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The proceedings of the international research-to-practice conference on 'Climate Services: Science and Education' are presented in the collected volume. The reports cover the principle results of researches in the field of issues of climate services in the climate-sensitive economic sectors; education in climate services; climate risks and adaptation to climate change on regional and local levels.

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ISSUES OF CLIMATE SERVICES IN CLIMATE-SENSITIVE ECONOMIC SECTORS

VISUAL DECODING OF ERODED SOILS TO THE SENTINEL IMAGES

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Soil erosion is a global environmental problem. According to [1], up to 40% of land in Asia, 30% in Africa, 25% in Europe and 35% in America are subject to water erosion. Unfortunately, Ukraine is no exception. According to experts, the area of land affected by water erosion in Ukraine is about 40%. Due to this the country's economy loses up to 10 billion of US dollars annually.

Erosion processes contribute to the climatic changes both through the increase in the mineralization of soil organic matter and consequent increased emissions of greenhouse gasses, and through alteration of the radiological balance due to the deterioration of the surface vegetation cover and the accompanying changes in albedo.

To solve the problem of erosion, it is necessary to have information about the state of soils in Ukraine and the rate of ongoing erosion processes. It is necessary to use geographic information systems and remote sensing of the Earth's surface to obtain such data.

Modern remote sensing systems make it possible to obtain information quickly and relatively inexpensively, and in some cases even free of charge. For example, the Sentinel-2A and Sentinel-2B satellites provide free images with a spatial resolution of 10 m, and a temporal resolution of 5 days. It is fully suitable for monitoring and mapping eroded soils [2].

It should be noted that space monitoring involves the continuous collection of huge amounts of data that must be analyzed quickly and efficiently. The most desirable and difficult option is the option of automatic decoding of remote sensing data with minimal human intervention.

However, today there is no reliable technology for the automatic interpretation of eroded soils. This is due to the diversity of soil types and the complexity of their interpretation (Fig.1). Our research was aimed at carrying out visual interpretation of satellite images of the visible range of Sentinel in order to identify eroded soils.

The sample of spectral images of eroded soils obtained in the course of the work will become the basis for training a computer algorithm based on the method of «computer vision».

The research was carried out in the territory of the forest-steppe physical-geographical zone and the north-steppe physical-geographical subzone of Ukraine during 2019-2020. The study area was 12058.7 km2, determined by the size of the standard site of the Sentinel-2a spacecraft.

Fig. 1. An example of a field where the heterogeneity of color is caused by several different factors. Numbers indicate: 1 – manifestations of water erosion of the soil, 2 – plant remains, left after the cultivation of the soil, 3 – field path, 4 – part of the field with unplowed stubble.

To improve the accuracy of diagnosis, visual decoding was performed only in fields where there was no vegetation and plant remains. As a result, the total surveyed area was 2,055.3 km2.

Both linear and surface erosions were identified in the area. In such cases, the soils were considered eroded only if the expert was 100% confident about it. As a result of the decoding, 935 vector polygons were identified, characterizing the erosion processes on arable lands. The total allocated territories are 50.2 km2.

In our studies, we established a combination of decoding signs to determine the manifestations of linear and surface water erosion features from images. Specific characteristics of the reflected signal in the areas covered by chernozem soils with high humus content makes it possible to correctly identify moderately and heavily eroded soils.

Analysis of the Sentinel satellite image allowed us to assess the share of moderately and heavily eroded soils on arable lands within the studied territory at 2.4% of their total area.

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AN EXPERIMENTAL STUDY ON DRAW SOLUTION PERFORMANCE IN FERTILIZER DRAWN FORWARD OSMOSIS UNDER WATER ENERGY FOOD NEXUS FRAMEWORK IN EGYPT

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Keywords: Brackish Water, Desalination, Forward Osmosis, Hydroponics mixture, WEF Nexus

Water–Energy–Food nexus (WEF Nexus) has been recently developed as an efficient perception for describing the complex and interconnected nature of our global resource systems, on which we rely to attain different social, economic and environmental goals (Endo et al., 2017)

This research investigates the application of Fertilizer Drawn Forward Osmosis FDFO technique and its potential use in Egypt under the Framework of the Water-Energy-Food Nexus. In this work, feed solution used is real brackish groundwater extracted from a well in Tor, Egypt. Two sets of experiments have been conducted. The objective of having two separate scenarios is to provide informative assessment that is useful for the two main agriculture techniques, the conventional soil based one and the hydroponics technique. The first set examined three commonly used fertilizers in Egypt: Urea, Di-Ammonium Phosphate and Potassium Nitrate to compare between their performances. The second set examined standard hydroponic recipe, which is a mixture of nutrients, as a draw solution to fertilize crops in hydroponics systems. The nutrients mixture performance was tested and compared to that of the individual components at the same concentrations. Mixing nutrients boosted the osmotic pressure and enhanced the driving force for fresh water permeation. Hence, it can be concluded that mixed nutrients have better performance than single fertilizers, not only for the enhanced desalination features and for water extraction performance, but also because they provide a complete set of nutrients necessary for growing crops

Summary of Results and Conclusion. Regarding the first set, Di-Ammonium Phosphate resulted in the best performance as draw solute among the three tested draw solutes, it exhibited a significant water flux equivalent to 13.8 LMH, a feed ions rejection reaching 98% and acceptable concentrations of draw solute ions in the final product water, figure 1 illustrates an Average Flux comparison between KNO_3, DAP and Urea.

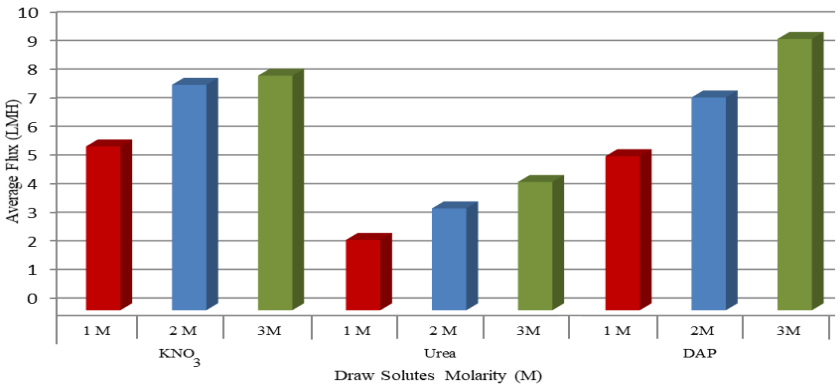

Fig. 1. Average Flux comparison between KNO3, DAP and Urea

For the Second set, The Hydroponics nutrients mixture exhibited better performance as draw solution compared to its individual macro-components. The use of the nutrient mixture as draw solute resulted in a flux of 11.7 LMH, 95% feed ions rejection compared to 9.2 LMH, 91%, and 10.03 LMH, 93% for its individual components, figure 2 summarizes the comparison between Water Flux of the Hydroponics Mix vs. its individual Macro Components.

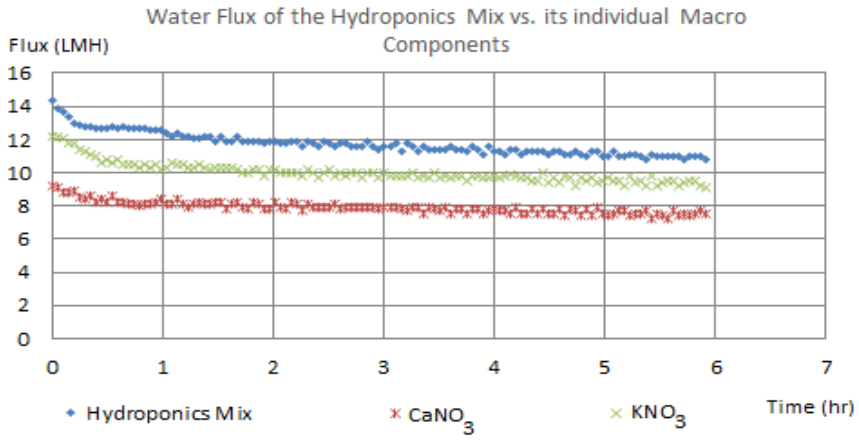

Fig. 2. Water Flux of the Hydroponics Mix vs. its individual Macro Components

Based on the conducted research and its conclusion, for single fertilizers, it is crucial to select a draw solute with high molecular weight and larger number of species formation due to their vital impact on the performance during the desalination process. On the other hand, fertilizer blending is recommended over the individual nutrients. Not Only due to the ability of the mixture to meet plant nutritional requirements without the need of further addition of more fertilizers, but also due to the higher osmotic potential of the mixture and its ability to mitigate a major Forward Osmosis limitation, which is the need of product water dilution.

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RAINFALL AND TEMPERATURE VARIABILITY AND PREVALENCE OF MALARIA IN DAMATURU, NIGERIA

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Keywords: Rainfall, Temperature, Public Health, Malaria, Weather, Climate

The frequency and intensity of weather-related health incidences are expanding from micro-scale to global scale with intensive direct and indirect impacts. The prevalence of malaria has been of serious concerns, and the roles played by weather parameters is of utmost interest.

This has led to the study of the impacts of rainfall and temperature on the prevalence of malaria in Damaturu, Yobe State from 2009 to 2018, which was achieved by determining both the monthly and annual variation of temperature and rainfall occurrence in relation to malaria prevalence in the study area. Monthly analysis of these parameters indicated the peak periods and shows a one-month lag between the peaks of rainfall and malaria occurrences, which happened to be the coldest month for this location.

Introduction. The magnitude and frequency of rainfall and temperature health related cases in Nigeria were expanding from micro scale to global scale with intensive direct and indirect impacts (Ekpoh and Bassey, 2016). In Nigeria, variability in rainfall and temperature have resulted to an increase in the geographical ranges of diseases occurrences especially in the Northeast (Eludoyin and Adelekan, 2013). Thus, Malaria is claiming one to two million lives annually and recent modeling exercised have predicted that malaria will increase by 5% to 7% by 2100 (Tanser et al., 2003). This study therefore aims at investigating the annual and monthly variation of malaria over Damaturu and how it is impacted by rainfall and temperature.

Damaturu town located between latitude 11.39^{o}N-11.47^{o}N and longitude 11.54^{o}E-12.02^{o}E. It's the administrative town of Yobe State, which serves as a nodal town connecting different regions of the state and Maiduguri. Damaturu and its neighbouring towns are located in the Sudano-Sahelian transitional climatic belts of northern Nigeria.

Data and Method of Analysis. Clinical records of malaria occurrences at the primary health care centres within the vicinity of Damaturu town from 2009 to 2018, while monthly record of temperature and rainfall from 2009 to 2018 was collected from Desert Research, Monitoring and Control and Centre (DRMCC) in Yobe State University and Global Weather Data for SWAT were obtained for Damaturu town. Simple and basic statistics like trend and correlation analyses were carried out.

