Directive);
- Directive 2007/60/EC on the assessment and management of flood risks (The Floods Directive).

<u>Legislation of Ukraine related to River basin management planning</u> is described below:

- Water Code;

- Law of Ukraine on amendments to certain legislative acts of Ukraine regarding implementation of integrated approaches in water resources management based on the basin principle dated 04.10.2016 № 1641-VIII

Resolutions of the Cabinet of Ministers of Ukraine:

- On Approving the Procedure for the Development of River Basin Management Plans dated 18.05.2017 № 336;

- On Approval of the Procedure of State Monitoring of Water Resources dated 19.09.2018 № 758;

Orders of the Ministry of Energy and Environmental Protection of Ukraine:

- On Identification of Sub-Basins and Water Management Units within the Established River Basin Districts;

- On Delineation of River Basin Districts, Sub-Basins and Water Management Units;

- On Approving the Procedure for the Development of Water Balances;

- On Approving the List of Priority Substances;

- On Approving the Model Regulation on River Basin Councils;

- On Approving the List of Pollutants for the identification of the Chemical Condition of Surface and Groundwater Bodies.

Prior to September 2018, water potential of Ukrainian rivers was managed solely by public bodies, first of all, the State Water Agency. Neither citizens nor businesses had direct access to decision making in this area.

A new Water Code was adopted in Ukraine in October 2016. A new advisory body – basin council – had to be established in accordance with European legislation and Ukraine's commitments under the Association Agreement.

In the fall of 2017, these councils went operational. They bring together all water users (i.e. businesses, agricultural enterprises, citizens and public bodies) to jointly solve the problems of Ukrainian bodies of water.

There are 13 active basin councils presently in Ukraine, according to the number of geographic basins of large rivers. Their work procedures have been borrowed from European experience.

The new procedure for the water monitoring program, approved by the Cabinet of Ministers of Ukraine in 2018, came into force as from January 1, 2019. This procedure is aligned with the EU directives and will help to get more information about the state of water in the country.

A new system of the monitoring of water provides the next points:

- clear division or responsibilities between organization, which measure the rates without duplication of the authorities;

- extended lists of the biologic, hydromorphological, chemical and physical and chemical indicators for the monitoring

- implemented six-year cycle of monitoring

- implementation of the classification of state of the waters: five classes of ecological state and two classes of chemical state;

- increase of the number of points of monitoring of the waters from a few hundred up to a few thousands.

Basics of water quality monitoring

Water quality and quantity are intimately linked although not often measured simultaneously.

Water quantity is often measured by means of remote hydrological monitoring stations which record water level, discharge, and velocity. Monitoring of water quantity can be undertaken, to a certain degree, with a minimal amount of human intervention, once a monitoring station has been set up.

In contrast, ***water quality*** is usually determined by analysing samples of water collected by teams of personnel visiting monitoring stations at regular intervals.

The costs associated with monitoring the many parameters that influence water quality, when compared to those associated with monitoring only a few water quantity variables, usually means that water quality monitoring is not undertaken as frequently as water quantity monitoring. However, the results of water quality monitoring are vital to being able to track both spatial and temporal trends in surface and ground waters.

The quality of any body of surface or ground water is a function of either or both natural influences and human activities.

Without human influences, water quality would be determined by the weathering of bedrock minerals, by the atmospheric processes of evapotranspiration and the deposition of dust and salt by wind, by the natural leaching of organic matter and nutrients from soil, by hydrological factors that lead to runoff, and by biological processes within the aquatic environment that can alter the physical and chemical composition of water.

As a result, water in the natural environment contains many dissolved substances and non-dissolved particulate matter.

Surface runoff is extremely variable. It is influenced by latitude, local differences in elevation (orography) and location on continents. In regions where runoff is less than 25 mm/year, rivers are not perennial unless fed by wetter basins further upstream.

Water quality is neither a static condition of a system, nor can it be defined by the measurement of only one parameter. Rather, it is variable in both time and space and requires routine monitoring to detect spatial patterns and changes over time.

There is a range of chemical, physical, and biological components that affect water quality and hundreds of variables could be examined and measured. Some variables provide a general indication of water pollution, whereas others enable the direct tracking of pollution sources.

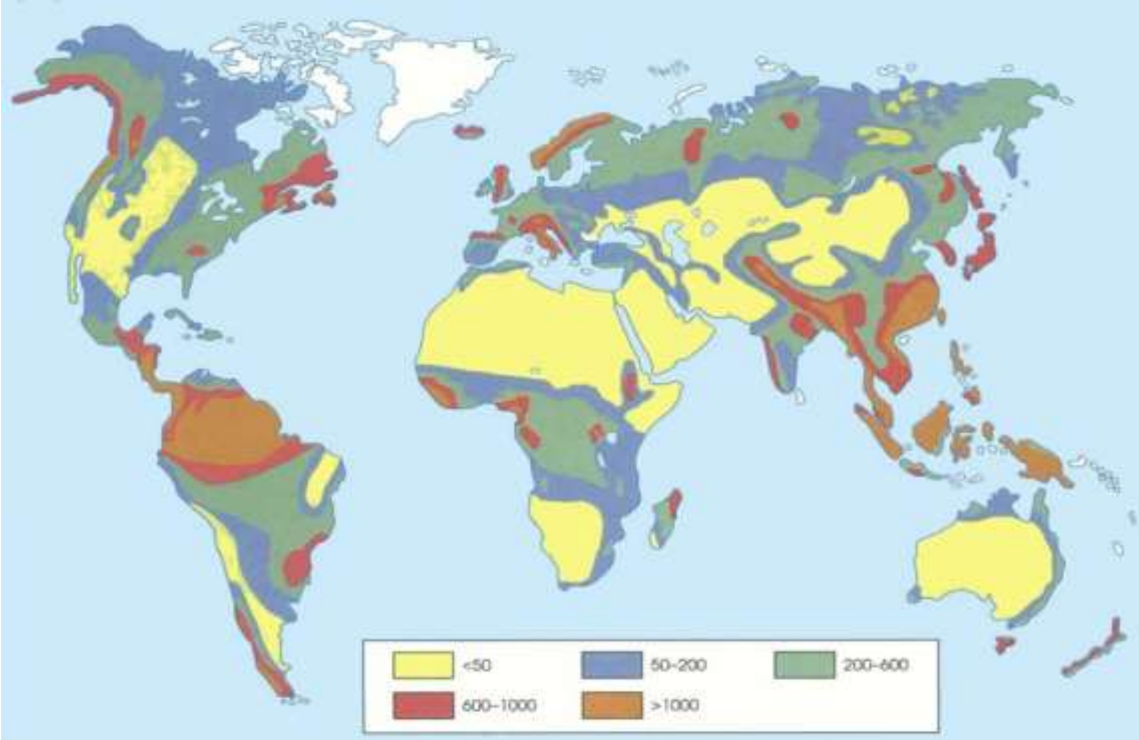


Figure 4.7 – Global distribution of annual surface runoff (UNEP)

Water quality parameter

Temperature

Temperature affects the speed of chemical reactions, the rate at which algae and aquatic plants photosynthesize, the metabolic rate of other organisms, as well as how pollutants, parasites, and other pathogens interact with aquatic residents.

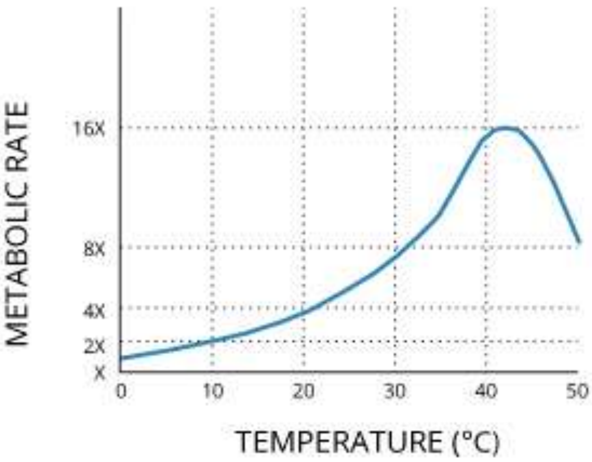


Figure 4.8 – The metabolic rates of aquatic organisms increase as the water temperature increases

Temperature is important in aquatic systems because it can cause mortality and it can influence the solubility of Dissolved Oxygen (DO) and other materials in the water column (e.g., ammonia).

Water temperatures fluctuate naturally both daily and seasonally.

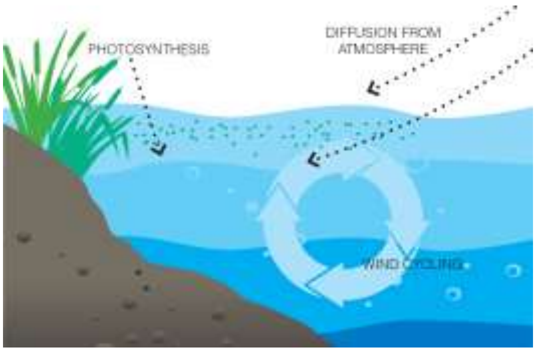
Aquatic organisms often have narrow temperature tolerances. Thus, although water bodies have the ability to buffer against atmospheric temperature extremes, even moderate changes in water temperatures can have serious impacts on aquatic life, including bacteria, algae, invertebrates and fish.

Thermal pollution comes in the form of direct impacts, such as the discharge of industrial cooling water into aquatic receiving bodies, or indirectly through human activities such as the removal of shading stream bank vegetation or the construction of impoundments.

Dissolved Oxygen

Oxygen that is dissolved in the water column is one of the most important components of aquatic systems. Oxygen is required for the metabolism of aerobic organisms, and it influences inorganic chemical reactions. Oxygen is often used as an indicator of water quality, such that high concentrations of oxygen usually indicate good water quality.

Oxygen enters water through diffusion across the water's surface, by rapid movement such as waterfalls or riffles in streams (aeration), or as a by-product of photosynthesis.



The amount of dissolved oxygen gas depends highly on temperature and somewhat on atmospheric pressure.

Salinity also influences dissolved oxygen concentrations, such that oxygen is low in highly saline waters and vice versa. The amount of any gas, including oxygen, dissolved in water is inversely proportional to the temperature of the water; as temperature increases, the amount of dissolved oxygen (gas) decreases.

High algal production in the surface waters can lead to depleted oxygen concentrations at depth as cells die and settle to the bottom of the lake, where they are decomposed by bacteria. The decomposition process consumes oxygen from the water through bacterial respiration.

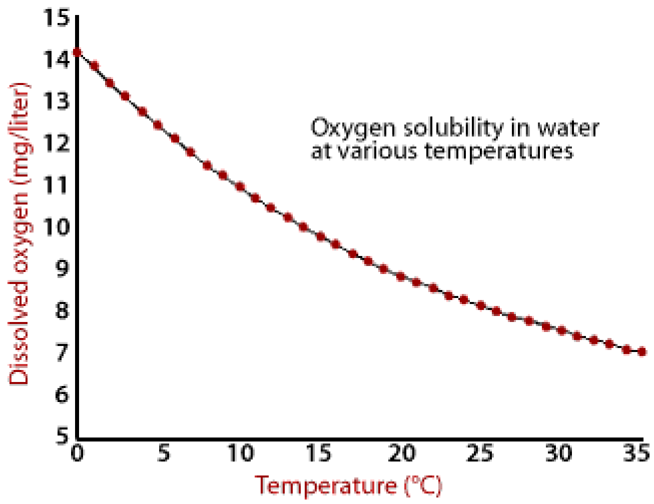
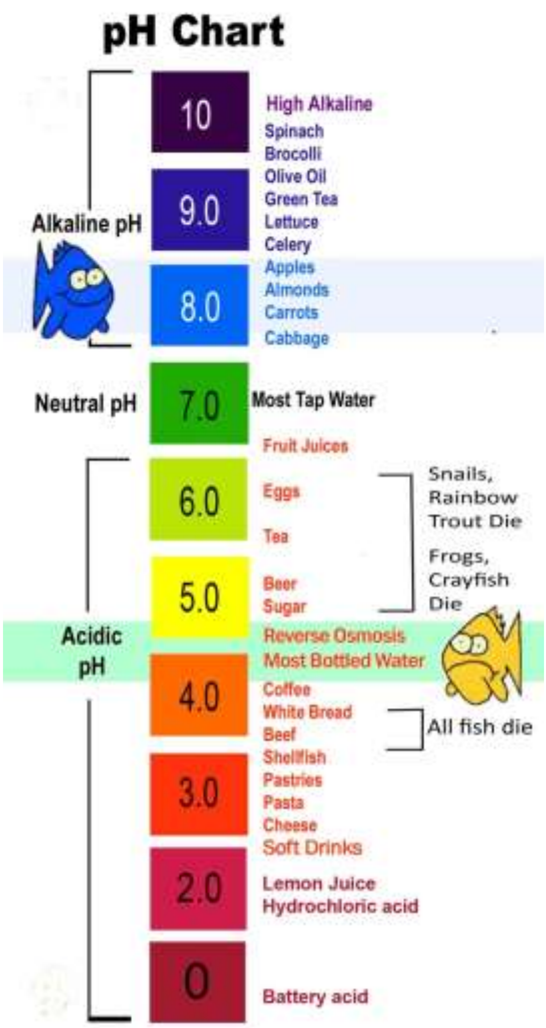


Figure 4.9 – The graph shows the maximum amount of oxygen that can be dissolved in water at various temperatures. Assuming a constant atmospheric pressure, water of low temperatures can hold more oxygen than water of high temperatures

pH and Alkalinity



In water, a small number of water (H_2O) molecules dissociate and form hydrogen (H+) and hydroxyl (OH-) ions.

If the relative proportion of the hydrogen ions is greater than the hydroxyl ions, then the water is defined as being acidic. If the hydroxyl ions dominate, then the water is defined as being alkaline.

The relative proportion of hydrogen and hydroxyl ions is measured on a negative logarithmic scale from 1 (acidic) to 14 (alkaline): 7 being neutral.

The pH of an aquatic ecosystem is important because it is closely linked to biological productivity. Although the tolerance of individual species varies, pH values between 6.5 and 8.5 usually indicate good water quality.

There are many factors that can affect pH in water, both natural and man-made. Most natural changes occur due to interactions with surrounding rock (particularly carbonate forms) and other materials.

pH can also fluctuate with precipitation (especially acid rain) and wastewater or mining discharges. In addition, CO_2 concentrations can influence pH levels.

<u>Turbidity, Suspended Solids and Water Clarity</u>

Turbidity refers to water clarity. The greater the amount of suspended solids in the water, the murkier it appears, and the higher the measured turbidity. The major source of turbidity in the open water zone of most lakes is typically phytoplankton, but closer to shore, particulates may also include clays and silts from shoreline erosion, re-suspended bottom sediments, and organic detritus from stream and/or water discharges.

Suspended solids in streams are often the result of sediments carried by the water. The source of these sediments includes natural and anthropogenic (human) activities in the watershed, such as natural or excessive soil erosion from agriculture, forestry or construction, urban runoff, industrial effluents, or excess phytoplankton growth.

Turbidity is often expressed as total suspended solids (TSS).

Figure 4.10 – Both organic and inorganic particles of all sizes can contribute to the suspended solids concentration

Water clarity is a physical characteristic defined by how clear or transparent water is. Clarity is determined by the depth that sunlight penetrates in water. The further sunlight can reach, the higher the water clarity.

Water clarity is directly related to turbidity, as turbidity is a measure of water clarity.

Turbidity and total suspended solids refer to particles present in the water column. Turbidity and water clarity are both visual properties of water based on light scattering and attenuation.

All three parameters are related to particles in the water column, whether directly or indirectly. Water clarity is the most subjective measurement of the these three parameters, as it is usually determined by human observation.

Salinity and Specific Conductance

Salinity is an indication of the concentration of dissolved salts in a body of water. The ions responsible for salinity include the major cations (calcium, Ca^{2+}; magnesium, Mg^{2+}; sodium, Na^{+}; and potassium, K^{+}) and the major anions (carbonates, sulphate, and chloride).

The level of salinity in aquatic systems is important to aquatic plants and animals as species can survive only within certain salinity ranges.

Salinity is measured by comparing the dissolved solids in a water sample with a standardized solution. The dissolved solids can be estimated using total dissolved solids (TDS) or by measuring the specific conductance.

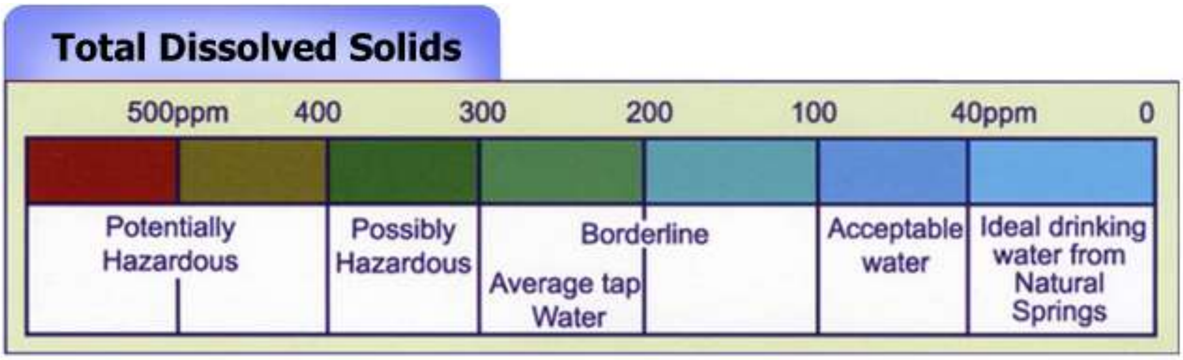


Figure 4.11 – TDS acceptable levels in drinking water

Total dissolved solids combine the sum of all ion particles that are smaller than 2 microns (0.0002 cm). In "clean" water, TDS is approximately equal to salinity. In wastewater or polluted areas, TDS can include organic solutes (such as hydrocarbons and urea) in addition to the salt ions.

Specific conductance, or *conductivity*, measures how well the water conducts an electrical current, a property that is proportional to the concentration of ions in solution. Conductivity is often used as a surrogate of salinity measurements and is considerably higher in saline systems than in non-saline systems.

Municipal, agricultural, and industrial discharges can contribute ions to receiving waters or can contain substances that are poor conductors (organic compounds) changing the conductivity of the receiving waters. Thus, specific conductance can also be used to detect pollution sources.

Nutrients

Nutrients are elements essential to life. The major nutrients, or macronutrients, required for metabolism and growth of organisms include carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulphur, magnesium, and calcium.

In aquatic systems, nitrogen and phosphorus are the two nutrients that most commonly limit maximum biomass of algae and aquatic plants (primary producers), which occurs when concentrations in the surrounding environment are below requirements for optimal growth of algae, plants and bacteria.

There are many micronutrients also required for metabolism and growth of organisms, but for the most part, demands for these nutrients do not exceed supply.

Compounds of nitrogen (N) and phosphorus (P) are major cellular components of organisms. Since the availability of these elements is often less than biological demand, environmental sources can regulate or limit the productivity of organisms in aquatic ecosystems.

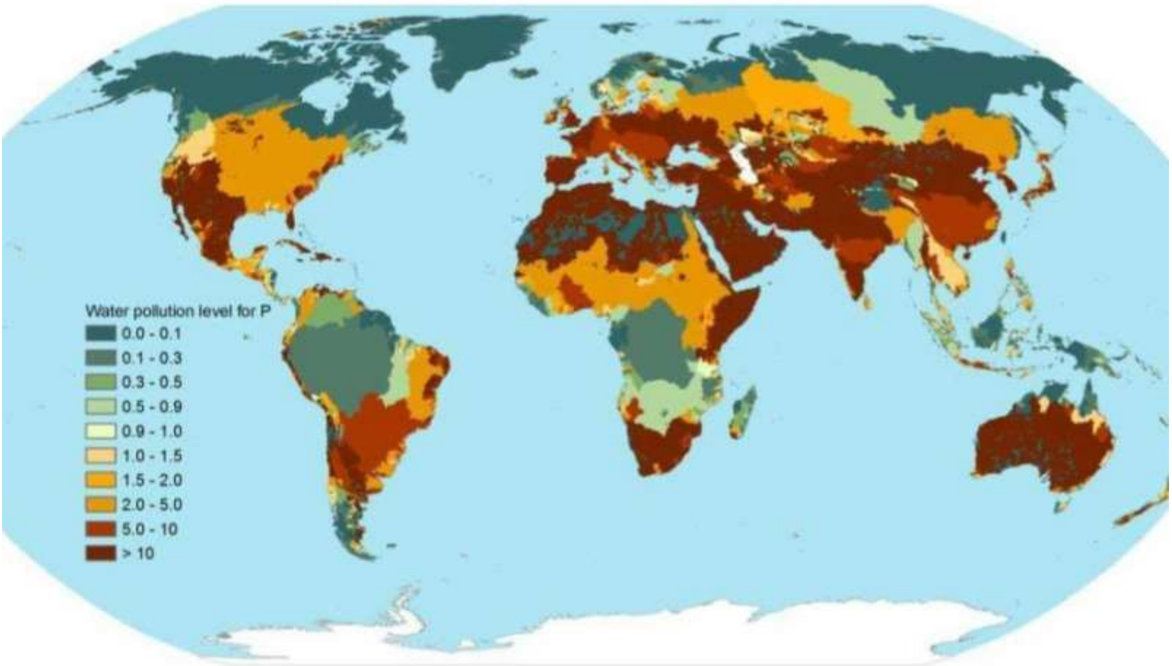


Figure 4.12 – Water pollution level per river basin related to human-induced phosphorus loads from the agricultural, industrial and domestic sectors from 2002-2010

Source: Mekonnen et al./WRR/AGU

Phosphorus is present in natural waters primarily as phosphates, which can be separated into inorganic and organic phosphates. Phosphates can enter aquatic environments from the natural weathering of minerals in the drainage basin, from biological decomposition, and as runoff from human activities in urban and agricultural areas.

Nitrogen occurs in water in a variety of inorganic and organic forms and the concentration of each form is primarily mediated by biological activity.

Phosphorus and nitrogen are considered to be the primary drivers of eutrophication of aquatic ecosystems, where increased nutrient concentrations lead to increased primary productivity.

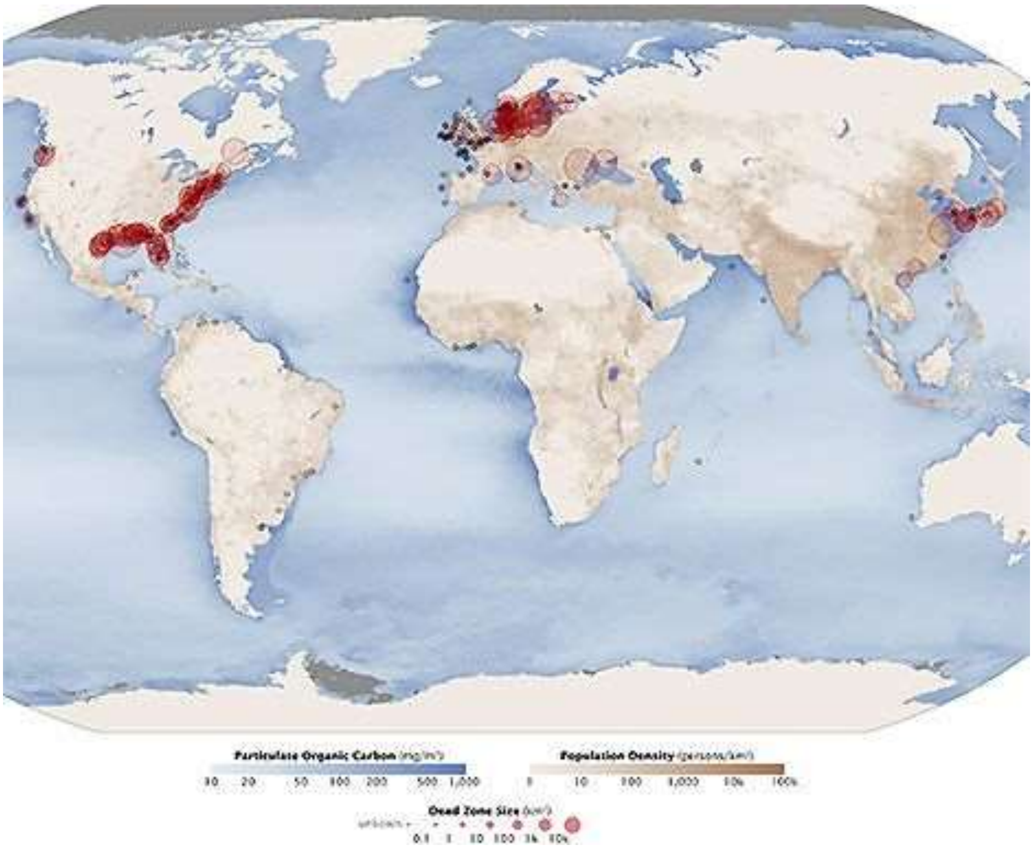


Figure 4.13 – Map of Aquatic Dead Zones
Image: NASA, public domain

Aquatic and marine dead zones can be caused by an increase in chemical nutrients (particularly nitrogen and phosphorus) in the water, known as eutrophication.

The degradation of water quality due to enrichment by nutrients, primarily nitrogen (N) and phosphorus (P), which results in excessive plant (principally algae) growth and decay. When levels of N:P are about 7:1, algae will thrive. Low dissolved oxygen (DO) in the water is a common consequence.

Degrees of eutrophication typically range from *Oligotrophic* water (maximum transparency, minimum chlorophyll-a, minimum phosphorus) through *Mesotrophic*, *Eutrophic*, to *Hypereutrophic* water (minimum transparency, maximum chlorophyll-a, maximum phosphorus).

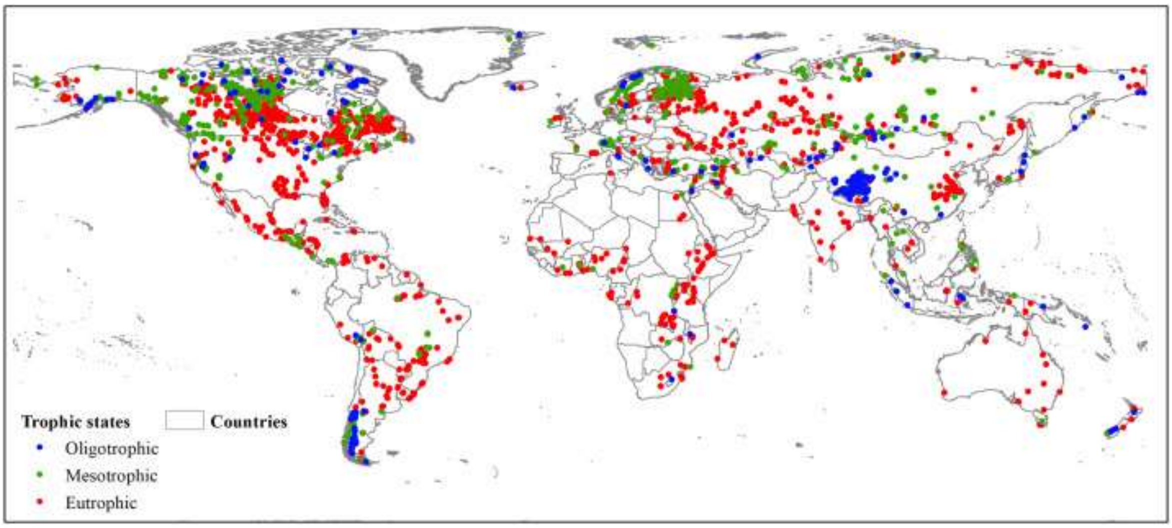


Figure 4.14 – Trophic state assessment of global inland waters
Source: https://www.sciencedirect.com/science/article/abs/pii/S0034425718304012

Organic Matter

Organic matter is important in the cycling of nutrients, carbon and energy between producers and consumers and back again in aquatic ecosystems. External subsidies of organic matter that enter aquatic ecosystems from a drainage basin through point sources such as effluent outfalls, or non-point sources such as runoff from agricultural areas, can enhance microbial respiration and invertebrate production of aquatic ecosystems.

Organic matter affects the biological availability of minerals and elements, and has important protective effects in many aquatic ecosystems, by influencing the degree of light penetration that can enter.

Many aquatic ecosystems rely heavily on external subsidies of organic matter to sustain production. However, excess inputs of organic matter from the drainage basin, such as those that may occur downstream of a sewage outfall, can upset the production balance of an aquatic system and lead to excessive bacterial production and consumption of dissolved oxygen that could compromise the integrity of the ecosystem and lead to favourable conditions for growth of less than ideal species.

Biochemical Oxygen Demand (BOD) and ***Chemical Oxygen Demand (COD)*** are two common measures of water quality that reflect the degree of organic matter pollution of a water body.

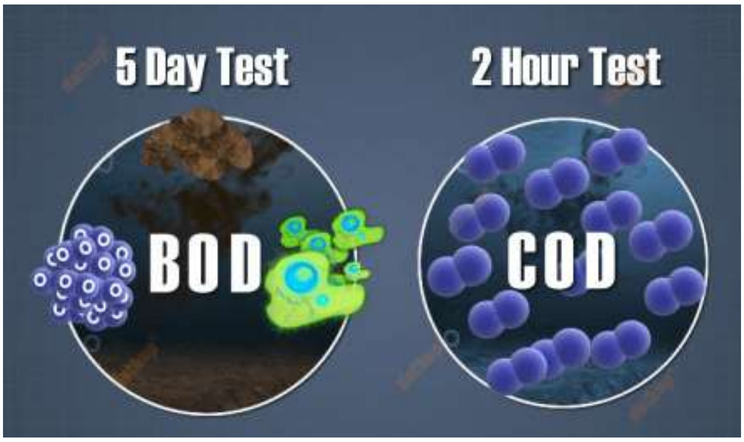
BOD is a measure of the amount of oxygen removed from aquatic environments by aerobic micro-organisms for their metabolic requirements during the breakdown of organic matter, and systems with high BOD tend to have low dissolved oxygen concentrations.

Table 4.1 – Water Quality and BOD

BOD Level in mg/liter	Water Quality
1 - 2	**Very Good:** There will not be much organic matter present in the water supply.
3 - 5	**Fair:** Moderately Clean
6 - 9	**Poor:** Somewhat Polluted - Usually indicates that organic matter present and microorganisms are decomposing that waste.
100 or more	**Very Poor:** Very Polluted - Contains organic matter.

Biochemical Oxygen Demand (BOD) is a measure of the quantity of dissolved oxygen, in milligrams per liter, necessary for the decomposition of organic matter by microorganisms, such as bacteria.

Chemical Oxygen Demand (COD) is a water quality measure used to indirectly measure the amount of organic compounds in water. This process converts all organic matter into carbon dioxide. It is limited in that it cannot differentiate between levels of biologically active organic substances and those that are biologically inactive.



Similar to BOD, COD is a general indicator of water quality. In contrast to BOD, COD testing only takes a few hours to complete. For this reason, wastewater treatment facilities use both BOD and COD testing to monitor the treatment process, with COD testing being used to scrutinise the day-to-day operations.

If BOD were the only testing available, treated wastewater would not be released until results are verified, and any problems detected during testing are resolved. The entire process would take far too long.

<u>Biological components</u>

Organisms, populations, and communities composed of different species make up the biological diversity of aquatic ecosystems.

From single-celled microbes such as viruses, bacteria, protists, and fungi, to multi-cellular organisms such as vascular plants, aquatic invertebrates, fish and wildfowl, the community of organisms that reside within and near aquatic ecosystems simultaneously plays a vital role in regulating biogeochemical fluxes in their surrounding environment and is influenced by these same biogeochemical fluxes.

Given the importance of biological communities to water quality, water pollution should be considered as a biological issue since it impairs the ability of resident and non-resident organisms to use resources provided by the ecosystem and to maintain ecological services.

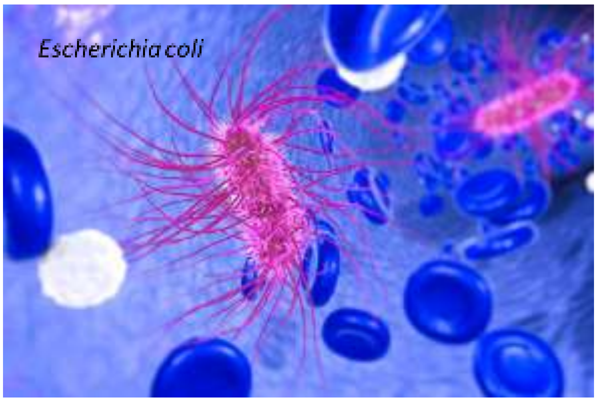
Physical loss of habitat and changes in the chemical composition of water can inhibit a species' ability to grow, reproduce, and interact with other species in the ecosystem.

Various pollutants have differing effects ranging from inducing catastrophic mortality to chronic illness, in addition to the effects of bio-accumulation through the food chain.

The monitoring of biological communities can be done at *a variety of trophic levels* including

- micro-organisms (bacteria, protists, and viruses),
- primary producers (algae and vascular plants),
- primary consumers (invertebrates) and
- secondary consumers (fish).

Monitoring microbes in surface or ground waters is used to detect the presence of pathogenic organisms in order to prevent disease.



The most revealing microorganism of water pollution is *coliform bacterium* (Escherichia coli, E. coli).

The degree of biological pollution is characterized by such indexes as coli-titer (the smallest volume of water per one E. coli) and coli index (absolute number of E. coli in 1 cubic decimetre of water).

Algae and *aquatic vascular plants* generally have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term environmental impacts. Algae and aquatic plants, as primary producers, are most directly affected by physical and chemical factors and are sensitive to pollutants which may not visibly affect other aquatic assemblages, or that may only affect other organisms at higher concentrations.

Aquatic invertebrates are consumers that feed, primarily, on bacteria, algae, and detrital matter that is both produced within and enters from the surrounding catchment.

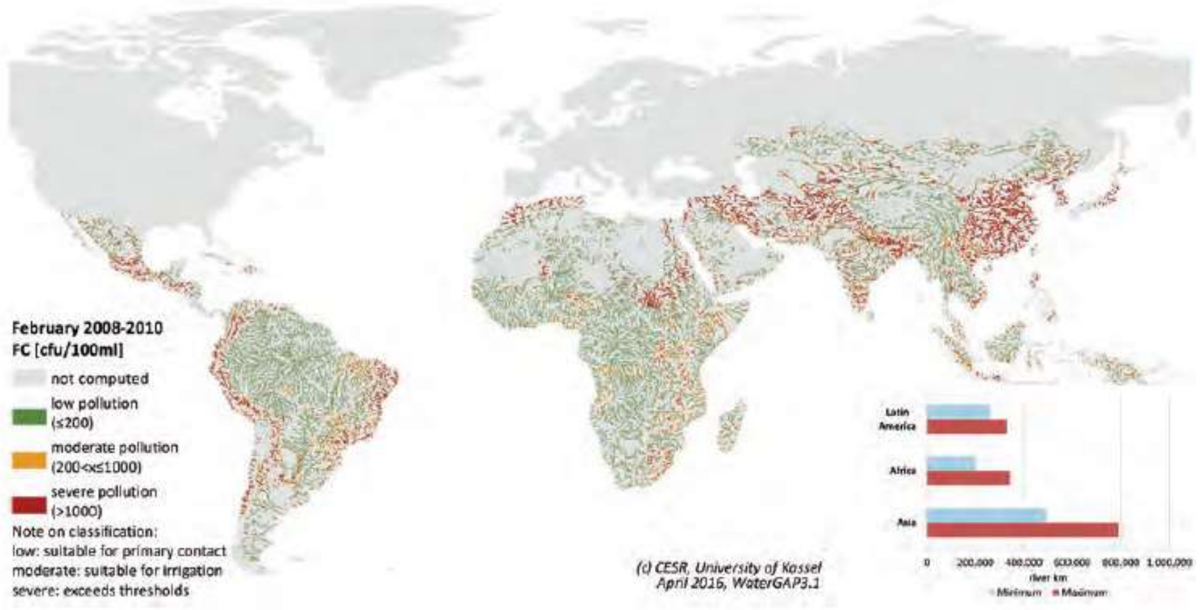


Figure 4.15 – Estimated in-stream concentrations of faecal coliform bacteria (FC) for Latin America, Africa and Asia for February 2008–2010.