Results and Discussion. Figures 1a and 1b show the annual trend malaria with rainfall and malaria with temperature respectively, with a significant increase

in malaria being noticed from 2009 to 2019. The year 2015 recorded the highest amount of malaria occurrences within that period. There was a significant decrease in temperature over the years (figure 1c) and increase in rainfall within the period of study.

Figures 1c and 1d show the monthly trend malaria with rainfall and malaria with temperature respectively. The average peak occurrence of malaria was observed in the month of September, which occurs one month after the lowest temperature for the year was recorded (figure 1c) and one month after the peak rainfall for the year was recorded (figure 1d). Therefore, a month between the peak rainfall, minimum temperature and maximum malaria occurrence is being established from this study.

Conclusion. The key period of prevalent malaria occurrence is in the month of September, which is a month after the maximum rainfall and minimum temperature. There is therefore a need to develop a proactive solutions that will provide a timely and accurate forecasting and projection of vulnerability of the Damaturu populace to the occurrence of this health scourge.

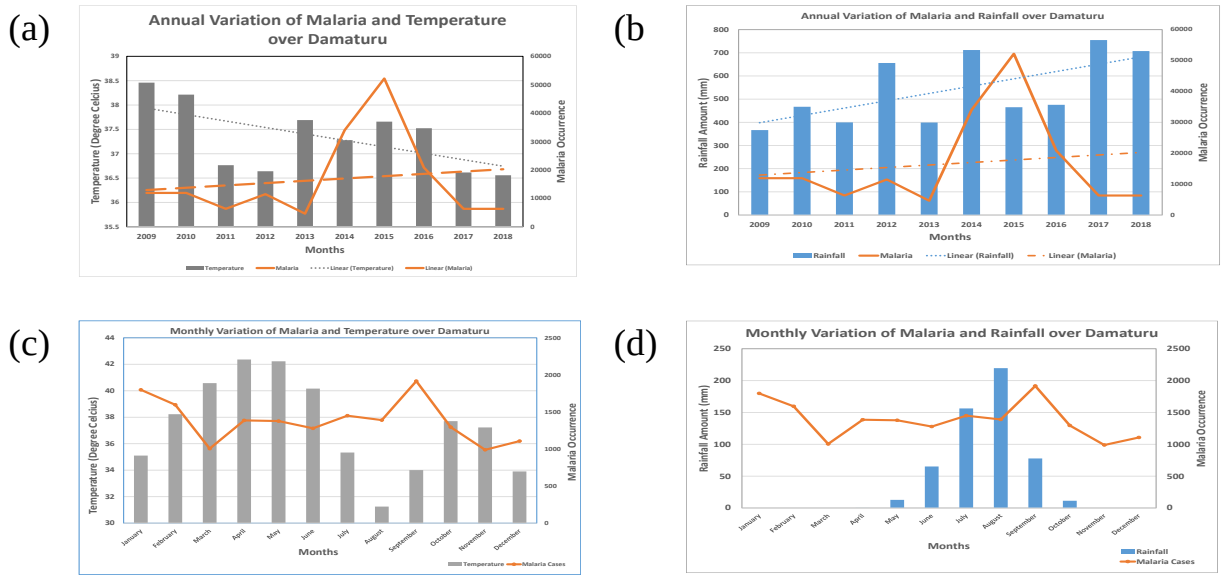

Figure 1: Annual and Monthly variation of rainfall, temperature and malaria over Damaturu

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SPECIAL ASPECTS OF STUDYING THE ENVIRONMENTAL FACTORS DURING THE PERIOD OF GRAIN CROPS OVERWINTERING UNDER CLIMATIC CHANGES

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It's known that each ecological zone of winter grain crops which grow in different regions of the world has its criteria of overwintering assessment. Late sowing terms contribute to studying the peculiarities of spring tillering of winter wheat varieties, which is very important, as in such a way there is a possibility to recover crop density after winter thinning.

Some of the determinative factors of detecting either the winter crop is ready to over-winter are temperature and light conditions during the period of autumn vegetation. Winter crops survivability depends on the capacity of the variety to resist unfavourable conditions as well as peculiarities of different agricultural ecosystems, in which it is grown. Such a situation contributed to a search for new or to improve the existing approaches as to frost- and winter resistance of grain crops. The systems of monitiring and forecasting of plants overwintering as well as the techniques of the ecological evaluation of crops frost resistance require some improvement.

The method of plant freezing in a seedbox under artificial climatic conditions (a cold room) has been widely used. It is known that a low-temperature stress results in hindering the plant growth, reducing the weight of a grain head, decreasing the amount of spikelets in a grain head and the length of a grain head. Trying to improve the yields, the plant breeders use in hybridization the varieties of an intensive type which are mostly not highly frost- resistant. New intensive varieties of winter wheat concede their extensive predecessors in winter resistance. Literature sources of a 45-year period (1927–1971) were analysed and the characteristic of 200 diagnostic techniques of winter-resistance of winter crops was given [1]. It has been established that winter-resistance is a very complicated and changeable property of a plant organism, which is stipulated by a complex of physical and biochemical characteristics as well as by morphological characters. In different regions, where winter wheat is sown, there are specific conditions of autumn-winter-spring period, but a potential frost-resistance is formed, as a rule, in 2-3 weeks after the autumn vegitation is over [2]. Multi-year research, conducted in a plant-breeding center of Myronivka Institute of Wheat after V.M. Remeslo, enabled us to show the dependence of frost-resistance on the ecological factors and on the genetic traits of a variety. Frost-resistance is a relative property. None variety under any growing conditions posesses absolute frost-resistance. The development of frost-resistance trait is determined by genetic factors and by autumn-winter-spring conditions of a vegitative period. It should be mentioned that, at present,

there is no common way of estimating and selecting frost- and winter- resistant forms, which is easy to use, simple, reliable and provides high credibility of the research. The goal of our research was to analyse the existing methods of assessing the frost- and winter- resistance of winter grain crops and on this basis to improve and to offer the technique of ecological evaluation and selection of winter wheat plants, triticale and rye which have higher frost-resistance, taking into account temperature and light parameters during the overwintering under specially created experimental natural conditions. The research was conducted in Forest Steppe (Myronivka Institute if Wheat after V.M. Remeslo) during 1989-2011, then the research continued under conditions of Polissia (Zhytomyr National Agroecological University) during 2011-2019 and since 2020 under conditions of Forest Steppe (Bila Tserkva National Agricultural University). Soil bathes 300 cm long, 100 cm wide and 50 cm high filled with black soil from the arable layer were put on appropriate racks 50 cm above the ground surface. In the third decade of September the varieties of winter wheat (50 seeds in each row, 7 cm of planting width) were sown in them. They were watered at the right time. The soil thermometers were installed when the vernalization conditions grew. By means of these thermometers was measured the temperature of the soil before its freezing in soil bathes and in cylinders. In 2020 the research was conducted when using 40 varieties of winter grain crops. They were sown late (on the 13th of November). Under such conditions they came through vernalization and hardening stages on the stage of germinated seeds.The first seedling appeared in the first decade of March. Practically all varieties overwintered to different extents, but some plants of winter barley Myrn variety, winter hard wheat MIW Lakomka and spring wheat- Myronivchanka have to be mentioned as survived. According to a research program, we are planning to receive the grain from these plants followed by their sowing under field conditions.

Thus, organic combination of natural extreme temperature backgrounds with field environment will promote to effective assessment and selection of plants, whose offsprings can be a starting material when creating new frost- and winter-resistant varieties. Under conditions of rapid climatic changes and the economic crisis, the introduction of such methods of assessment and selection will result in improving the efficiency of the ecologic selection.

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ADAPTATION MEASURES TO CLIMATE CHANGE IN WATER RESOURCES MANAGEMENT

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Today, at the international level, an approach such as the Integrated Water Resources Management (IWRM) is envisaged as a way forward for effective, equitable and sustainable development and management of the world's limited water resources and in order to meet conflicting demands.

When implementing IWRM, water authorities and their experts should be aware of the response of a particular water regime to human intervention and climate change in hydrological regimes and watercourses, including changes in land use, changes in water use, construction and management of dams and dams, and changes in interactions fresh and ocean waters, and be able to regulate these modes. The world community has developed standard methods for assessing and managing water-related risks, based largely on the ability to monitor and reproduce the environment on a variety of spatial and temporal scales. The functioning of the observation network on all water bodies and the general use of these observations is a key point for informed decision-making in the field of water resources management and minimization of negative consequences.

Existing water management methodologies, including the development of engineering structures, are generally based on the concept of stationarity of historical time series, which are extrapolated to the future, and the concept, which does not operate in climate change and adds additional uncertainties, especially to hydrometeorological extremes (floods and droughts).

To improve water management through the use of climate services, it is important to define the task and type of service, including climate forecasting products, seasonal indicative climate forecasts, downscaling products at different levels and various downscaling methodologies that describe assumptions and uncertainties. This requires the establishment of professional relationships between climate service developers and water managers at the scientific and operational levels.

The plan of the Water User Interface Platform (Water UIP)[1] provides a general framework for building partnerships and leadership, developing guidelines for the water sector, and opportunities to support and strengthen the decision-making process based on the use of climate information.

The main tasks in the implementation at the national level of the Water UIP should cover the following:

1. Identify the optimal methods for obtaining FEEDBACK from these communities on the usefulness and performance of climate services from the water community in support of IWRM.

2. Build DIALOGUE between users of climate services and information in the water sector and those responsible for the observation, research and information system components of the Framework.

3. Develop MONITORING AND EVALUATION measures for the Framework that may be agreed to between users and providers.

4. Improve CLIMATE LITERACY in the user community through a range of public education initiatives and on-line training programmes. In many instances there are opportunities for the better use of climate services, which are not taken up because of lack of awareness of their availability or capability.

5. Improve WATER LITERACY of climate service providers: strongly related to the dialogue aspects above, climate service providers need to better understand the decision-making context of water managers from different fields of application.

The connection between the weather and climate and the terrestrial water cycle, including the freshwater-ocean interface, appears fundamental, and thus a high level of synergy should exist between the disciplines involved. However, there are problems that are primarily related to the functions of the scale of operations, in water management operations are carried out at the scale of the basin, and meteorological information is usually available on a broader basis and in different spatial scales.

The main idea is to work closely with water and climate management professionals to develop tools and systems to help effectively predict and provide information and warnings that will improve water safety and sustainability through a significant increase in the time available to those involved water resources management, decisions and response measures.

Within the framework of the project “Multilevel Local, Nation- and Regionwide Education and Training in Climate Services, Climate Change Adaptation and Mitigation”,619285-EPP-1-2020-1-FI-EPPKA2-CBHE-JP (11/15/2020 - 11/14/2023), that is being implemented at the Odessa State Environmental University, it is planned to implement some of the tasks listed above. In particular, at the moment, a survey of representatives of the water industry of Ukraine has been conducted, in which 52 respondents from 32 organizations took part. Further analysis of the questionnaires will make it possible to identify the needs of the water sector in climate services, which will serve as a basis for the development of adaptation measures and strengthening cooperation in integrated water resources management.

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CYCLICITY AND PERIODICITY OF WATER RUNOFF OF THE SOUTHERN BUH RIVER AND THE POSSIBILITY OF ITS FORECASTING BY THE α METHOD

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Knowledge of the fluctuations in river flow is an important scientific and practical task. Now, scientific knowledge about the causes and factors of long-term cyclical fluctuations in river flow is very limited. There are judgments that such fluctuations are caused by the influence of not only climatic factors, but also processes that occur on a planetary scale, in near and far space. The influence of climatic factors on river runoff is the most studied. At the same time, we have a vague idea of space and terrestrial physical processes, as well as their interaction and influence on the formation of both meteorological and hydrological phenomena. There is very little research in this area. Nevertheless, such research allow to expand the knowledge about of formation mechanisms of a rivers water runoff.

Many scientists try to use the cyclic fluctuations of different duration for forecasting of rivers flow. One such approach is the long-term forecasting by the α method. It was developed by the Russian scientist Leonov (2010) in the investigation process of the time series cyclicity of rivers water flow of and lakes level around the world. Leonov was found a clear alternation of 15-year periods with increased and decreased flow.

The objective of this paper is to study the effect of solar activity, solar flares, comets, the Great Confrontations of Mars and Jupiter on the water flow of the Southern Buh, as well as its long-term forecasting taking into account its periodic fluctuations by the α method.

Investigation used the mean annual water flow on the Southern Buh near the Oleksandrivka village for the period 1914-2019, as well as the information about the solar activity, solar flares, the Great Confrontation of Mars and Jupiter, and the appearance of comets near Earth.

Correlation between the solar activity (expressed in Wolf numbers) and the mean annual water flow of the Southern Buh River near the Oleksandrivka village is the statistically insignificant, but in the years of maximum solar activity the mean annual water flow is on average 1.3 times the higher than in the years of minimum solar activity. In addition to the smooth fluctuations in activity, from time to time on the Sun there are flashes of varying power. For the Southern Buh River, it was found that the following year, after extreme solar flares, is observed a decrease in water flow. The mean decrease coefficient was 0.66.

The influence of comets with the approaching to the Earth is manifested in the changes of the electricity near-Earth space, increasing dustiness of the atmosphere, which, in turn, causes to a decrease in its transparency and increase precipitation. Following year, after the passage of comets near the Earth, there is an increase in the rivers water flow. For the Southern Buh River near the Oleksandrivka village, the mean increase coefficient of water flow is 1.21.

For the Southern Buh River near the Oleksandrivka village the multi-annual mean of water flow is 83.7 $m^3.s^{-1}$ (for the period 1914-2019). During the Great Confrontations of Mars, the mean annual discharges in the mean exceeds the multi-annual mean value by 1.12 times, and during the Great Confrontations of Jupiter – is only 0.91 from the multi-annual mean value. The next Great Confrontation of Mars will take place in 2035, and the Great Confrontation of Jupiter – in 2022. In these years the forecast values of mean annual discharges will be 94.1 and 76.0 $m^3.s^{-1}$, respectively.

Application of the α method for long-term forecasting of river water flow is possible in the case when in the time series have a sequential alternation of periods with increased and decreased water flow at a strictly defined of averaging period *T = 9, 10, 11, ..., n* years. On the Southern Buh near the Oleksandrivka village the time series of water flow have the successive alternation of 15-year periods with increased and decreased flow (Fig. 1). It is allowing to make a long-term forecasting of water flow for the periods 2012-2026 and 2027-2041. According to the forecast a significant increase in the mean annual water flow should be expected in the period 2020-2041 compared to 2015-2019 (Fig. 1).

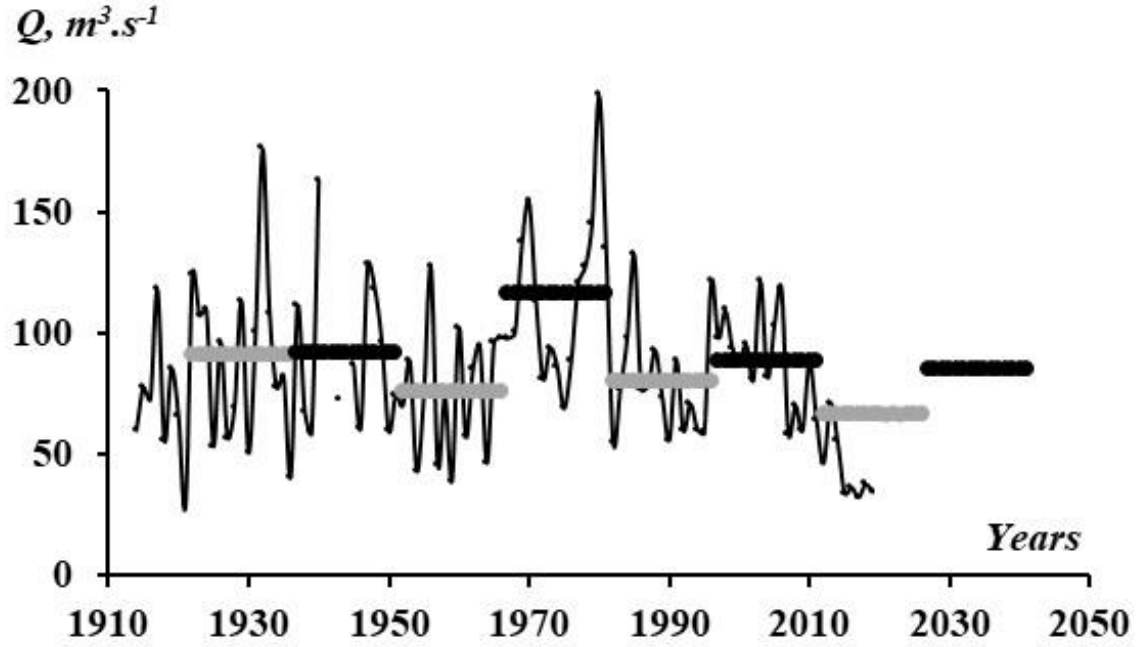

Fig. 1. Successive alternation of 15-year periods of water flow (gray color - years of low water flow, black color - years of high water flow) on the Southern Buh near the Oleksandrivka village and forecast for 2012-2026 and 2027-2041.

DISPERSAL AND DEVELOPMENT OF BEET WEBWORM LOXOSTEGE STICTICALIS (L.) IN DIFFERENT REGION OF UKRAINE

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The beet webworm *Loxostege sticticalis* (L.) belongs to the family Pyraustidae, type of Lepidoptera (Chen X. et al., 2008; Heppner J.B., 1998; Prado B.R. et al., 2011; Tunca H. et al., 2009). The beet webworm *Loxostege sticticalis* (L.) is characterized by cyclic outbreaks of population boom. Many scientists have tried to analyze the causes of this depredator's population boom. According to entomological chronicles, the first boom was dated in Ukraine in 1686 (Malysh J.M. et al., 2014).

It is a dangerous depredator that damages a wide range of crops, has high reproduction capability, adaptability and harm. They can fly over long distances and populate large areas within 2-3 days. This species is widespread in Eurasia and North America (Hampson G.F., 1899). This is a typical polyphagous depredator, and its caterpillars can damage plants from 35 families of crops (Karsholt O., Razowski J. (Eds.), 1996; Mayr E. et al., 2012; Michener C.D., et al. 1970). The favorable plants for it from agrestic weeds are like saltbush, bindweed, sagebrush to cultivated plants like beets, sunflowers, bean family. In different zones of Ukraine, one to three generations of the beet webworm *Loxostege sticticalis* (L.) develop in Polissia, the forest steppe and in the north of the steppe; there are two generations in the south of the steppe and three - in Crimea. The flight of the beet webworm *Loxostege sticticalis* (L.) is observed from May to October: the departure of the wintering generation starts at the end of April to May, the first - in June to July, the second - in July to September (Beletsky E.N., 1993; Masliiov S.V. et al., 2018; Pepper J.H., 2003).

The field data was obtained in 2021 at the research field in the different region of Ukraine (Zaporizhia, Luhansk, Donetsk, Kherson, Kyiv, Kharkiv, Dnipropetrovsk, Cherkasy regions).

In 2021, the first spring generation had the most favorable conditions for development - enough moisture, moderate temperatures, presence of flowering vegetation, which led to a significant increase in the number of depredators, especially in the centers of the southeastern and sometimes central areas. In most areas in the spreading zones, the beet webworm *Loxostege sticticalis* (L.), developed within three generations, except for Kharkiv, Poltava and Vinnytsia regions, where only two generations were noted.

The beet webworm *Loxostege sticticalis* (L.) flight began in mid-May last year. At the edges of the field of sunflower, winter wheat, corn, on noncroplands,

in perennial grasses in Kyiv, Kharkiv, Dnipropetrovsk, Cherkasy regions where the average number of depredators of bulla was from 2 to 22 ex./10 steps, sometimes in the centers of Zaporizhia, Luhansk, Donetsk regions its number ranged from 10 to 160 ex./10 steps. The flight strength of the meadow moths of the 1st generation (from 2 to 50 ex./10steps) was observed within all areas of the steppe zone and somewhat smaller (from 1 to 12 ex./10 steps) in Kyiv, Cherkasy and Sumy regions.

Mass rebirth of caterpillars began in early June. The caterpillars damaged beets, sunflower, corn, leguminous crops, perennial grasses. The average number of depredators was 2.0-12.0 ex./m², in Zaporizhia, Luhansk, Donetsk, Kharkiv, Sumy regions locally on lucerne, sunflower, soybeans, corn, sugar beet amounted to 6.0-14.0. ex./m². That means 5-20 % of plants were damaged.

Beet webworm *Loxostege sticticalis* (L.) flight of the 2nd generation began in the middle of June. Second generation of caterpillars was populated in the central and western regions and therefore from 4 to 22 % of plants within 2-10 % of areas of sunflower, corn was damaged. But the most locally were planted up to 46 % of areas of perennial grasses in Cherkasy region with the number of 0,3-6,0 ex./m². In the southern and eastern regions 8-28 % of plants were planted on the territory of 12-4 5% of sunflower areas, corn, in the amount from 2 to 12 ex / m², maximum - up to 30-55% of plants, that means up to 20 ex/m² that is on the threshold level in Zaporizhia and Mykolaiv regions. The third generation of phytophagus development occurred in the central regions from the end of August to the end of September. The flight strength of the beet webworm *Loxostege sticticalis* (L.) was different, in the eastern regions - 5 to 40 ex/10 steps, in the central ones - slightly weaker. The number of caterpillars was smaller than the previous generation (2 to 6 ex / m², maximum 32 ex. / m²) on the particular areas of Zaporizhia and Mykolaiv regions.