Bar charts show minimum and maximum monthly estimates of river stretches in the severe pollution class per continent in the 36-month period from 2008–2010

Zooplankton is the community of invertebrates that is suspended in the water column, whereas lake and river bottoms are inhabited by benthic macroinvertebrates.

Invertebrate assemblages are good indicators of localized conditions because many have limited migration patterns or are sessile (non-motile) and, thus, are useful for examining site-specific impacts. Individual invertebrate species respond differently to environmental changes.

Changes in the environment will be reflected in changes in the species assemblage both spatially and temporally (i.e., affected and unaffected sites over time). Therefore, these assemblages can be used to help assess environmental degradation from both single and cumulative sources.

Fish communities can be used to indicate longer term or wider ranging effects of changes in the aquatic environment because many fish species are relatively long-lived and mobile.

Fish are important for assessing contaminants in ecosystems since they generally represent the top of the food chain and are susceptible to bioaccumulation and bio- magnification of heavy metals and synthetic organic contaminants. They are relatively easy to collect and identify to species level.

Water quality index and surface water quality monitoring

Due to spatial and temporal variations in water quality, which often are difficult to interpret, monitoring of the composition of waters is necessary.

The assessment of water quality is a prerequisite for the implementation of water protection policies and optimal allocation of different water sources according to their uses. Indeed, surface water has often been evaluated using norms. However, sources of pollution are diverse: urban, industrial and agricultural pollution (diffuse or point source).

The frequency of monitoring and assessment of water quality helps to develop management strategies to control surface water pollution facing to increasing urbanization and anthropogenic pressure on water resources.

According to the European Environment Agency (EEA) water quality variables can be grouped into the following broad categories:

- Basic variables (eg. water temperature, pH, conductivity, dissolved oxygen, and discharge) used for a general characterization of water quality.
- Suspended particulate matter (eg. suspended solids, turbidity and organic matter (TOC, BOD and COD)).
- Organic pollution indicators (eg. dissolved oxygen, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), ammonium).
- Indicators of eutrophication: nutrients (eg. nitrogen and phosphorus), and various biological effect variables (eg. chlorophyll a, Secchi disc transparency, phytoplankton, zoobenthos).
- Indicators of acidification (eg. pH, alkalinity, conductivity, sulphate, nitrate, aluminium, phytoplankton and diatom sampling).
- Specific major ions (eg. chloride, sulphate, sodium, potassium, calcium and magnesium) as essential factors in determining the suitability of water for most uses (eg. public water supply, livestock watering and crop irrigation).
- Metals (eg. cadmium, mercury, copper and zinc).
- Organic micropollutants such as pesticides and the numerous chemical substances used in industrial processes (eg. PCB, HCH, PAH).
- Indicators of radioactivity (eg. total alpha and beta activity, ^{137}Cs, ^{90}Sr).
- Microbiological indicator organism (eg. total coliforms, faecal coliforms and faecal streptococci bacteria).
- Biological indicators of the environmental state of the ecosystem (eg. phytoplankton, zooplankton, zoobenthos, fish, macrophytes and birds and animals related to surface waters).

Water quality index (WQI) is valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment technique to meet the concerned issues.

Initially, WQI was developed by Horton (1965) in United States by selecting 10 most commonly used water quality variables like dissolved oxygen (DO), pH, coliforms, specific conductance, alkalinity and chloride etc. and has been widely applied and accepted in European, African and Asian countries.

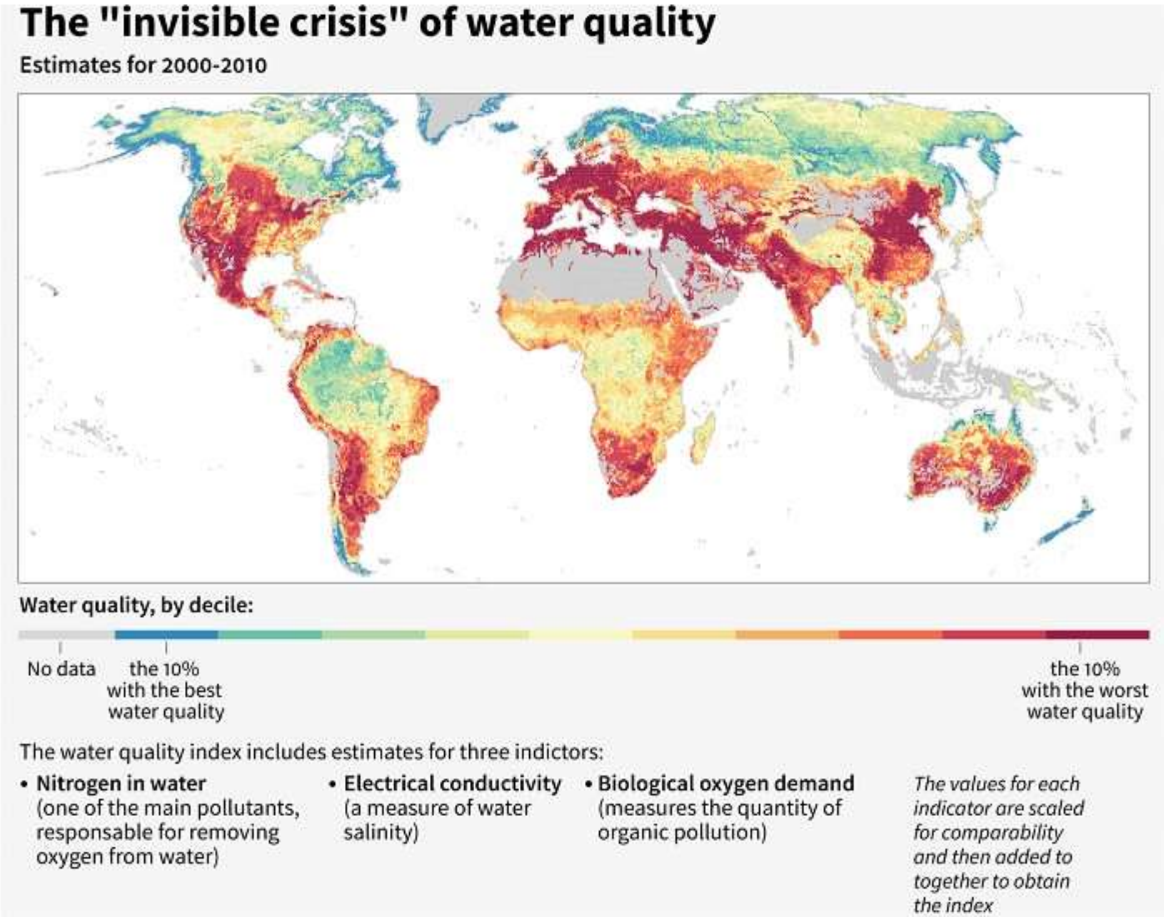


Figure 4.16 – World map of water quality around the world based on an index of key indicators from 2000 to 2010, according to a World Bank study

The assigned weight reflected significance of a parameter for a particular use and has considerable impact on the index. Furthermore, a new WQI similar to Horton's index has also been developed by the group of Brown in 1970, which was based on weights to individual parameter. Recently, many modifications have been considered for WQI concept through various scientists and experts.

5. SEA WATER MONITORING AND CONTROL

Sea water covers approximately 71% of the total area of earth.

Sea pollution is a major problem now. Many people may not realize that sea pollution affects not only the seas and oceans, but also the rest of the earth. Pollution in the ocean and seas directly affect marine organisms and indirectly affects human health and resources. Oil spills, toxic wastes, and dumping of other harmful materials are all major sources of pollution in the ocean.

Causes of seawater pollution

Oil Pollution

Oil is such a chemical which can persist with sea water for many years. Primarily specific gravity of oil is less than water, so it can see that oil make laminar or thick layers on water surface. Then it reacts with atmospheric chemical components, products of which make effect on sea life. Large oil pollution comes from tanker accident.

Land-based petroleum carried out by rain water is another cause of oil pollution. This includes drips of oils, fuels, and fluid from cars and trucks.

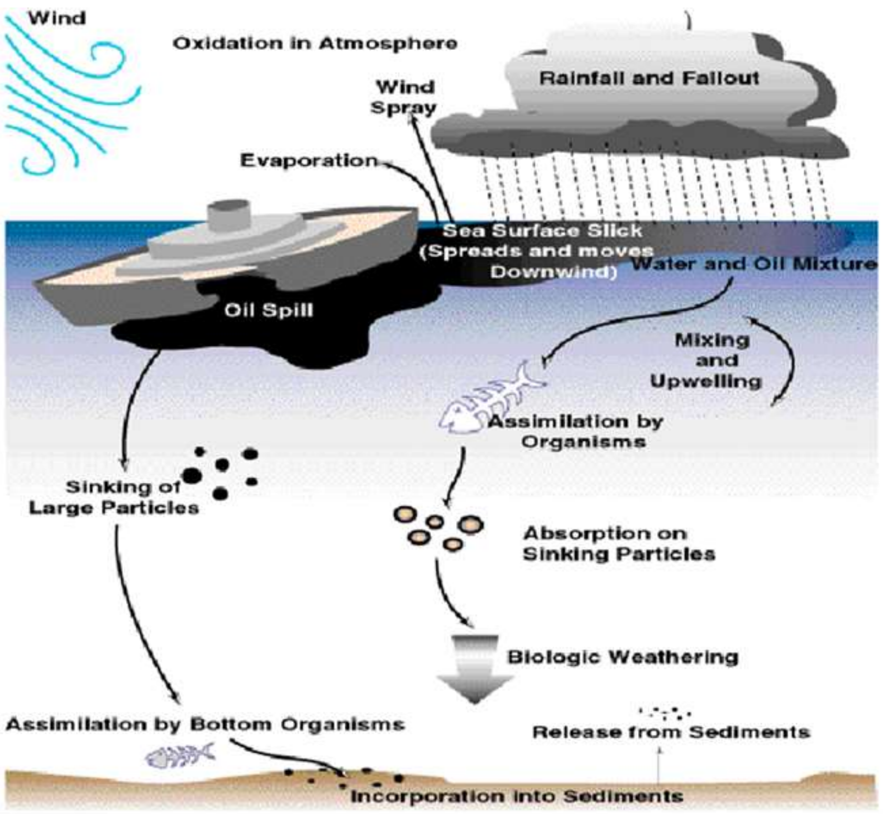


Figure 5.1 – Effects of oil on marine environment

Urban waste and sewage

Urban waste consists of garbage dumping, storm water, industrial waste etc. Urban waste goes through sewage pipe line to sea.

Many sewage pipelines were built years ago when people did not know the negative effect of pollution. And it was thought that sea would dilute the sewage. Since then amount of swage has been increased terribly.

Waste from garbage dump taken away by rain water mix with sea water can cause heavy pollution. Industries emits large amount of waste every day. These wastes are directly dumped to river and sea. The toxic and poisonous materials of waste can harm many plant and animals and our health also. When toxic waste harms an organism it can quickly be passed along the food chain and imbalance the ecology.

Gas impact

Gases have multiple effects on sea pollution. CO_2 emission in atmosphere can alter ocean chemistry. About 1/3 of atmospheric CO_2 is absorbed by ocean surface, which make carbonic acid in sea water and damage corals. It also increases the acidity of sea water which is very much harmful for phytoplankton and zooplankton. But these are the base of food chain in marine environment.

The pH scale of seawater lowers every year drastically because of presence of CO_2 in water.

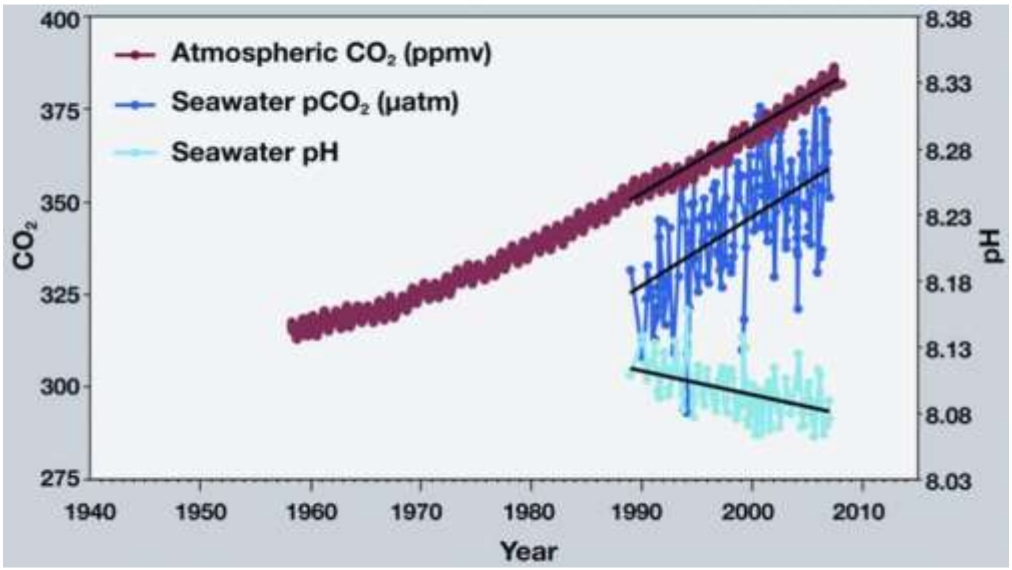


Figure 5.2 − Ocean Acidification Graph

Source: NOAA PMEL Carbon Program

Sulfur gas in environment coming from industrial areas and also from cars and vehicles mixed with air and then with cloud. It causes acid rain. Acid rain is dangerous for sea water. It kills fish and sea plants. NH_4 (ammonia) pollution basically comes from agricultural sectors. But living beings produce large amount of ammonia every day. This ammonia is a compound of hydrogen and nitrogen.

So ammonia can be disintegrated in to these elements causing extra amount of nitrogen in sea water. This nitrogen then gets mixed with oxygen and form NO_2. This is a strong green-house-gas. CH_4 (methane) gas comes from industrial and garbage waste. This methane gas disintegrated to carbon and hydrogen. Extra amount of carbon give birth too many algae and other sea plant.

Agricultural waste

Agricultural waste contains harmful toxic elements which pollutes sea water. These are two types. One is fertilizers like phosphate, sulfate, nitrate, and other metallic salts. These chemicals get mixed to rivers, lakes and seas. It causes huge algae growth power in less deep water. Decomposition of algae consumes all oxygen present in water and cause massive death of sea lives.

Another type of agricultural waste is pesticides. It pollutes sea in the same way to fertilizers and cause death to fishes and also causes infection in their body. Then death fish cause another type of pollution. Many fishermen believe that toxic chemicals are killing majority of fishes. This is also a problem to our food chain as we eat fish to fulfil requirement of protein.

Radioactive Waste

Radioactive waste has a long terrible effect on sea plans and animals. Volcanic eruption under sea is the basic cause of these wastes.

Figure 5.3 − Distribution of sea dumping sites used for disposal of low- level radioactive waste

Source: http://large.stanford.edu/courses/2017/ph241/jones-a2/docs/calmet.pdf

When volcanoes under sea are blast, it emits lava, fumes, hard rocks and many harmful radiations. These radiations and wastes have permanent impact on sea environment.

Mining is another type of radioactive pollution. It exposes many heavy metals and sulfur compounds which were locked in earth core. Rain water washes away these compounds to sea. Nowadays mining also happened in deep sea level. And radioactive pollutants are thrown to sea water directly without any consideration.

Nuclear power plant emits large amount of nuclear waste which is highly radioactive. It is also discharged to sea water causing damage of sea lives and ecosystem.

Ocean Trash[9]

Garbage patches in the ocean aren't piled-up islands of trash and debris, as is the common perception. But that doesn't mean the tiny, swirling plastic bits are nothing to worry about.

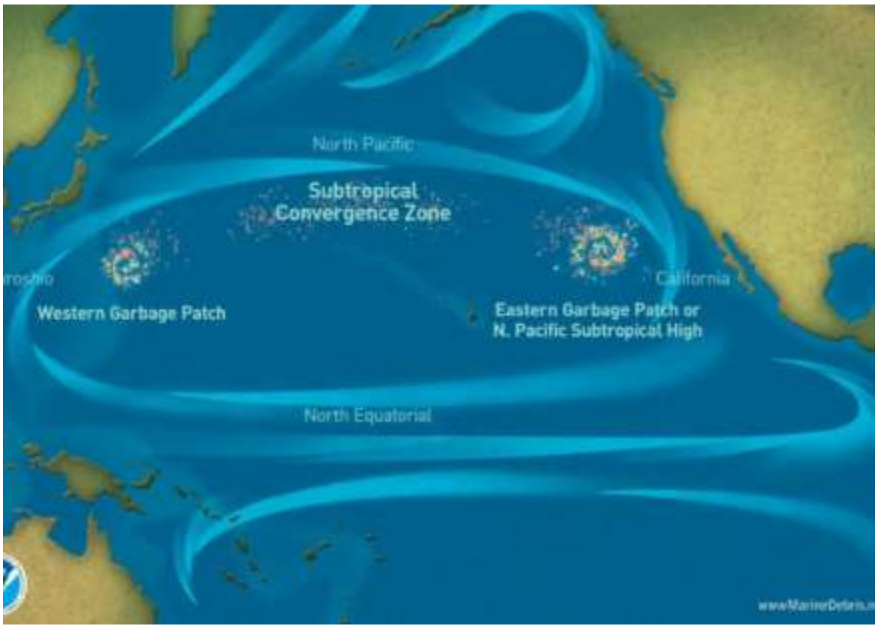


Figure 5.4 − The currents of the North Pacific gyre collect trash − mostly bits of microscopic plastic − into what are known as "garbage patches."
Source: NOAA Marine Debris Program

In the Pacific Ocean, four ocean currents merge to form the North Pacific gyre which spans the western US to Japan, and Hawaii to California. This enormous rotating vortex has collected floating garbage from across the Pacific,

[9] https://ocean.si.edu/planet-ocean/tides-currents/ocean-trash-plaguing-our-sea

but much of the debris can typically be found in the calm center of this rotating area, often referred to as the "eastern Pacific garbage patch." Keep in mind, however, that this is no island or blanket of trash that can be seen with satellite or aerial photographs − most of the floating trash is tiny pieces of plastic, many of them so small as to be invisible to the human eye.

Its vast size and the small size of the trash left the garbage patch largely unnoticed until the early 1990s. While the garbage patch has received a lot of attention because of its size, it is not the only area where marine debris can be found: marine debris affects waters and coastlines around the world. A 2014 study estimated that 8 million metric tons of plastic trash enter the sea from land every year − the equivalent of five plastic bags filled with trash for every foot of coastline around the world.

Animals frequently become entangled in large pieces of debris, and can be cut, drowned, or slowed down by dragging the extra weight. Additionally, heavy gear, such as fishing nets, can damage reefs and other important habitats.

Because of its durability, low cost, and our increased use in recent decades, plastic makes up the majority of marine debris seen on shorelines and floating in oceans worldwide. This creates a difficult problem because most plastics are not biodegradable. Instead, as plastic ages, the sun's light and heat break it into smaller and smaller pieces.

Monitoring of sea waters in Ukraine

Ukraine is located on the cross-road of the trade routes of Eastern Europe and the Mediterranean. It is washed by the Black Sea and the Sea of Azov belonging to the Atlantic Ocean basin.

The total length of Ukrainian seacoast exceeds 2 500 km (Black Sea – 1 652.2 km, Sea of Azov – 874.8 km). Seagate from the Black and Azov Seas through the straits such as Bosporus, Dardanelles, Gibraltar and Suez Canal to the World Ocean allows Ukraine to use ocean resources for economic needs and ranks it together with maritime states, which according to the rules of international law possess the most favored advantages and benefits.

The State Emergency Service of Ukraine (Ukrainian Hydrometeorological Center) monitors the state of coastal water at the monitoring stations that are located next to the sites of sewage water discharge, as well as scientific and research centres that are located at the coastal zones of the Azov and Black Seas. The monitoring network (as for 01.01.2019) consists of 56 monitoring sites and 9 scientific and research stations (dumping stations) that measure 16-24 hydrochemical parameters of water and sediments.

State Environmental Inspections of the Azov and Black Seas (the Ministry of Energy and Environmental Protection of Ukraine) have their own monitoring network. Every month they take samples and analyze the impact of the sources of pollution that are located along the coast; monitor pollutants discharge from the vessels; pollution coming from exploration and extraction activities for oil, gas and construction materials at the sea shelf; control the use of the sea resources.

The State Sanitary and Epidemiological Survey monitors sea water quality in recreation zones.

Also the monitoring of sea water as well as marine ecological researches are carried out by Ukrainian Scientific Center of Ecology of Sea (UkrSCES), Institute of marine biology of the National Academy of Sciences of Ukraine (both are located in Odessa) and other institutions.

In Ukraine ecological monitoring is performed on 3 levels (Fig. 5.5):

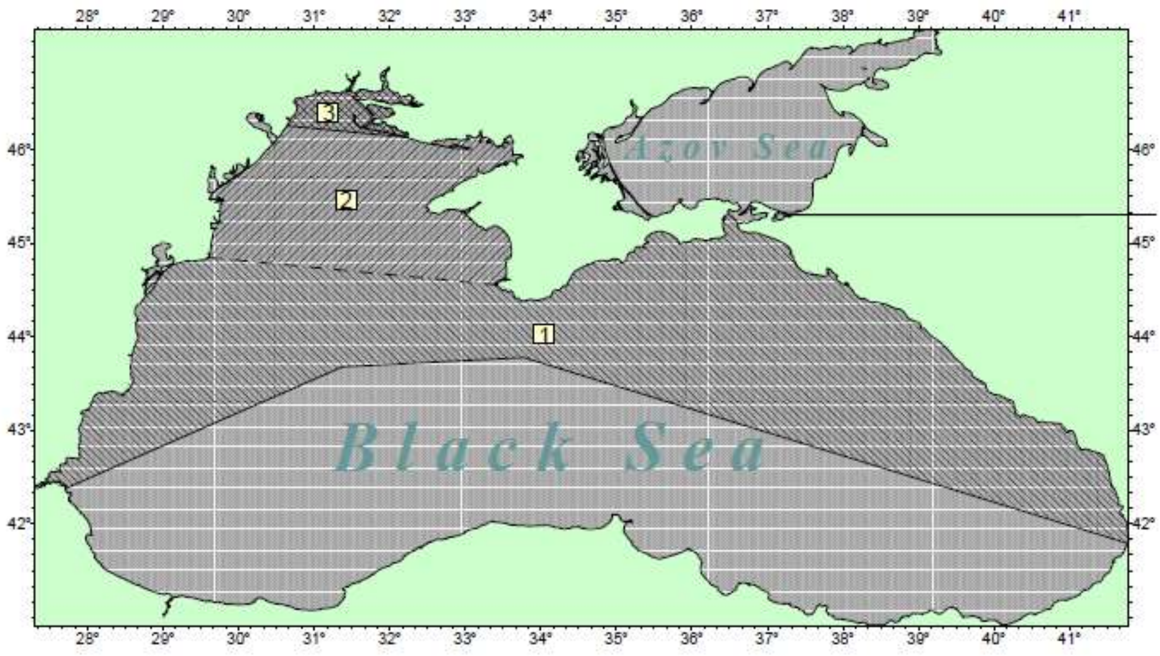


Figure 5.5 – Levels of sea monitoring: 1-Background; 2-Regional; 3-Local

On all levels of monitoring are investigated:

1) the main hydrochemical mode;

2) the hydrobiological parameters;

3) the main pollutants;

4) the hydrometeorological mode;

5) the radiochemical parameters in water bottom sediments, hydrobionts and surface atmosphere.

The *first level* is the monitoring of impact zones, i.e. most polluted water areas. The researchers are conducted every ten days. The frequency of a choice of a grid of ecological servers is chosen with a particular discretization necessary for the registration of all local processes and sources of pollution, which happen and are with in this water area.

The problems of priority at this level are:

• microbial pollution;

• hydrological, synoptic etc. conditions on allocation and transference of numerous impurities;

• eutrophication.

This (first) level of monitoring includes:

a) Inventory of land based sources (point, diffuse) with the complete chemical analysis;

b) Monitoring of beaches;

c) Monitoring of impact zones;

d) Development of water quality, bottom sediments, surface atmosphere standards.

The *second level* includes:

e) Monitoring of the shelf zone of the Black Sea.

The *third level*:

f) Background monitoring of the open part of the sea.

The modern state of pollution of coastal (recreational) zone of the Black Sea is characterized, by the last years, as progressing anthropogenous pollution; practically many pollutants are stationary components of coastal marine waters.

Here by we have petroleum, polyaromatic hydrocarbons, phenols, organic matters, heavy metals, chlororganic pesticides, polychlorbiphenyls, synthetic surfactants and biogenic substances (nitrogen, phosphorus, silicon).

According to the results of the Joint Black Sea Surveys presented by the EU/UNDP-funded project "Improving Environmental Monitoring in the Black Sea: Selected Measures" (EMBLAS-Plus) and the Ministry of Ecology and Natural Resources of Ukraine in 2019, the amount of marine litter in the Black Sea is almost twice as high as in the Mediterranean Sea, while concentrations of some pollutants exceed their toxicity threshold value.

The key findings of the environmental monitoring of the Black Sea are as follows[10]:

[10] https://www.ua.undp.org/content/ukraine/en/home/presscenter/pressreleases/2019/black-sea-twice-as-polluted-by-marine-litter-as-mediterranean-se.html

83% of the ***marine litter*** found in the Black Sea is plastic, namely bottles, packaging and bags. The large rivers (in Ukraine study included the Danube and the Dniester) bring to the sea from 6 to 50 items of litter per hour. The amount of marine litter in the Black Sea is almost twice as high as in the Mediterranean Sea (90.5 vs. 50 litter items / km^2). Microplastics were found in the sediments of the Black Sea both in its shelf parts and in the depths of more than 2,000 m.

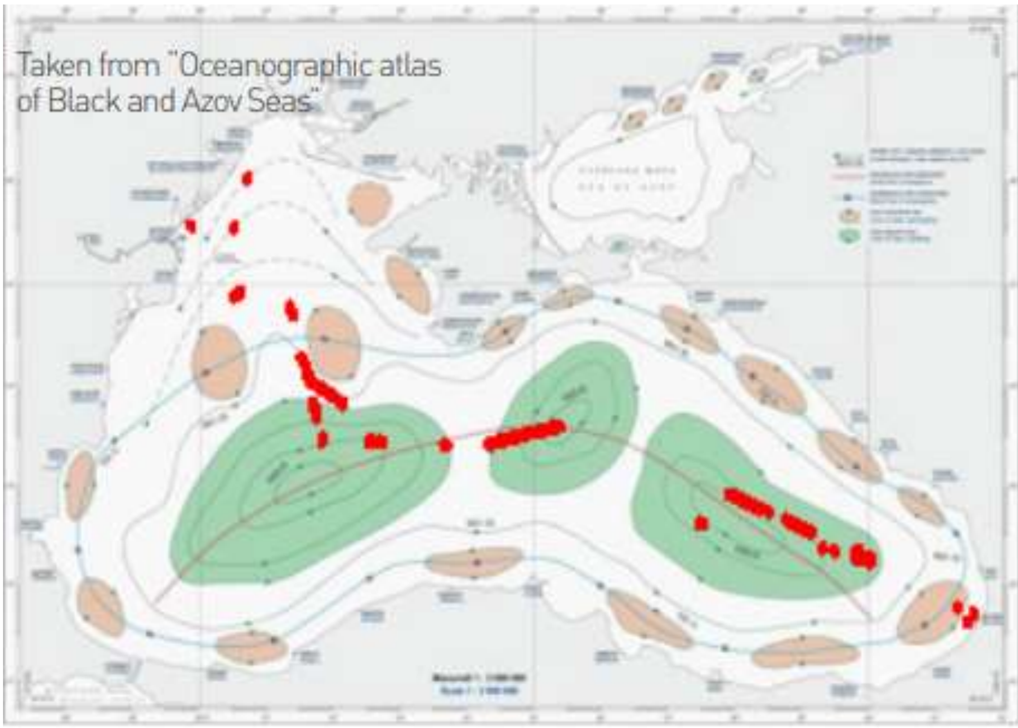
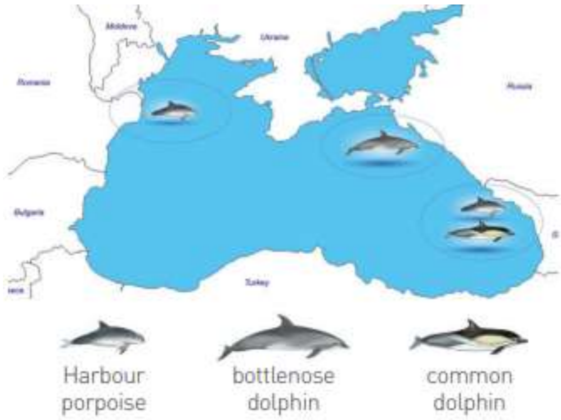


Figure 5.6 − Marine litter concentrations, fixed during the surveys and system of currents in the Black Sea

The concentrations of ***some priority hazardous chemical substances*** dangerous for marine and human life exceed their toxicity threshold values. Among these substances were benzo(a)pyrene, several pesticides, insecticides and also mercury and flame retardants in fish. In addition, 124 chemicals dangerous for the sea ecosystem and human health were identified including persistent organic pollutants, metals, pesticides, biocides, pharmaceuticals, flame retardants, industrial pollutants and personal care products. These substances had not been monitored earlier and they will be proposed to be included for regular monitoring.

At the moment of the survey (June 2019), at least 1,000 ***dolphins*** of each species occurred in Ukrainian territorial waters of the north-western Black Sea, between the Danube Delta and the Tendra Spit in Kherson region.



These values are relatively low. The greatest aggregations of dolphins in Ukrainian waters were identified near the Danube Delta and Zmiinyi (Snake) Island. Having the new data on where the most dolphins are concentrated and when we can try to reduce the pressures on them, from e.g. noise pollution (which is really painful for them) by changing navigation routes or timing of underwater works.

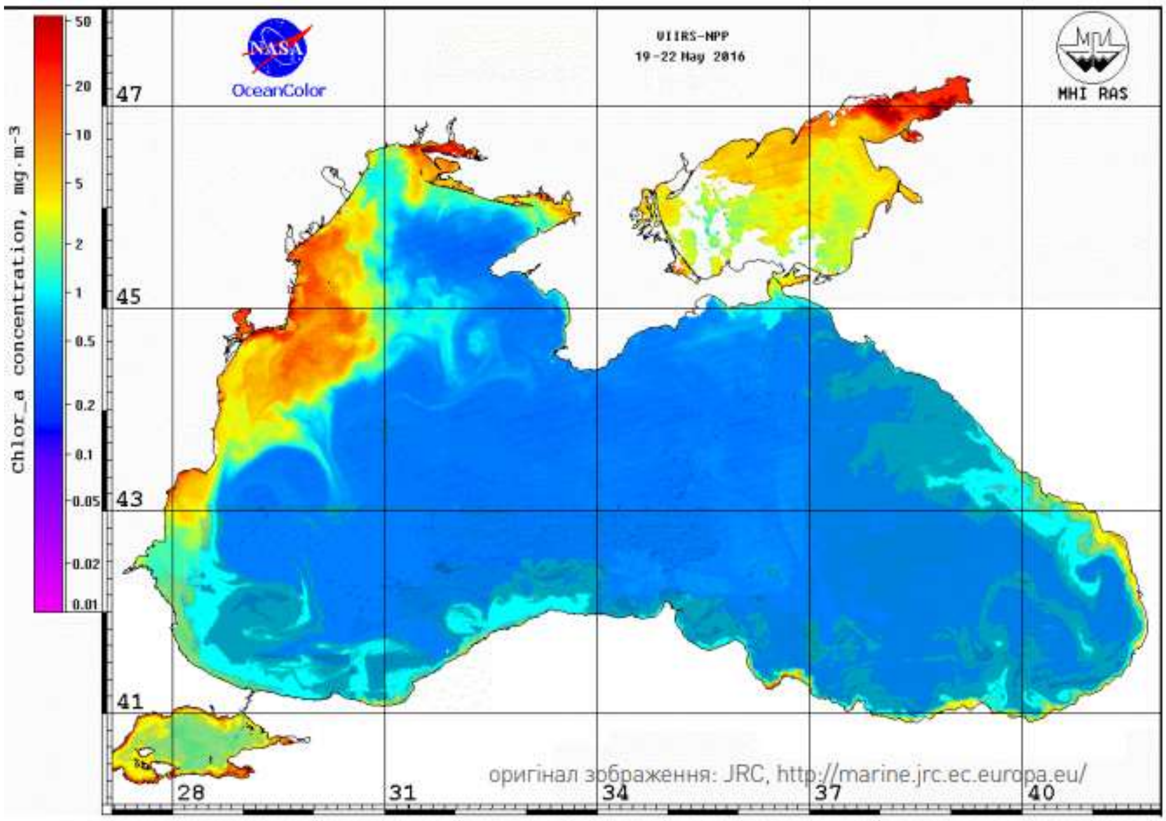


Figure 5.7 – Satellite image of the concentration of the chlorophyll –a in the Black, Azov Seas and Sea of Marmara for 19-22 May, 2016

Source: EC/UNDP funded project "Improving Environmental Monitoring in the Black Sea – Phase II (EMBLAS-II)

The pressure of ***invasive species*** – non-native species which may damage local environment – at the Black Sea is growing. Using a new method of detection of DNA dissolved in sea water to discover fauna living there (e-DNA) new Mediterranean species were found in the Black Sea, including Monrovia doctorfish; red barracuda, burrowing goby (*Trypauchen vagina*) etc. The good news is that DNA of European sturgeon (*Acipenser sturio*) which was considered almost extinct in the Black Sea was found in many samples across the Black Sea. Same goes for the endangered beluga.

There are also signs of ***rehabilitation of the Black Sea ecosystem***. The biggest red algae field in the world – the Zernov's Phyllophora Field improved its status from category 'poor' to 'moderate'.

In compliance with the Law of Ukraine No 1207-VII of 15 April 2014 'On Securing the Rights and Freedoms of Citizens and the Legal Regime on the Temporarily Occupied Territory of Ukraine', inland waterways and territorial sea of Ukraine around Crimean Peninsula, as well as the territory of exclusive (maritime) economic zone of Ukraine along Crimean coastline have been defined as temporarily occupied territories.