Since the beginning of 2000 the sunflower growing areas in Ukraine have increased twofold in fact and they exaggerated a scientifically substantiated and recommended index – 8 % in the structure of the crops interchange system without hard crop rotation which has become the main reason for a strong increase of the number of the beet webworm *Loxostege sticticalis* (L.) and appearance of a new-old pest, aggressiveness of which have increased to the utmost under such conditions. Thus, it can be concluded that within recent years, as a result of the ecological and economic factors (decreasing the land cultivation, deterioration of agricultural technology and global warming) constant locations of meadow moths were formed in the southern regions. The condition of the population indicates an average degree of threat. However, the danger of possible population boom of depredator wintering generation still remains in Zaporizhia, Luhansk, Donetsk and Kherson regions, somehow lower - in the northern and central regions.

THERMODYNAMIC FACTORS RESPONSIBLE FOR PRE-MONSOON THUNDERSTORMS OVER LAGOS AND KANO, NIGERIA

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The Convective developments occurring during February to May in Lagos are termed as pre-monsoon thunderstorms. Accurate prediction of thunderstorm during the pre-monsoon seasons over Lagos and Kano is very essential for human activities such as construction, aviation and agriculture. This work is based on the vertical atmospheric profile available from the (1200 UTC) radiosonde at Lagos and Kano Meteorological stations of Nigerian Meteorological Agency from January to December, 2014. Thermodynamic parameters such as equivalent and saturated equivalent potential temperatures, absolute humidity parameters (Specific humidity and saturated specific humidity with moisture availability were calculated, evaluated and daily profiles of each parameter was studied over the period using Matlab software. Kano was relatively warmer than Lagos based the values Θe and Θes and any day with a decrease in the value of Θe was an indication of convective activity for both Lagos and Kano. The stability of the atmosphere for the two stations was investigated and some thunderstorm indices such as; Convective Available Potential Energy (CAPE), the Convective Inhibition Energy (CINE), Lifted Index (LI) to show the amount of energy available for convection during the period of analysis was indicated using the Tephigram Mastery. The CAPE values indicate that the atmosphere over Lagos was very unstable with moderate lifting arising from convergence and thermal heating while over Kano, the atmosphere was found to be extremely unstable with very strong lifting arising from thermal heating. This profile method seemed to be a detailed analytical tool for forecasting pre-monsoon thunderstorm/rainfall.

Case Study: 7th, 8th, 9th and 10th May over Lagos.

Table 1 showed that on the 8th to 9th, the atmosphere was stable hence there were no lifting as shown by the values of the lifted indices; 52J/kg, 71J/kg for CAPE and 0, 0.5 for Lifted index as shown in the tephigram for those days. Invariably there were fair weather on these days. But on the 10th, the CAPE value was 3313J/kg the strong Lifted index of -5.9. The Convection Inhibition values for these days were -270 and -159 depicting that there was not enough energy for trigger off lifting. The thickness of the layer between the LCL and the LFC was seen to be larger on the 8th and 9th about 157m and 160m than on the 10th which was about 58m.

Table 1. Storm indices for 8th to 11th May over Lagos

DATE	LCL (hPa)	LFC(hPa)	L-I	CAPE (J/kg)	CINE (J/kg)
8/5/2014	934	654	0	52	-270
9/5/2014	960	679	0.5	71	-159
10/5/2014	963	905	-5.9	3313	0
11/5/2014	973	828	-1.6	727	-10

Case Study: 20th, 26th and 27th May over Kano

From table 2, it was observed that the atmosphere was moderately unstable with CAPE value of 33J/kg. The lifting was weak, the mid layer was humid, and the wind was easterlies as shown by the wind profile which is cool and dry causing subsidence as shown in the amount the inhibition energy (CIN ~ 271J/kg), hence no activity on that day. On the 26th, the atmosphere was absolutely stable, the values of Θ and Θe are almost the same showing that there was no energy at lower level hence the there was no CAPE on that day and the atmosphere was dry from the RH value of about 32% which was significantly low. But on the 27th, the atmosphere was very unstable (CAPE ~ 2392J/kg) and the parcel temperature warmer than the environment with moderate lifting. With equivalent potential value of about 370K, and relative humidity of about 42% and moisture laden wind extending up to 550hPa, and the LCL at 811hPa, there was convective low cloud and with moisture supplied by the AEJ., the storm was sustained to give rainfall amount of about 120mm.

Table 2. Storm indices for 20th, 26th and 27th May over Kano

DATE	LCL (hPa)	LFC (hPa)	L-I	CAPE(J/kg)	CINE(J/kg)
25/5/2014	790	708	-0.9	330	-271
26/5/2014	766	685	-4.2	0	-110
27/5/2014	811	708	-3.9	2392	-96

RESEARCH OF THE EXPECTED INDEXES OF WINTER CLIMATE DISCOMFORT IN UKRAINE

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Introduction. Despite the forecasted decline of expression of extreme colds, as a result of the global warming, they will continue to influence on considerable part of the European region, especially in north breadths. A surplus death rate is denoted in majority of European countries during winter period with the range from 5 to 30%.

The aim of this work is estimation of bioclimatic conditions of cold season on the basis of indexes of weather harshness and analysis of their dynamics in different regions of Ukraine.

Initial information. The database is presented by ranges of mean ten-day values of air temperature and wind speed in winter months for three researched periods (1986-2005, 2011-2030, 2031-2050) on twenty two stations (to determine the Bodman index). Besides there were used the minimum for twenty-four hours values of air temperature and mean daily values of wind speed on six stations to determine the Wind Chill Temperature Index, because exactly on these stations the most severe winters are educed on territory of the country and they are located in different regions of the country. All initial information is the result of modeling according to the A1B and A2 climate change scenarios.

Research methodology. One of the most commonly used methods for estimating severe weather in the winter season is the Bodman method. According to it, the degree of severity (harshness) of the weather S – Bodman bioclimatic index – is determined by the formula

$$S = (1 - 0{,}04t)(1 + 0{,}272v), \quad (1)$$

where t is air temperature, v is wind speed.

In addition, Wind Cill Temperature Index of Sipple and Passel (WCT) was used, which has the form (2) – this is the formula of the U.S. National Weather Service

$$WCT = 13{,}12 + 0{,}6215t - 11{,}37v^{0{,}16} + 0{,}3965tv^{0{,}16}. \quad (2)$$

With the help of this index you can adequately assess the risk of hypothermia and frostbite, give recommendations on how to dress and how to behave under certain conditions.

Research results. The results of calculations are the following. Mean on periods values of S are within the limits of 2-3 points on swingeing majority of territory of Ukraine, and it shows that in certain winter months and in average

mildly severe conditions prevail in winter period. But in regions (Uzhhorod) Bodman index even in January during three periods that was examined, will be less than 2 points, ie the winter here is not severe. Similar winter conditions in some periods can be expected in other parts of the country, especially in the south. It should be noted that S doesn't vary very much in different scenarios.

During all winter months Bodman index tends to decrease throughout the country.

Cold stress indices, including Bodman index, should be taken into account when studying the spread of infectious epidemics and "cold" diseases.

The analysis of calculations of WCT showed the following. According to A1B scenario in January and December during the first and second periods there can be even a high risk of supercooling and frostbite of open areas of skin for 5-10 minutes (WCT = -40÷-47 ºC), although maximal probability is 1,9% in Sumy. Most severe terms are at Sumy station in January-February during a period from 2011 to 2030: in 50% cases – small its risk of frost-bite (WCT = -10÷-27 ºC), discomfort, risk of hypothermia in case of the protracted being outdoors without appropriate clothing and 13% – a middle risk of frostbite of open areas of skin is during 10-30 minutes (WCT = -28÷-39 ºC).

In the third period, an increase in the Wind Chill Temperature Index is expected and in the winter months WCT = 0 ÷ -9 ºC will prevail, which means a small risk of frostbite, some discomfort.

The least severe conditions are in Kropyvnytskyi. And here the Wind Chill Temperature Index tends to decrease throughout the study time. At other stations, the recurrence of WCT values in the range of -10 ÷ -47 ºC from the first to the second period will increase, and from 2031 to 2050 it is expected to decrease.

According to A2 scenario, the recurrence of the Wind Chill Temperature Index in the range of 0 ÷ -9 ºC prevails in December-January of all periods except January 1981-2005, when its maximum recurrence is -10 ÷ -27 ºC.

The recurrence of WCT ≥ 0 and 0 ÷ -9 ºC in A2 scenario will significantly exceed the recurrence of these gradations in A1B scenario, ie it is in the latter scenario that more severe winter conditions are expected.

The weather conditions in February are tougher in the first and third periods, in the second – in January (according to the A1B scenario), in the second scenario for the whole studied period – in January.

It should be noted that such things like wet clothes (shoes), poor nutrition, lack of hot food, inability to warm up, blood loss, disease etc. increase risk of frostbite.

Thus, in general, the number of deaths in winter may decrease due to an increase in average temperature this season, but low temperatures on some days, which are expected in the future, will affect the spread of infectious epidemics and "cold" diseases and can lead to different stages of frostbite.

ASSESSMENT OF IMPACT OF FUTURE CLIMATE CHANGE ON THE LAND-BASED TRANSPORTATION OF UKRAINE BASED ON RCP SCENARIOS

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Transportation not only affects climate, but are strongly influenced with the climate conditions, and key hubs of the transportation sector are cities. The impacts will vary by mode of transportation and region of the country, but they will be widespread and costly in both human and economic terms and will require significant changes in the planning, design, construction, operation, and maintenance of transportation systems.

Database. In the study impact of climate change on operation of land-based transport along highways are analyzed on the basis of RCP 2.5 and RCP 4.5 scenarios. Modelled data were obtained from the EURO-CORDEX regional climate models such as SMHI-RCA4 (Sweden), MPI-CSC-REMO2009 (Germany) and CLMcom-CLM-CCLM4-8-17 (EU). To reduce uncertainty inherent to all scenarios, we aggregated the results of three models using averaging ensemble technique. Data contains series of daily mean and maximum temperature, daily liquid precipitation, daily mean relative humidity and daily mean and maximum wind speed, obtained for the period of 2021 to 2050 for 27 cities which are connected by road network. The road network contains 8 highways. The comparative analysis of the current results with the ones derived in [1,2] on the basis of one model data for RCP 4.5 and RCP8.5 scenarios was done.

Results. Both RCP2.6 and RCP4.5 scenarios showed that along all highways in question in the period of 2021-2050 mean monthly and annual temperature will increase by 2-3ºC, with respect to 1961–1990. Growth of temperature for RCP4.5 is predicted to exceed growth of temperature for RCP2.6 by about 0.5ºC. Extreme temperatures are observed more frequently. High temperatures bring on growth in frequency of wildfires and heat waves. The conclusions obtained compared with ones derived in [1,2] demonstrate more significant increase in temperature indicating that ensemble shows more plausible results if we'll take current rate of global warming into account.