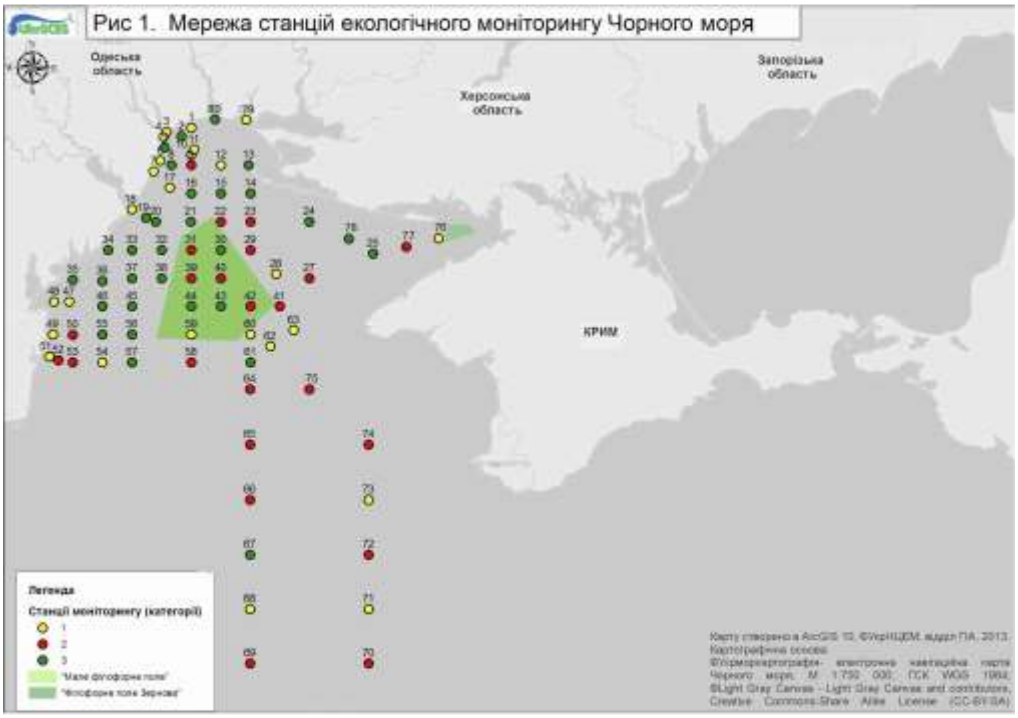


Figure 5.8 − Network of sea water monitoring (80 stations as at May 2014)

Stations categories:

- 1st rank – stations with sea water and bottom sediments (BS) and biota sampling for determination of the full complex of standard hydrophysical, hydrochemical and hydrobiological characteristic and pollution substances in water, BS and biota;

- 2nd rank - stations with sea water sampling for determination of standard hydrochemical characteristic and pollutant substances in water;

- 3rd rank - stations with sea water sampling for determination of standard hydrochemical characteristic for investigation of euthrophication and hypoxia problems.

The marine environment is a precious heritage that must be protected, preserved and, where feasible, restored in order to maintain biodiversity, ecosystem functioning and to ensure clean, healthy and productive seas. The marine ecosystem is threatened by various pressures, notably pollution, eutrophication, overfishing, introduction of exotic species, climate change and other human related activities.

For this reason, in the July 2008, the Marine Strategy Framework Directive (2008/56/EC) (MSFD) entered into force. The Directive establishes a legal framework for the protection and management of European seas and ensures their long-term sustainable use. The main objective of the Directive is to achieve and/or maintain Good Environmental Status (GES) by 2020.

To this end, EU member states are obliged to develop a strategy for their marine waters by implementing appropriate measures and monitoring programs to protect, conserve and monitor the marine environment, preventing degradation or, if possible, restoring marine ecosystems in areas where it has been adversely affected.

To protect and conserve the marine environment and ecosystem functioning, Member States should also establish Marine Protected Areas (MPAs), within the framework of the program of measures of MSFD, in order to achieve and maintain GES. This is also in line with the Habitats Directive (92/43/EEC) and other Regional and International Conventions.

Additionally, in September 2010, the EU adopted the Commission Decision on criteria and methodological standards on good environmental status of marine waters (2010/477 / EU). This Commission Decision establishes a set of criteria and indicators for each of the 11 Descriptors of Annex I of the MSFD which assesses the extent to which they achieve Good Environmental Status in marine waters.

The 11 Descriptors the Marine Strategy Framework Directive (2008/56/EC) (MSFD)

To ensure that human pressures and impacts are maintained at levels which do not deteriorate the marine environment and are in line with the achievement of GES, while enabling the sustainable use of marine goods and services by present and future generations as mentioned above, the Commission has established specific methodological standards, criteria and indicators for each of the 11 Descriptors of GES.

This also ensures consistency among the Member States in fulfilling their obligations under the MSFD. The 11 Descriptors which are provided for by Annex I of the MSFD for the determination of GES are as follows:

1. Biodiversity

Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.

2. Non-indigenous species

The non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.

3. Commercially exploited fish and shellfish

Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.

4. Food webs

All elements of the marine food webs, to the extent that they are known, are in a normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.

5. Eutrophication

Human-induced eutrophication is minimised, especially the adversely effects of it, such as loss in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.

6. Sea-floor integrity

Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.

7. Hydrographic Conditions

Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.

8. Contaminants

Concentrations of contaminants are at levels not giving rise to pollution effects.

9. Contaminants in Fish

Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.

10. Marine Litter

Properties and quantities of marine litter do not cause harm to the coastal and marine environment.

11. Energy, including underwater noise

Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

In April 2017, Minecoenergo presented a draft of Ukraine's Marine Strategy and launched public consultations on it. This is the result of Ukraine's carrying out its obligations under the Directive 2008/56 / EC which introduces a new approach to the EU environmental policy regarding the protection of the marine environment and aims at achieving Good Environmental Status (GES) in marine waters.

Implementing the requirements of the Directive, Ukraine will face a number of challenges that need to be resolved: for instance, elaborating appropriate monitoring programmes as well as carrying out the monitoring of marine environment in the exclusive (maritime) economic zone.

Given that the Directive is on various implementation stages in the EU member states, this opens new opportunities for Ukraine to develop and implement approaches of securing Good Environmental Status, in particular, in the Black Sea and the Azov Sea along and together with the EU member states.

6. LAND AND SOIL MONITORING. ASSESSMENT OF LAND DEGRADATION

Meaning of land[11]

Land is an essential building block of civilization. Land, literally the ground beneath our feet, is a finite resource composed of soil, water, minerals, plants, and animals. It is an essential part of our life support system and the key building block of our societies and economies.

Land, and its associated resources, comprise a stock of natural capital.

The increasing demand for land-based goods and services, and the manner in which they are today produced is adversely impacting the health and future productivity of the planet.

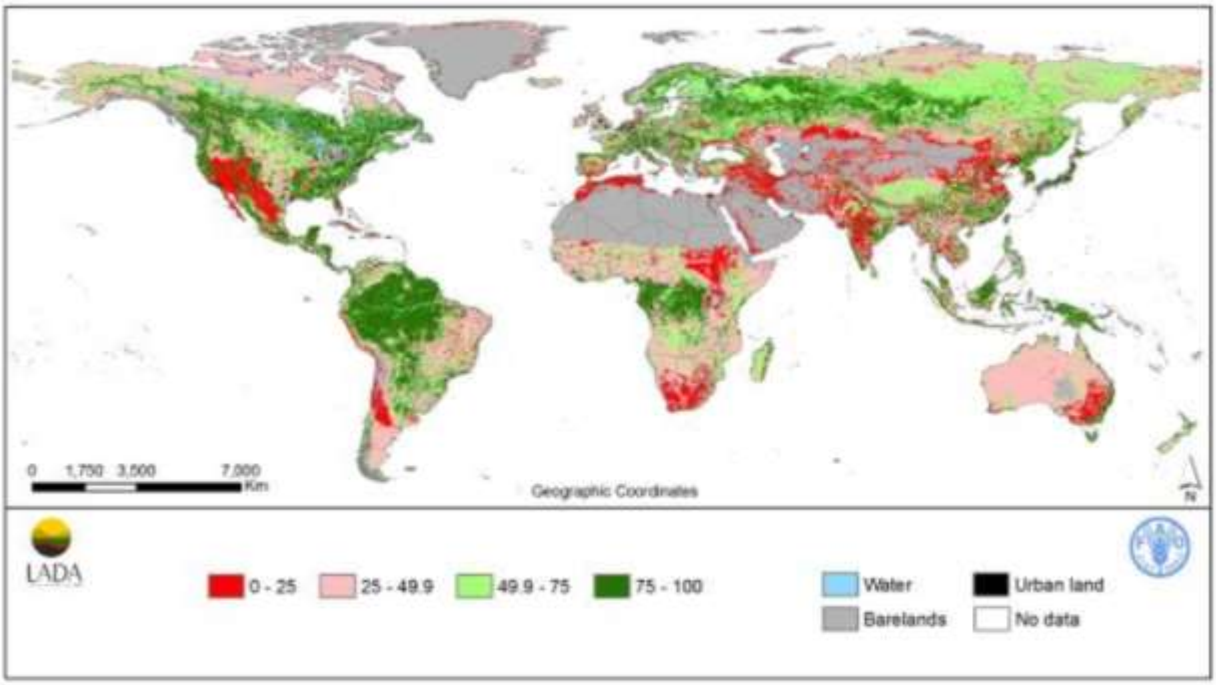


Figure 6.1 − Status of the land' (Capacity of ecosystems to provide services)
Sources: LADA (Land Degradation Assessment in Drylands); FAO (Food and Agriculture Organization of the United Nations)

The misuse and over-exploitation of land resources are threatening human security on multiple fronts: diminishing food and water security as well as reduced soil health and ecosystem resilience make us more vulnerable to extreme weather events and the impacts of climate change, and even threaten stability and security within and between nations.

[11] Global Land Outlook, First edition 2017

Keeping land in a healthy state is an essential contribution to human security – access to food and water, the stability of employment and livelihoods, resilience to climate change and extreme weather events, and ultimately social and political security.

Definitions of land

The United Nations Convention to Combat Desertification (UNCCD) defines land as "the terrestrial bioproductive system that comprises soil, vegetation, other biota, and the ecological and hydrological processes that operate within the system."

Alternatively, land is defined as "a delineable area of the Earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers and associated groundwater reserve, the plant and animal populations (biodiversity), the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.)."[12]

Land use and land degradation

Beginning around 8,000 years ago, agricultural land use expanded in Mesopotamia and in the Fertile Crescent areas of southwest Asia; this was followed by growth in China, India, and Europe.

By approximately 6,000 years ago, agricultural expansion had spread across most continents, leading to the clearing of native vegetation and to the culling, or domestication, of herbivores.

Starting around 1750, the transformation of land started to accelerate, and rapid land use change continues to be a dominant influence today.

The pressures on global land resources are greater than at any other time in human history. A rapidly increasing population, coupled with rising levels of consumption, is placing ever-larger demands on our land-based natural capital.

This results in growing competition among land uses and its provisioning of goods and services.

At the same time, degradation is reducing the amount of productive land available.

[12] Convention on Sustainable Development (CSD). 1996. Progress Report on Chapter 10 of Agenda 21. United Nations, New York, NY, USA.

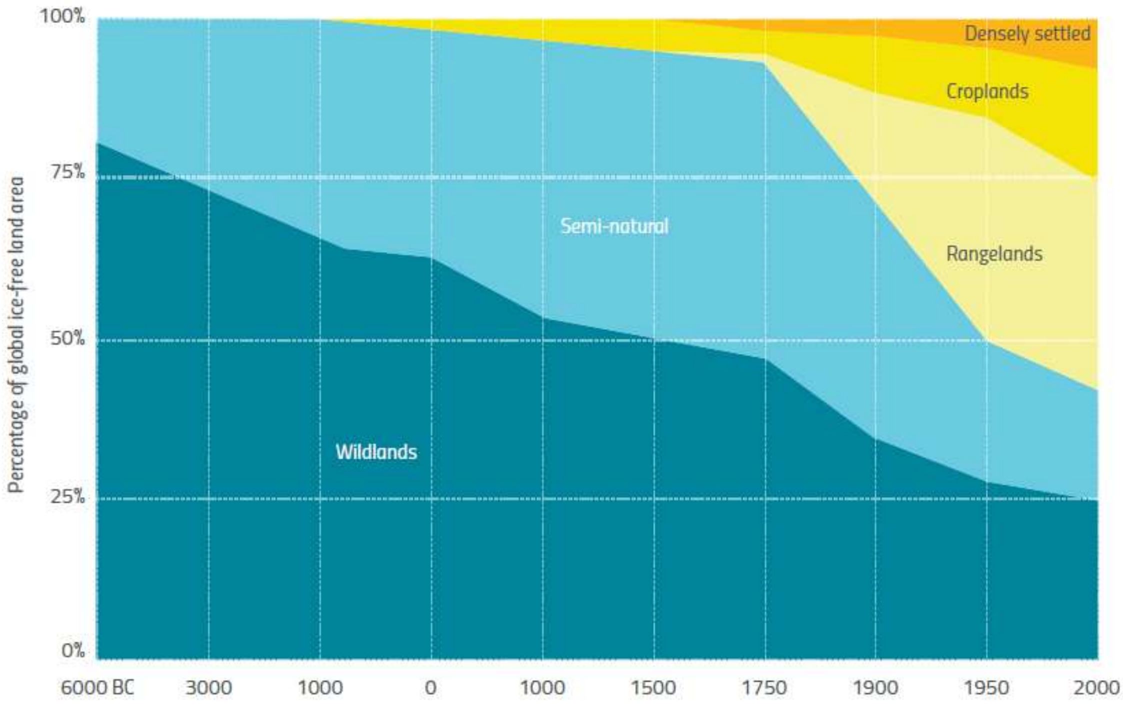


Figure 6.2 – Transformation of the biosphere over 8000 years
Source: Global Land Outlook (UNCCD, 2017)

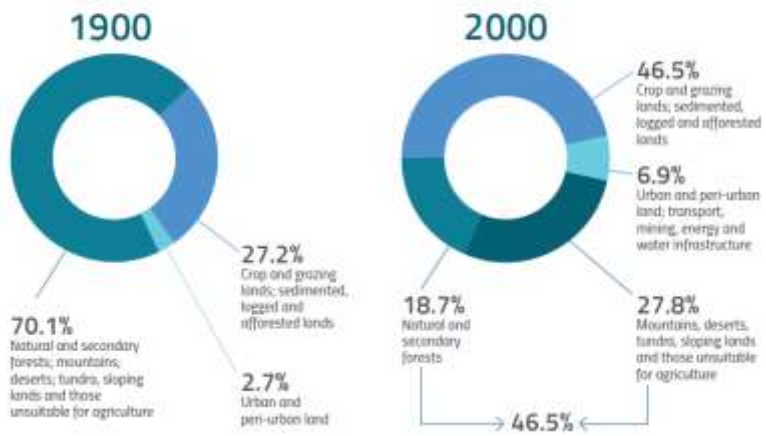


Figure 6.3 – A century of land use change
Source: Hooke, R. L., Martín-Duque, J. F., & Pedraza, J. 2012. Land transformation by humans: a review. GSA today, 22: 4-10.

Land degradation is the reduction or loss of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest, and woodlands resulting from land uses or from a process or combination of processes arising from human activities.

The drivers of land degradation are mainly external factors that directly or indirectly impact the health and productivity of land and its associated resources, such as soil, water, and biodiversity.

Direct drivers are either natural (e.g., earthquakes, landslides, drought, floods) or anthropogenic (i.e., human-induced); some of the latter influence what would formerly be thought of as natural climatic events.

Human-induced drivers such as deforestation, wetland drainage, overgrazing, unsustainable land use practices, and the expansion of agricultural, industrial, and urban areas (i.e., land use change) continue to be the most significant proximate cause of land degradation.

Many modern crop and livestock management practices lead directly to soil erosion/compaction, reduced water filtration/availability, and declining biodiversity, both above and below ground. Meanwhile, mining and infrastructure for transport, energy, and industry are increasingly enlarging their footprint in the landscape and impacting land resources at ever larger scales.

Over the last one hundred years, the amount of land used for urban and peri-urban areas has doubled, and is expected to accelerate further over the next few decades. However, while still relatively small in scale – at approximately 5 per cent of the global land area – urban areas often cover some of the most fertile soils and productive lands.

The indirect or underlying causes of land degradation are linked to lifestyles, economies, and consumption patterns, a complex mixture of demographic, technological, institutional, and socio-cultural factors. These include international markets and commodity prices, population growth and migration, domestic markets and consumer demand, policies and governance, as well as more local trends such as changes in household behavior.

Indirect drivers are far more complex and operate at larger and longer scales and farther from the area of degradation.

Direct and indirect drivers interact, mutually reinforcing each other and together drive land degradation in many parts of the world.

Drivers of soil degradation

Soil degradation is a key factor undermining food security. Soils can be degraded over time either qualitatively (e.g., salinization) and quantitatively (e.g., erosion). There are several major types of soil degradation processes.

Physical degradation: the structural breakdown of the soil through the disruption of aggregates. This results in the loss of pore function, which in turn leads to a reduction in surface infiltration, increased water run-off, and decreased drainage. In time, this leads to a decrease in the availability of gases for plants and biota. Physical degradation processes include erosion, sealing and crusting, and compaction.

a) b) c)

Figure 6.4 − Physical degradation:
a) Urban soil sealing; b) Soil Compaction; c) Soil Crusting

Chemical degradation: processes leading to soil chemical imbalances, including salinization, loss of nutrients, acidification, and toxification.

Biological degradation: the artificial disruption of soil structure (e.g., through tillage) can lead to excessive activity of soil biota due to oxygenation and excessive mineralization of organic matter leading to the loss of structure and nutrients.

All these processes can be influenced by a number of direct drivers, natural and anthropogenic, influencing soil processes in different ways, including the nature and speed of the processes.

Direct natural drivers include climate, natural hazards, geology and geomorphology, and biodiversity.

Climate has a significant impact on soil processes and the provision of ecosystem services. Local climate (e.g., rainfall intensity, temperature, sunshine) influences supporting processes and biodiversity by driving soil moisture and temperature.

Natural hazards, like earthquakes or volcanic eruptions for example, can change the soil environment and the geological origin of parent material determines the initial minerals that drive soil development and properties as will the type and variety of species present.

Anthropogenic drivers, such as land use, farming practices and technologies, also greatly influence soil processes. The type of land use (e.g., cropping, livestock) determines the type of disturbance (e.g., tillage, treading, use of agrochemicals) as well as applied inputs (e.g., excrements, synthetic fertilizers).

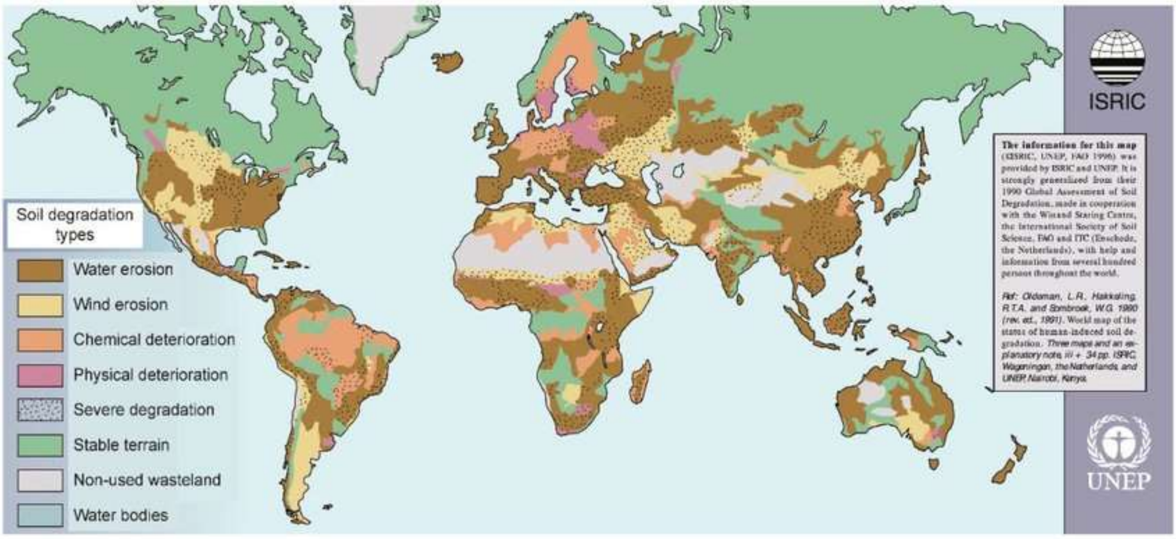


Figure 6.5 − World Map Showing Human Induced Soil Degradation
Source: International Soil Reference and Information Centre (ISRIC), 2017

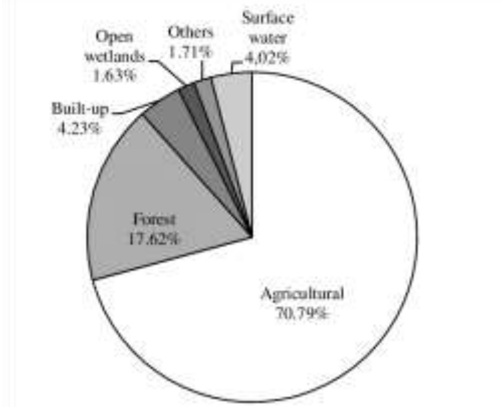
Farming practices determine the intensity of disturbances (e.g., organic versus conventional cropping) and the amount of inputs (e.g., quantity and timing of fertilization).

Land classification and land use in Ukraine

Ukraine's land fund is one of the largest in Europe. If for example, arable lands occupy between 30 and 32 percent of the total area in developed European countries, in Ukraine this indicator rises to 56.1 percent.

As a result of reduced forest lands, meadows and pastures, changes occur in the microclimate and soil water deposit levels.

Additionally, land aridity and desertification occurs, and water and wind erosion develops, which causes soil fertility to decline, agricultural ecosystems productivity degradation and decline and makes sustainable development impossible, which is related to not just the country's ecology, but also food safety.



The Land Code of Ukraine (dated 25.10.2001 № 2768-III) regulates public relations regarding owning, use and disposal of land.

The lands of Ukraine include all lands within its territory, as well as islands and lands occupied by water objects, which are divided into 9 categories by their purposeful designation.

The Ukrainian land fund's general territory amounts to 60.4 million hectares.

Agricultural lands cover 71 % of Ukraine's territory!

The structure of agricultural lands, just like the structure of Ukraine's land fund, is characterized by a very high index of agricultural development.

Due to the abundance of very fertile land, including over 25 per cent of the world's resources of chernozem soil, the proportion of agricultural and arable land is very high, significantly exceeding the ecologically justified limit.

The country's agricultural production resources are as follows:

- 78.4% arable land;
- 13.1% pastures;
- 5.8% hayfields;
- 2.1% multi-annual plantings;
- 0.6% fallow.

Forests and other territories covered with forestation comprise 17.6% of the country's territory; lands that have been built on represent 4.2%; areas with water 4.2%; swamps 1.6%; others 3.5%.

In general, Ukraine's land fund is characterized by high bio-productive qualities. According to scientific opinion, in conditions of optimal land use and with a corresponding level of agricultural culture, the country would be able to feed up to 300-320 million people.

Land and soil monitoring in Ukraine

The State Emergency Service of Ukraine monitors soil contamination with pesticides and heavy metals in 20 populated areas. Samples are taken once in every five years and sometimes on an annual basis. The control covers 27 soil parameters.

The State Ecological Inspection of Ukraine takes soil samples at industrial sites of enterprises. The measurements encompass 27 parameters.

The State Sanitary and Epidemiological Service monitors the state of soils on the territories with potential adverse impact on people's health.

The State Agency of Water Resources of Ukraine monitors irrigated and drained agricultural lands, in particular, the degree of salinity and alkalinity of soils.

The State Agency of Forest Resources of Ukraine provides monitoring of the lands of forest fund. The control covers radiological parameters, residual level of pesticides, agrochemicals and heavy metals.

The State Service of Ukraine on Geodesy, Cartography and Cadastre carries out qualitative and quantitative land inventory. Quantitative land inventory held annually for all categories of land fund. But the last comprehensive inventory of soil quality has conducted in 1996!

The State Institution "Soil Protection Institute of Ukraine" (the Ministry of Economic Development, Trade and Agriculture of Ukraine) monitors agricultural soils. The control covers radiological, agro-chemical and toxicological parameters, residual level of pesticides, agricultural chemicals and heavy metals.

Monitoring, which carries out that Institute is called Eco- agrochemical passportization (or certification) of fields and land areas. This passportization is carried out since 1965 every 5 years.

Land degradation and desertification in Ukraine

As previously noted, land degradation is any change in the condition of the land which reduces its productive potential. It is the deterioration in the quality of land, its topsoil, vegetation, and/or water resources, caused usually by excessive or inappropriate exploitation.

Desertification means land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities.[13]

Land degradation and desertification are some of the most serious challenges for sustainable development of the country, which are the cause of substantial ecological, economic and social problems.

The most large-scale degradation processes in Ukraine include water and wind erosion of soil (nearly 57 percent of country's territory), waterlogging of land (about 12 percent), acidification (almost 18 percent), salinization and alkalinization of soil (over 6 percent).

According to various criteria, approximately 20 percent of Ukrainian lands are polluted.

Over 150 thousands hectares of land are disturbed by mining and other activities. The number of underground and surface karst phenomena amounts to 27 thousands hectares.

Because of land degradation during 1986-2010 the humus content in soils decreased by 0.22 percent.

[13] United Nations Convention to combat desertification (UNCCD)

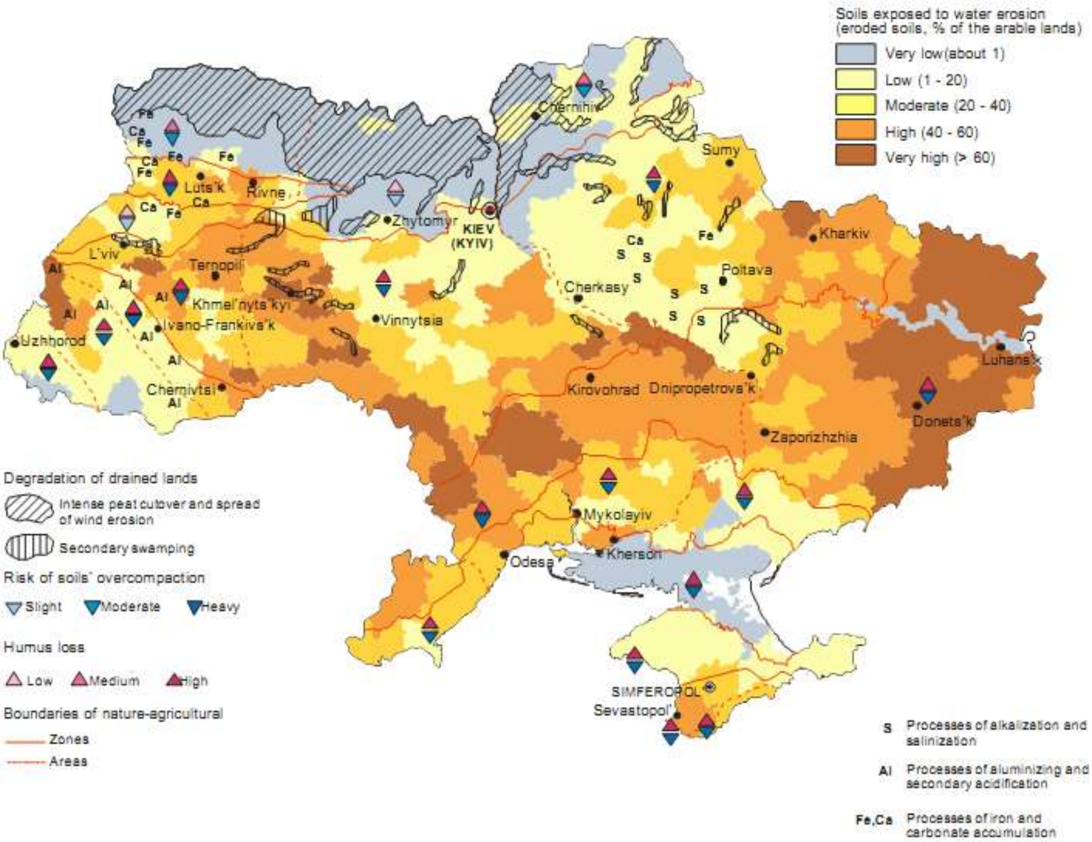


Figure 6.6 – Distribution of soil and land degradation processes in Ukraine
Source: http://www.fao.org/3/a-i3905e.pdf

During this period, the loss of humus in the topsoil amounted to 5500 kilograms per hectare. Each year 77–135 kilograms of nutrients (nitrogen, phosphorus and potassium) are irreversibly removed with the yield from each hectare of the land.

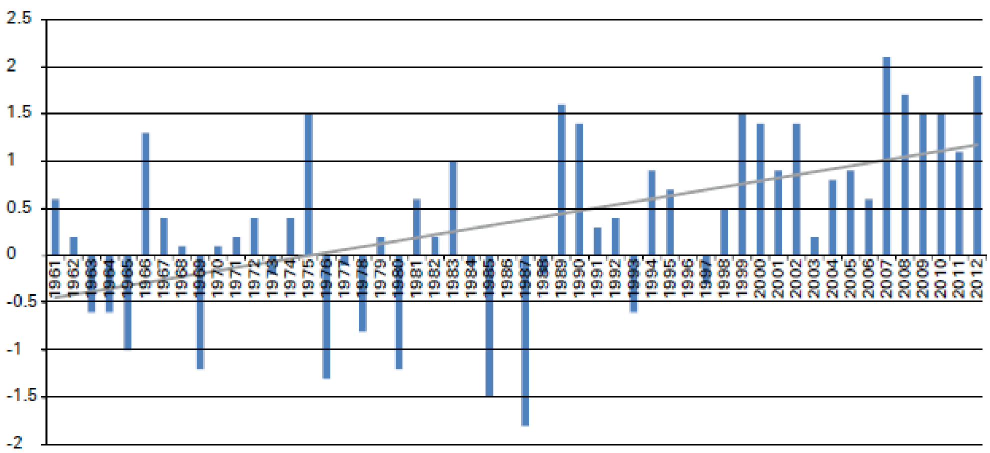


Figure 6.7 – The climate of Ukraine is changing, 1961-2012.
Average annual air temperature deviation from the norm

The problems of land degradation and desertification aggravate due to the *rapid climate change* (see Fig. 6.7 above), accompanied by the increase of annual average temperatures, recurrence and intensity of extreme weather events including draughts, which occur every two or three years on 10 to 30 percent of country's territory and every 10-12 years on 50 to 70 percent of the total area.

Land degradation and desertification lead to biodiversity loss, deterioration or disappearance of water bodies, exacerbation of the water supply problems for population and businesses and, as a consequence, worsening of people's living conditions.

The poverty level of rural population, which traditionally depends, to a high degree, on the state of use and protection of land and other natural resources, during the recent 10 years is by 2−11 percent higher, than the country's average, which leads to overexploitation of the natural resources, their further exhaustion and degradation.

The problems are caused by[14]:

- unjustifiably high level of economic (mainly agricultural) use of the territory and unbalanced proportion among land use types;
- violation of science-based principles of land use and basics of cropping including failure to follow the crop rotation plans, decreased volumes of applied agrochemicals, for the most part fertilizers, including organic fertilizers;
- unreasonable location of industrial and residential properties, particularly violation of the principle of locating the water demanding facilities taking into account availability of local water resources;
- insufficient area of lands designed for conservation of the environment, recreation, healing, historic and cultural purposes;
- unsatisfactory state of the land planning, particularly the development of documentation for conservation of lands and implementation of the planned measures, as well as insufficient provision of information for the State Land Cadastre system;
- insufficient functional maintenance of the state monitoring system of land and environment, of the draughts early warning and monitoring system as well as of the hydrometeorological observation network;
- insufficient level of government units' access to the material, technical and human resources as related to management of land and other natural resources;

[14] Final country report NATIONAL TARGET SETTING TO ACHIEVE LAND DEGRADATION NEUTRALITY IN UKRAINE. Kyiv, 2018

- the necessity of wider use of modern technologies, including geoinformation technologies and remote sensing as well as innovative scientific findings in the area of making and implementing of managerial decisions;

- insufficient volume of financial resources allocated for solving of problems related to conservation and sustainable use of lands;

- insufficient coordination as well as departments' and sector's oriented measures related to combating land degradation and desertification without considering the multifactorality of the causes and consequences;

- unsatisfactory level of awareness among the population, lack of interest and capacity of the land owners and users, whose numbers exceeded 25 million, in ensuring the sustainable use of land and solving the problems of land degradation.

One of the main contributors to the overall negative environmental impact is the military conflict in eastern Ukraine. The critical situation in the Donetsk and Luhansk regions, which covering an area of about 30 thousand square kilometer, is due to the fact that military activities take place in a large industrial region with a high concentration of potentially hazardous facilities, including coalmines, metallurgical, chemical and energy enterprises, storage facilities for industrial hazardous waste etc. Their destruction creates a danger to the life safety of the population and directly affects on all parameters of the environment.

A considerable part of the liberated territory of Donetsk and Luhansk oblasts with the total area of 7 thousand square kilometer is contaminated with explosive ordnance and requires measures of reconnaissance and humanitarian demining.

Substantial efforts, resources and time are required to recover damaged landscapes and restore the infrastructure of Donetsk and Luhansk oblasts.

The concept of Land Degradation Neutrality[15]

Land resources provide food, feed and fibre, and support the often-overlooked regulating and supporting services on which these provisioning services depend, as well as the cultural services delivered by healthy ecosystems.

Pressure on the world's finite land resources will grow as the population grows and increases in affluence. Increased competition for land resources is likely to increase social and political instability, exacerbating food insecurity,

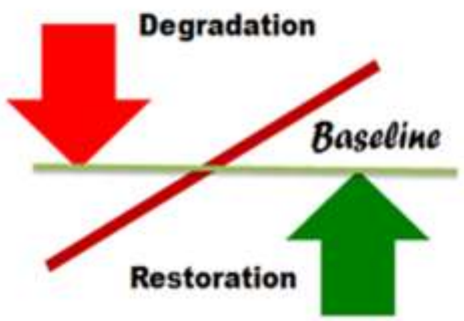
[15] https://www.unccd.int/actions/achieving-land-degradation-neutrality
https://www.unccd.int/actions/global-land-outlook-glo

poverty, conflict and migration. Maintaining the land's ability to deliver ecosystem services will depend on building resilience of the land resource base.

While demands on the global land resources are increasing, the overall health and productivity of land is declining. Thus, it is critical to find effective measures to address land degradation.

Avoiding and reversing land degradation will have co-benefits for climate change mitigation and adaptation, and also for biodiversity conservation, in addition to enhancing food security and sustainable development.

Land Degradation Neutrality (LDN) is the new paradigm for managing land degradation, introduced to halt the ongoing loss of healthy land as a result of unsustainable management and land conversion.



Defined as "a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems," the goal of LDN is to maintain the land resource base so that it can continue to supply ecosystem services such as provision of food and regulation of water and climate, while enhancing the resilience of the communities that depend on the land.

The target of LDN is a major plank in the global 2030 Agenda for Sustainable Development: LDN will underpin the achievement of multiple Sustainable Development Goals (SDGs) related to food security, poverty reduction, environmental protection and the sustainable use of natural resources.