For Ukraine average, in winter the extreme low temperatures as well as the extreme high ones are predicted to increase by about 2-3ºC, with respect to 1961–1990. Thus, in winter diurnal temperature range (DTR) remains the same as it was in the past. And in summer there will also increase in the extreme high temperature, but the extreme low temperature will sharply decrease by about 2-3ºC. It means that in the future in summertime the DTR will increase by 4-6ºC resulting in creating harmful conditions for operation of land-based

transportation. In [1,2] the DTR is predicted to increase by 8-9ºC in summer and winter for the most of territory of Ukraine. Such temperature fluctuations could affect very badly on land-based transport and transportation infrastructure.

Extreme high temperatures are predicted to increase by 2-3ºC, with respect to 1960–1990 and number of days with daily maximum temperatures higher than 30, 35 and 40ºC will significantly increase for southern and northern parts of Ukraine. For meridionally oriented routes number days with such temperatures could increase by 50 per cent. And for latitudinal routes (West and East Ukraine) number of such days is predicted to decrease.

For Ukraine average, annual minimum temperatures will increase by 2-3ºC in the period of 2021-2050, with respect to 1961–1990. Along all highways number of days with negative temperatures will sharply decrease. The conclusions obtained in [1,2] showed similar results, except number of days with maximum temperatures for which strong decrease was obtained.

For the most territory of Ukraine in the next 30 years precipitation is predicted to increase by 5-20% under the RCP2.6 scenario and by 10-35% under the RCP4.5 scenario, with respect to 1961–1990, except Uzhhorod city where increase in precipitation will be 37 and 47% for RCP2.6 and RCP4.5, respectively. Uzhhorod is located in in mountain region where growth in precipitation could cause flooding and landslides. The most part of precipitation (about 55-70%) will fall during the warm season.

For all stations slight precipitation (up to 5 mm^{-1}) is predicted to increase twice compared with the climate normal of 1961-1990. Increase in number days with such precipitation could reduce wet grip and rolling resistance creating hazards for transport. The heavy precipitation (more than 10 mm day^{-1}), on the contrary, is foreseen to decrease.

Results in [1,2] showed decrease in annual precipitation for both scenarios for the most part of Ukraine except the western mountain and northern regions, where precipitation amount increase on 35% (maximum increase in precipitation was predicted for Uzhhorod).

Mean annual wind speed will slightly increases (about 1 ms^{-1}) throughout Ukraine under both scenarios, except Dnipro and Chernivtsi. Number of days with high wind speed (more than 15 ms^{-1}) is predicted to be observed very rarely. The same results was obtained in [1,2].

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GROUND-BASED LIGHTNING DETECTION SYSTEM AS A TOOL FOR ESTIMATION OF EXTREME WEATHER EVENTS IN UKRAINE

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Ukrainian Total Lightning Network (**UTLN**), as a part of **Earth Networks**, installed in Ukraine is capable to detects the components of both intra-cloud (IC) and cloud-to-ground (CG) flashes, and algorithms use waveform shapes to differentiate between the IC and CG pulses (i.e., components) with a high efficiency and very precise spatial detection (200 m). Figure 1 shows sensors location, IC, CG lightning detection efficiency and lightning detection accuracy over Ukraine.

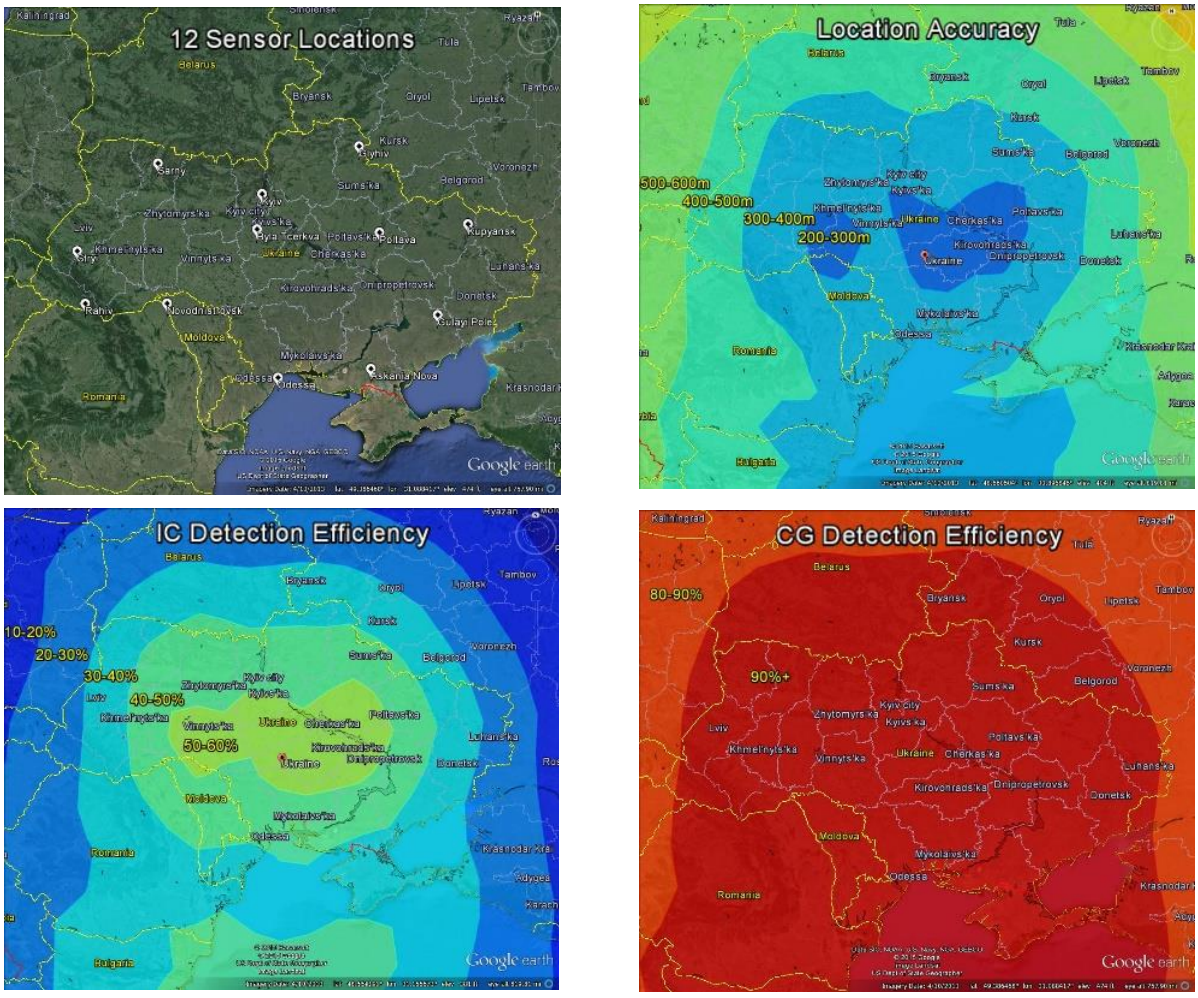

Fig.1. Sensors location, lightning detection accuracy, IC and CG lightning detection efficiency over Ukraine.

Many studies [1,2] have shown that the use of **total lightning** (IC and CG) provides significantly better identification of extreme weather events or/and storm severity. In order to define the components of total lightning detection and Dangerous Thunderstorm Alert at the first stage a lightning cell (a cluster of flashes with a boundary as a polygon determined by the flash density value for a given period) is estimated. Then the cell tracks and directions can be determined by correlating the cell polygons over a period of time (6 min). By counting the flashes in the cell, it is possible to estimate the lightning flash rate (flashes/min). The cell speed and area are also calculated. Once a lightning cell is located and tracked, the total flash rates, including **IC** and **CG**, are calculated. By monitoring the flash rates and the rate changes, the severe storm cells or the ones to potentially become severe, can be identified. When a cell is identified and the total lightning rate jumps passing the threshold, a dangerous thunderstorm alert (DTA) can be issued. The threshold of total lightning rate may vary in different regions or different type of storms. To simplify the study, a threshold of 25 flashes/min was chosen. Combining the information from the cells, such as the moving speed and direction and size of the cell, a warning area ahead of the storm cell can be determined. The cell may reenergize and repeat the process again and trigger more alerts. Depend on severity of storms there are three levels:

- level 1 (flashes/min in lightning cell < 10);
- level 2 (<10 flashes/min in lightning cell < 25);
- DTA (flashes/min in lightning cell >25).

The results showed that these data could be a new, qualitative source of data for climatological studies, as well as real-time data acquisition allows the creation of a series of products for a wide range of consumers interested in a short-term forecasting.

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CLIMATE SERVICE PROBLEMS. FOOD SECURITY WITH WOFOST MODEL

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Food security is one of the key issues of any country, because it is the key to its social stability and sustainable socio-economic development. For many countries, this problem plays a significant role due to the lack of economic development, as well as significant climate change.

To solve this problem, we need a tool that allows to assess the production of agricultural products at the state level - the biophysical model. This model will allow to quickly and efficiently assess changes in meteorological conditions, their impact on vegetation development, possible yields, measures to ensure food security, support agricultural producers and marketing policies. Currently, one of the most popular biophysical models is WOFOST, which was originated in Wageningen and implemented in the CGMS system (Crop Growth Monitoring System), developed at the Joint Research Center EC (Ispra, Italy). Today, the WOFOST model is used in many countries around the world, including Ukraine [1].

The motivation of this study was to show the possibility to estimate the Climate Change impact on biomass production of crops in the next decades up to 2050 in Ukraine using WOFOST. Eventually the results of this study shall help the formulation of appropriate policy options and the development of adequate policy instruments to support the adaptation to climate change in Ukraine.

This study has been realized in collaboration between Ukrainian Hydrometeorological Institute (UHMI) and World Bank.

The analysis includes the following crops: barley, maize, soybean, sunflower, and winter wheat. Projections have been developed for the 2030- and 2050-time horizons using two climate scenarios: RCP 4.5 and RCP 8.5.

WOFOST was adapted for use in Ukraine [1,2] through:

- Generation of a new soil database based on a soil map of Ukraine 1:2500000 with spatial resolution 10×10 kilometers (km). Data obtained for 40 soil types were correlated with WRB (World Reference Base for Soil Resources) soil classification and correspondent soil physical characteristics.
- Calibration of phrenological coefficients for crops (sowing date, sum of temperature from sowing to emergence, emergency to anthesis and anthesis to maturity) based on phrenological observations on local agrometeorological stations.

The study has been carried out at a highly granular level, covering more than 7400 grid cells. The yield projections from WOFOST model in the first phase have been aggregated to provide analysis at the oblast level, which is a compromise between spatial variability and supply of information at a level that allows for policy discussion. This aggregation of data allows policymakers to examine the significant differences among administrative regions regarding climate change impacts on agriculture.