Achieving neutrality: Actions to achieve LDN include sustainable land management approaches that avoid or reduce degradation, coupled with efforts to reverse degradation through restoration or rehabilitation of degraded land. The response hierarchy of Avoid > Reduce > Reverse land degradation (see

Figure) expresses the priorities in planning LDN interventions: most effort should be applied to avoiding land degradation, on the basis that "prevention is better than cure", because restoring degraded land is time-consuming and expensive.

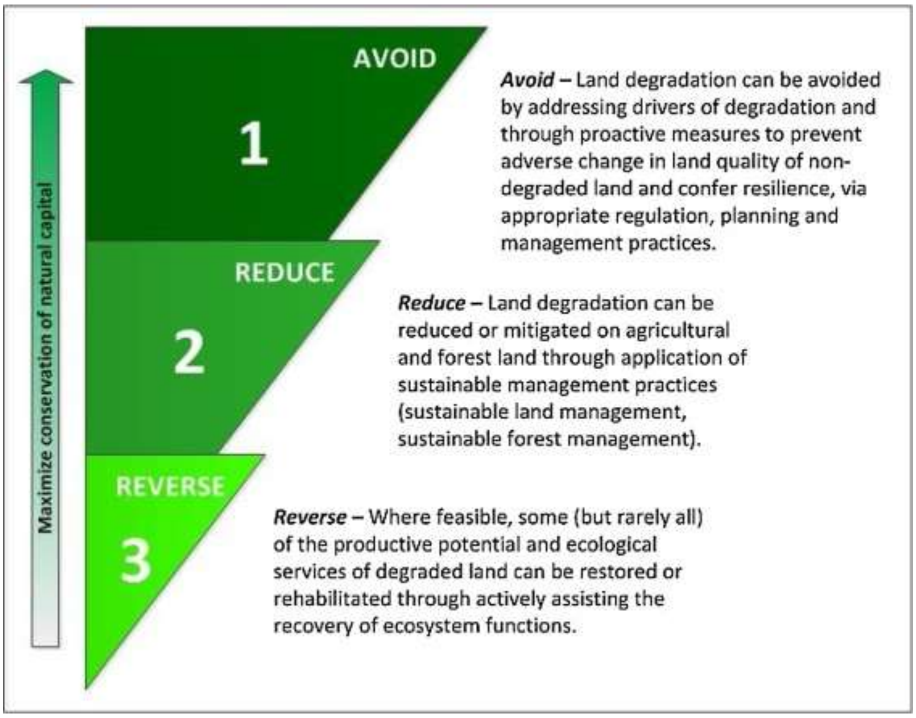


Figure 6.8 – The LDN response hierarchy
encourages broad adoption of measures to avoid and reduce land degradation, combined with localised action to reverse degradation, to achieve LDN across each land type.
Source: UNCCD

The indicator adopted to measure the achievement of SDG target 15.3 is "Proportion of land that is degraded over total land area".

The monitoring of this indicator as well as monitoring LDN is based on the combined use of three sub-indicators, namely

1) land cover,

2) land productivity and

3) carbon stocks above and below ground,

enhanced and complemented with other nationally relevant indicators and contextualised with information at the national and sub-national level.

For the purposes of LDN, it is important to note that the three indicators provide good coverage of the land-based ecosystem services underpinning LDN and together can be used to monitor the quantity and quality of land-based natural capital and the ecosystem services that flow from that land base.

In addition, the indicators address change in the system in different yet highly relevant ways.

Land cover provides a first indication of a reduction or increase in vegetation, habitat fragmentation and land conversion, land productivity captures relatively fast changes while SOC (Soil Organic Carbon) reflects slower changes that suggest trajectory and proximity to thresholds.

In order to achieve the SDG target of a land degradation-neutral world, countries have been invited to commit voluntarily to LDN at the national level.

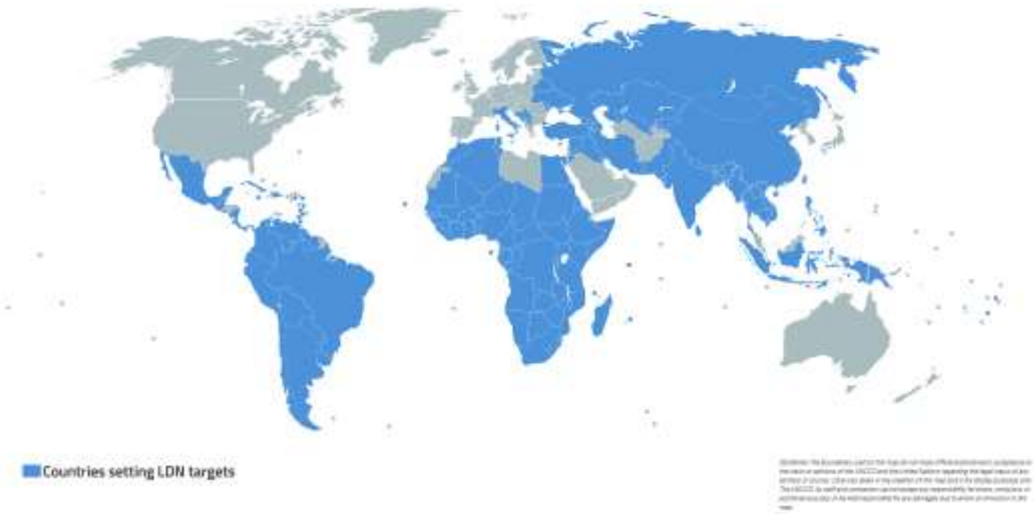


Figure 6.9 − As of today, 123 countries have committed to set LDN targets

Implementation of the concept of LDN in Ukraine

Ukraine joined to LDN TSP launched by the UNCCD Secretariat with support of multilateral and bilateral partners. LDN national target setting process resulted in elaboration of proposals relating to possible national voluntary LDN targets.

These proposals were summarized by the National Academy of Agrarian Sciences of Ukraine and then these proposals were considered and agreed on by the Coordination Council to Combat Land Degradation and Desertification in Ukraine during its meeting on 4th May 2018.

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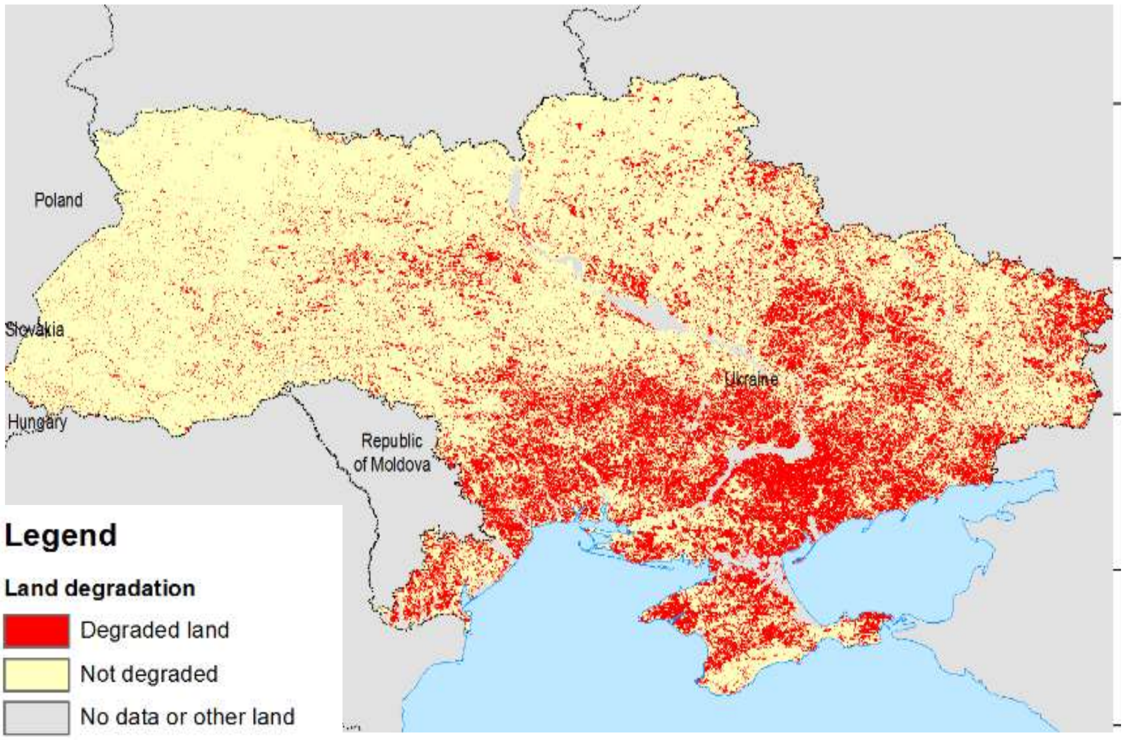


Figure 6.10 − Proportion of land that is degraded over total land area (Sustainable Development Goal indicator 15.3.1). Map of land degradation in Ukraine (2000-2015) with using of global default data
Source: UNCCD

National voluntary LDN targets in Ukraine

LDN target:

- Stabilization of soil organic carbon content in agricultural land

By 2020 to achieve the stable level of the content of soil organic carbon (humus) in agricultural land (not below the baseline).

By 2030 to increase the content of soil organic carbon (humus) in agricultural land not less than 0.1%, including as it relates to zones:

- Polissya - by 0.10–0.16%;
- Forest Steppe and Steppe − by 0.08–0.10%.

Supplementary tasks:

- Rehabilitation and sustainable use of peatlands;
- Restoration of irrigation and improvement of ecological and reclamation conditions of irrigated lands.

Associated measures for national LDN target "Stabilization of soil organic carbon content in agricultural lands" include:

1. Increase the input of organic matter into the soils of agricultural lands by:

- increasing crop productivity;

- change in the structure of cultivated area through increasing the proportion of legumes as well as including green manure crops to crop rotation;

- promotion of livestock production, including establishment of public hayfields and pastures;

- encouragement of expansion of organic fertilizers production and use, including recycled organic raw materials (waste recycling for fertilizers) and local natural resources (sapropels, compost etc.);

- incentives for development of organic agriculture etc.

2. Prevention / minimization of organic matter decline by:

- transformation of arable lands on slopes over 7 degrees and other lands which are not suitable for plowing to other types of land use, conservation of degraded lands etc.;

- preservation and improvement of existing forest shelter belts and other protective plantings as well as creation of new ones;

- wider use of soil protection technologies (min-till and No-till etc.);

- prevention of burning of crop residues, including stubbles, on fields etc.

3. Improvement of legal, regulatory, informational and organizational provisions, including:

- elaboration and implementation of legal acts to improve economical mechanisms for sustainable land use, land and soil protection, to strengthen land owners and land users responsibility for deterioration of land and soil characteristics etc.;

- development and implementation of standards and regulations relating to soil organic matter management, production and use of organic fertilizers;

- establishment of a National soil information center, conducting SOC monitoring and mapping as well as agrochemical survey and certification of agricultural lands etc.

7. CLIMATE CHANGE AND CLIMATE MONITORING

Weather and climate

Climate is defined as the average weather over a thirty-year period. Therefore, climate change can only be perceived and understood if measurements of all factors that can determine or influence the climate are taken over long periods of time.

This includes factors such as temperature, wind, greenhouse gas concentrations, natural emissions and man-made emissions.

Climate can be observed locally and globally. Statements on climate change usually concern worldwide averages, which show a change measured over a longer period of time. However, changes in the local climate are often more relevant to people.

These changes can be very different and even opposite to the global changes. The climate is highly variable by nature. No two years are alike. Therefore, trend-related changes are only provable if they exceed the noise of normal and local variations.

Taking measurements, organizing data and constructing explanatory and predictive models for how the different climate factors affect each other is what we call climate monitoring.

Climate monitoring and climate change

Climate monitoring concerns the monitoring of the atmosphere and of other components of the earth system as well as the monitoring of global climate indicators (e.g. global mean earth surface temperature and precipitation).

Satellite measurements appear to satisfy the need for global measurements.

The earth climate shows great variability over different time scales spanning from decades to thousands of years and more. Past climate are studied by analysing ice cores, sea/lake sediments, shorelines movements, tree pollen, etc.

The knowledge of past climate can help in predicting the future. Abrupt changes may serve in the identification of thresholds values that can trigger a non-linear behavior of the earth system (and hence may cause high variations). The overlapping of climate variability on different time scales is the very challenge in predicting climatic changes.

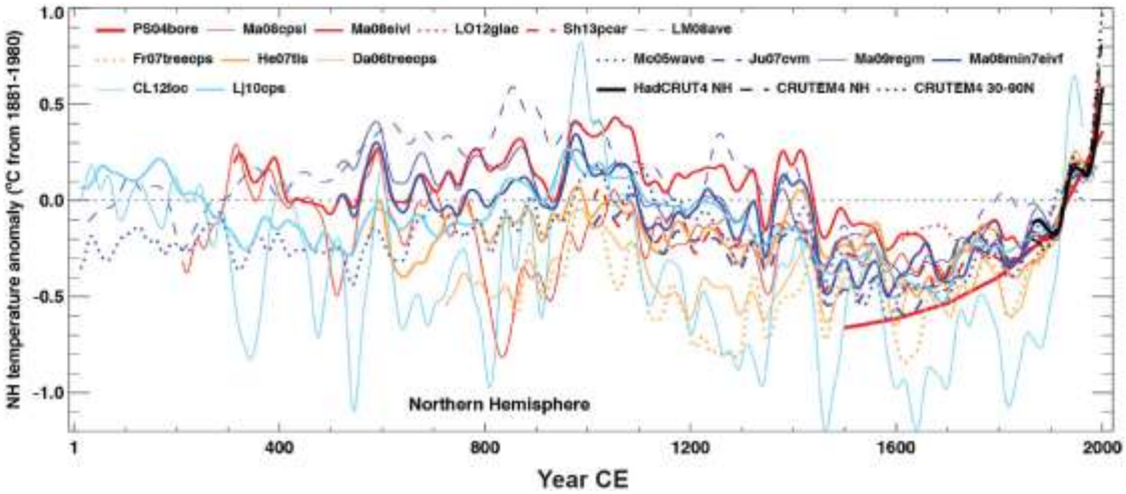


Figure 7.1 − Reconstructed Northern Hemisphere annual temperature during the last 2,000 years

Source: https://www.ncdc.noaa.gov/global-warming/last-2000-years

Many lines of scientific evidence show ***the Earth's climate is changing***. It is worth noting that increasing global temperature is only one element of observed global climate change. Precipitation patterns are also changing; storms and other extremes are changing as well.

How do we know the Earth's climate is warming?

Thousands of land and ocean temperature measurements are recorded each day around the globe.

This includes measurements from climate reference stations, weather stations, ships, buoys and autonomous gliders in the oceans. These surface measurements are also supplemented with satellite measurements.

These measurements are processed, examined for random and systematic errors, and then finally combined to produce a time series of global average temperature change. A number of agencies around the world have produced datasets of global-scale changes in surface temperature using different techniques to process the data and remove measurement errors that could lead to false interpretations of temperature trends.

The warming trend that is apparent in all of the independent methods of calculating global temperature change is also confirmed by other independent observations, such as the melting of mountain glaciers on every continent, reductions in the extent of snow cover, earlier blooming of plants in spring, a shorter ice season on lakes and rivers, ocean heat content, reduced arctic sea ice, and rising sea levels.

According to latest IPCC (the Intergovernmental Panel on Climate Change) Special Report "*human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels*, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate".

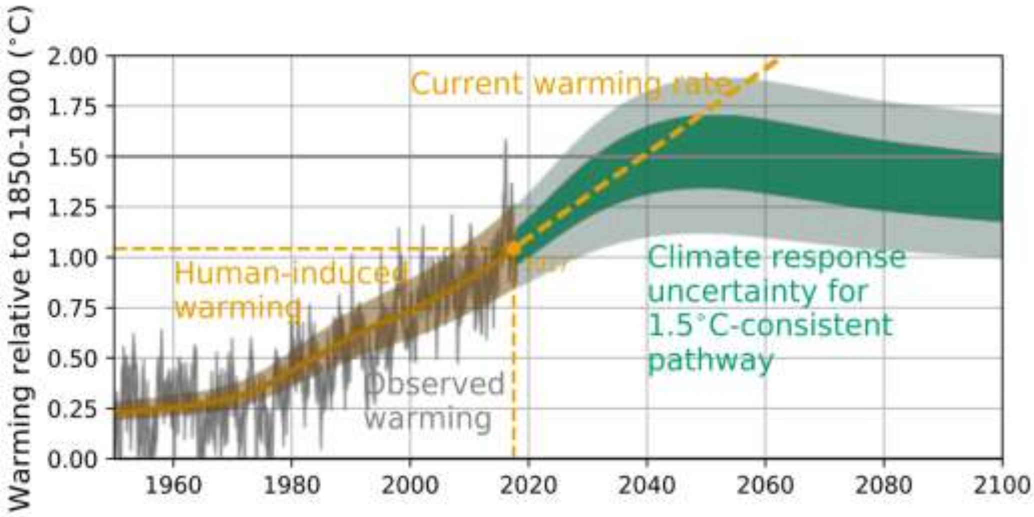


Figure 7.2 − IPCC Special Report on Global Warming of 1.5°C

The global surface temperature is based on air temperature data over land and sea-surface temperatures observed from ships, buoys and satellites. Notably, the 20 warmest years have all occurred since 1981, and the 10 warmest have all occurred in the past 12 years.

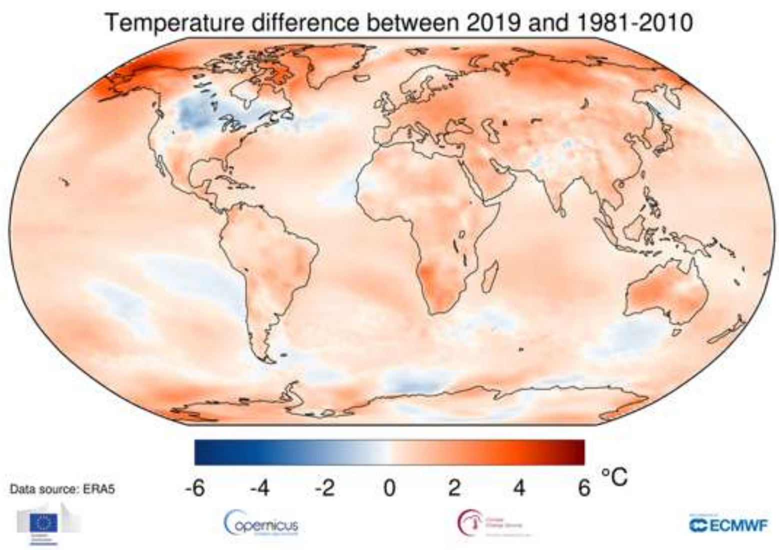


Figure 7.3 − Air temperature at a height of two metres for 2019, shown relative to its 1981–2010 average

Source: ERA5. Credit: Copernicus Climate Change Service (C3S)/ECMWF

Global mean sea level has been rising at an average rate of approximately 1.7 mm/year over the past 100 years (measured from tide gauge observations), which is significantly larger than the rate averaged over the last several thousand years.

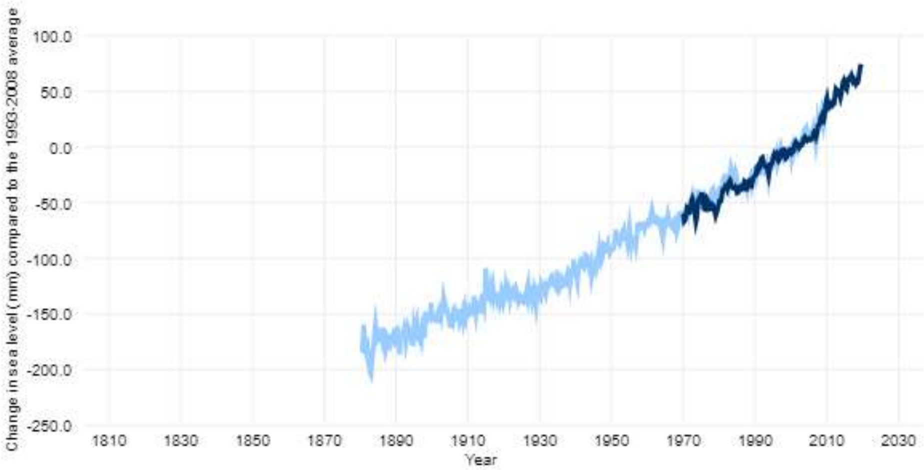


Figure 7.4 – Sea level since 1880

The light blue line shows seasonal (3-month) sea level estimates from Church and White (2011). The darker line is based on University of Hawaii Fast Delivery sea level data

Much of the sea level rise to date is a result of increasing heat of the ocean causing it to expand. It is expected that melting land ice (e.g. from Greenland and mountain glaciers) will play a more significant role in contributing to future sea level rise.

Northern Hemisphere Snow Cover is Retreating. Northern Hemisphere average annual snow cover has declined in recent decades.

This pattern is consistent with warmer global temperatures. Some of the largest declines have been observed in the spring and summer months.

Changes in climate can affect how much snow falls and influence the timing of the winter snow season. Between 1966 and 2010, the amount of land and sea ice that is snow-covered each year has decreased over many Northern Hemisphere regions, especially during the spring snowmelt season. Scientists are modeling how Earth's climate might change over the next 100 years, and the results suggest that snow will cover less of the planet, particularly over Europe and Asia. Climate warming can reduce snowfall, and cause earlier spring melts and shorter snow cover seasons.

Glacier Volume is Shrinking. Warming temperatures lead to the melting of glaciers and ice sheets. The total volume of glaciers on Earth is declining sharply.

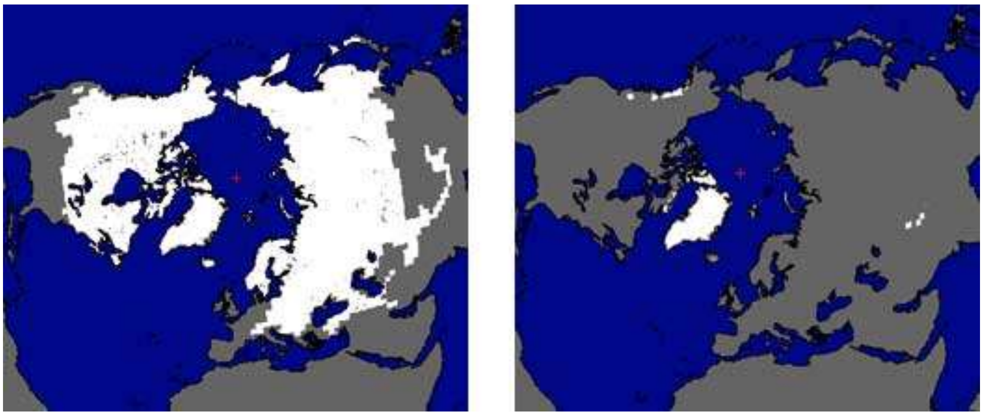


Figure 7.5 – Average snow extent across the Northern Hemisphere reaches its maximum in January (left), and its minimum in August (right).
White indicates snow, blue shows oceans and water, and gray indicates land.
(Larger image not available)
Source: https://nsidc.org/cryosphere/snow/climate.html

Glaciers have been retreating worldwide for at least the last century; the rate of retreat has increased in the past decade. Only a few glaciers are actually advancing (in locations that were well below freezing, and where increased precipitation has outpaced melting).

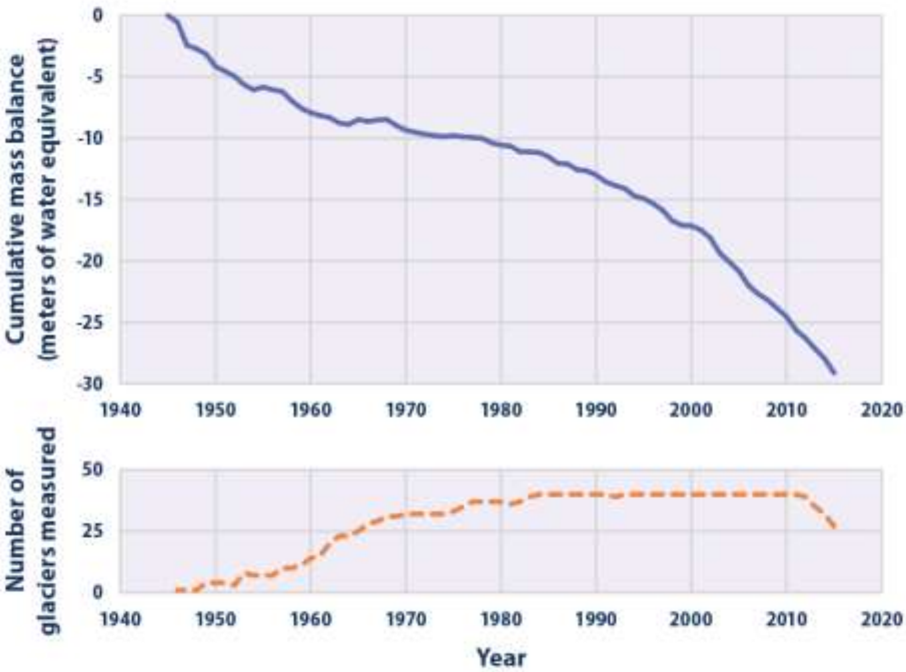


Figure 7.6 – Average Cumulative Mass Balance of "Reference" Glaciers Worldwide, 1945–2015
Sources: World Glacier Monitoring Service (WGMS), 2016

The progressive disappearance of glaciers has implications not only for a rising global sea level, but also for water supplies in certain regions of Asia and South America.

A large body of evidence supports the conclusion that ***human activity is the primary driver of recent warming***!

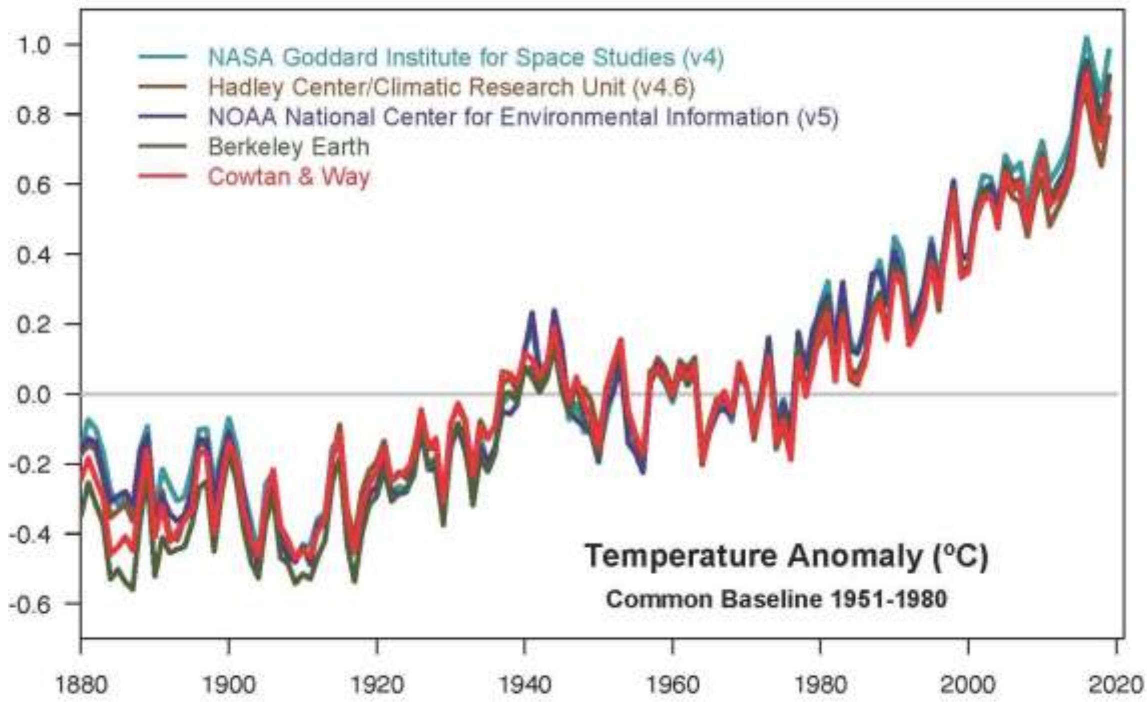


Figure 7.7 – Temperature data showing rapid warming in the past few decades, the latest data going up to 2019.
Source: NASA/NOAA.

Multiple studies published in peer-reviewed scientific journals show that 97 percent or more of actively publishing climate scientists agree: Climate-warming trends over the past century are extremely likely due to human activities. In addition, most of the leading scientific organizations worldwide have issued public statements endorsing this position.

Characteristics and uses of climate observations

Climate observations are important because they help satisfy important social, economic and environmental needs. They are an integral part of reducing the risk of loss of life and damage to property.

Climate observations are sourced from the numerous meteorological and related observational networks and systems that underpin applications such as weather forecasting, air pollution modelling and environmental impact assessments.

However, climate observations differ in a number of important aspects.

Firstly, climate observations need to account for the full range of elements that describe the climate system – not just those that describe the atmosphere. Extensive observations of the ocean and terrestrial-based systems are required.

Secondly, an observation at any point in time needs a reference climate against which it can be evaluated, i.e. a reference climatological period must be selected. In this regard, the observations from a station that only exists for a short period (i.e. from days to a few years) or which relocates very frequently will generally be of less value than those observations from a station whose records have been maintained to established standards over many years.

Thus, in order to derive a satisfactory climatological average (or normal) for a particular climate element, a sufficient period record of homogeneous, continuous and good quality observations for that element is required.

Thirdly, a climate observation should be associated – either directly or indirectly - with a set of metadata that will provide users with information, often implicitly, on how the observation should be interpreted and used.

So, while climate observations serve multiple purposes beyond specific climate needs, we must ensure that they retain, and acquire, particular characteristics that serve a range of climate needs.

Climate change in Ukraine

Ukraine is located in the central part of the European continent under difficult physiographic conditions, which determines the originality of the impact of major climate-forming factors on the formation of climate − the inflow of solar radiation, the atmospheric circulation as well as human activities.

The peculiarities of their implication depend on the latitude, altitude elevation, orography etc. and are indicators of the climatic conditions of the area. In general, the climate of Ukraine is temperate continental, on the Southern coast of Crimea – a subtropical Mediterranean climate. Ukraine receives sufficient heat and moisture, which create favorable natural-climatic conditions on its territory.

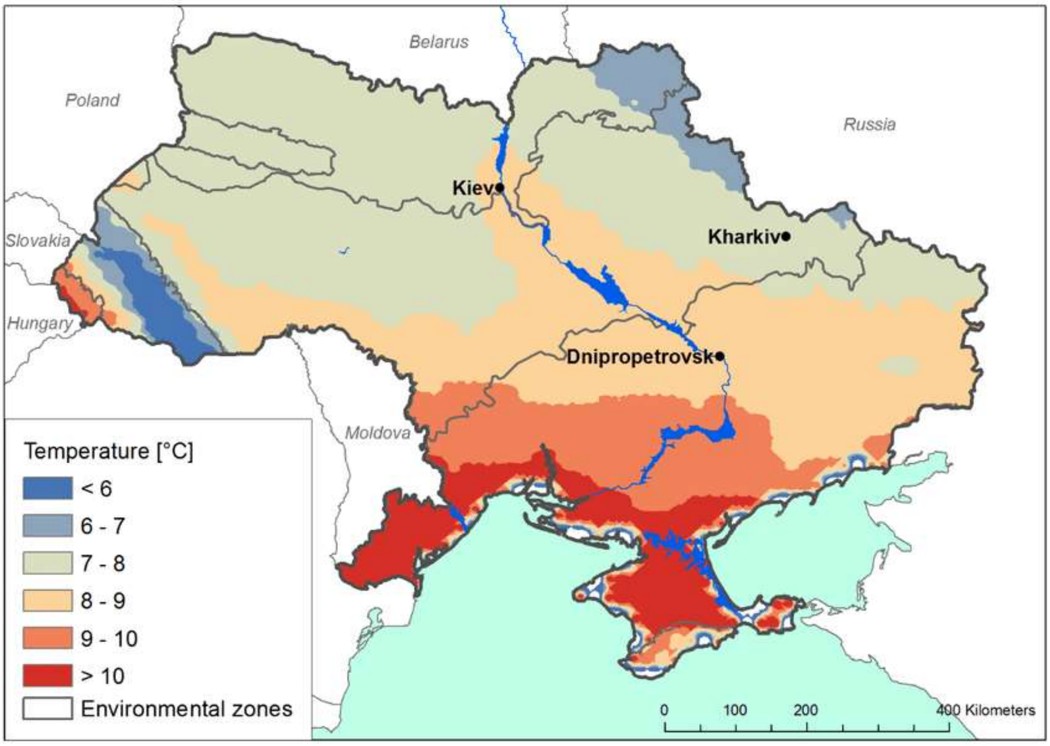


Figure 7.8 – Average annual temperature (°C) and precipitation (mm) in Ukraine, 2005 to 2012

Source: Impact of climate change on wheat production in Ukraine/ Working Paper May 2016

The knowledge about the climate of Ukraine is based on the laws of the space-time distribution of quantitative field indicators of the basic meteorological variables that characterize the state of the atmosphere as a component of the climate system and depend on both the natural and anthropogenic factors.

However, in the view of most researchers, current climate changes are caused by the greenhouse effect. In its turn, the greenhouse effect is the result of excessive man-made CO_2 emissions into the atmosphere.

Ukrainian scientists also guess that the most of global average warming over the past 50 years is likely due to anthropogenic GHG increases.

Actually, global warming is a result of a combination of climate changes natural cycles with anthropogenic effects on climate, including GHG emission.

According to the Intergovernmental Panel on Climate Change (IPCC), climate system changes are unequivocal, as is now evident from observation of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. And climate of Ukraine is involved in these system changes.

The signs of climate change are apparent in Ukraine: extremes of temperature, an increase in the number of hot days, an overall reduction in atmospheric precipitation (although with a drastic rise in some areas), together with an increase in gales and rainstorms, catastrophic floods and droughts, forest fires and desertification.

The consequences of these trends are having a negative impact on agriculture, forests, water and other sectors, as well as on people's health and safety.

The longest period of warming in Ukraine over more than 120 years of instrumental observations happened at the end of the 20th and beginning of the 21st centuries.

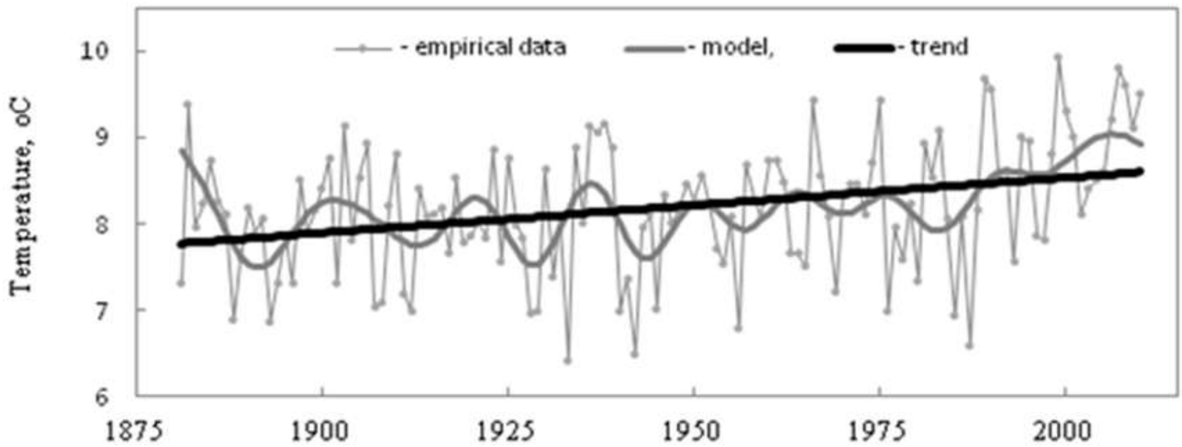


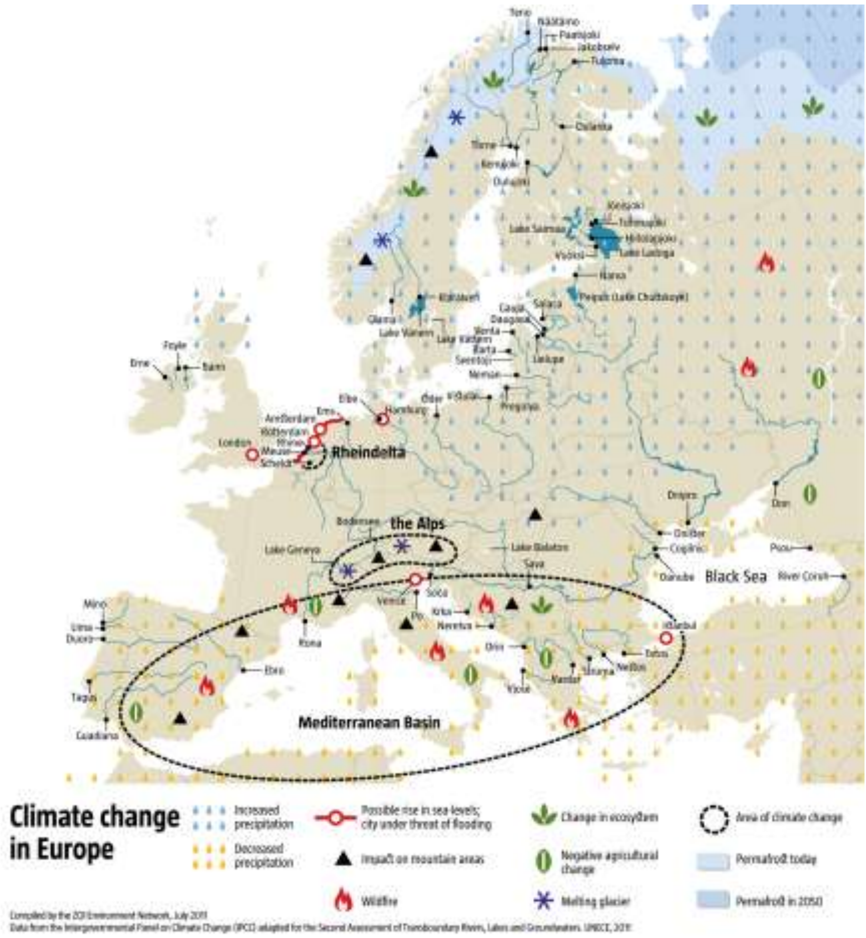
Figure 7.9 – Century course of fluctuations of annual temperature in Ukraine for the period 1881-2010

The average high air temperature for the year rose more in the western regions (up to 0.9° C), in the central regions, in the north, the south it is somewhat smaller (up to 0.6° C). The average minimum temperature also rose in the west by up to 0.5–0.7° C, in the east – by up to 0.4 – 0.5° C.

On average, between 1988 and 2007, the air temperature increased by 1.1-2.0°C, and according to projections a gradual increase will continue in the future.

The number of days with so-called "tropical nights", when the temperature after sunset does not fall below 25°C, has also increased.

If greenhouse gas emissions are not reduced, in Ukraine, due to its large size, the changes of the air temperature will be different in different parts of the country, as well as throughout the year.



Scientists predict that the temperature increase will be between 1 and 5°C in various parts of the country by 2100. It is mainly the winter and spring months that will become warmer.

Some researchers believe that a tropical climate will reach Ukraine, and that the subtropical zone already present in country will further expand.

Although there is no unequivocal prediction of expected changes in the regime and amounts of precipitation, it is certain that these changes will be different in different parts of the country and at different times of year.

Ukrainian researchers believe that the country's climate has already become less continental and is growing more similar to a maritime climate in some areas.

These transformations have triggered a shift of climate zones that are slowly moving northward and are changing the natural system as they destroy natural ecosystems. The forest-steppe parts of Ukraine are no longer considered to be evenly humidified areas.

The repetitiveness and length of the summer heat periods (with air temperature above 25°C or 30°C) rose.

Droughts became more frequent and tended to cover bigger areas. In the past, they happened once every two to three years and covered from 10 to 30% of the country, but between 1989 and 2010 their frequency doubled, and the droughts started to spread through a wider area that previously had sufficient precipitation.

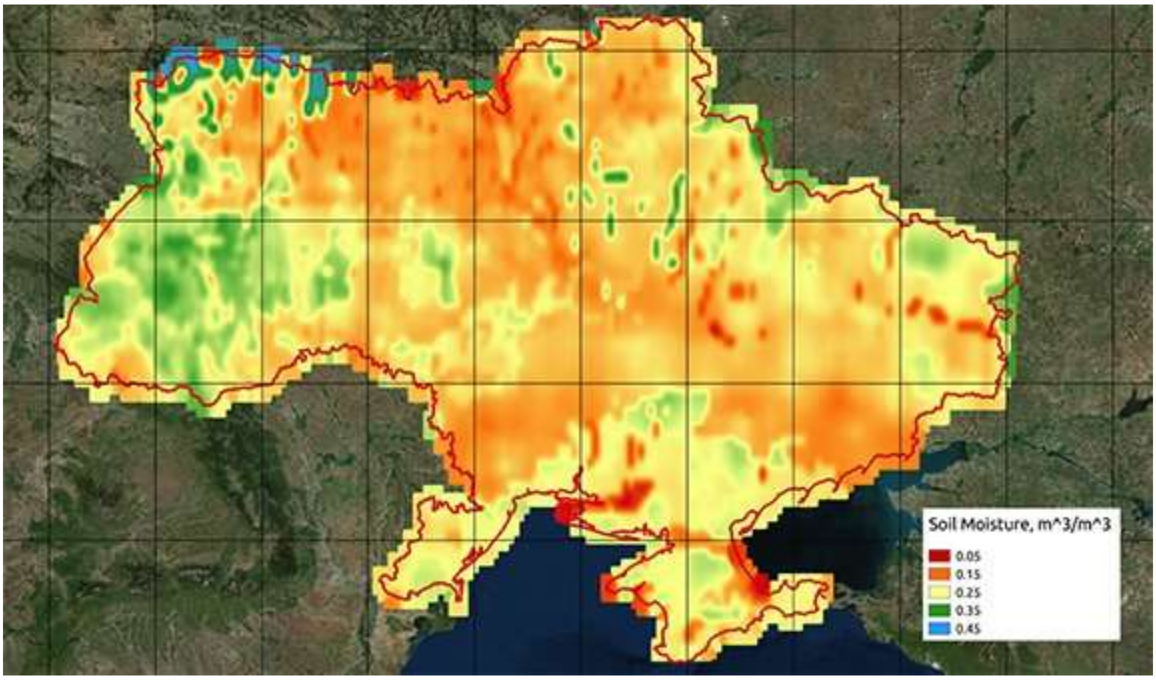


Figure 7.10 – Soil moisture
Source: https://eos.com/agriculture/soil-moisture/

Greenhouse gas emissions in Ukraine

From 1990 to 2005 greenhouse gas emissions in Ukraine fell by 55%. The reduction happened gradually and was linked to a decrease in the economy growth rate after the end of the Soviet Union. The maximum reduction happened in 2000. After that emissions started to grow again and are continuing to rise.

At international climate negotiations Ukraine is classed as an "industrial country with its economy in transition" and thus agrees to reduce its emissions by 20% by 2020 and by 50% by 2050, taking 1990 as a baseline. And as a country with a transition economy it is allowed to engage in international financial mechanisms to reduce emissions.

CO_2 accounted for the biggest share of GHG emissions in 1990 at about 75% of the total, with methane at 18% and nitrous oxide 7%. The biggest contribution to total GHG emissions is the extraction, production and consumption of energy.

Possible impact of climate change on Ukraine

All transformations of climate have been affecting various areas of life in Ukraine for a while now. Their effect is particularly visible in agriculture, which accounts for over 8% of Ukraine's GDP.

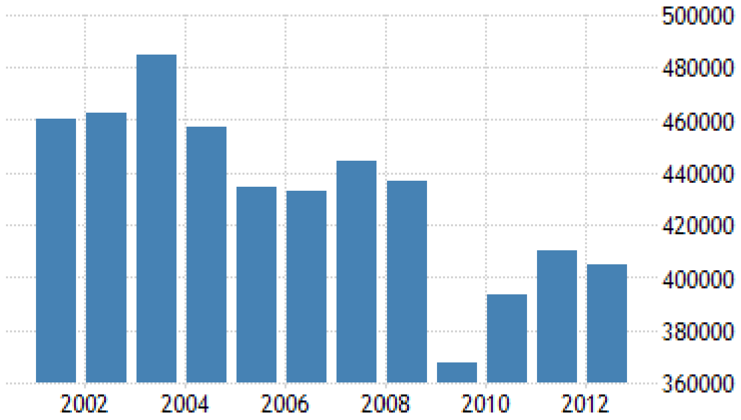


Figure 7.11 – Ukraine - Total Greenhouse Gas Emissions (kt of CO_2 Equivalent)
Source: World Bank collection of development indicators

Despite optimistic expert projections of better grain crops in the case of mild warming, the expected rapid rise of the average annual temperature will have a disastrous impact on Ukrainian agriculture, if it fails to adapt itself to new climate conditions.

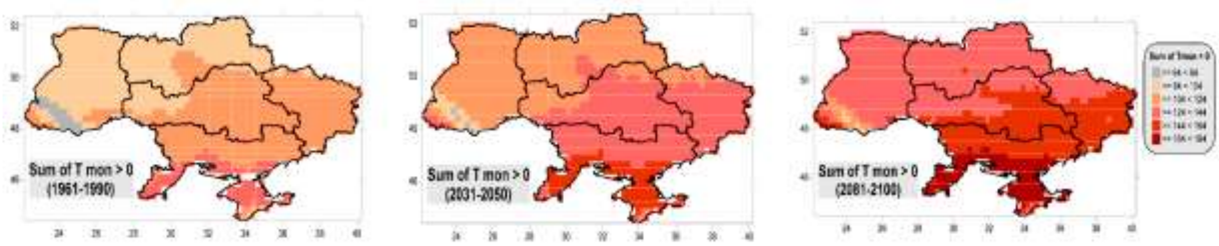


Figure 7.12 – Dynamics of sums of positive monthly temperatures (indicator of heat availability by Vorobjov) for 1961–1990, 2031–2050 and 2081–2100
Source: https://www.mdpi.com/2071-1050/9/7/1152/htm

Agricultural output will decline, while its share in GDP will drop by several percent in the long term. In addition to insect–pests, the amount of which is boosted by the warming, fertile soil can be damaged by erosion and desertification, as a result of the microclimate becoming more arid.

Currently, Ukrainian agriculture is not responding to climate change properly, as it is choosing the easiest way. To minimize the losses caused by natural disasters, many farms are switching to growing technical plants that are less vulnerable to bad weather.

As a result, the area under rapeseed crops being grown instead of wheat and vegetables is increasing significantly, particularly in Crimea and the Odesa, Mykolayiv and Kherson Oblasts.

Climate Stressors and Climate Risks AGRICULTURE PRODUCTION	
Stressors	**Risks**
Rising temperatures **Fewer frost days** **Changes in precipitation type and amount** **Shift in onset of seasons** **Drought**	Reduced losses from early spring frost
	Rise in winter wheat yields in north
	Decrease in rainfed high-input cereal yield in the south
	Delayed sowing dates; overall plant length cycles substantially unchanged
	Increased moisture evaporation from the soil surface
	Intensified decomposition of humus, resulting in decreased soil fertility
	Reduced capacity of the soil to retain moisture as a result of erosion from extreme wind/water events
	Increased vulnerability of winter crops from reduced snow cover
	Decreased grain quality resulting from higher CO_2 concentrations
	Increased volatility of sector and world prices

In 2008, Ukraine was the top European country for area planted with rapeseed which, along with sunflower, covered 1/5 of the total area under crops. Experts have already categorized rapeseed as an environmental weapon against Ukraine, exhausting the fields and turning chornozem, the fertile black soil, into the lands that can no longer be farmed.

Global warming will have a heavy impact on the water supply, primarily drinking water, in the most arid areas.

Crimea and some Southern oblasts of Ukraine are already suffering from a shortage of good quality water, and the problem of the increase in the annual temperature will aggravate this.

The quality of surface water, especially in shallow rivers, could also worsen, which will lead to the spread of infections.

In social terms, climate change will disproportionately affect people with a low income, having the heaviest impact on socially vulnerable groups with limited access to energy, water and a good quality food supply, as well as other services, including healthcare.

8. BIODIVERSITY AND BIOMONITORING

Biodiversity: The Web of Life

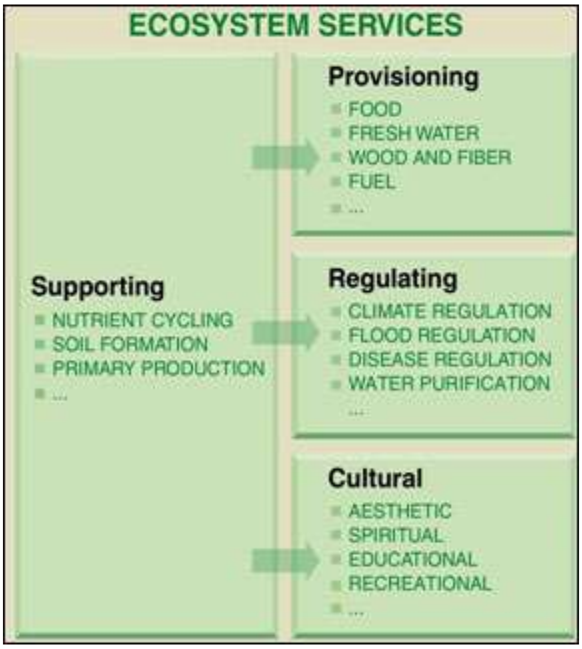
Biological diversity − or biodiversity − is the term given to the variety of life on Earth and the natural patterns it forms.

The biodiversity we see today is the fruit of billions of years of evolution, shaped by natural processes and, increasingly, by the influence of humans. It forms the web of life of which we are an integral part and upon which we so fully depend.

This diversity is often understood in terms of the wide variety of plants, animals and microorganisms. So far, about 1.75 million species have been identified, mostly small creatures such as insects. Scientists reckon that there are actually about 13 million species, though estimates range from three to 100 million.

Biodiversity also includes genetic differences within each species - for example, between varieties of crops and breeds of livestock. Chromosomes, genes, and DNA-the building blocks of life-determine the uniqueness of each individual and each species.

Yet another aspect of biodiversity is the variety of ecosystems such as those that occur in deserts, forests, wetlands, mountains, lakes, rivers, and agricultural landscapes. In each ecosystem, living creatures, including humans, form a community, interacting with one another and with the air, water, and soil around them.



It is the combination of life forms and their interactions with each other and with the rest of the environment that has made Earth a uniquely habitable place for humans.

Biodiversity provides a large number of "*goods and services*" that sustain our lives:

- Provision of food, fuel and fibre;
- Provision of shelter and building materials;
- Purification of air and water;
- Detoxification and decomposition of wastes;

- Stabilization and moderation of the Earth's climate;
- Moderation of floods, droughts, temperature extremes and the forces of wind;
- Generation and renewal of soil fertility, including nutrient cycling;
- Pollination of plants, including many crops;
- Control of pests and diseases;
- Maintenance of genetic resources as key inputs to crop varieties and livestock breeds, medicines, and other products;
- Cultural and aesthetic benefits;
- Ability to adapt to change.

Biodiversity and biomonitoring in Ukraine

The preservation of biodiversity is one of the global environmental challenges. Human impact on the environment has led to the decline of thousands of species of plants and animals, extinction rates have increased by a thousand compared to natural rates. This is a challenge to Ukraine as well.

The third edition of the Red Data Book of Ukraine (2009) includes 839 species of plants and 542 animal species, much more than was in the previous edition.

Strong efforts should be applied and a complex approach implemented to preserve biodiversity in modern Ukraine. The methods to be used include the development of the network of protected areas, building the ecological network, designing and implementing action plans for protecting and restoring numbers of certain rare and declining species, finding environmentally friendly technologies to be applied in farming, transportation etc.

Ecological network (Econet) is the only territorial system, which is formed to improve conditions for the creation and restoration of the environment, enhancing natural resources in Ukraine, preservation of landscape and biodiversity, places of settlement and growth of species of flora and fauna, genetic stock, migration routes of animals through a combination territories and objects of natural reserve fund and other areas that are of particular value to environmental protection.

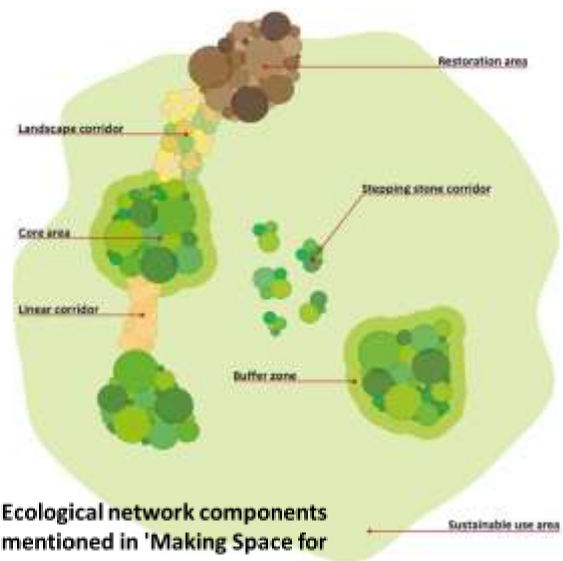
The idea of creating the Pan-European Ecological Network (European Ecological Network or EECONET) as a system of interconnected valuable from an environmental point of view of natural areas was proposed by a group of Dutch researchers in 1993 at the International Conference "Protection of the natural heritage of Europe through the establishment of the European ecological network" (Maastricht, the Netherlands). It seamlessly integrates into the idea of sustainable development and is one of the powerful tools of expression[16].

Table 8.1 – Protected Areas of Ukraine, 2017
(Source: MENR, State Department for Protected Areas)

PA Category Name (Eng/Ukr)	#	Area, ha	Percentage of PA Network	Principle Purposes	IUCN Category
National Nature Preserve/ Natsionalny Pryrodnyy Zapovednik	19	206,631	4.7	Strict protection, scientific research, education	I
Biosphere Preserve/ Biosphernyy Zapovednik	5	479,111	11.09	Strict protection, scientific research, education	I
National Nature Park/ Natsionalnyy Pryrodnyy Park	49	1,311,638	30.37	Conservation, nature recreation, science, education	II
Regional Landscape Park/ Regionalnyy Landshaftnyy Park	81	786,025	18.2	Conservation, nature recreation, education	V
Nature Reserve/Zakaznik	3,167	1,389,674	32.18	Conservation, restoration of natural habitats & species	IV, VI
Protected Site/ Zapovidne Urochyshe	812	97,860	2.27	Protect specific natural feature	III
Nature Monument/Pamyatnyk Pryrody	3441	29,769	0.68	Protect specific natural feature	III
Other categories, not natural	671	17,516	0.4	Zoos, botanic gardens, parks	N/A
Total	**8,245**	4,318,224	**100.0**		

According to most existing views, the main goal of creating an ecological network can be considered a general improvement of the environment and the human condition, sustainability existence of the biosphere by eliminating anthropogenic fragmentation biogeocenotic cover, established in the historical development of society, the creation of its continuity and functional integrity and strengthening, due to this, the ability to heal itself.

But the application of these methods for protecting and enhancing biodiversity require the evaluation of



Ecological network components mentioned in 'Making Space for Nature' report (Lawton and others 2010)

[16] http://necu.org.ua/ekonet/

what we have achieved, were our efforts successful. The grounds for such an assessment are set by monitoring biological objects.

The monitoring of biological diversity is a system of long-term, standardized collecting, accumulation and analysis of information about biological objects.

Such monitoring establishes the basis for nature conservation policies and assessment of the efficiency of nature conservation measures, as well as for the sustainable use of natural resources.

In these terms the monitoring of biological diversity integrates into international agreements and the national legislation in Ukraine directed towards nature conservation.

Among international agreements concerning biodiversity conservation (and to which Ukraine is a contracting party) the following should be mentioned:

- the Convention on Biological Diversity (CBD);
- the Convention on Migratory Species (CMS);
- the Convention on Wetlands of International Importance, especially as Waterfowl Habitat (Ramsar Convention);
- the European Landscape Convention.

An important tool for biodiversity conservation is the Pan-European Biological and Landscape Diversity Strategy (PEBLDS), which is the mechanism for implementing the CBD in Europe.

According to Ukrainian legislation, biodiversity monitoring is a constituent of the monitoring of the environment of the country:

- The law 'On animal wildlife' (2001);
- The law 'On plant wildlife' (1999);
- The law 'On the Red Data Book of Ukraine' (2002);
- The law 'On the state programme for developing the national ecological network in Ukraine for the years 2000–2015' (2000);
- The law 'On the ecological network of Ukraine' (2004);
- The 'Forest Code of Ukraine' (2006).

In addition, the monitoring of biodiversity in Ukraine is subjected to regulations set by the Cabinet of Ministers of Ukraine: 'On the order for maintaining the national cadastre for animal wildlife' (1994) and 'On the approval of the order for maintaining the national accounting and cadastre of plant wildlife' (2006).

These cadastres are considered as a systematized assemblage of information concerning the geographical distribution of species (groups of species), their numbers and status, features characterizing their habitat and current use, other information.

A great drawback of the current environmental protection legislation is the need to elaborate and adopt various by-laws. The lack of these documents or their shortcomings hamper the practical implementation of the existing laws and quite often this is the real cause for failure.

An analysis of the current state of biodiversity monitoring in Ukraine shows that on the whole such monitoring here is in its primary stages of development, although certain orientations in this field have been fairly well developed and have a long history.

Amongst these the 'Chronicles of Nature' programme should be mentioned. This programme has been maintained for decades by authorized staff of protected areas.

Game animal counts regularly carried out by managers may to a certain extent be considered a form of monitoring programme. The information collected contributes to the national statistical report.

Besides monitoring programmes involving certain animal and plant groups and financially supported by the State, there are programmes conducted by volunteers or programmes receiving support from international funding agencies (IWC, IBA, White Stork, Aquatic Warbler, etc.).

Out of 95 biodiversity monitoring programmes in Ukraine about a third of them are related to phytodiversity; others are devoted to monitoring animal wildlife.

The monitoring of phytodiversity covers several issues:

- investigations into the population status of particular species,
- monitoring vegetation (geobotanical studies),
- forestry research,
- monitoring and research of wild plant
- resources and monitoring the flora of particular regions.

Most of the programmes focus on populations.

Creating a system for monitoring biodiversity in Ukraine will take a lot of time. Even if we take into account monitoring species we have to deal with around 70 thousand species of fungi, plants and animals in the country. Including other aspects of biodiversity − gene pools, populations, communities and ecosystems − makes the task almost impossible. Under these circumstances there is a need to distinguish monitoring priorities and implement the national monitoring system step by step.

Objects for the first stage of the biomonitoring development (lasting at least 10 years) should be priority biological species, plant communities and ecosystems[17]:

a) species:

• species listed in the Red Data Book of Ukraine, international 'red' lists (European List, IUCN - International Union for Conservation of Nature etc.) and in annexes to international agreements to which Ukraine is a contracting party (Bonn Convention, Berne Convention, EUROBATS etc.);

• species subjected to legal and illegal commercial use; these are commercial fish species, game animals, medicinal plants and animals, some other groups of species;

• species indicating general changes in the biodiversity of the country (for instance, common bird species in farmland areas, forest ecosystems, etc.);

• alien species, particularly those of a hazardous character.

b) plant communities:

Priority communities are those listed in the Green Data Book of Ukraine.

c) ecosystems:

Environmental issues in Ukraine and obligations assumed under certain international agreements point out those top-priority ecosystems should be Steppe, wetlands and certain kinds of forest ecosystems.

Steppe ecosystems have almost entirely disappeared due to agriculture, wetlands have been reduced by millions of hectares due to drainage, or have been depleted through unwise economic use and heavy recreational pressure, most forest ecosystems are artificial and only a minor portion of them are of native origin (for instance, virgin forests in the Carpathians).

The development of an efficient monitoring system is impossible without taking advantage of modern methods of field investigation, accumulation and analysis of data, and exchange of information.

[17] Kostiushyn, V.A., Gubar, S.I., Domashlinets, V.G. Strategy for developing the monitoring of biodiversity in Ukraine. — Kyiv, 2009. http://uncg.org.ua/wp-content/strategy.pdf

The development of the national system of biomonitoring must use widely as possible GIS technologies, remote sensing, relational databases, web technologies and other novel possibilities.

Taking into account the European vector in the development of Ukraine as a nation, the national system for monitoring biological diversity should be harmonized with the existing European initiatives and approaches towards creating a European system for monitoring, including the set of bioindicators.

During the past decades various international and national organizations have been developing sets of indicators to measure and assess the status of “biological resources” from both quantitative and qualitative points of view with particular attention given to biological diversity (biodiversity).

"Biological resources" includes genetic resources, organisms or parts thereof, populations, or any other biotic component of ecosystems with actual or potential use or value for humanity (UN Convention on Biological Diversity, Art 2).

According to UN Convention on Biological Diversity, "Biological diversity" means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

The European Environment Agency (EEA) has developed a set of 26 indicators SEBI (Streamlining European 2010 Biodiversity Indicators). The Pan-European SEBI initiative was launched in 2005.

Its aim was to develop a European set of biodiversity indicators – based on those already existing, plus new indicators as necessary. From its inception SEBI linked the global framework set by the Convention on Biological Diversity with regional and national indicator initiatives.

One of the principal working methods of SEBI is to build on current monitoring and available data to avoid duplication of efforts and to complement and not replace other activities to describe, model and understand biodiversity and the pressures upon it.

This means that a large part of the 26 SEBI indicators originates from various external ongoing programmes and processes at the national, European and global levels.

From the very beginning, the proposed set of indicators has been seen holistically, stressing mutual relationships among the individual indicators and their power to deal with uncertainty.

Table 8.2 − SEBI 2010 indicators within CBD focal areas and EU headline indicators

Source: Streamlining European biodiversity indicators 2020: Building a future on lessons learnt from the SEBI 2010 process. EEA Technical report No 11/2012

CBD focal area	Headline indicator	SEBI 2010 specific indicator
Status and trends of the components of biological diversity	Trends in the abundance and distribution of selected species	1. Abundance and distribution of selected species a. birds b. butterflies
	Change in status of threatened and/or protected species	2. Red List Index for European species
		3. Species of European interest
	Trends in extent of selected biomes, ecosystems and habitats	4. Ecosystem coverage
		5. Habitats of European interest
	Trends in genetic diversity of domesticated animals, cultivated plants, and fish species of major socio-economic importance	6. Livestock genetic diversity
	Coverage of protected areas	7. Nationally designated protected areas
		8. Sites designated under the EU Habitats and Birds Directives
Threats to biodiversity	Nitrogen deposition	9. Critical load exceedance for nitrogen
	Trends in invasive alien species (numbers and costs of invasive alien species)	10. Invasive alien species in Europe
	Impact of climate change on biodiversity	11. Impact of climatic change on bird populations
Ecosystem integrity and ecosystem goods and services	Marine Trophic Index	12. Marine Trophic Index of European seas
	Connectivity/fragmentation of ecosystems	13. Fragmentation of natural and semi-natural areas
		14. Fragmentation of river systems
	Water quality in aquatic ecosystems	15. Nutrients in transitional, coastal and marine waters
		16. Freshwater quality
Sustainable use	Area of forest, agricultural, fishery and aquaculture ecosystems under sustainable management	17. Forest: growing stock, increment and fellings
		18. Forest: deadwood
		19. Agriculture: nitrogen balance
		20. Agriculture: area under management practices potentially supporting biodiversity
		21. Fisheries: European commercial fish stocks
		22. Aquaculture: effluent water quality from finfish farms
	Ecological Footprint of European countries	23. Ecological Footprint of European countries
Status of access and benefits sharing	Percentage of European patent applications for inventions based on genetic resources	24. Patent applications based on genetic resources
Status of resource transfers	Funding to biodiversity	25. Financing biodiversity management
Public opinion (additional EU focal Area)	Public awareness and participation	26. Public awareness

Special attention was paid to the task to produce user-friendly indicators. Furthermore SEBI aimed at improving the provision of information to policy-makers along the DPSIR chain (Drivers, Pressures, State, Impact, Responses) in support of policy effectiveness.

Monitoring, models, scenarios, targets, baselines and critical levels are elements supporting any indicator. Monitoring is a major concern. For several indicators, the data are non-standardised or incomplete, or there is a serious lack of geographical coverage. The monitoring of the state of biodiversity is slowly improving. Threats, goods (such as fish and timber) and some responses are reasonably well-monitored as part of the well-developed socio-economic and environmental monitoring. Services are hardly monitored, partly because they are still ill-defined[18].

In 2010, the Convention on Biological Diversity (CBD) agreed on 20 global biodiversity targets (Aichi Targets) to guiding conservation efforts on national level.

Figure 8.1 − Aichi Biodiversity Targets

Source: https://www.cbd.int/sp/targets/

To shed light on member states' advancements towards the Aichi Targets, indicators were developed by an Ad Hoc Technical Expert Group (ATHEG) constituted under the CBD.

Table 8.3 − The Aichi Biodiversity Targets

Source: Aichi Biodiversity Targets – Strategic Goals (CBD) (https://wedocs.unep.org/bitstream/handle/20.500.11822/11106/swio_wg1_pre%20%285%29.pdf?sequence=1&isAllowed=y)

Strategic Goal A	Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society
Strategic Goal B	Reduce the direct pressures on biodiversity and promote sustainable use
Strategic Goal C	To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity
Strategic Goal D	Enhance the benefits to all from biodiversity and ecosystem services
Strategic Goal E	Enhance implementation through participatory planning, knowledge management and capacity building

[18] Streamlining European biodiversity indicators 2020: Building a future on lessons learnt from the SEBI 2010 process. EEA Technical report No 11/2012

The Ad Hoc Technical Expert Group identified three categories of operational indicators.

- Indicators which are ready for use at the global level are denoted by the letter (A).

- Indicators which could be used at the global level but which require further development to be ready for use are denoted by the letter (B).

- Additional indicators for consideration for use at the national or other sub-global level are denoted by the letter (C).

The set of (A) and (B) indicators are those which should be used to assess progress at the global level, while the (C) indicators are illustrative of some of the additional indicators available to CBD Parties to use at the national level, according to their national priorities and circumstances.

The year 2020 marks the end-date of the Strategic Plan for Biodiversity 2011-2020 and the 20 global biodiversity targets (Aichi Targets).

In 2020 the Convention on Biological Diversity will adopt a post-2020 global biodiversity framework as a stepping stone towards the 2050 Vision of 'Living in harmony with nature'.

he vision of the Strategic Plan for Biodiversity 2011-2020, with its Aichi Targets was a world of "*Living in harmony with nature*" where "By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential

9. ENVIRONMENTAL PROTECTION IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

Concept of the environmental protection

Environmental protection[19] refers to any activity to maintain or restore the quality of environmental media through preventing the emission of pollutants or reducing the presence of polluting substances in environmental media. It may consist of:

(a) changes in characteristics of goods and services,

(b) changes in consumption patterns,

(c) changes in production techniques,

(d) treatment or disposal of residuals in separate environmental protection facilities,

(e) recycling, and

(f) prevention of degradation of the landscape and ecosystems.

Environmental protection can be defined as the prevention of unwanted changes to ecosystems and their constituent parts[20]. This includes

• the protection of ecosystems and their constituent parts from changes associated with human activities; and

• the prevention of unwanted natural changes to ecosystems and their constituent parts.

One issue associated with this definition is whether “ecosystems and their constituent parts” include humans and communities, or whether environmental protection is only concerned with the protection of natural capital.

From an ecological perspective, humans are regarded as an integral part of the ecosystem. Separating humanity from the natural environment can therefore be seen as artificial. While this is true, the phrase environmental protection is not used to refer to measures that are designed to regulate or mediate direct interaction between people.

For example, laws prohibiting assault are not regarded as environmental protection measures. Environmental protection is concerned with the relationship between people and the natural environment rather than the relationships between people and communities.

Another issue is whether environmental protection relates to preservation, conservation, or both. *Preservation* refers to the protection of an ecosystem or natural environment from change, while conservation is generally associated

[19] Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, United Nations, New York, 1997

[20] Clive Hamilton, ... Simone Bastianoni, in Encyclopedia of Ecology (Second Edition), 2019

with the sustainable use of natural resources. The objective of *conservation* is to ensure the maintenance of a stock of renewable resources that is being exploited for human purposes rather than the protection of the natural environment from any anthropogenic modifications.

The exploitation of natural resources for human purposes is not environmental protection as it is not associated with the prevention of unwanted changes. The change associated with exploitation is deliberate and wanted, at least by those doing the exploitation.

However, measures that are put in place to prevent overexploitation of natural resources do constitute environmental protection. They are designed to prevent exploitation beyond a point that is deemed desirable or sustainable. For example, catch quotas in fisheries and air pollution limits are environmental protection measures because, while they accept some environmental degradation, they aim to limit it.

The distinction between preservation and conservation has dissipated in recent years with growing recognition of the dynamic nature of natural systems, humanity's place in the biosphere, and the need for active human involvement to maintain the integrity of certain ecosystems.

Consequently, environmental protection is now generally used to refer to measures that have traditionally been associated with preservation (e.g., reserves, including national parks), as well as conservation and natural resource management initiatives.

A critical aspect of environmental protection is that it is driven by the values that humans attribute to different aspects of the environment. These values need not be instrumental, but the motivating factor for environmental protection is always the prevention of changes to the environment that humans do not want.

This is why measures associated with the prevention of unwanted natural changes to ecosystems − like the prevention of coastal erosion or systematic burning in reserves to reduce the risk of wildfires − can be included as environmental protection. Such measures do not aim to protect ecosystems from human activities but rather from natural forces that are deemed to threaten human interests.

Environmental remediation is distinct from environmental protection as its primary objective is to restore an ecosystem or natural environment to a previous state; that is, like exploitation, it is associated with deliberately induced change, as opposed to the prevention of change.

Environmental remediation and restoration focus on the development and implementation of strategies geared to reverse negative environmental impacts.