In the table 1 changes in overall production for major crops due to climate change are presented (based on the mean changes in yields multiplied by the crop areas in each oblast are relative to 2010 levels).

Table 1. Changes in overall production for major crops due to climate change.

	2030		**2050**	
	RCP 4.5	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
Barley	- 3%	- 11%	- 14%	- 15%
Maize	- 12%	- 3%	12%	15%
Soybean	20%	22%	13%	19%
Sunflower	- 11%	- 3%	- 8%	- 5%
Wheat	32%	34%	43%	55%

Barley and sunflower show a consistently negative trend under both RCP 4.5 and RCP 8.5. The changing climate conditions until middle of the century will become beneficial for maize. Wheat and soybean show a clear positive trend until middle of the century in both scenarios. However, these trends should be interpreted as indicative, with considerable uncertainty ranges for the production of each crop in each region. It is important to note that the crop production simulation assumes the reallocation of land for each crop as an adaption measure.

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REGIONAL EVALUATION OF CHANGE IN THE SUM OF ACTIVE TEMPERATURES FOR OPTIMIZATION OF AGRICULTURAL PRODUCTION

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Each crop has a growing season, which differs in early and late varieties. It is the maturation period that is affected by the sum of active temperatures (SAT) (°C). The more heat-loving the culture is, the greater the amount of active temperatures it needs [1, 2].

Therefore, in order to adequately assess the prospects for changing the structure of sown areas in the region according to climate change, it is advisable to study trends in the amounts of active temperatures and take them into account when selecting crops for cultivation.

The purpose of this work is a regional assessment of changes in the sum of active temperatures (SAT) (°C) over the last quarter of a century to adjust the structure of sown areas of major crops.

Now, as a quarter of a century ago, the structure of sown areas of Kharkiv region is dominated by cereals and legumes, sugar beets, sunflowers and potatoes [3]. The authors have used a correlation analysis to determine the current dependence level of sown area sizes on climate change over the last quarter of a century. According to its results, we have found that between SAT (°C) and the area of crops of cereals, legumes and sunflower a there is an insignificant direct linear relationship (correlation coefficient 0.5), for sugar beet there is a slight linear feedback (correlation coefficient -0.35), while in other crops there is no linear correlation. That is, we can say that there is no obvious relationship between the components.

To increase the productivity of agricultural crops in the conditions of climate change, it is absolutely necessary to bring the structure of sown areas in line with the existing climatic conditions of the region. For this purpose, we conduct research on the dynamics of the SAT (°C) of Kharkiv region and year-on-year fluctuations and deviations from the long-term average (Fig. 1).

The authors revealed a tendency to gradual growth of SAT (°C) on average for the region with significant year-on-year fluctuations, which is confirmed by the trend line with positive coefficients.

At the same time, since 2012, the deviation from the average long-term SAT (°C) indicator has been negative. This was tendency was not found in the first decade of the study period when annual fluctuations occurred - some time above or below the average.

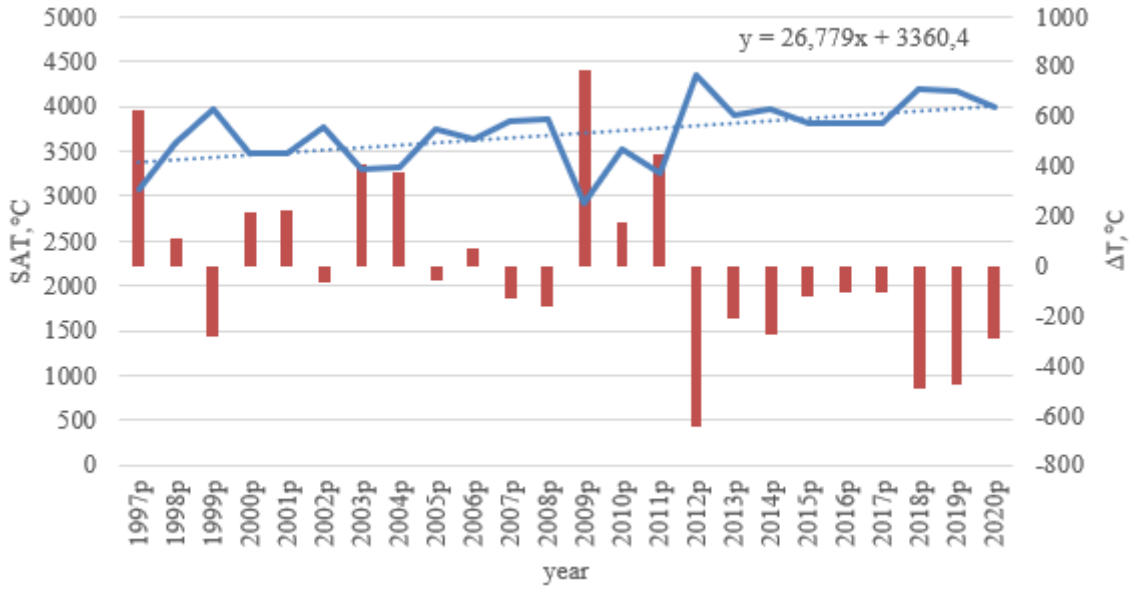

Fig.1. SAT (°C) dynamics and deviation from the long-term average.

To ensure good yields in such conditions, it is necessary to monitor and coordinate agricultural production constantly with temperature fluctuations.

The authors carried out a detailed monthly analysis of SAT (°C) changes and identified characteristics of agricultural crops that should be grown in the region in accordance with recent climate change.

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EFFECTIVE PURIFICATION OF LANDFILL FILTRATES IN THE CONTEXT OF POLLUTION MINIMIZATION PROVOCATED BY CLIMATE CHANGE

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Due to the lack of a solid waste management system (MSW) in Ukraine, a significant number of them still continue to be stored on sites that are not equipped with systems:

- collection and purification of filtrates;
- shielding of the bottom and prevention of leachate into groundwater;
- collection of biogas at storage sites (landfills).

This situation in the management of solid waste provokes pollution of the hydrosphere and atmosphere, and hence an increase in the dynamics of climate change. The situation is greatly complicated by the lack of effective technologies for treatment of landfill leachate, which are collected in reservoir lakes or filtered into groundwater, causing not only environmental pollution but also provoking climate change and preventing further technical and biological reclamation of landfills. And the existence of non-reclaimed landfills poses serious environmental threats and contributes to the dynamics of climate change.

Thus, the total number of solid waste storage facilities in Ukraine today is estimated at 6,700 units, and their total area - 10,000 hectares. Based on the average annual height of the precipitation layer of 500 mm / year and the values of the runoff coefficient of 0.05−0.1, annually at these sites is formed 2.5–5 million m^3 of filtrates. The largest volumes of filtrates (about 100 thousand m^3 and more) are collected in storage ponds at the largest landfills in Ukraine, in particular, at the Kyiv and Lviv (Hrybovytchi) landfills. Depending on the degree of dilution by atmospheric water, the concentration of the main pollutants in the filtrates is 5–50 times higher than the limit values. Due to the lack of organized collection and treatment of leachate in many landfills and dumps, highly toxic effluents enter directly into soils, groundwater and surface water, causing great damage to the environment.

Problems of purification of the landfill filtrates are relevant during the design, operation and planned closure of these facilities. At the design stage, as a rule, an innovative technology of purification of the filtrates collected by the drainage system is laid, the productivity of which corresponds to the calculated one. During operation, the priorities in choosing the method of leachate purification depend on the history of operation and the state of the filtrate collection system. As a rule, in Ukraine at the stage of closing landfills there is no

treatment system at all, and quite often uncontrolled leakage of leachate leads to the accumulation of significant volumes in storage ponds.

In solving the problem of liquidation of ecological danger caused by filtrates from landfills and dumps in Ukraine at the stage of their liquidation and reclamation, it is necessary to distinguish two characteristic stages:

- stage №1: purification of accumulated filtrates in order to rehabilitate the landfill or dump
- stage №2: purification of leachates, which for decades will continue to be formed in the body of the closed landfill as a result of biological processes of the waste`s organic component decomposition.

It is inefficient to envisage a single technology for the implementation of these two stages both from a technological and financial point of view. Technologies that are traditionally used to purify the filtrates of existing landfills (reverse osmosis, evaporation and drying, filtrate binding, biochemical treatment in anaerobic and aerobic environments) are energy and resource-intensive, their implementation requires significant capital and operating costs, implementation of them in practice, it is often inefficient for accumulated leachates and landfills that are closed and subject to reclamation.

It should be noted that the composition of filtrates differs significantly for different landfills where they are formed. To a large extent, their composition is determined by the composition of the most stored waste, geographical and climatic conditions of the storage site, the age of the landfill where they are generated. Therefore, we investigated the treatment of leachates of both the "old" landfill (Hrybovytchi landfill) and the "young" landfill (Chervonohrad landfill).

We have proposed a biological aerobic technology for pre-treatment of leachates in landfills and dumps. Laboratory researches are carried out for the purpose of establishment of optimum parameters of realization of biological aerobic technology of purifying landfill filtrates. It is established that in the conditions of aeration after some time the biocenosis in the mass of filtrates is inactivated, which is resistant to the action of concentrated contaminants and successfully uses them in its food chains. For both investigated types of filtrates, the technology of biological aerobic pre-treatment proved to be effective. Thus, the optimum delay time in an aerated environment in the case of biological aerobic treatment for the filtrate at Hrybovytchi landfill and the selected study conditions is 11 days. In this case, 35% purification of filtrates from ammonium ions and 50% reduction of COD is achieved.

Based on the analysis of the research, recommendations for the practical implementation of the proposed technology for purifying landfill filtrates. The basic schemes of research unit of preliminary purification of landfill and dump filtrates are offered.

CLIMATE SERVICES AND VULNERABILITY OF WATER RESOURCES

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The objective of this paper is to assess present and future vulnerability of water resources at different spatial units ranging from local, to national and continental scales in the South East European (SEE) region. This EU-project (CC-Ware) has been executed in close collaboration with governmental institutions from Austria, Bulgaria, Croatia, Greece, Hungary, Italy, Romania, Serbia, together with water supply companies in this region. The final task was to elaborate water supply strategies for local and large-scale water suppliers. A time span from 1961-2050 has been analyzed under consideration of climate change, economic and technological development including demographic and land use changes. These changes originated from several climate change models and possible EU-development strategies to describe the main drivers acting on water resources vulnerability.

Methodology. Following IPCC definitions, vulnerability was defined by the degree to which a system (water resources) is susceptible to adverse effects of climate change, including climate variability and extremes. Vulnerability of freshwater resources is characterized by several indicators describing water availability, increasing demand and the future qualitative state of the environmental system in comparison with drinking water standards. The methodology applied in CC-WARE builds on this description of vulnerability by examining the exposure (predicted changes in the climate), sensitivity (the responsiveness of water resources to climatic influences) and adaptive capacity (the ability of land cover types with relation to water resources to adapt or to cope with the climate changes) in the SEE region (Figure 1).