Sustainable Development and Environmental Protection

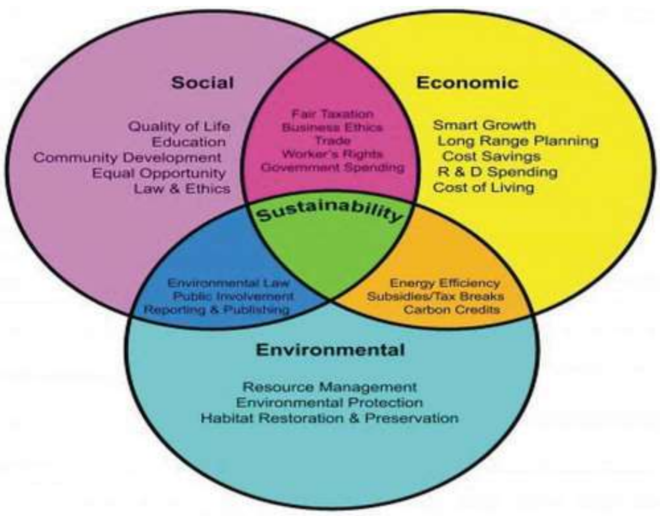
Problems of sustainable development (SD) and environmental protection pose a challenge to humanity unprecedented in scope and complexity.

The concept of sustainable development has made society conscientious and, in the same time, recognize, the role and importance of environmental factors as well as of the functions and the services the environment provides.

The concept of sustainable use of earth's resource is an ancient one. Without the principles of sustainability as a way of life, humans would not have survived in the 20th century.

The principle of sustainable development received impetus with the adoption of Stockholm Declaration in 1972, World Conservation Strategy prepared in 1980 by the World Conservation Union (IUCN) with the advice and assistance of the United Nations Environment Programme (UNEP), World Charter for Nature of 1982, Report of the World Commission on Environment and Development under the chairmanship of Gro Harlem Brundtland (Brundtland Report), Our Common Future of 1987, the document Caring for the Earth; A Strategy for the Sustainable Living developed by the second world conservation project comprised of the representatives of the IUCN, UNEP and the Worldwide Fund for the Nature.

The concept of sustainable development is the foundation stone of the Montreal Protocol for the Protection of Ozone Layer of 1987 and the instruments adopted at the UN Conference on Environment and Development (World Summit) held at Rio in 1992.



The Brundtland Report defines, 'sustainable development' as '***development that meets the needs of the present generation without compromising on the ability of the future generations to meet their own needs***.' The report emphasizes that sustainable development means an integration of economics and ecology in decision making at all levels.

The concept of sustainable development rejects the old notion that development and environment are antithesis of each other. On the contrary, it emphasizes that development and environment are synthesis of each other. Both are complimentary and mutually supportive.

Sustainable development is a process in which development can be sustained for generations. It means improving the quality of human life while at the same time living in harmony with nature and maintaining the carrying capacity of the life supporting ecosystem. Development means increasing the society's ability to meet human needs. Economic growth is an important component but cannot be a goal in itself. The real aim must be to improve the quality of human existence to ensure people to enjoy long, healthy and fulfilling lives.

Sustainable development focuses at integration of development and environmental imperatives. To be sustainable, development must possess both economic and ecological sustainability. The concept of sustainable development indicates the way in which development planning should be approached.

For being sustainable development must be both economic and environmentally viable. The necessary condition for achieving sustainable development is ecological security, economic efficiency and social equity.

Sustainable development is, in fact, a multi-dimensional concept involving three interacting aspects – ecology, economy and ethics.

Ecological restoration, economic betterment and social justice mutually reinforce one another. In practice environment protection is the development because environment degradation leads to poverty and distorted development. Sustainable development is the only path for conserving and promoting the socio-economic well-being of people.

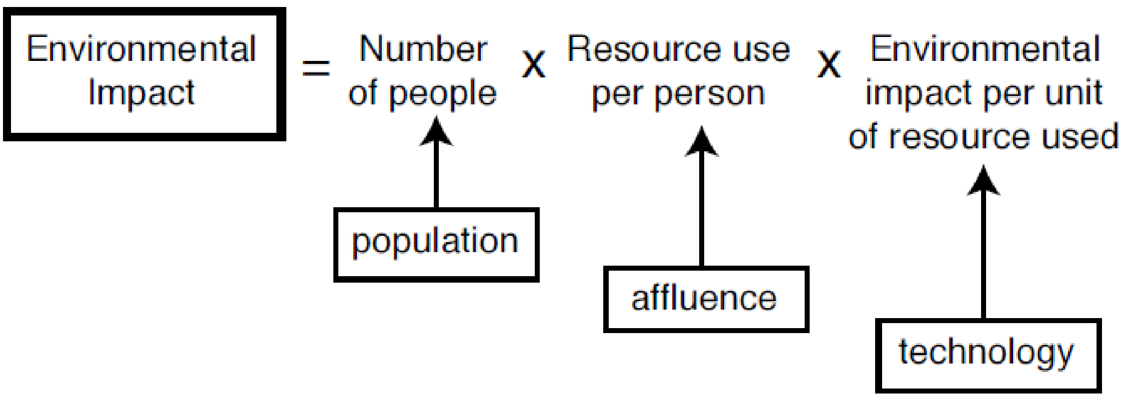


Figure 9.1 – The factors determining environmental impact[21]

[21] Environmental Principles and Policies, 2006. https://documents.uow.edu.au/~sharonb/principles.html

The *concept of environmental sustainability*[22] is about the natural environment and how it remains productive and resilient to support human life. Environmental sustainability relates to ecosystem integrity and carrying capacity of natural environment.

It requires that natural capital be sustainably used as a source of economic inputs and as a sink for waste. The implication is that natural resources must be harvested no faster than they can be regenerated while waste must be emitted no faster than they can be assimilated by the environment. This is because the earth systems have limits or boundaries within which equilibrium is maintained.

However, the quest for unbridled growth is imposing ever greater demands on the earth system and placing ever greater strain on these limits because technological advancement may fail to support exponential growth.

Evidence to support concerns about the sustainability of the environment is increasing. The effects of climate change, for instance, provide a convincing argument for the need for environmental sustainability.

Climate change refers to significant and long-lasting changes in the climate system caused by natural climate variability or by human activities. These changes include warming of the atmosphere and oceans, diminishing ice levels, rising sea level, increasing acidification of the oceans and increasing concentrations of greenhouse gases.

Climate change has already shown signs of affecting biodiversity. In particular, Kumar et al.[23] have observed that higher temperatures tend to affect the timing of reproduction in animal and plant species, migration patterns of animals and species distributions and population sizes. Ukaga et al.[24] have argued that while dire predictions abound, the full impacts of global warming are not known.

What is clearly advisable, according to Campagnolo et al.[25] is that, for the sake of sustainability, all societies must adjust to the emerging realities with respect to managing ecosystems and natural limits to growth.

The current rate of biodiversity loss exceeds the natural rate of extinction.

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[22] Justice Mensah & Sandra Ricart Casadevall (Reviewing editor) (2019) Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review, Cogent Social Sciences, 5:1

[23] Kumar, S., Raizada, A., & Biswas, H. (2014). Prioritising development planning in the Indian semi-arid Deccan using sustainable livelihood security index approach. International Journal of Sustainable Development & World Ecology, 21, 4. Taylor and Francis Group.

[24] Ukaga, U., Maser., C., & Reichenbach, M. (2011). Sustainable development: principles, frameworks, and case studies. International Journal of Sustainability in Higher Education, 12(2), Emerald Group Publishing Limited.

[25] Campagnolo, L., Carraro, C., Eboli, F., Farnia, L., Parrado, R., & Pierfederici, R. (2018). The ex-ante evaluation of achieving sustainable development goals. Social Indicators Research, 136, 73–116.

The boundaries of the world's biomes are expected to change with climate change as species are expected to shift to higher latitudes and altitudes and as global vegetation cover changes.

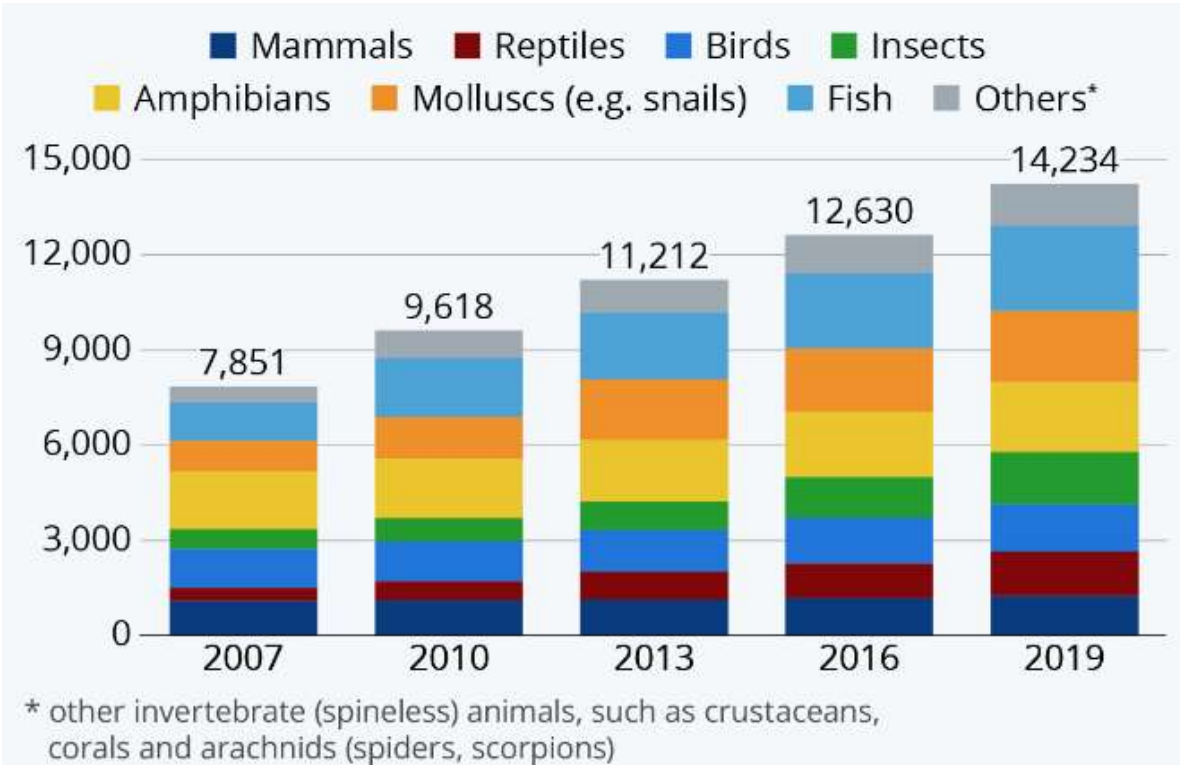

Figure 9.2 – Number of animal species of the IUCN Red List, by class
(Source: https://www.statista.com/chart/17122/number-of-threatened-species-red-list/)

If species are not able to adjust to unfamiliar geographical distributions, their chances of survival will be reduced. It is predicted that, by the year 2080, about 20% of coastal wetlands could be lost due to sea-level rise[26]. All of these are important issues of environmental sustainability because as already pointed out, they have implications for how the natural environment remains productively stable and resilient to support human life and development.

Achieving SD hinges on a number of principles. However, the preponderant message in regard to the principles of sustainable development gravitates towards the economy, environment and society. Specifically, they relate, among others, to conservation of ecosystem and biodiversity, production systems, population control, human resource management, conservation of progressive culture and people's participation[27] [28].

[26] UNSD. (2018c). SDG indicators metadata repository.

[27] Ben-Eli, M. (2015) Sustainability: Definition and five core principles a new framework the sustainability laboratory New York, NYinfo@sustainabilitylabs.org | www.sustainabilitylabs.

One key principle of SD is the conservation of the ecosystem. There is the need to conserve the ecosystem and biodiversity because without these, living organism will cease to exist.

The limited means and resources on the earth cannot be enough for the unlimited needs of the people.

Over-exploitation of the resources has negative effects on the environment and, therefore, for development to be sustainable, exploitation of the natural resources must be within the carrying capacity of the earth. This means development activities must be carried out according to the capacity of the earth.

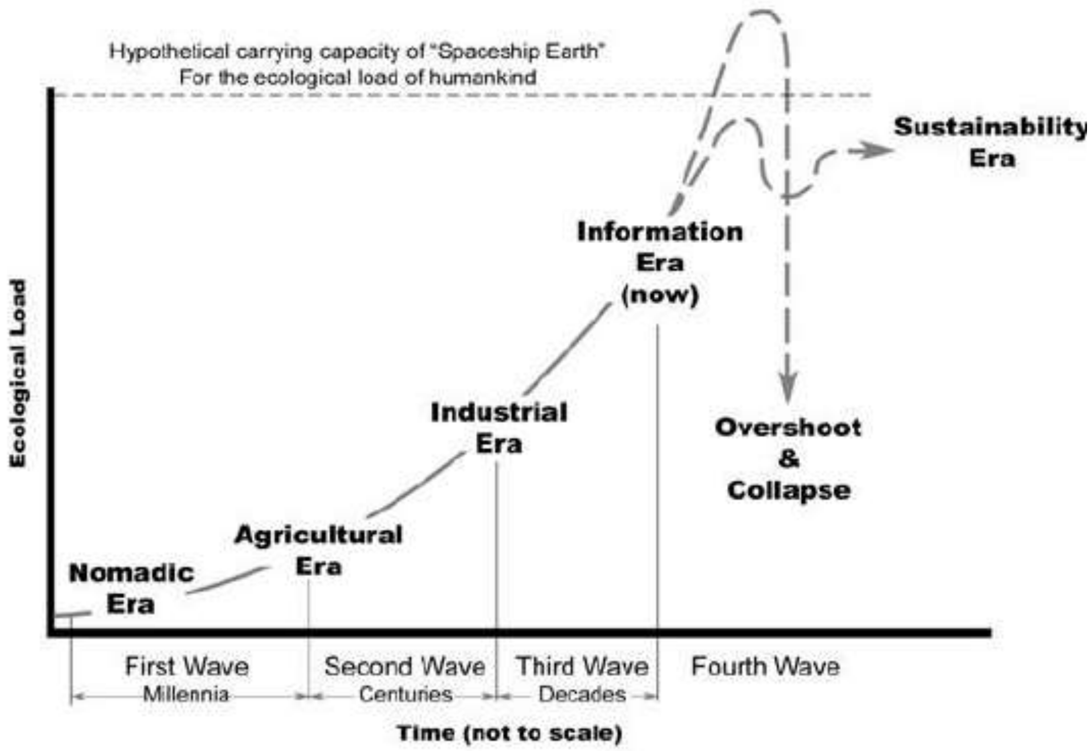

Figure 9.3 − The Carrying Capacity[29]

That is why it is important, for instance, to have alternative sources of energy such as solar, instead of depending heavily on petroleum products and hydro-electricity.

[28] Molinoari, E., Kruglanski, A. W., Bonaiuto, F., Bonnes, M., Cicero, L., Fornara, F., ... & Degroot, W. (2019). Motivations to act for the protection of nature biodiversity and the environment: A matter of "Significance". Environment and Behaviour. Page 1–31.

[29] NELSON, J. (2009) Carrying Capacity Reached: The Need for Population Stability. [Online] Available from: http://steadystaterevolution.org/carrying-capacity-reached-the-need-for-population-stability/ [Accessed: 24th May 2013].

Wang[30] opines that proper human resource management is another important principle of SD. It is the people who have to ensure that the principles are adopted and adhered to. It is people who have the responsibility to utilise and conserve the environment. It is people who have to ensure that there is peace.

This makes the role of human resource in the quest for SD critical. It implies that the human knowledge and skill in caring for the environment, economy and society need to be developed[31].

This can be done basically through education and training as well as proper healthcare services since a sound mind resides in a sound body. These elements could also assist in developing positive attitude towards nature. Education can also influence society towards conserving the environment and appreciating human values as well as acceptable production methods.

It is also argued that, the process of SD must be participatory in order to be successful and sustainable. It is a collective responsibility which requires the participation of all people and relevant entities.

SD is built on the principle of participation, which requires positive attitudes of the people so that meaningful progress can be achieved with responsibility and accountability for stability.

The ultimate aim of SD is to achieve a balance among environmental, economic and social sustainability, thus, SD cannot be achieved through isolated initiatives, but rather integrated efforts at various levels, comprising social, environmental and economic aspects.

All people must be aware and acknowledge that their survival and the survival of the future generation depend on responsible behavior regarding consumption and production, environment and progressives social values.

In the matter of our subject matter, experts[32] believe that governments of all countries should promote “smart growth” through proper land use and alignment of their economies with nature’s regeneration capacity.

All countries should adopt appropriate production and consumption practices that fully align with the planet’s ecological processes. This could be done through taxation and subsidy policies which accentuate the acceptable and eliminate unacceptable outcomes.

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[30] Wang, X. G. (2016). Civil law expression of environmental rights and interests—reflections on the greening of civil code. People Rule Law, 3, 25–27.

[31] Collste, D., Pedercini, M., & Cornell, S. E. (2017). Policy coherence to achieve the SDGs: Using integrated simulation models to assess effective policies. Sustainability Science, 12, 921–931.

[32] Justice Mensah & Sandra Ricart Casadevall (Reviewing editor) (2019) Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review, Cogent Social Sciences, 5:1, DOI: 10.1080/23311886.2019.1653531

In this respect, all countries should, for example, regarding pollution, enforce the polluter-pays-principle whereby governments require environment-polluting entities to bear the costs of their pollution rather than impose those costs on others or on the environment.

Principles of environmental sustainability

The Bruntdland Commissions Report of 1986 underlined the importance that environmental protection has to following sustainable development.

The Rio Declaration in 1992 affirms the will of the international community to implement and favor the protection and sustainable development of a global ecological and durable economy. The Rio Declaration stipulated twenty-seven principles[33] with "the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people" around the articulation of sustainable development.

The first four principles shed new light on the definition of the concept:

Principle 1. *Human beings are at the center of concern for sustainable development. They are entitled to a healthy and productive life in harmony with nature*.

Principle 2. *States have*, in accordance with the UN Charter and the principles of international law, *the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction*.

Principle 3. *The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations*.

Principle 4. *In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it*.

The United Nations Conference on Environment and Development (UNCED, Rio de Janeiro 1992) was adopted another important document named Agenda 21. This document draws the fundamental principles of sustainable development.

Both documents (Rio Declaration and Agenda 21) mentioned afore unveil a holistic approach of environmental protection that entails a merger between

[33] General Assembly, Report of the United Nation Conference on Environment and Development, U.N. Doc. A/CONF. 151/26 (June 13, 1992); 31 I.L.M. 874 (1992).

environmental protection and economic development, as circumscribed in the principles of sustainable development.

The following concepts, among others, may contribute towards sustainable development[34]:

Policy Integration − Economic, ecological, and social goals are interdependent and can be achieved only with an integrated approach:

Sustainable Resource Use − Natural resource exploitation should proceed in a way and at a rate that does not lead to the long-term decline of these resources and guards against their future exhaustion.

Equity − Natural resources should be used and shared in an equitable manner, which implies taking into account the needs of other users and also the needs of present and future generations.

Transparency and Public Participation − Citizens should participate in environmental decision-making and have appropriate access to information and to judicial and administrative proceedings.

Biodiversity − National and international development strategies should be developed on the premise that the protection of biodiversity is critical to the resilience of the global ecosystem, which incorporates all aspects of the biosphere including man-made environments.

Ecological Interdependence − During the past three decades, scientific understanding of the ecological interdependence of the planet's resources has increased dramatically, leading to the consensus that degradation to certain resources can have implications for the continued functioning of other resources and of the planet as a whole.

Intergenerational Equity and Intragenerational Equity. The concept of "*intergenerational equity*" recognizes each generation's responsibility to be fair to the next generation by leaving a legacy of wealth no less than they themselves had inherited. Meeting this goal implies emphasizing the sustainable use of natural resources for subsequent generations and avoiding any irreversible environmental damage.

The concept of "*intragenerational equity*" recognizes that the lessening of economic inequality in the current generation must be seen as a primary goal of development rather than as a secondary or separate process. In the Brundtland Report, equity is seen chiefly in terms of alleviating poverty in the developing world where the links between environmental stress and hunger are so apparent. Nonetheless, in some developed nations, relative poverty is a significant and

[34] ENVIRONMENTAL PRINCIPES AND CONCEPTS. OCDE/GD(95)124

growing economic and social problem, and the relationship to environmental stress is becoming more apparent.

Common but Differentiated Responsibilities − This concept refers to the shared responsibilities of countries for the protection of shared resources, with the caveat that these responsibilities may be different depending on the contribution of the country to the environmental problem and its capability for addressing the environmental problem.

Shared or Transboundary Resources − The concept of "shared or transboundary resources" refers to resources that do not fall wholly within the territorial jurisdiction of one country, but straddle common political borders or migrate from one territory to another. Examples of resources which may be shared or transboundary include river basins, enclosed and semi-enclosed seas, watershed areas, marine living resources, and migratory wildlife.

Harm Prevention − The notion that countries must ensure that activities within their jurisdiction or control do not damage the environment of other countries through "transboundary spillover effects" is a customary principle of international environmental law.

Global Commons − The concept of "global commons" refers to those areas beyond the limits of national jurisdiction such as the high seas, Antarctica, outer space and the ozone layer. Although the global commons are open for legitimate, peaceful and reasonable use by all nations, they cannot be appropriated by any one nation. Countries should cooperate in the conservation and sustainable utilization of the natural resources of the global commons, and, in the purest application of this concept, should share in the economic wealth of those areas.

International Co-operation − "International co-operation", widely acknowledged as a customary principle of international law, relates to the legal obligation of countries to cooperate with other countries in cases of transboundary and global environmental concerns.

Virtually every international environmental agreement has provisions requiring co-operation in generating and exchanging relevant information, partly for monitoring the domestic implementation of international environmental obligations.

Polluter Pays Principle and related principles and concepts

Polluter Pays Principle − The Polluter Pays Principle was initially adopted in the early 1970s when strict environmental regulations were first being introduced in OECD[35] countries, and complaints about high costs and negative effects on competitiveness were beginning to emanate from industry. The 1972 OECD Recommendation of the Council on Guiding Principles concerning International Economic Aspects of Environmental Policies included recommendations not to subsidize the environmental costs of industry, except in limited cases, and not to use trade remedies or import duties to compensate for these costs.

Principle 16 of the Rio Declaration relating to the internalization of environmental costs makes reference to the Polluter Pays Principle.

This principle states that *the polluter should bear the expenses of carrying out pollution prevention measures or paying for damage caused by pollution*.

According to the 1974 OECD Recommendation, government assistance for pollution control might be given: 1) to ease transition periods when especially stringent pollution control regimes are being implemented; 2) to stimulate the development of new pollution control technologies; and 3) in the context of measures to achieve specific socio-economic objectives, such as the reduction of serious interregional imbalances. The OECD interpretation of the Polluter Pays Principle was adopted later by the European Community.

Internalization of Environmental Costs − The concept of "internalization of environmental costs" implies that market prices should reflect the environmental costs of the production and use of a product in terms of natural resource utilization, pollution, waste generation, consumption, disposal and other factors. The internalisation of environmental costs has been a focal point of environmental economics. It underlies the conceptual and analytical work in such areas as resource pricing, use of economic instruments in environmental policy, calculation of environmental costs and benefits, and green accounting methods.

Environmental costs, largely related to the provision of public goods like fresh air and clean water, are often unaccounted for in market transactions and are commonly referred to as "externalities." Since it is difficult to quantify such externalities in terms of monetary values (due partly to the absence of obvious units of environmental measurement), industry and government planners rarely include environmental externalities in the decision-making process.

Although it is sometimes related to the Polluter Pays Principle, the concept of internalization of environmental costs concerns how to measure environmental costs and benefits and how much should be paid to cover environmental costs.

[35] Organisation for Economic Co-operation and Development

Environmental taxes, charges, tradeable permits and other economic instruments, if well designed, can help move market prices more closely towards full environmental costs. To date, however, they have not been widely implemented and are generally used in conjunction with environmental regulations. Governments have found it difficult to measure environmental costs and benefits and to internalize these costs and benefits at the national level.

User Pays Principle – This principle centres on the idea that the user of a public facility, or consumer of a public good, pays for the environmental good or service or the damages which may arise from that use. The User Pays Principle underlies approaches in international environmental policy where countries possessing resources or assets of common concern to mankind, such as genetic resources or rainforests, would be compensated for the environmental services they provide.

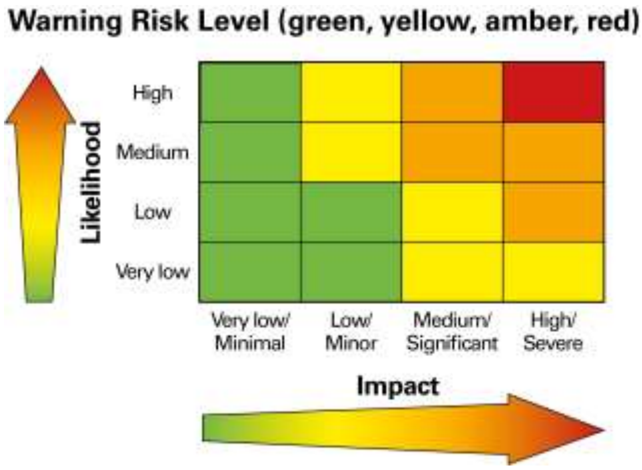
Precautionary Principle and related concepts

Precautionary Principle − This principle evolved from the recognition that scientific certainty often comes too late to design effective environmental policy responses; it thus recommends action in responding to potential environmental threats instead of waiting for absolute scientific proof.

Formulations of the Precautionary Principle vary widely, but as stated in Principle 15 of the 1992 Rio Declaration: "*Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."*

The Precautionary Principle has become widely used in international environmental law and has been applied to areas such as general environmental management, managing hazardous wastes, preventing pollution and protecting endangered species.

Risk Management − The concept of "risk management," which is closely related to the Precautionary Principle, involves assessing an environmental risk or potential environmental impact and making decisions based on that assessment.



Risk can be broadly defined as the possibility of the potential loss of something of value. Assessing the risk involves identifying, describing, and, when possible, measuring the potential for such loss.

The overall objective of risk management is to reduce risks to human health and the environment.

The environmental risk management process is based on four steps:

1) identifying the hazards to society or the environment;

2) estimating the extent of these hazards, including the probability of exposure and the relative toxicity of the agent;

3) ascertaining the acceptability of that level of risk; and

4) making a decision to reduce the risk to the appropriate level.

This is the basic process used for setting national environmental standards.

Pollution Prevention – This is an environmental management approach which places emphasis on process and product changes leading to pollution reduction and/or prevention over approaches which focus on pollution control or clean-up through end-of-pipe devices.

Therefore, "clean technologies", which are total systems for preventing pollution throughout the life-cycle of a product, contribute to pollution prevention.

Key characteristics of clean technologies incude:

- the use of as little energy and raw material inputs as possible per unit of product output;

- minimal releases to air, water and soil during fabrication and use of the product;

- the production of goods with reduced or no harmful components; and

- maximization of the durability and lifetime of products and their re-usability or disposability.

Critical Load − The concept of "critical load", like the concept of "sustainable yield", is subject to much controversy and uncertainty as scientific exploration of these concepts continues. Critical load refers to an ecosystem’s level of tolerance for a particular pollutant and also to an ecosystem’s level of tolerance for the depletion of a particular natural resource, beyond which irreversible damage will likely occur.

Loading is the rate at which a pollutant is introduced to the environment. If small loads of pollutants are added to a natural ecosystem for a limited amount of time, and depending on the size of the load and the nature of the pollutant, many ecosystems seem to have an extraordinary ability to recuperate.

However, as the load or the rate of loading increases, it becomes more difficult and it takes longer for the ecosystem to recover. In some cases, the likelihood of major, irreversible changes associated with loadings increases significantly.

Life-Cycle Assessment − The concepts of "life-cycle assessment" and "life-cycle management" mark the evolution of environmental management practices from an initial focus on end-of-pipe solutions to the development of integrated environmental approaches intended to encompass the entire "*life-cycle*" of the product.

Figure 9.4 − Components of life-cycle analysis
(Source: https://www.nist.gov/systems-integration-division/lifecycle-graphic)

An analytic tool developed by industry, particularly the chemicals sector, life-cycle assessment is intended to evaluate each stage in the life of a product, from the initial appropriation of raw materials and per unit energy and other production inputs, to product re-use, recyclability and disposal characteristics.

Environmental Impact Assessment. "Environmental Impact Assessment" (EIA) is a process for examining, analyzing and assessing proposed activities in order to minimize environmental degradation and maximize the potential for environmentally-sound and sustainable development.

In general, the EIA process should ensure that: (1) government authorities have fully identified and considered the environmental effects of proposed activities, as well as alternatives that avoid or mitigate environmental effects; and (2) affected citizens have an opportunity to understand the proposed project or policy and to express their views to decision-makers in advance.

Many international environmental instruments now require some form of environmental impact assessment for projects, including the Rio Declaration in its Principle 17, the Biodiversity Convention, the World Charter for Nature and others. For example, the Biodiversity Convention states that the signatories shall: "*introduce appropriate procedures requiring environmental impact assessment of its proposed projects that are likely to have significant adverse effects on biological diversity with a view to avoiding or minimizing such effects and, where appropriate, allow for public participation in such procedures.*"

Environmental impact assessment methodology has traditionally been applied to assessing the environmental effects of particular projects on physical ecosystems.

Sustainable Development and Environmental legal protection in the European Union

The evolution of environmental protection by means of law and policy in the EU has been a long and winding road. It started in the 1970s with the Commission's First Communication on Environmental Policy.

Just a year after the release of the United Nations Brundtland Report “Our Common Future“, the European Council commenced its shift from mere environmental protection towards sustainable development.

It took almost a decade, however, before sustainable development was formally integrated into the European legal order.

The Treaty of Maastricht (1993) made the environment an official EU policy area, introduced the co-decision procedure and made qualified majority voting in the Council the general rule.

The Treaty of Amsterdam (1999) established the duty to integrate environmental protection into all EU sectoral policies with a view to promoting sustainable development.

“Combating climate change“ became a specific goal with the Treaty of Lisbon (2009), as did sustainable development in relations with third countries.

Legal personality now enabled the EU to conclude international agreements.

The high level of protection and improvement of the quality of the environment principle that defines the sustainable development of the EU's internal market according to Article 3(3) of the Treaty on European Union (2012) must incorporate:

1) the precautionary principle;

2) the source principle;

3) the polluter-pays principle;

4) the prevention principle; and

5) the safeguard clause.

The precautionary principle is a risk management tool that may be invoked when there is scientific uncertainty about a suspected risk to human health or to the environment emanating from a certain action or policy. For instance, should doubts arise about the potentially harmful effects of a product, and should − following an objective scientific evaluation − uncertainty persist, instructions may be given to stop the distribution of the product or to remove it from the market. Such measures must be non-discriminatory and proportionate, and must be reviewed once more scientific information is available.

The 'polluter pays' principle is implemented by the Environmental Liability Directive[36], which aims to prevent or otherwise remedy environmental damage to protected species or to natural habitats, water and soil. Operators of certain occupational activities such as the transport of dangerous substances, or of activities that imply discharge into waters, have to take preventive measures in case of an imminent threat to the environment.

If damage has already occurred, they are obliged to take the appropriate measures to remedy it and pay for the costs. The scope of the directive has been broadened three times to include the management of extractive waste, the operation of geological storage sites, and the safety of offshore oil and gas operations respectively.

The prevention principle requires preventive measures be taken to anticipate and avoid environmental damage before it happens.

Environmental damage should be rectified at source: Working alongside the prevention principle, this ensures damage or pollution is dealt with where it occurs. It operates in many areas of EU environmental policy to prioritise the way environmental damage is addressed.

The integration principle requires that environmental protection is integrated into all other policy areas, in line with promoting sustainable development. That is to say all government departments have responsibilities to protect our environment.

EU environmental principles are used to interpret policies, provide a basis to scrutinise and challenge government actions in court, and guide local authority decision-making.

In recent years, environmental policy integration has made significant progress, for instance in the field of energy policy, as reflected in the parallel

[36] Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage

development of the EU's climate and energy package or in the Roadmap for moving to a competitive low-carbon economy by 2050[37].

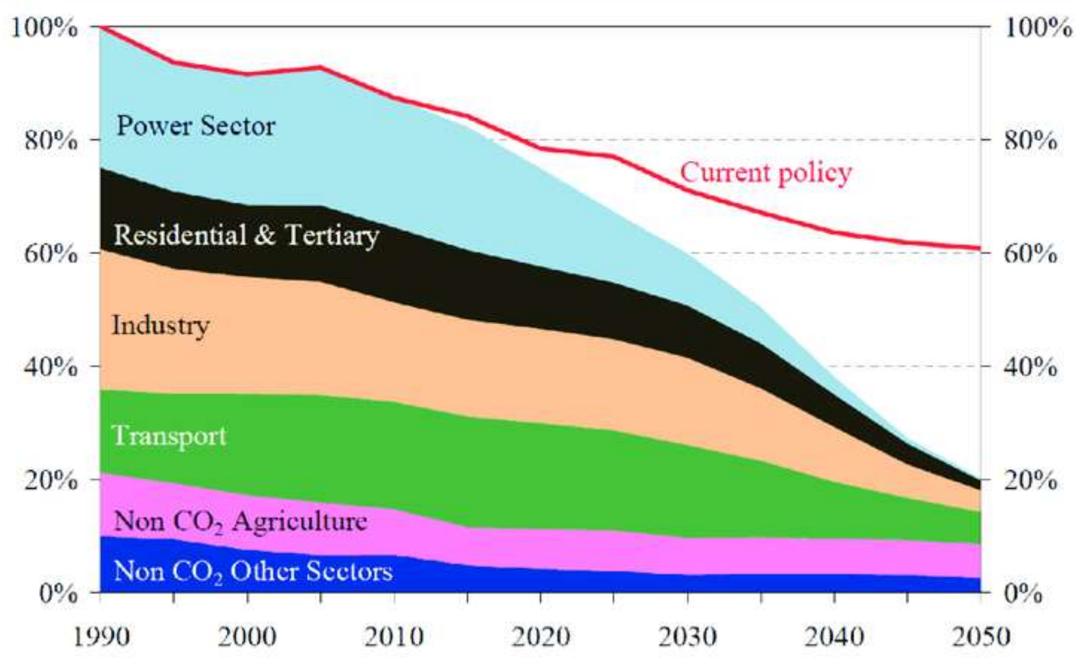


Figure 9.5 − Roadmap towards a competitive low carbon economy, sectoral perspectives
(Source: ec.europa.eu/clima/policies/roadmap)

The Roadmap provides a cost-efficient pathway to a cleaner, climate-friendly and competitive European economy in the long term and will help to put key economic sectors on the right track from the beginning. According to this document, EU should achieve an overall 80% reduction in domestic emissions by 2050; to achieve this long-term target cost-efficiently, the EU should reduce its domestic emissions by 40% and 60% by 2030 and 2040, respectively.

The EU also plays a key role in international environmental negotiations[38]. It is a party to numerous global, regional or sub-regional environmental agreements on a wide range of issues, such as nature protection and biodiversity, climate change, and transboundary air or water pollution.

At the 10th Conference of the Parties to the Convention on Biological Diversity, held in Nagoya (Japan) in 2010, the EU made a major contribution to

[37] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0112:FIN:EN:PDF
[38] ENVIRONMENT POLICY: GENERAL PRINCIPLES AND BASIC FRAMEWORK (https://www.europarl.europa.eu/ftu/pdf/en/FTU_2.5.1.pdf)

achieving an agreement on a global strategy to halt the loss of biodiversity by 2020.

Likewise, the Union helped shape several major international agreements adopted in 2015 at UN level, such as the 2030 Agenda for Sustainable Development (which includes the 17 global Sustainable Development Goals (SDGs) and their 169 associated targets), the Paris Agreement on Climate Change and the Sendai Framework for Disaster Risk Reduction.

Principles of environmental protection in Ukraine

Article 50 of the Constitution of Ukraine proclaims every citizen’s right to environment, safe for human life and health, and to compensation of any damage caused by the violation of this right.

Similar right is stipulated by Article 9 of the Law “On Environmental Protection” of June 25, 1991, No.1264-XXII. The state is a guarantor of observance of this right. Its mission in this context should consist in maintaining safe and healthy environment, non-exhaustive use of the natural resources. This can be achieved by integrating environmental policy as priority component into the state policy, in compliance with sustainable development principles.

According to Article 3 of that law “Basic Principles of Environmental Protection“ in the original wording, the basic principles of environmental protection were:

a) priority of the requirements of ecological safety, strict compliance with ecological standards, quotas and limitations as to the utilization of natural resources in pursuing economic, management and other activity;

b) guarantee of ecological safety of the environment for the life and health of people;

c) preventive character of measures in environmental protection;

d) ecology-oriented material production on the basis of comprehensive solutions of environmental protection issues, utilization and regeneration of recoverable natural resources, wide introduction of the latest technologies;

e) preservation of the spacial and species diversity and integrity of natural objects and complexes;

f) scientifically substantiated coordination of ecological, economic and social interests of society on the basis of combining interdisciplinary knowledge of ecological, social, natural and technical sciences and forecasting of environmental conditions;

g) mandatory examination by experts;

h) transparency and democratism in adopting decisions, the implementation of which impacts on the environment, shaping in the population an ecological awareness;

i) scientifically substantiated standardization of the effects of economic and other activity on the environment;

j) free general and payable utilization of natural resources for economic activity;

k) imposition of fines for the pollution of the environment and deterioration of the quality of natural resources, compensation for damage caused by violation of legislation on environmental protection;

l) solution of environmental protection issues and utilization of natural resources with due account of the degree of anthropogenic changes of the territories and the aggregate effect of factors negatively impacting on the environment;

m) combination of measures for stimulation and responsibility in environmental protection;

n) solution of environmental protection issues on the basis of broad cooperation between states[39].

It is worthy of note that last modified of this law includes such basic principle as "taking into account the results of strategic environmental assessment".

The entry into force of the Law on Strategic Environmental Assessment dated March 20, 2018, No. 2354-VIII, which determines the introduction of European rules until 01.01.2020, provides for preliminary preparation of methods, establishment of an advisory base, development of normative and methodological documents on strategic environmental assessment, generalizes the practice of implementing a strategic ecological assessment, and application of the newest methods of environmental assessment, development of scientific substantiation of complex norms aimed at prevention of ecological harm, integration of ecological requirements and approval of documents made by means of public planning[40].

The natural resources of Ukraine shall be the property of the people of Ukraine who have the right to own, utilize and dispose of the natural resources of the Republic.

Objects of Legal Protection of the Environment Subject to state protection and regulation of utilization on the territory of Ukraine shall be the following:

[39] https://zakon.rada.gov.ua/laws/show/1264-12

[40] Ukrainian strategies relevant to sustainability. A4U Analytical Studies and Business Consultations N21, June 2018

the environment as an aggregate of natural and natural-social conditions and processes, natural resources that are both involved in the economic cycle and not involved in the national economy at a given period (land, mineral resources, water, atmospheric air, forests and other vegetation, animal world), landscapes and other natural complexes.

Subject to special state protection shall be the territories and objects of the nature preserves of Ukraine and other territories and objects determined in conformity with the legislation of Ukraine.

The health and life of people shall also be subject to state protection against the negative influence of unfavorable ecological conditions.

As Ukraine took a course towards European Union integration, the key step on this road was made on September 16, 2014, by ratification of the Association Agreement between Ukraine and the European Union, which defined the principles of cooperation in different spheres, including environmental protection and natural resources management[41].

Another important step was made on November 21, 2014, by the signing of the Coalition Agreement of Ukrainian Parliament's Parties. This document includes a chapter "Environmental Management Reform and Integration of Environmental Policy to Other Sectoral Policies."

Implementation of European environmental policy in Ukraine demands obligatory coordination of organizational, economic and legal aspects of governance that is crucial for its effective functioning.

Most European directives and regulations are formulated very specific, with the establishment of parameters and criteria of quality of environmental components, specific responsibilities of specific subjects. Instead, Ukrainian environmental legislation establishes general requirements, defines the principles, goals, but does not determine the ways of their achievement. Specific regulatory parameters can be found only in the state standards, most of which are not in the public domain[42].

To ensure the implementation of European environmental standards into Ukrainian legislation just adoption of laws is not enough. For implementation it is also necessary to ensure the availability of appropriate institutions and budgets for the implementation of these laws and other normative legal acts. Also it is necessary to create an effective system of monitoring and sanctions in order to insure that requirements of the laws are implemented completely and appropriately.

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[41] The World Bank. Report No: ACS16696 - Ukraine Country Environmental Analysis, January 2016

[42] Implementation of European Environmental Policy in Ukraine: Problems and Prospects By Viktor Ladychenko, Liudmyla Golovko. .European Journal of Sustainable Development (2017), 6, 3, 333-339

QUESTIONS FOR REVISION AND SELF-CHECK

Chapter 1

1. When and where the term "monitoring" has started up?

2. How many basic types of activity does a total system for environmental control include? Should the environmental monitoring be described as activities of the first type?

3. Name the four main areas of the environmental monitoring.

4. The environmental monitoring provides (choose the correct answers):

a) observation of the environment and the factors that affect the separate elements of the environment;

b) evaluation and analysis of the actual state of all components of the environment;

c) predictions of the state of environment and evaluation of the environmental condition;

d) providing scientific information to support for management decision making;

e) participation in bilateral agreements.

5. How many levels have the system of environmental monitoring of Ukraine? Name them in ascending order.

6. The principles of classification of current monitoring systems (choose the correct correspondences):

1 By universality of system	*A Monitoring of anthropogenic changes in atmosphere, hydrosphere and lithosphere*
2 By the main components of the biosphere	*B Aerospace monitoring (remote sensing methods)*
	Monitoring of physical, chemical and biological parameters
3 By the methods of observation	*C Global, national, "international", regional*

7. European Environment Agency (EEA) uses five types of integrated indicators (choose the right answers):

a) Descriptive indicators

b) Estimated indicators

c) Performance indicators

d) Efficiency indicators

e) Indicators of political efficiency

f) Aggregate welfare indicators

8. What do EEA performance indicators characterize?

9. When and where was the 1-st Intergovernmental Meeting on Monitoring held?

10. What is the highest priority among the observations over areas?

11. Classification of priority pollutants by priority classes (choose the correct correspondences):

1 class	*A Nitrates, nitrites, Nitrogen oxide*
2 class	*B Sulfur dioxide, suspended solids, Radionuclides (^{90}Sr + ^{137}Cs)*
3 class	*C Microtoxins, Microbiological pollution, Reactive pollution*
8 class	*D Ozone, DDT (dichlorodiphenyltrichloroethane) and other chloroorganics, Cadmium and its compounds*

12. What is the purpose of environmental monitoring?

13. Why the results of environmental monitoring are so important?

Chapter 2

1. Please specify a few legislative acts of Ukraine in the field of environmental protection and monitoring.

2. What are the levels of environmental monitoring (according to Resolution of the Cabinet of Ministers of Ukraine, 1998)?

3. What does the abbreviation „SEMS" mean?

4. In what document were defined the main principles of SEMS?

5. Among the bodies of State Environmental Monitoring System of Ukraine are (choose the right answers):

a) The Ministry of Energy and Environmental Protection of Ukraine;

b) The State Emergency Service of Ukraine;

c) The State Statistics Survey of Ukraine;

d) The State Agency of Ukraine on Exclusion Zone Management;

e) The Ministry of Economic Development, Trade and Agriculture of Ukraine.

6. What is the only principle in the system of environmental monitoring in Ukraine?

7. Who is ensured the organizational integration of environmental monitoring bodies at all levels in Ukraine?

8. What is the role of the State Statistics Survey of Ukraine in the system of environmental monitoring?

9. What does include a series of environmental reports that are published in Ukraine?

10. Is statistical information in Ukraine collected in relation to the natural environments?

11. Fill the gaps in the statement: "Absence of a … for interpretation of data and … of environmental monitoring results makes it difficult to assess the quality of the environment".

12. Groups of environmental indicators that are traditionally used in the development of national state of the environment reports (choose the right answers):

a) Air pollution and depletion of the ozone layer;

b) Climate change;

c) Water resources;

d) Biodiversity;

e) Radionuclides;

f) Land resources and soils;

g) Waste;

h) Agrochemistry;

i) Agriculture.

13. Global multilateral environmental agreements and obligations (choose the correct correspondences):

1 UN Framework Convention on Climate Change	*A Vienna, 1985*
2 Kyoto Protocol	*B Stockholm, 2001*
3 Convention for the Protection of the Ozone Layer	*C New-York, 1992*
4 Convention on Persistent Organic Pollutants	*D Kyoto, 1997*
5 UN Convention on Biological Diversity	*E Paris, 1994*
6 UN Convention to Combat Desertification	*F Rio-de-Janeiro, 1992*

Chapter 3

1. Name several major components of dry clean air in ground atmospheric layer in a descending order.

2. Air pollution includes contaminants in the form of **…** or **…** (fill in the missing words).

3. What are the two air pollutants that most significantly affect human health? In what way they affect human health?

4. What are the course and fine particles? What are the sources of fine particles production?

5 What is the mechanism of ground-level ozone formation?

6. Air pollution damages environment over (choose the right answers):

a) Acidification

b) Aesthetic damage

c) Deforestation

d) Eutrophication

e) Livestock damage

f) Crop damage

7. What kinds of anthropogenic sources of air pollution do you know?

8. What kinds of natural sources of air pollution do you know?

9. Are concentrations of ozone, $PM_{2,5}$ and PM_{10} not controlled in human settlements in Ukraine?

10. What are the main pollutants from stationary sources dominate in Ukraine now?

11. What are the main air polluters in Ukraine?

12. Is the automobile transport the major polluter from mobile sources? What is the emissions structure of the main chemical substances that came into the air during the exploitation of vehicles?

13. What does the existing network of Ukrainian air pollution survey include? What does selecting of site location depend on?

14. The network of national air pollution survey (choose the correct correspondences):

1. stationary sites	*A. are designed for sampling in smoke (gas) plume to identify zone of influence of a particular source of industrial emissions*
2. route sites	*B. are intended to provide for a regular air sampling to identify and register pollution content*
3. under plume sites	*C. are intended to provide for a regular air sampling in areas where impossible or impractical to set a stationary site*

15. How many monitoring programs of regular observations at stationary sites do you know? Name them.

16. For which purpose do they use the Air Quality Index (AQI)?

Chapter 4

1. Does Ukraine belong to the least provided with water resources European countries?

2. What is the peculiarity of distribution of water resources in Ukraine?

3. The basic priorities of water use in Ukraine are (choose the correct answers):

a) population;

b) forests;

c) agriculture;

d) industry;

e) nature reserves.

4. The chief pollutants of surface waters in Ukraine (choose the correct answers):

a) vegetable oils;

b) oil products;

c) biogenic elements;

d) sodium salt;

e) heavy metallic salts.

5. What is the water security? Can you describe the key challenges to ensure water security in Ukraine?

6. Is level of radionuclides in the surface waters controlled as part of radiation monitoring?

7. What problems can we identify in organization of water quality monitoring in Ukraine?

8. Please shortly describe the new approaches to organization of water monitoring in Ukraine. What are the key elements of structural arrangement of basin councils?

9. Water quality monitoring (choose the correct answers):

a) can be undertaken with a minimal amount of human intervention;

b) are vital;

c) is undertaken quite often;

d) is not undertaken frequently enough;

e). requires personnel visiting monitoring stations at regular intervals.

10. Complete the sentences with a omitted word: ”The quality of any body of surface or ground water is a function of either or both … influences and … activities”.

11. Physical and chemical characteristics of a water body (choose the correct correspondences):

1. Physical characteristics	*A Salinity*
2. Chemical characteristics	*B Temperature*
	C Alkalinity
	D Dissolved Oxygen
	E Turbidity

12. Why the temperature is important in aquatic systems?

13. How does thermal pollution come in the form of direct impact?

14. Are the high concentrations of oxygen usually indicate good water quality?

15. The amount of dissolved oxygen gas depends on (choose the correct answers):

a) rapid movement;

b) temperature;

c) atmospheric pressure;

d) by-product of photosynthesis;

e) salinity.

16. Why the pH of an aquatic ecosystem is so important?

17. Insert numerical values in the statement: The relative proportion of hydrogen and hydroxyl ions is measured on a negative logarithmic scale from … (acidic) to … (alkaline): … being neutral.

18. Salinity is an indication of the (choose the correct answers):

a) bacterial respiration;

b) total suspended solids;

c) concentration of dissolved salts in a body of water;

d) pollution sources.

19. How salinity can be measured?

20. What are the two nutrients that most commonly limit maximum biomass of algae and aquatic plants in aquatic systems? Choose the right answers.

a) phosphorus;

b) potassium;

c) nitrogen;

d) calcium.

21. What is the cause of the eutrophication of aquatic ecosystems?

22. Put in order from high to low degrees of eutrophication (choose the correct answers):

a) Mesotrophic water;

b) Hypereutrophic water;

c) Oligotrophic water;

d) Eutrophic water.

23. What are two common measures of water quality that reflect the degree of organic matter pollution of a water body?

24. Trophic levels can be done for the monitoring of biological communities of water bodies (choose the correct correspondences):

1 micro-organisms	*A algae and vascular plants*
2 primary producers	*B fish*
3 primary consumers	*C bacteria, protists, and viruses*
4 secondary consumers	*D invertebrates*

25. What indexes are used for characteristic of the degree of water biological pollution?

26. What are the water quality variables tend to include to water quality monitoring (relative to WQI)?

Chapter 5

1. Are the oil products the one of the least causes of seawater pollution?

2. What are the types of agricultural waste which pollutes sea water?

3. What gases are the major pollutants of sea water?

4. What types of radioactive pollution do you know?

5. How often do the State Environmental Inspections of the Azov and Black Seas take samples of sea water? Choose the correct answer.

a) Monthly;

b) Bimonthly;

c) Twice a year;

d) Once a year.

6. Is the main hydrochemical mode investigated on all levels of sea water monitoring in Ukraine?

7. Levels of ecological monitoring of seawater in Ukraine (choose the correct correspondences):

1. The first level	*A background monitoring of the open part of the sea*
2. The second level	*B monitoring of impact zones*
3. The third level	*C monitoring of the shelf zone of the Black Sea*

8. Give the short characteristic of the modern state of pollution of coastal zone of the Black Sea.

9. What are the physical and chemical features of marine environmental policy according to Directive 2008/56/EC (Marine Strategy Framework Directive)?

10. What are the main pressure and impact as consequence of biological disturbance identified by Marine Strategy Framework Directive?

11. Why plastic pollution of seas and ocean is so dangerous?

Chapter 6

1. Why land is so important for humanity?

2. The misuse and over-exploitation of land resources are threatening human security as follows (choose the correct answers):

a) diminishing food and water security;

b) make us more vulnerable to extreme weather events;

c) make us more vulnerable to extreme high radiation;

d) reduced soil health and ecosystem resilience.

3. Are the pressures on global land resources now greater than at any other time in human history? (*yes* or *no*)

4. What does land degradation mean?

5. Fill in omitted words: "The drivers of land degradation are mainly external factors that … or … impact the health and productivity of land".

6. Give some natural drivers of land degradation.

7. Among human-induced drivers of land degradation are (choose the correct answers):

a) earthquakes;

b) wetland drainage;

c) droughts;

d) overgrazing.

8. What are the indirect drivers of land degradation linked to?

9. Are indirect drivers far more complex and operate at larger and longer scales and farther from the area of degradation? (*yes* or *no*)

10. How many major types of soil degradation processes do you know?

11. What is physical degradation of soil?

12. Name direct natural drivers of soil degradation processes. Does climate have a significant impact on soil processes?

13. Direct drivers of soil degradation (choose the correct correspondences):

1 Natural	*A geology and geomorphology*
2 Anthropogenic	*B land use*
	C farming practices and technologies
	D biodiversity

14. How many percent do arable lands occupy in developed European countries?

15. How many categories have the land fund according to Land Code of Ukraine?

16. The structure of agricultural lands in Ukraine is as follows (choose the correct correspondences):

1 78,4 %	*A pastures*
2 13,1 %	*B multi-annual plantings*
3 5.8 %	*C fallow*
4 2.1 %	*D arable land*
5 0.6 %	*E hayfields*

17. Among different types of soil of Ukraine predominate (choose the correct answers):

a) regular chornozems;

b) northern chornozems;

c) typical chornozems;

d) podzolized chornozems;

e) chestnut chornozem.

18. Fill the gap in the statement: "The State Service of Ukraine on Geodesy, Cartography and Cadaster carries out … and … land inventory".

19. What parameters are monitored by State Institution "Soil Protection Institute of Ukraine"?

20. How frequently eco- agrochemical passportization of fields and land areas is carried out?

21. The most large-scale degradation processes in Ukraine include (choose the correct correspondences):

1	*water and wind erosion*	*A 18%*
2	*waterlogging of land*	*B 20%*
3	*acidification*	*C 57%*
4	*salinization and alkalinization*	*D 6%*
5	*pollution*	*E 12%*

22. The monitoring of indicator adopted to measure the achievement of SDG target 15.3 is based on the combined use of such sub-indicators (choose the correct answers):

a) amount of restored degraded land;

b) land cover;

c) land productivity;

d) land fertility;

e) carbon stocks above and below ground.

23. Describe the concept of Land Degradation Neutrality.

Chapter 7

1. What is climate? Give the short definition.

2. Past climate are studied by analyzing (choose the correct answers):

a) ice cores;

b) sea currents;

c) sea/lake sediments;

d) shorelines movements;

e) tree pollen.

3. Is the human activity the primary driver of recent global warming?

4. How do we know the Earth's climate is changing? Provide some examples.

5. The greenhouse effect is the result of (choose the correct answer):

a) excessive man-made dust emissions into the atmosphere;

b) excessive man-made CO_2 emissions into the atmosphere;
c) solar particle increase;
d) solar radiation increase.

6. The signs of global climate change (choose the correct correspondences):

1 average temperature	*A is rising*
2 sea level	*B is retreating*
3 land ice	*C is increasing*
4 Northern Hemisphere snow cover	*D is shrinking*
5 glacier volume	*E is melting*

7. Why the climate observations are so important?

8. Do climate observations need to account for the full range of elements that describe the climate system?

9. Fill in omitted word: "the climate of Ukraine is … continental".

10. Is climate of Ukraine involved or uninvolved in global climate system changes?

11. What are the signs of climate change that are apparent in Ukraine?

12. What trend can we see in average air temperature in Ukraine?

13. The biggest contribution to total GHG emissions in Ukraine is (choose the correct answer):

a) agriculture;
b) waste;
c) energy;
d) industrial processes.

14. Possible impact of climate change in Ukraine (choose the correct correspondences):

1 agriculture	*A will have a heavy impact on the drinking water in the most arid areas*
2 water supply	*B can affect people with a low income*
3 social environment	*C the amount of insect–pests can be boosted by the warming*
	D can have a heavy impact on healthcare
	E fertile soil can be damaged by erosion and desertification

Chapter 8

1. Describe the concept of biological diversity. What does biodiversity include?

2. "Goods and Services" provided by ecosystems include (choose the correct answers):

a) Provision of food, fuel and fibre;

b) Control of industrial accident hazard;

c) Purification of air and water;

d) Control of pests and diseases;

e) Ability to adapt to change.

3. What is the monitoring of biological diversity?

4. When was the last edition of Red Data Book of Ukraine developed?

5. The "Chronicles of Nature" programme has been maintained by: (choose the correct answer):

a) central executive authorities

b) authorized staff of protected areas

c) volunteers with supporting from international funding agencies

6. What objects should be priority for the first stage of the biomonitoring development in Ukraine?

7. Among the priority biological species that should be the objects for the first stage of the biomonitoring are alien species, aren't they?

8. Priority communities for biomonitoring are those listed in (choose the correct answer):

a) the Red Data Book of Ukraine;

b) the Cadastre of plant wildlife;

c) the Green Data Book of Ukraine.

9. Top-priority ecosystems for biomonitoring (choose the correct correspondences):

1 forest	*A have almost entirely disappeared due to agriculture*
2 steppe	*B have been reduced due to drainage*
3 wetlands	*C are artificial*

10. How many categories of indicators were identified on the Strategic Plan for Biodiversity 2011-2020?

Chapter 9

1. Environmental protection may consist of (choose the correct answers):

a) changes in characteristics of fuel;

b) changes in consumption patterns;

c) changes in production techniques;

d) treatment or disposal of residuals in separate environmental protection facilities;

e) recreating;

f) prevention of degradation of the landscape and ecosystems.

2. Are humans regarded as an integral part of the ecosystem?

3. What is a critical aspect of environmental protection?

4. Fill in omitted words: “Environmental remediation and restoration focus on the … and … of strategies geared to reverse negative environmental impacts”.

5. Environmental protection relates to (choose the correct correspondences):

1 Preservation	*A is generally associated with the sustainable use of natural resources*
2 Conservation	*B its primary objective is to restore an ecosystem or natural environment to a previous state*
3 Remediation	*C it refers to the protection of an ecosystem or natural environment from change*

6. Give the definition of “sustainable development” according to the Brundtland Report.

7. The necessary condition for achieving sustainable development is (choose the correct answers):

a) social equity;

b) economic competition;

c) economic efficiency;

d) ecological security;

e) protection of ozone layer.

8. Does environmental sustainability relate to ecosystem integrity and carrying capacity of natural environment?

9. Why do we need to conserve the ecosystem and biodiversity?

10. Development activities must be carried out according to the (choose the correct answer):

a) increasing human demands;

b) capacity of the earth;

c) economic costs.

11. What does Polluter Pays Principle state?

12. Precautionary Principle means (choose the correct answer):

a) market prices should reflect the environmental costs of the production and use of a product in terms of natural resource utilization, pollution, waste generation, consumption, disposal and other factors;

b) it relates to the legal obligation of countries to cooperate with other countries in cases of transboundary and global environmental concerns;

c) it recommends action in responding to potential environmental threats instead of waiting for absolute scientific proof;

d) it recognizes each generation's responsibility to be fair to the next generation by leaving a legacy of wealth no less than they themselves had inherited.

13. Concepts that contribute towards sustainable development (choose the correct correspondences):

1 Sustainable Resource Use	*A Degradation to certain resources can have implications for the continued functioning of other resources and of the planet as a whole*
2 Ecological Interdependence	*B Countries must ensure that activities within their jurisdiction or control do not damage the environment of other countries*
3 Harm Prevention	*C The concept refers to those areas beyond the limits of national jurisdiction such as the high seas, Antarctica, outer space and the ozone layer.*
4 Global Commons	*D Natural resource exploitation should proceed in a way and at a rate that does not lead to the long-term decline of these resources*

14. What is life-cycle assessment intended to evaluate?

15. Among EU environmental principles are (choose the correct answers):

a) the prevention principle;

b) the precautionary principle;

c) the principle of least effort;

d) the integration principle.

16. What law provides for basic principles of environmental protection in Ukraine?

GLOSSARY

Acid: A corrosive solution with a pH less than 7.

Acid Aerosol: Acidic liquid or solid particles small enough to become airborne. High concentrations can irritate the lungs and have been associated with respiratory diseases like asthma.

Acid Deposition: A complex chemical and atmospheric phenomenon that occurs when emissions of sulfur and nitrogen compounds and other substances are transformed by chemical processes in the atmosphere, often far from the original sources, and then deposited on earth in either wet or dry form. The wet forms, popularly called "acid rain," can fall to earth as rain, snow, or fog. The dry forms are acidic gases or particulates.

Adaptation: Changes in an organism's physiological structure or function or habits that allow it to survive in new surroundings.

Adsorption: Removal of a pollutant from air or water by collecting the pollutant on the surface of a solid material; e.g., an advanced method of treating waste in which activated carbon removes organic matter from waste-water.

Aeration: A process which promotes biological degradation of organic matter in water. The process may be passive (as when waste is exposed to air), or active (as when a mixing or bubbling device introduces the air).

Aerosol: (1) Small droplets or particles suspended in the atmosphere, typically containing sulfur. They are usually emitted naturally (e.g. in volcanic eruptions) and as the result of anthropogenic (human) activities such as burning fossil fuels. (2) The pressurized gas used to propel substances out of a container.

Agent: Any physical, chemical, or biological entity that can be harmful to an organism.

Agricultural Pollution: Farming wastes, including runoff and leaching of pesticides and fertilizers; erosion and dust from plowing; improper disposal of animal manure and carcasses; crop residues, and debris.

Agricultural Waste: Poultry and livestock manure, and residual materials in liquid or solid form generated from the production and marketing of poultry, livestock or fur-bearing animals; also includes grain, vegetable, and fruit harvest residue.

Agroecosystem: Land used for crops, pasture, and livestock; the adjacent uncultivated land that supports other vegetation and wildlife; and the associated atmosphere, the underlying soils, groundwater, and drainage networks.

Air Pollutant: (1) Substance in air that could, at high enough concentrations, harm human beings, animals, vegetation or material. Air pollutants may thus include forms of matter of almost any natural or artificial composition capable of being airborne. They may consist of solid particles, liquid droplets or gases, or combinations of these forms. (2) Any pollutant agent or combination of such agents, including any physical, chemical, biological, radioactive substance or matter which is emitted into or otherwise enters the ambient air and can, in high enough concentrations, harm humans, animals, vegetation or material.

Air Pollution: Introduction as a result of human activities, directly or indirectly, of substances or energy into the air that are likely to have harmful effects on human health, the environment as a whole and property.

Air Quality: The degree to which air is polluted; the type and maximum concentration of man-produced pollutants that should be permitted in the atmosphere.

Air Quality Criteria: The levels of pollution and lengths of exposure above which adverse health and welfare effects may occur.

Aircraft: Any structure, machine, or contrivance, especially a vehicle, designed to be supported by the air, either by the dynamic action of the air upon the surfaces of the structure or object or by its own buoyancy.

Algal Blooms: Sudden spurts of algal growth, which can affect water quality adversely and indicate potentially hazardous changes in local water chemistry.

Alien Species: a species that has been transported by human activities, intentional or accidental, into a region where it does not naturally occur (Also known as an exotic or introduced species).

Alkaline: The condition of water or soil which contains a sufficient amount of alkali substance to raise the pH above 7.0.

Alkalinity: The capacity of bases to neutralize acids. An example is lime added to lakes to decrease acidity.

Alternative Fuels: Substitutes for traditional liquid, oil-derived motor vehicle fuels like gasoline and diesel. Includes mixtures of alcohol-based fuels with gasoline, methanol, ethanol, compressed natural gas, and others.

Ambient Air: Any unconfined portion of the atmosphere: open air, surrounding air.

Ammonia: In its pure state and under usual environmental conditions, ammonia exists as a colorless, pungent-smelling gas. It is alkaline, caustic and an irritant. Under high pressure, ammonia can be stored as a liquid. It is highly soluble in water. It reacts with acids to form ammonium salts.

Aniline: An organic base used to make dyes, drugs, explosives, plastics, and photographic and rubber chemicals.

Applied Dose: In exposure assessment, the amount of a substance in contact with the primary absorption boundaries of an organism (e.g. skin, lung tissue, gastrointestinal track) and available for absorption.

Arable Land: Land under temporary crops, temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years).

Area Source: Any source of air pollution that is released over a relatively small area but which cannot be classified as a point source. Such sources may include vehicles and other small engines, small businesses and household activities, or biogenic sources such as a forest that releases hydrocarbons.

Artesian (Aquifer or Well): Water held under pressure in porous rock or soil confined by impermeable geological formations.

Ash: The mineral content of a product remaining after complete combustion.

Assessment: Formal efforts to assemble selected knowledge with a view toward making it publicly available in a form intended to be useful for decision-making (Mitchell and others 2006). By 'formal' the definition requires that the assessment should be sufficiently organized to identify components such as products, participants and issuing authority. 'Selected knowledge' indicates that the content has a defined scope or purpose and that not all information compiled and contributed is necessarily included in the report. The sources of knowledge may vary. While results from research and scientific knowledge predominate, assessments can supplement this with local, traditional or indigenous knowledge. Further, assessments can evaluate both existing information and research conducted expressly for the purpose. The definition also notes the importance of ensuring that assessments are in the public domain, as they may influence public debate and different types of decision-makers.

Assimilative Capacity: The capacity of a natural body of water to receive wastewaters or toxic materials without deleterious effects and without damage to aquatic life or humans who consume the water.

Background Level: (1) The concentration of a substance in an environmental media (air, water, or soil) that occurs naturally or is not the result of human activities. (2) In exposure assessment the concentration of a substance in a defined control area, during a fixed period of time before, during, or after a data-gathering operation.

Benz (a) pyrene: A five-ring aromatic hydrocarbon found in coal tar, in cigarette smoke, and as a product of incomplete combustion.

Benzene: Benzene is a colorless, volatile and flammable liquid with a distinctive odour. It evaporates into the air very quickly and is a dangerous fire hazard when exposed to heat or flame. It is only slightly soluble in water, but will mix with most organic solvents. Benzene is one of the simplest organic chemicals known as 'aromatic' compounds - their carbon atoms are arranged in rings rather than chains.

Bioaccumulants: Substances that increase in concentration in living organisms as they take in contaminated air, water, or food because the substances are very slowly metabolized or excreted.

Biochemical Oxygen Demand (BOD): An approximate measure of the amount of biochemically degradable organic matter in water bodies. It is defined as the amount of oxygen required for the aerobic microorganisms present in a water sample to oxidise the organic matter to a stable form. BOD is often used as a measure of efficiency of treatment of urban wastewater and the permit for wastewater treatment plants often establishes the BOD of discharges. The BOD is rather time consuming to measure, and can be estimated from the chemical oxygen demand.

Biodiversity: (1) Genetic diversity: the variation between individuals and between populations within a species; species diversity: the different types of plants, animals and other life forms within a region; community or ecosystem diversity: the variety of habitats found within an area (grassland, marsh, and woodland for instance. (2) An umbrella term to describe collectively the variety and variability of nature. It encompasses three basic levels of organization in living systems: the genetic, species, and ecosystem levels. Plant and animal species are the most commonly recognized units of biological diversity, thus public concern has been mainly devoted to conserving species diversity.

Biological Contamination: The presence in the environment of living organisms or agents derived by viruses, bacteria, fungi, and mammal and bird antigens that can cause many health effects.

Biological Control: In pest control, the use of animals and organisms that eat or otherwise kill or out-compete pests.

Biological Integrity: The ability to support and maintain balanced, integrated, functionality in the natural habitat of a given region. Concept is applied primarily in drinking water management.

Biological Pesticides: Certain microorganism, including bacteria, fungi, viruses, and protozoa that are effective in controlling pests. These agents usually do not have toxic effects on animals and people and do not leave toxic or persistent chemical residues in the environment.

Biomonitoring: (1) Analysis of the amounts of potentially toxic substances or their metabolites present in body tissues and fluids as a means of assessing exposure to these substances and aiding timely action to prevent adverse effects. (2) The term is also used for an assessment of the biological status of populations and bio-communities at risk in order to protect them and to have an early warning of possible hazards to human or environmental health.

Bioremediation: Use of living organisms to clean up oil spills or remove other pollutants from soil, water, or wastewater; use of organisms such as non-harmful insects to remove agricultural pests or counteract diseases of trees, plants, and garden soil.

BOD/COD: A rough measure of the ability of bacteria to digest organic matter present, the so-called biodegradability. In natural water the BOD/COD ratio is approximately 0.7-0.8. If other organic or inorganic materials are present, the BOD/COD ratio decreases.

Body of Surface Water: A discrete and significant element of surface water such as a lake, reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water.

Buffer: A solution or liquid whose chemical makeup is such that it minimizes changes in pH when acids or bases are added to it.

Built-up Land: Land under houses, roads, mines and quarries and any other facilities, including their auxiliary spaces, deliberately installed for the pursuit of human activities. Included area also certain types of open land (non-built-up land), which are closely related to these activities, such as waste tips, derelict land in built-up areas, junk yards, city parks and gardens, etc. Land occupied by scattered farm buildings, yards and their annexes are excluded. Land under closed villages or similar rural localities is included.

By-product: Material, other than the principal product, generated as a consequence of an industrial process or as a breakdown product in a living system.

Carbon Dioxide: A colourless gas with a faint tingling smell and taste. Atmospheric carbon dioxide is the source of carbon for plants. As carbon dioxide is heavier than air and does not support combustion, it is used in fire extinguishers. It is a normal constituent of the atmosphere, relatively innocuous in itself but playing an important role in the greenhouse effect. It is produced during the combustion of fossil fuels when the carbon content of the fuels reacts with the oxygen during combustion. It is also produced when living organisms respire. It is essential for plant nutrition and in the ocean phytoplankton is capable of absorbing and releasing large quantities of the gas.

Carbon Monoxide: Colourless, odourless, tasteless, non-corrosive, highly poisonous gas of about the same density as that of air. Very flammable, burning in air with bright blue flame. Although each molecule of CO has one carbon atom and one oxygen atom, it has a shape similar to that of an oxygen molecule (two atoms of oxygen), which is important with regard to its lethality.

Carbon Sulfide: A clear, flammable liquid, CS_2, used to manufacture viscose rayon and cellophane, as a solvent for fats, rubber, resins, waxes, and sulfur, and in matches, fumigants, and pesticides.

Carrying Capacity: (1) In recreation management, the amount of use a recreation area can sustain without loss of quality. (2) In wildlife management, the maximum number of animals an area can support during a given period.

Case Study: A brief fact sheet providing risk, cost, and performance information on alternative methods and other pollution prevention ideas, compliance initiatives, voluntary efforts, etc.

Chemical Compound: A distinct and pure substance formed by the union or two or more elements in definite proportion by weight.

Chemical Element: A fundamental substance comprising one kind of atom; the simplest form of matter.

Chemical Oxygen Demand (COD): (1) A measure of the oxygen required to oxidize all compounds, both organic and inorganic, in water. (2) COD is widely used as a measure of the susceptibility to oxidation of organic and inorganic materials in waters. Strong chemical oxidants, such as dichromate (COD-Cr) and permanganate (COD-Mn) are used in measuring COD. In unpolluted waters, COD values are in the order of 20 mg O2/l or less. The chemical oxygen demand of the effluent indicates the more persistent chemical components in the effluent. This compares with the biochemical demand, where oxygen is absorbed through bacteria. The latter process takes quite a long time for daily operational performance checking of effluent treating plants. Provided that a waste water treatment plant has a constant input, the COD is measured as a routine analysis to estimate the BOD of the effluent once the correlation ratio has been established. See BOD, and BOD/COD ratio.

Chemical Treatment: Any one of a variety of technologies that use chemicals or a variety of chemical processes to treat waste.