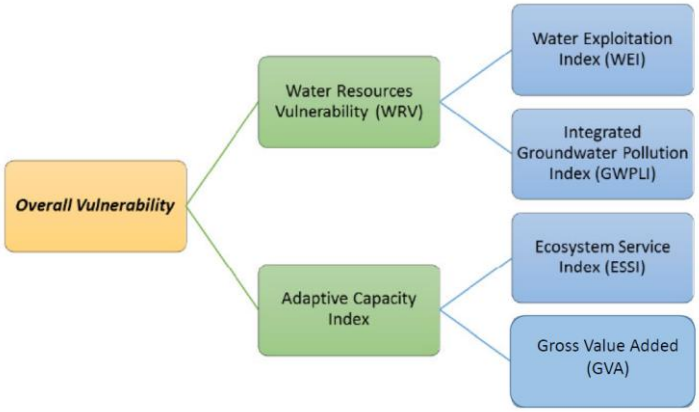

Fig. 1. Schematic diagram to assess overall water resources vulnerability

The combination of several indicators into a single overall water resources vulnerability depends on the weighting of individual indicators and on the type of combination. A weighted distance based approach has been applied to put the emphasis on the weakest element.

Database. Referring to the boxes in Fig. 1, the following data were utilized. The water exploitation index is the ratio of total water demand, including domestic, agricultural and industrial requirements, and water availability, characterized by total runoff in a spatial unit. These quantities were obtained at a 25x25 km grid scale, from local analysis at a 1x1 km scale, covering the catchment of the intake area. The hydro-meteorological data referred to precipitation, potential evaporation and temperature. These data were obtained from climate models including RegCM3, ALADIN and PROMES models between future (2021-2050) and present (1961-2020) period. The climate model data were adjusted by quantile mapping technique.

The "integrated groundwater pollution index" was derived from land use data (Corinne data set) and hydrogeological maps characterizing the vulnerability of water resources.

Ecosystem services (ESS) for water supply were assessed with respect to three elements: Provisioning Ecosystem Service, Water Regulation and Water Quality Regulation. For estimation of the ecosystem services potential for drinking water, an indicator has been assigned to each land use category and ESS type to reflect its role in water supply. E.g., extended wetlands or forest covers reduce the vulnerability while intensive agriculture over a shallow aquifer increases the risk.

The economic wealth of a region/country provides options to take alternative measures to ensure high quality drinking water supply. The EU-development strategies refer to the PRELUDE scenarios for future land use changes, described in detail in EEA reports.

Results. The water supply schemes in the SEE-region include quite different water bodies exposed to different climate regions. Vulnerability maps were established for different climate change ensembles as well as economic development paths, providing a sound information source for risk identification of water supply schemes. Several country specific supply schemes were analyzed in detail and strategies were jointly elaborated with companies to cope with future risks emerging from climate and/or global change. Guidelines for long-term safeguarding of water resources were elaborated for the whole SEE-region.

PROBABILISTIC-STOCHASTIC MODELING OF THE SPRING FLOOD MAXIMUM RUNOFF AS A PART OF THE CLIMATE SERVICE IN THE WATER MANAGEMENT OF UKRAINE

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Water services or agencies and professionals are dealing with the impact of human interventions and climate variability and change on flow regimes. Water is a key driver of economic and social development while it also has a basic function in maintaining the integrity of the natural environment. However water is only one of a number of vital natural resources and it is imperative that water issues are not considered in isolation. Managers, whether in the government or private sectors, have to make difficult decisions on water allocation. More and more they have to apportion diminishing supplies between ever-increasing demands. Drivers such as demography and climate change further increase the stress on water resources.

As a result, the Integrated Water Resources Management (IWRM) approach, a more holistic approach to water management, has now been accepted internationally as the way forward for efficient, equitable and sustainable development and management of the world's limited water resources and for coping with conflicting demands.

The water community has a need for a range of services to support decisions relating to a range of uses related to IWRM planning, which include:

- Identification of extreme weather and climate hazards that pose water-related risks;
- Identification of populations vulnerable to weather and climate hazards, including those in the coastal zone;
- Allocation and re-allocation of water resources;
- Design and placement of infrastructure and personnel (i.e. water management organizations, structures and facilities);
- Implementation of risk management and emergency preparedness practices and procedures;
- Dissemination of information to users, including the public, i.e. Public Service forecasts and alerts;
- Development and implementation of water and environmental policy;
- Development and implementation of water and flood management policies and strategies;
- Development and implementation of water management regulations and laws.

The water-related priorities and activities articulated in this Water UIP implementation plan will inform and benefit from the developments made in the

other pillars of the Framework, Climate Services Information System (CSIS), Observations and Monitoring (OBS), Research, Modelling and Prediction (RMP), and particularly, Capacity Development (CD)[1].

Probabilistic-stochastic modeling of individual phases of the water regime of rivers refers to water-related priorities Research, Modeling and Prediction (RMP). Most of the lowland rivers of Ukraine receive their main nourishment from the inflow of water during the spring flood. The volume of spring river runoff forms a supply of fresh water for the entire agro-industrial complex of the region and contributes to an increase in the efficiency of management decisions with the rational use of water resources. On the other hand, with the formation of catastrophic floods, there is a threat of water coming out to the floodplain, flooding of industrial and populated areas, cultural heritage sites and the emergence of economic losses, threats to human life. At the same time, the runoff of small rivers is also significantly influenced by the inflow of flood waters in summer and autumn. The author proposed a new modified version of the operator model for determining the maximum runoff of spring flood, which allows taking into account the possible impact of climate change on the estimated values of the maximum modules 1% probability of exceeding. Climate change is taken into account by introducing a separate coefficient, based on a comparison of the main parameters of the method obtained on the basis of current data (maximum snow supply at the beginning of the spring flood, precipitation during the spring flood and runoff coefficients), and similar values obtained from climatic modeling data.

For the plain rivers of Ukraine the author's modified version of the calculating method for determining the characteristics of spring flood in climate change conditions has implement. The implementation of the proposed calculation option using different models and scenarios has shown that the results differ significantly, but in practically all cases up to 2050. It is forecasted a significant decrease in the runoff of spring flood (from 10-20% in the north and 40-50% in the south Ukraine). At the same time, there is a possibility of high local rain floods during the warm period of the year, which can lead to significant losses and sometimes to human losses [2].

The results of modeling the maximum runoff of rivers taking into account data on climate change should become an important component of the climate service system that is being created in Ukraine.

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ACTUAL INDICATORS OF CHANGES IN CLIMATIC CONDITIONS IN THE AGRICULTURAL SECTOR

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Global warming is observed in the world. Climate change is manifested in the growth of the average annual temperature on the planet's surface, rising ocean levels, increasing the number of natural disasters and cataclysms [1]. Studies are being conducted on all human-populated continents in different climatic zones.

The main measure to fight the global warming today is the Paris Agreement; it's a global agreement between countries to take measures to keep temperatures rising below 2 ° C compared to the pre-industrial period and measures to limit temperature rises to 1.5 ° C compared to pre-industrial. To do this, it is necessary to limit greenhouse gas emissions (CO2, CH4, N2O and halocarbons) into the atmosphere [2].

Active study of global climate change, the effects of heat stress on the body and productivity of farm animals began in the 50-60s of the 20th century.

A significant number of scientific articles have been published on this issue. The southern regions of Ukraine are characterized by a decrease in precipitation with a simultaneous increase in temperature. This leads to increasing droughts, desertification, weakening food security and threatening to reduce natural diversity. Our data show a significant increase in temperature load in the Kherson region: in 2012 it exceeded long-term norms by 67%, and in 2020 by 35%. Ukrainian scientists claim that by 2030 the duration of the period with temperatures above 15 °C in the southern steppe will be 183 days (average monthly 61 temperature in July is 24.1 °C), and in the north - 174 days (average monthly temperature in July is 23 °C) [3].

A study by British scientists [4] showed that each degree of global temperature increase leads to a multiple increase in the frequency of heat waves and heat stress. The analysis conducted by scientists proved that the number and duration of heat waves in Ukraine is growing [5]. Thus, the study of the effects of heat stress in Ukraine and especially in its southern regions is relevant.

The state of the modern climate is due to changes in large-scale atmospheric circulation, namely changes in the position of the centers of action of the atmospheric circulation and the atypical distribution of warm air masses in the troposphere, which is a consequence of global warming. This causes changes in air temperature, precipitation, increasing natural meteorological phenomena [6]. These factors affect the functioning of Ukraine's economic complex and require

the development and implementation of measures to adapt the cattle to climate change in all regions.

In Ukraine, every 10 years the temperature rises by an average of 0.3–0.4°C, i.e. in 30 years it will increase by 1 °C. According to the scientists from the Institute of Botany of the National Academy of Sciences of Ukraine, this can lead to the movement of natural areas for 160 km [7].

According to the data of Ukrainian Hydrometeorological Center, warming will continue and the temperature will rise by an average of 0.2–0.3ºC. The temperature rise in Ukraine is faster than the global rise.

If this trend continues, there is a risk of drought, which will lead to the cultivation of crops in the southern regions in 2030 only in the conditions of irrigation, which will affect the state of the fodder base and, accordingly, will negatively affect the prospects for the development of dairy and meat cattle breeds in Ukraine.

To reduce climatic risks in animal husbandry, it is necessary to study how potential environmental stress factors (temperature, humidity, heat radiation, wind speed) can directly affect the functioning of the animal and their health, the realization of genetic potential.

The problem of heat stress is extremely relevant in regions where the weather is characterized by high positive temperatures and humidity.

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ESTIMATION OF NO_2 AND SO_2 INCREASE DURING THE HEATING SEASON IN UKRAINE USING TROPOMI DATA

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Ukrainian Hydrometeorological Institute, Ukraine

The heating season, which usually lasts from November till March in Ukraine, plays significant role in air pollution. The increase content of different pollutants affected population and might strengthen health problems [1, 2]. Relatively low number of monitoring sites could not provide the full picture of air pollution during the heating season. Analysis of satellite data showed that rural areas and remote regions also are affected by air pollution [3] and air quality management also is needed there. This study is aimed to estimate the spatial scales and the level of NO_2 and SO_2 content increase during the heating season.

The study is based on two offline (OFFL) products derived from the TROPOMI instrument (Sentinel-5P satellite): NO_2 tropospheric and SO_2 total column number density. The total period from November 2018 till March 2021 was divided into 5 intervals: 3 heating seasons (2018/2019, 2019/2020, and 2020/2021) and 2 warm periods between them (in 2019 and 2020).