Clarification: Clearing action that occurs during wastewater treatment when solids settle out. This is often aided by centrifugal action and chemically induced coagulation in wastewater.

Clean Fuels: Blends or substitutes for gasoline fuels, including compressed natural gas, methanol, ethanol, and liquified petroleum gas.

Climate Change: Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines 'climate change' as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.

Coliform Index: A rating of the purity of water based on a count of fecal bacteria.

Coliform Organism: Microorganisms found in the intestinal tract of humans and animals. Their presence in water indicates fecal pollution and potentially dangerous bacterial contamination by disease-causing microorganisms.

Combustion: (1) Burning, or rapid oxidation, accompanied by release of energy in the form of heat and light. (2) Refers to controlled burning of waste, in which heat chemically alters organic compounds, converting into stable inorganics such as carbon dioxide and water.

Concentration: The relative amount of a substance mixed with another substance. An example is five ppm of carbon monoxide in air or 1 mg/l of iron in water.

Conductivity: A measure of the ability of a solution to carry an electrical current.

Conservation: Preserving and renewing, when possible, human and natural resources. The use, protection, and improvement of natural resources according to principles that will ensure their highest economic or social benefits.

Contaminant: Any physical, chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil.

Contamination: Introduction into water, air, and soil of microorganisms, chemicals, toxic substances, wastes, or wastewater in a concentration that makes the medium unfit for its next intended use. Also applies to surfaces of objects, buildings, and various household and agricultural use products.

Cost/Benefit Analysis: A quantitative evaluation of the costs which would have incurred by implementing an environmental regulation versus the overall benefits to society of the proposed action.

Cover Crop: A crop that provides temporary protection for delicate seedlings and/or provides a cover canopy for seasonal soil protection and improvement between normal crop production periods.

Crop Rotation: Planting a succession of different crops on the same land rea as opposed to planting the same crop time after time.

Cross Contamination: The movement of underground contaminants from one level or area to another due to invasive subsurface activities.

Cumulative Ecological Risk Assessment: Consideration of the total ecological risk from multiple stressors to a given eco-zone.

Cumulative Exposure: The sum of exposures of an organism to a pollutant over a period of time.

Data Base: A computerized compilation of data, facts and records that is organized for convenient access, management and updating.

Data Collection: Compiling data and information to be put into databases or archives for retrieval and information purposes.

DDT: The first chlorinated hydrocarbon insecticide chemical name: Dichloro-Diphenyl-Trichloroethane. It has a half-life of 15 years and can collect in fatty tissues of certain animals.

Debris: Any solid material exceeding a 60 mm particle size that is intended for disposal and that is a manufactured object, or plant or animal matter, or natural geologic material.

Decomposition: The breakdown of matter by bacteria and fungi, changing the chemical makeup and physical appearance of materials.

Decontamination: Removal of harmful substances such as noxious chemicals, harmful bacteria or other organisms, or radioactive material from exposed individuals, rooms and furnishings in buildings, or the exterior environment.

Demineralization: A treatment process that removes dissolved minerals from water.

Denitrification: The biological reduction of nitrate to nitrogen gas by denitrifying bacteria in soil.

Density: A measure of how heavy a specific volume of a solid, liquid, or gas is in comparison to water. depending on the chemical.

Discharge: All effluents or other materials that are put into the environment. In US, most commonly, “discharge” is considered to be the release of any liquid waste into the environment from a point source, but also can refer to air emissions.

Disposal: Final placement or destruction of toxic, radioactive, or other wastes; surplus or banned pesticides or other chemicals; polluted soils; and drums containing hazardous materials from removal actions or accidental releases. Disposal may be accomplished through use of approved secure landfills, surface impoundments, land farming, deep-well injection, ocean dumping, or incineration.

Dissolved Oxygen (DO): The oxygen freely available in water, vital to fish and other aquatic life and for the prevention of odors. DO levels are considered a most important indicator of a water body's ability to support desirable aquatic life. Secondary and advanced waste treatment are generally designed to ensure adequate DO in waste-receiving waters.

Dissolved solids: Disintegrated organic and inorganic material contained in water. Excessive amounts make water unsuitable for drinking or for use in industrial processes.

Disturbance: Any event or series of events that disrupt ecosystem, community, or population structure and alters the physical environment.

Domestic Application: Pesticide application in and around houses, office buildings, motels, and other living or working areas.

Dosage/Dose: (1) The actual quantity of a chemical administered to an organism or to which it is exposed. (2) The amount of a substance that reaches a specific tissue (e.g. the liver). (3) The amount of a substance available for interaction with metabolic processes after crossing the outer boundary of an organism.

Drainage: Improving the productivity of agricultural land by removing excess water from the soil by such means as ditches or subsurface drainage tiles.

Dump: A site used to dispose of solid waste without environmental controls.

Dumping: Disposing of waste illegally by not using bins or official recycling centres, civic amenity sites or landfills.

Ecological/Environmental Sustainability: Maintenance of ecosystem components and functions for future generations.

Ecological Impact: The effect that a man-caused or natural activity has on living organisms and their non-living (abiotic) environment.

Ecological Indicator: A characteristic of an ecosystem that is related to, or derived from, a measure of biotic or abiotic variable, that can provide quantitative information on ecological structure and function. An indicator can contribute to a measure of integrity and sustainability.

Ecological Risk Assessment: The application of a formal framework, analytical process, or model to estimate the effects of human actions(s) on a natural resource and to interpret the significance of those effects in light of the uncertainties identified in each component of the assessment process. Such analysis includes initial hazard identification, exposure and dose-response assessments, and risk characterization.

Effluent: Wastewater--treated or untreated--that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.

Emergency (Chemical): A situation created by an accidental release or spill of hazardous chemicals that poses a threat to the safety of workers, residents, the environment, or property.

Emission: Any direct or indirect release of substances, vibrations, heat or noise from individual or diffuse sources of an installation into the environment (air, water or land). Emissions are generally used in relation to releases to the air, while discharges relate to releases to water.

Emission Control: Procedures aiming at reducing or preventing the harm caused by atmospheric emissions.

Emission Factor: The relationship between the amount of pollution produced and the amount of raw material processed. For example, an emission factor for a blast furnace making iron would be the number of pounds of particulates per ton of raw materials.

Emission Inventory: A listing, by source, of the amount of air pollutants discharged into the atmosphere of a community; used to establish emission standards.

Endangered Species: Animals, birds, fish, plants, or other living organisms threatened with extinction by man-made or natural changes in their environment. Requirements for declaring a species endangered are contained in the Endangered Species Act.

Energy Recovery: Obtaining energy from waste through a variety of processes (e.g. combustion).

Enrichment: Addition of nitrogen, phosphorous and carbon compounds or other nutrients into a water body, thereby increasing the potential for growth of algae and other aquatic plants. Most frequently, enrichment results from the inflow of sewage effluents or from agricultural run-off.

Environment: The sum of all external conditions affecting the life, development and survival of an organism.

Environmental Assessment: An environmental analysis prepared pursuant to the National Environmental Policy Act to determine whether a federal action would significantly affect the environment and thus require a more detailed environmental impact statement.

Environmental Audit: An independent assessment of the current status of a party's compliance with applicable environmental requirements or of a party's environmental compliance policies, practices, and controls.

Environmental Data: (1) Any parameters or pieces of information collected or produced from measurements, analyses, or models of environmental processes, conditions, and effects of pollutants on human health and the ecology, including results from laboratory analyses or from experimental systems representing such processes and conditions. (2) Information concerning the state or condition of the environment.

Environmental/Ecological Risk: The potential for adverse effects on living organisms associated with pollution of the environment by effluents, emissions, wastes, or accidental chemical releases; energy use; or the depletion of natural resources.

Environmental Equity/Justice: Equal protection from environmental hazards for individuals, groups, or communities regardless of race, ethnicity, or economic status. This applies to the development, implementation, and enforcement of environmental laws, regulations, and policies, and implies that no population of people should be forced to shoulder a disproportionate share of negative environmental impacts of pollution or environmental hazard due to a lack of political or economic strength levels.

Environmental Exposure: Human exposure to pollutants originating from facility emissions. Threshold levels are not necessarily surpassed, but low-level chronic pollutant exposure is one of the most common forms of environmental exposure.

Environmental Indicator: A measurement, statistic or value that provides a proximate gauge or evidence of the effects of environmental management programs or of the state or condition of the environment.

Environmental Impact Assessment (EIA): EIA is the term applied to the systematic examination of the likely impacts of development proposals on the environment prior to the beginning of any activity.

Environmental Information covers a broad range of topics, such as: the environment itself, including air, water, earth, and the habitats of animals and plants; other things that affect the environment, such as emissions, radiation, noise and other forms of pollution; policies, plans and laws on the environment.

Environmental Monitoring: 1. The repetitive and continued observation, measurement and evaluation of environmental data to follow changes over a period of time to assess the efficiency of control measures. 2. Periodic and/or continued measuring, evaluating, and determining environmental parameters and/or pollution levels in order to prevent negative and damaging effects to the environment. Also include the forecasting of possible changes in ecosystem and/or the biosphere as a whole.

Environmental Report: An account or statement, usually in writing, describing in detail events, situations or conditions pertaining to the ecosystem, its natural resources or any of the external factors surrounding and affecting human life.

Environmental Sustainability: Long-term maintenance of ecosystem components and functions for future generations.

Environmentally Dangerous Substance: Substance that causes undesirable change in the physical, chemical, or biological characteristics of the air, water, or land that can harmfully affect the health, survival, or activities of human or other living organisms.

Equipment: Any collection of materials, supplies or apparatuses stored, furnished or provided for an undertaking or activity.

Erosion: The general process or the group of processes whereby the materials of Earth's crust are loosened , dissolved, or worn away and simultaneously moved from one place to another, by natural agencies, which include weathering, solution, corrosion, and transportation, but usually exclude mass wasting.

European Environment Agency (EEA) was established by Regulation (EEC) No 1210/1990, amended by Regulation (EEC) No 933/1990, and has been operational since 1994. The EEA aims to support sustainable development and to help achieve significant and measurable improvement in Europe's environment through the provision of timely, targeted, relevant and reliable information to policy-making agents and the public. The Agency processes data from the member countries to knowledge at European level, and co-operates with the European environment information and observation network (Eionet) and other international partners to gather, process and distribute data and information.

Eutrophication: Excessive enrichment of waters with nutrients, and the associated adverse biological effects.

Evapotranspiration: The combined processes of evaporation and transpiration. It can be defined as the sum of water used by vegetation and water lost by evaporation.

Exposure: The amount of radiation or pollutant present in a given environment that represents a potential health threat to living organisms.

Extremely Hazardous Substances: Any of 406 chemicals identified by EPA as toxic, and listed under SARA Title III. The list is subject to periodic revision.

Field Sampling: On site sample taking, e.g., samples of water (effluent), soil, air pollution. Sample taking requires experienced, well trained and qualified inspectors or laboratory technicians and equipment in order to be able to proceed with an enforcement action if and when needed.

Filtration: A treatment process, under the control of qualified operators, for removing solid (particulate) matter from water by means of porous media such as sand or a man-made filter; often used to remove particles that contain pathogens.

Fine Dust. Air-borne solid particles, originating from human activity and natural sources, such as wind-blown soil and fires, that eventually settle through the force of gravity, and can cause injury to human and other animal respiratory systems through excessive inhalation.

Fluorides: Gaseous, solid, or dissolved compounds containing fluorine that result from industrial processes. Excessive amounts in food can lead to fluorosis.

Food Waste: Uneaten food and food preparation wastes from residences and commercial establishments such as grocery stores, restaurants, and produce stands, institutional cafeterias and kitchens, and industrial sources like employee lunchrooms.

Forecast: An estimate or prediction of a future condition.

Formaldehyde: A colorless, pungent, and irritating gas, CH20, used chiefly as a disinfectant and preservative and in synthesizing other compounds like resins.

Fossil Fuel: Coal, natural gas and petroleum products (such as oil) formed from the decayed bodies of animals and plants that died millions of years ago.

Fresh Water: Water that generally contains less than 1,000 milligrams-per-liter of dissolved solids.

Garbage: Animal and vegetable waste resulting from the handling, storage, sale, preparation, cooking, and serving of foods.

Gaseous Air Pollutant: Uncondensed or volatile gases, usually comprised of chemical compounds, discharged to the atmosphere.

Genetic Diversity: The diversity of genes within and among populations of a species. This is the lowest level of biological diversity. - variation in the genetic composition of individuals within or among species; the heritable genetic variation within and among populations.

Genetic Engineering: A process of inserting new genetic information into existing cells in order to modify a specific organism for the purpose of changing one of its characteristics.

GHG: Greenhouse gas. A gas such as carbon dioxide or methane that reflects infrared radiation emitted by the earth, thereby helping to retain heat in the atmosphere.

GIS (Geographic information system): A collection of computer hardware, software, and geographic data designed to capture, store, update, manipulate, analyze, and display geographically referenced data.

Global Warming: An increase in the near surface temperature of the Earth. Global warming has occurred in the distant past as the result of natural influences, but the term is most often used to refer to the warming predicted to occur as a result of increased emissions of greenhouse gases. Scientists generally agree that the Earth's surface has warmed by about 1 degree Fahrenheit in the past 140 years. The Intergovernmental Panel on Climate Change (IPCC) recently concluded that increased concentrations of greenhouse gases are causing an increase in the Earth's surface temperature and that increased concentrations of sulfate aerosols have led to relative cooling in some regions, generally over and downwind of heavily industrialized areas.

Global Environmental Monitoring System (GEMS): A global environmental monitoring system that was established in 1973 under the United Nations Environment Programme, which collects data relating to atmosphere, climate, pollution, and renewable resources.

Ground Water: The supply of fresh water found beneath the Earth's surface, usually in aquifers, which supply wells and springs. Because ground water is a major source of drinking water, there is growing concern over contamination from leaching agricultural or industrial pollutants or leaking underground storage tanks.

Ground-level Ozone is ozone present as a secondary pollutant in the lower atmosphere, where its formation can be enhanced by other pollutants. It is highly toxic at levels above 0.1 parts per million (p.p.m.).

Hazard: 1. Potential for radiation, a chemical or other pollutant to cause human illness or injury. 2. In the pesticide program, the inherent toxicity of a compound. Hazard identification of a given substances is an informed judgment based on verifiable toxicity data from animal models or human studies.

Hazard Assessment: Evaluating the effects of a stressor or determining a margin of safety for an organism by comparing the concentration which causes toxic effects with an estimate of exposure to the organism.

Hazard Evaluation: A component of risk evaluation that involves gathering and evaluating data on the types of health injuries or diseases that may be produced by a chemical and on the conditions of exposure under which such health effects are produced.

Hazard Identification: Determining if a chemical or a microbe can cause adverse health effects in humans and what those effects might be.

Hazardous Substance: Any material that poses a threat to human health and- /or the environment. Typical hazardous substances are toxic, corrosive, ignitable, explosive, or chemically reactive.

Hazardous Waste: By-products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity), or appears on special lists.

Heavy Metal: Metallic elements with high atomic weights, e.g., mercury, chromium, cadmium, arsenic, and lead; can damage living things at low concentrations and tend to accumulate in the food chain.

Herbicide: A chemical pesticide designed to control or destroy plants, weeds, or grasses.

Household Waste (Domestic Waste): Solid waste, composed of garbage and rubbish, which normally originates in a private home or apartment house. Domestic waste may contain a significant amount of toxic or hazardous waste.

Human Health Risk: The likelihood that a given exposure or series of exposures may have damaged or will damage the health of individuals.

Hydrogen Chloride: Hydrochloric acid, solution is a colorless watery liquid with a sharp, irritating odor. Consists of hydrogen chloride, a gas, dissolved in water. Sinks and mixes with water. Produces irritating vapor.

Hydrogen Cyanide is a colourless gas or liquid that has a faint, bitter, almond-like odour. Its water solution is a weak acid, commonly known as hydrocyanic or prussic acid. Hydrogen cyanide melts at 14 ^{0}C and boils at 26 ^{0}C. It is very flammable and a potentially explosive hazard on exposure to air, sources of ignition, including heat, or open flame; and when stored for long periods of time.

Hydrogen Fluoride is an atmospheric contaminant derived from industrial emissions, such as aluminum and steel smelting, ceramic production, and the fabrication of phosphorus fertilizer.

Hydrogen Sulfide: Flammable, poisonous gas with characteristic odour of rotten eggs, perceptible in air in a dilution of 0.002 mg/l. It is used as a reagent in chemical analysis; extremely hazardous; collapse, coma and death from respiratory failure may come within a few seconds after one or two inspirations; low concentrations produce irritation of conjunctiva and mucous membranes. Headache, dizziness, nausea, lassitude may appear after exposure.

Indicator: (1) In biology, any biological entity or processes, or community whose characteristics show the presence of specific environmental conditions. (2) In chemistry, a substance that shows a visible change, usually of color, at a desired point in a chemical reaction. (3) A device that indicates the result of a measurement; e.g. a pressure gauge or a moveable scale.

Indirect Source: Any facility or building, property, road or parking area that attracts motor vehicle traffic and, indirectly, causes pollution.

Indoor Air: The breathable air inside a habitable structure or conveyance.

Indoor Air Pollution: Chemical, physical, or biological contaminants in indoor air.

Industrial Waste: Unwanted materials from an industrial operation; may be liquid, sludge, solid, or hazardous waste.

Influent: Water, wastewater, or other liquid flowing into a reservoir, basin, or treatment plant.

Innovative Technologies: New or inventive methods to treat effectively hazardous waste and reduce risks to human health and the environment.

Inorganic Chemicals: Chemical substances of mineral origin, not of basically carbon structure.

Insecticide: A pesticide compound specifically used to kill or prevent the growth of insects.

Integrated Waste Management: Using a variety of practices to handle municipal solid waste; can include source reduction, recycling, incineration, and landfilling.

Irrigation: Applying water or wastewater to land areas to supply the water and nutrient needs of plants.

Land Cover reflects the (bio) physical dimension of the earth's surface and corresponds in some regard to the notion of ecosystems. Typical examples for land cover categories are built-up areas, grassland, forests or rivers and lakes.

Land Degradation is the reduction or loss of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest or woodlands resulting from natural processes, land uses or other human activities and habitation patterns such as land contamination, soil erosion and the destruction of the vegetation cover.

Land Use is based on the functional dimension of land for different human purposes or economic activities. Typical categories for land use are dwellings, industrial use, transport, recreational use or nature protection areas.

LC 50/Lethal Concentration: Median level concentration, a standard measure of toxicity. It tells how much of a substance is needed to kill half of a group of experimental organisms in a given time. (See: LD 50.)

LD 50/ Lethal Dose: The dose of a toxicant or microbe that will kill 50 percent of the test organisms within a designated period. The lower the LD 50, the more toxic the compound.

Leaching: The process by which soluble constituents are dissolved and filtered through the soil by a percolating fluid.

Level (monthly, quarterly, annual) **data**. Data expressed as levels are expressed in absolute terms (values, numbers, units) for a given period (month, quarter, year).

Life Cycle of a Product: All stages of a product's development, from extraction of fuel for power to production, marketing, use, and disposal.

Limiting Factor: A condition whose absence or excessive concentration, is incompatible with the needs or tolerance of a species or population and which may have a negative influence on their ability to thrive.

Load: An amount per unit of time emitted.

Map Resolution: The accuracy with which the location and shape of map features are depicted for a given map scale.

Map Scale: A statement of a measure on the map and the equivalent measure on the earth, often expressed as a representative fraction of distance, such as 1:10 000.

Marine pollution refers to direct or indirect introduction by humans of substances or energy into the marine environment (including estuaries), resulting in harm to living resources, hazards to human health, hindrances to marine activities including fishing, impairment of the quality of sea water and reduction of amenities.

Maximum Allowable Concentrations: Means the quantity of a hazardous substance present in the environment and calculated per unit of volume or weight of a certain media that does not influence adversely human health or ecosystems during a permanent or limited time exposure. Maximum allowable concentrations are established for air, water and soil pollutants, and have been developed mostly based on human health safety criteria. These standards take into consideration both acute and chronic exposure. Standard setting process, originating in the Soviet period, did not take into account available control technology, economic feasibility, and ability in practice to measure emission levels and ambient concentrations of pollutants. Furthermore, in relation to water bodies, two types of MACs are applied. If a water body is used for drinking water supply, recreation and household or industrial purposes, sanitary MACs are applied. If a water body is used for fishery purposes, fishery MACs are applied. The list of regulated substances is extensive comprising thousands of substances. On the basis of these MACs, volumetric norms are calculated individually for each industrial facility.

Microclimate: (1) Localized climate conditions within an urban area or neighborhood. (2) The climate around a tree or shrub or a stand of trees.

Mobile Source: Any non-stationary source of pollution such as cars, trucks, motorcycles, buses, aircrafts, etc.

Monitoring. The observing, sample collection, analysis and reporting of information on, for example, emissions from installations or the ambient air quality in a particular location. It includes determining the actual state of the environment (often published in State of the Environment Reports on a regular basis).

Monitoring Programme: A documented account of the facilities, activities and timetable for measurement work which is needed for compliance monitoring purposes.

Monitoring Wells. Wells drilled at a site to collect groundwater samples for the purpose of physical, chemical, or biological analysis to determine the amounts, types, and distribution of contaminants in the groundwater beneath the site.

Montreal Protocol: Treaty, signed in 1987, governs stratospheric ozone protection and research, and the production and use of ozone-depleting substances. It provides for the end of production of ozone-depleting substances such as CFCS. Under the Protocol, various research groups continue to assess the ozone layer. The Multilateral Fund provides resources to developing nations to promote the transition to ozone-safe technologies.

Multilateral Environmental Agreements are the agreements between states which may include obligations varying from more general principles about a particular environmental issue, through to definitive actions to be taken to achieve an environmental objective.

Natural Pollutant is a pollutant created by substances of natural origin such as volcanic dust, sea salt particles, photochemically formed ozone, and products of forest fibers, among others.

Neutralization: Decreasing the acidity or alkalinity of a substance by adding alkaline or acidic materials, respectively.

Nitrate: A compound containing nitrogen that can exist in the atmosphere or as a dissolved gas in water and which can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants and domestic animals. A plant nutrient and inorganic fertilizer, nitrate is found in septic systems, animal feed lots, agricultural fertilizers, manure, industrial waste waters, sanitary landfills, and garbage dumps.

Nitrification: The process whereby ammonia in wastewater is oxidized to nitrite and then to nitrate by bacterial or chemical reactions.

Nitrite: (1) An intermediate in the process of nitrification. (2) Nitrous oxide salts used in food preservation.

Nitrogen Dioxide: A reddish-brown gas; it exists in varying degrees of concentration in equilibrium with other nitrogen oxides; used to produce nitric acid.

Nitrogen Oxides: Oxides formed and released in all common types of combustion; they are formed by the oxidation of atmospheric nitrogen at high temperatures. Introduced into the atmosphere from car exhausts, furnace stacks, incinerators, power stations and similar sources, the oxides include nitrous oxide, nitric oxide, nitrogen dioxide, nitrogen pentoxide and nitric acid. The oxides of nitrogen undergo many reactions in the atmosphere to form photochemical smog.

Nitrogenous Oxygen Demand (NOD) is a quantitative measure of the amount of dissolved oxygen required for the biological oxidation of nitrogenous material, for example, nitrogen in ammonia, and organic nitrogen in waste water.

No Till: Planting crops without prior seedbed preparation, into an existing cover crop, sod, or crop residues, and eliminating subsequent tillage operations.

Non-Point Sources: Diffuse pollution sources (i.e. without a single point of origin or not introduced into a receiving stream from a specific outlet). The pollutants are generally carried off the land by storm water. Common non-point sources are agriculture, forestry, urban, mining, construction, dams, channels, land disposal, saltwater intrusion, and city streets.

Nuclide: An atom characterized by the number of protons, neturons, and energy in the nucleus.

Nutrient: Any substance assimilated by living things that promotes growth. The term is generally applied to nitrogen and phosphorus in wastewater, but is also applied to other essential and trace elements.

Nutrient Pollution: Contamination of water resources by excessive inputs of nutrients. In surface waters, excess algal production is a major concern.

Observation: An observation is the value, at a particular period, of a particular variable.

Oil spill: An oil spill is oil, discharged accidentally or intentionally, that floats on the surface of water bodies as a discrete mass and is carried by the wind, currents and tides. Oil spills can be partially controlled by chemical dispersion, combustion, mechanical containment and adsorption. They have destructive effects on coastal ecosystems.

Organic: (1) Referring to or derived from living organisms. (2) In chemistry, any compound containing carbon.

Organic Chemicals/Compounds: Naturally occurring (animal or plant-produced or synthetic) substances containing mainly carbon, hydrogen, nitrogen, and oxygen.

Organic Matter: Carbonaceous waste contained in plant or animal matter and originating from domestic or industrial sources.

Ozone Depletion is the destruction of ozone in the stratosphere, where it shields the earth from harmful ultraviolet radiation. Its destruction is caused by chemical reactions in which oxides of hydrogen, nitrogen, chlorine and bromine act as catalysts.

Parameter: A variable, measurable property whose value is a determinant of the characteristics of a system; e.g. temperature, pressure, and density are parameters of the atmosphere.

Particulate Matter: Fine solid or liquid particles that pollute the air and are added to the atmosphere by natural and man-made processes at the Earth's surface. Examples of particulate matter include dust, smoke, soot, pollen and soil particles.

Particulates: Liquid or solid particles such as dust, smoke, mist, or smog found in air emissions.

Parts Per Billion (ppb)/Parts Per Million (ppm): Units commonly used to express contamination ratios, as in establishing the maximum permissible amount of a contaminant in water, land, or air.

Pathogens: Microorganisms (e.g., bacteria, viruses, or parasites) that can cause disease in humans, animals and plants.

Persistence: Refers to the length of time a compound stays in the environment, once introduced. A compound may persist for less than a second or indefinitely.

Persistent Pesticides: Pesticides that do not break down chemically or break down very slowly and remain in the environment after a growing season.

Pesticide: Substances or mixture there of intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant.

pH: An expression of the intensity of the basic or acid condition of a liquid; may range from 0 to 14, where 0 is the most acid and 7 is neutral. Natural waters usually have a pH between 6.5 and 8.5.

Phenol: A very poisonous chemical substance made from tar and also found in some plants and essential oils (scented liquid taken from plants). Phenol is used to make plastics, nylon, epoxy, medicines, and to kill germs. Also called carbolic acid.

Phosphates: Certain chemical compounds containing phosphorus.

Photochemical Smog: Air pollution caused by chemical reactions of various pollutants emitted from different sources.

Phytoplankton: That portion of the plankton community comprised of tiny plants; e.g. algae, diatoms.

Plume: A concentration of contaminants in air, soil, or water usually extending over an area from a distinct source.

PM-10/PM-2.5: PM 10 is measure of particles in the atmosphere with a diameter of less than ten or equal to a nominal 10 micrometers. PM-2.5 is a measure of smaller particles in the air.

Point Source: A stationary location or fixed facility from which pollutants are discharged; any single identifiable source of pollution; e.g. a pipe, ditch, ship, ore pit, factory smokestack.

Pollutant: Any substance (or effect) introduced by humans which adversely affects the environment.

Pollution: (1) Presence of substances and heat in environmental media (air, water, land) whose nature, location, or quantity produces undesirable environmental effects. (2) Activity that generates pollutants.

Precautionary Principle: When information about potential risks is incomplete, basing decisions about the best ways to manage or reduce risks on a preference for avoiding unnecessary health risks instead of on unnecessary economic expenditures.

Precursor: In photochemistry, a compound antecedent to a pollutant. For example, volatile organic compounds (VOCs) and nitric oxides of nitrogen react in sunlight to form ozone or other photochemical oxidants. As such, VOCs and oxides of nitrogen are precursors.

Qualitative Data is data describing the attributes or properties that an object possesses. The properties are categorized into classes that may be assigned numeric values. However, there is no significance to the data values themselves, they simply represent attributes of the object concerned.

Quantitative Data is data expressing a certain quantity, amount or range. Usually, there are measurement units associated with the data, e.g. metres, in the case of the height of a person. It makes sense to set boundary limits to such data, and it is also meaningful to apply arithmetic operations to the data.

Radioactive Substances: Substances that emit ionizing radiation.

Radionuclide: Radioactive particle, man-made (anthropogenic) or natural, with a distinct atomic weight number. Can have a long life as soil or water pollutant.

Real-time Instruments of Monitoring: This involves making direct measurements of pollutant concentrations in situ with instruments that give immediate and continuous readings. This method gives information with high time resolution and virtually no time delay, but instruments are difficult and costly to calibrate and require special maintenance under possibly adverse or difficult field conditions.

Recycle/Reuse: Minimizing waste generation by recovering and reprocessing usable products that might otherwise become waste (.i.e. recycling of aluminum cans, paper, and bottles, etc.).

Release: Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment of any pollutant.

Remote Sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance from the targeted area. Special cameras collect remotely sensed images of the Earth, which help researchers "sense" things about the Earth.

Residential Waste: Waste generated in single and multi-family homes, including newspapers, clothing, disposable tableware, food packaging, cans, bottles, food scraps, and yard trimmings other than those that are diverted to backyard composting.

Residual: Amount of a pollutant remaining in the environment after a natural or technological process has taken place; e.g., the sludge remaining after initial wastewater treatment, or particulates remaining in air after it passes through a scrubbing or other process.

Restoration: Measures taken to return a site to pre-violation conditions.

Reuse: Using a product or component of municipal solid waste in its original form more than once; e.g., refilling a glass bottle that has been returned or using a coffee can to hold nuts and bolts.

Risk: A measure of the probability that damage to life, health, property, and/or the environment will occur as a result of a given hazard.

Risk Assessment: Qualitative and quantitative evaluation of the risk posed to human health and/or the environment by the actual or potential presence and/or use of specific pollutants.

Risk Management: The process of evaluating and selecting alternative regulatory and non-regulatory responses to risk. The selection process necessarily requires the consideration of legal, economic, and behavioral factors.

River Basin: The land area drained by a river and its tributaries.

Run-Off: That part of precipitation, snow melt, or irrigation water that runs off the land into streams or other surface-water. It can carry pollutants from the air and land into receiving waters.

Safe: Condition of exposure under which there is a practical certainty that no harm will result to exposed individuals.

Salinity: The percentage of salt in water.

Sampling: The obtaining of small representative quantities of material for the purpose of analysis.

Sediments: Soil, sand, and minerals washed from land into water, usually after rain.

Sewage: The waste and wastewater produced by residential and commercial sources and discharged into sewers.

Sludge: A semi-solid residue from any of a number of air or water treatment processes; can be a hazardous waste.

Smog: Air pollution typically associated with oxidants.

Soil Degradation: Refers to the process(es) by which soil declines in quality and is thus made less fit for a specific purpose, such as crop production.

Soil Organic Matter is carbon-containing material in the soil that derives from living organisms.

Solid Waste: Non-liquid, non-soluble materials ranging from municipal garbage to industrial wastes that contain complex and sometimes hazardous substances. Solid wastes also include sewage sludge, agricultural refuse, demolition wastes, and mining residues. Technically, solid waste also refers to liquids and gases in containers.

Soot: Carbon dust formed by incomplete combustion.

Source: A facility, installation or individual from where the pollution or information etc. originates.

Source Area: The location of liquid hydrocarbons or the zone of highest soil or groundwater concentrations, or both, of the chemical of concern.

Spatial Data is any data with a direct or indirect reference to a specific location or geographical area.

Stakeholder: Any organization, governmental entity, or individual that has a stake in or may be impacted by a given approach to environmental regulation, pollution prevention, energy conservation, etc.

Standards: Norms that impose limits on the amount of pollutants or emissions produced.

State Environmental Monitoring System is an open information system, priority operations of which are the protection of vital important ecological interests of human and society; preservation of natural ecosystems; prevention crisis changes in the ecological state of the environment and prevention of emergency environmental situation.

Stationary Source: A fixed-site producer of pollution, mainly power plants and other facilities using industrial combustion processes.

Statistical Data refers to data from a survey or administrative source used to produce statistics.

Storage: Temporary holding of waste pending treatment or disposal, as in containers, tanks, waste piles, and surface impoundments.

Sulphur Dioxide: Heavy, pungent, colourless gas formed primarily by the combustion of fossil fuels. It is harmful to human beings and vegetation, and contributes to the acidity in precipitation.

Surface Water: All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.).

Suspended Solids: Small particles of solid pollutants that float on the surface of, or are suspended in, sewage or other liquids. They resist removal by conventional means.

Synthetic Organic Chemicals (SOCs): Man-made (anthropogenic) organic chemicals. Some SOCs are volatile; others tend to stay dissolved in water instead of evaporating.

Thermal Pollution: Discharge of heated water from industrial processes that can kill or injure aquatic organisms.

Toxic Pollutants: Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.

Toxic Waste: A waste that can produce injury if inhaled, swallowed, or absorbed through the skin.

Toxicant: A harmful substance or agent that may injure an exposed organism.

Toxicity: The degree to which a substance or mixture of substances can harm humans or animals. Acute toxicity involves harmful effects in an organism through a single or short-term exposure.

Treatment: (1) Any method, technique, or process designed to remove solids and/or pollutants from solid waste, waste-streams, effluents, and air emissions. (2) Methods used to change the biological character or composition of any regulated medical waste so as to substantially reduce or eliminate its potential for causing disease.

Turbidity: (1) Haziness in air caused by the presence of particles and pollutants. (2) A similar cloudy condition in water due to suspended silt or organic matter.

Ultraviolet Rays: Radiation from the sun that can be useful or potentially harmful. UV rays from one part of the spectrum (UV-A) enhance plant life. UV rays from other parts of the spectrum (UV-B) can cause skin cancer or other tissue damage. The ozone layer in the atmosphere partly shields us from ultraviolet rays reaching the earth's surface.

Underground Sources of Drinking Water: Aquifers currently being used as a source of drinking water or those capable of supplying a public water system. They have a total dissolved solids content of 10,000 milligrams per liter or less, and are not "exempted aquifers."

Volatile Organic Compound (VOC): Organic chemical compounds that under normal conditions are gaseous or can vaporise and enter the atmosphere. VOCs include such compounds as methane, benzene, xylene, propane and butane. Methane is primarily emitted from agriculture (from ruminants and cultivation), whereas non-methane VOCs (or NMVOCs) are mainly emitted from transportation, industrial processes and use of organic solvents.

Wastes: (1) Unwanted materials left over from a manufacturing process. (2) Refuse from places of human or animal habitation.

Wastewater (WW): Wastes that contain less than 1% by weight total organic carbon (TOC) and less than 1% by weight total suspended solids (TSS).

Water Pollution: The presence in water of enough harmful or objectionable material to damage water quality.

Water Quality Criteria: Specific levels of water quality that, if reached, are expected to render a body of water suitable for its designated use. The criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water Table: The level of groundwater.

Watershed: The land area that drains into a stream; the watershed for a major river may encompass a number of smaller watersheds that ultimately combine at a common point.

Well: A bored, drilled, or driven shaft, or a dug hole whose depth is greater than the largest surface dimension and whose purpose is to reach underground water supplies or oil, or to store or bury fluids below ground.

Wetlands: An area that is regularly saturated by surface water or groundwater and is subsequently characterized by a prevalence of vegetation adapted for life in saturated soil conditions. Examples include swamps, bogs, fens, marshes, and estuaries.

Zooplankton: Small (often microscopic) free-floating aquatic plants or animals.

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