The prevailing fuel which is used by power plants defines the features of air pollution in Ukraine. The coal-fired power plants caused significant CO, NO_2 and SO_2 content increase, while the gas-fired – mainly NO_2. Hence, it is possible for using TROPOMI data for detecting the emission sources which are used different fuel and analyze the air pollution. Due to the shorter lifetime of NO_2 and SO_2 in the atmosphere, in comparison to CO, these pollutants better indicates air quality changes during the heating season over particular regions and industrial areas.

NO_2 tropospheric column is 5–10 times higher during the heating season than during the warm period (fig. 1). The most elevated pollution levels observed over the eastern part of Ukraine reaching $1.3–1.4 \cdot 10^{-4}$ mol/m^2.

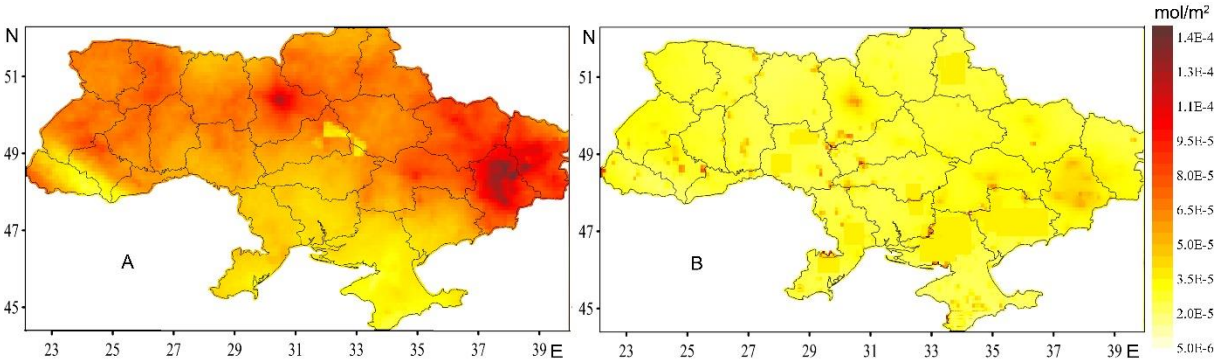

Fig. 1. Average NO_2 tropospheric column number density during the heating season (A) and during the warm period (B).

High NO_2 content was observed also on the northern and the western part of Ukraine. Looking on the south, it is well seen the role of warmer weather in lower emissions and better air quality conditions. NO_2 concentrations there are close to the non-heating period and vary within $2.0–5.0 \cdot 10^{-5}$ mol/m^2.

It must be noted that the emissions from power plants is not the only reason for elevated NO_2 content. Unfavorable weather conditions for NO_2 removal together with frequent air temperature inversions contribute to air pollution.

SO_2 total column number density allowed to detect coal-fired power plants and the regions with intense domestic heating (fig. 2). SO_2 content is 10–20 times higher during the heating season reaching $1.7 \cdot 10^{-4}$ mol/m^2 over industrial regions with coal-fired power plants. The most polluted regions are the eastern part of Ukraine and near the Carpathian mountains.

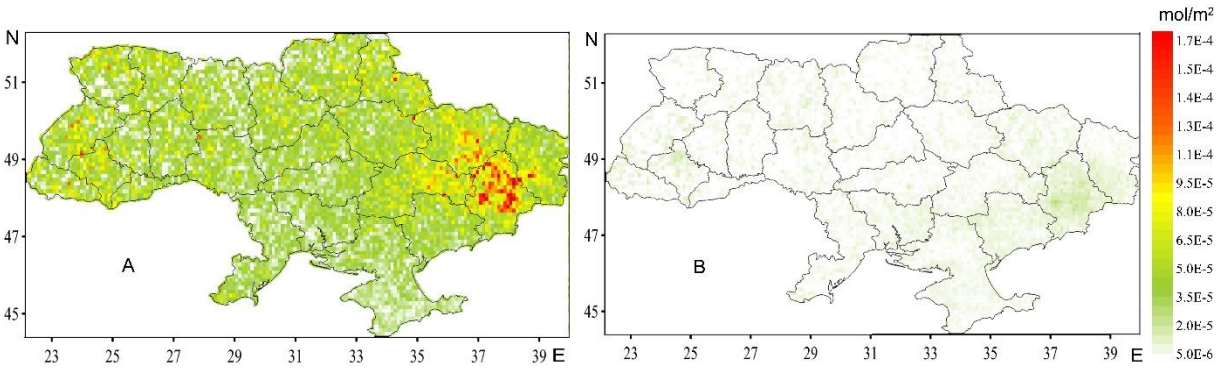

Fig. 2. Average SO_2 total column number density during the heating season (A) and during the warm period (B).

The usual average SO_2 column number density over the most polluted areas during the warm period is of about $2.0–4.0 \cdot 10^{-5}$ mol/m^2. The heating season caused SO_2 increase to these values even in rural areas (fig. 2a), whereas daily values over coal-fired power plants could reach $2.2–4.0 \cdot 10^{-3}$ mol/m^2.

Concerning the limitations of ground-based measurements connected with spatial coverage, the satellite data seems one of the best instruments for air quality management during the heating seasons. TROPOMI NRTI data could be used for warning about potential elevated pollution levels by NO_2 and SO_2, while the OFFL data gives good qualitative approach for estimation the consequences.

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CLIMATE SERVICES AND AGRICULTURE: UNDERSTANDING THE DEMAND SIDE. SMALLHOLDERS PERCEPTIONS IN ODEMIRA, PORTUGAL

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Being faced with climate change and an ever-growing number of social, environmental and economic challenges, coherent policy design requires a careful consideration of the interactions between climate patterns, agricultural trends and the achievement of food security. Climate change has been affecting agriculture in many different ways through divergent patterns and factors such as biological diversity and soil loss or incidence of pests/diseases have been challenging our ways of agricultural management. Even if, from a sustainable development point of view, keeping focus on the needs of the most vulnerable – i.e. the small-scale or traditional farming agents – is considered pivotal, sound understanding of local risks and vulnerabilities are often overlooked.

This entry seeks to clarify what kind of needs, risks and vulnerabilities the local population face and explore what kind of strategies, frameworks and instruments the local small scale population use to increment regional adaptive capacity, when facing the limitations imposed by a changing climate and society. At the same time, through semi-structured interviews, this entry explores the perceptions of marginalized local small scale farmers regarding a) impacts of climate change and assessments of local vulnerabilities; b) ways or platforms used by the small scale farmers to collect climate-relevant information; c) understand what are the climate service information needs defined by the local population.

The case study was selected based on the sociological, economic and environmental patterns and tensions that can be observed in the region of Odemira: on one side, the municipality of Odemira considers climate change to be one of the most important challenges of the 21st century and is an integrant part of a Climate Adaptation Strategy (ClimAdaPT.Local). On the other side, Odemira, being Portugal biggest municipality, in terms of hectares, can be characterized by extensive livestock sector (cattle, sheep and goat) that marks the physical and economic landscape of a large area of the region. Equally essential to the agricultural production in the territory is horticulture, fruit growing and intensive floriculture. This type of high input development in the agricultural sector often clashes with the more traditional farm management, that is associated to small scale farms. This eventually could lead to competition for resources and ecosystem services, reason for future turmoil and social and environmental injustices.

SCIENTIFICALLY SUBSTANTIATED RECOMMENDATIONS OF WATER MANAGEMENT OF KATLABUKH LAKE UNDER CURRENT AND FUTURE CLIMATE CHANGE

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The relevance of the work is related to the study of water and salt regimes of the Danube Katlabukh Lake, which is one of the sources of water supply in the southern region of Ukraine. In this case, the hydrological regime of the lake is poorly understood, and some components of the water and salt balance do not have systematic observations, which requires the development of methods for their assessment and determination. In recent decades, water exchange in the lake, as an artificially regulated reservoir, has deteriorated, leading to a critical decrease in water levels and an increase in the mineralization of water in it. This has led to restrictions on the use of lake water for water management and drinking water supply [1]. Therefore, one of the important tasks is the restoration and rational use of the natural resources of Katlabukh Lake, improving its hydrological and hydrochemical regimes in the interaction of natural and anthropogenic factors and in the conditions of present and future climate fluctuations, developing recommendations for improving the conditions of the reservoir's functioning.

In terms of climate, the study area is characterized by a temperate continental climate with insufficient humidity. The annual rainfall (for the period 1961-2020) for the meteorological stations Bolgrad and Izmail are 487 mm and 454 mm (respectively), and their greater mass (from 64-66% of the annual sum) falls in the warm period (IV-X). The average annual air temperatures at these stations are 10.9°C and 11.1°C and are higher by 0.6-0.5°C than the climate standard.

Analysis of the data on observations of air temperature and precipitation at the meteorological stations Bolgrad and Izmail as a whole confirms the available data on the current warming of the climate - the increase in annual air temperatures over the period 1961-2020 averages 1.0 °C than the climate standard. Synchronization is observed annual rainfall and temporal trends are insignificant. Regarding the evaporation values from the water surface (station Bolgrad), which are an expense component of water balances of reservoirs, with the average annual (for the period 1960-2020) the evaporation value for the year 819 mm, they tend to increase, especially since 2012.

The research of the water regime of Katlabukh Lake [1], its rivers and the Danube [2] have shown that they have long-term trends and seasonal variations, and for Katlabukh Lake they have a regulatory influence on hydraulic structures. Against the backdrop of not significantly decreasing water levels in the Katlabukh Lake (1980-2020), in recent years (since 2012), there have been long-term seasonal reductions, with minimal levels sometimes below the dead storage (LDS = 0,7mBS). In the hydrologic regime of the rivers Veliki Katlabukh,

Yenika and Tashbunar, which flow into Katlabukh lake the development of anthropogenic use of rivers, as well as the current climatic conditions have led to a decrease in the water content of the rivers and a deterioration of water quality in them.

It is established that the main reasons for increasing the water mineralization of the lake are the seasonal decrease of the water levels in the lake (almost to the mark of LDS = 0,7mBS) due to the increase of evaporation volumes from the water surface and reduction of water exchange from the Danube. The deterioration of water exchange conditions in the reservoir is also associated with a decrease in irrigation water intakes in the northern part of the reservoir, which led to critical values of water mineralization in this water area of the lake (up to 3.1-3.35 g/dm^3 and more). At the same time, in the southern part of the lake, where water is exchanged with fresh water in the Danube, the water mineralization is somewhat lower - by an average of 18%. The estimated values of mineralization were obtained in water-salt balances slightly higher than observed, which resulted in a decrease in the flow of mineralized waters of rivers flowing into the lake in the current period of their water (by about 50%) [1].

Using data from the SMHI-RCA4 Climate Model Ensemble (RCP4.5 scenario), the variability of water levels and lake salt regime was simulated under current (2006-2018) and future climatic change (up to 2050). It is established that the modeled and, according to the climate models, the level and, accordingly, the salt regime of the Katlabukh Lake are largely determined by the water content of the Danube, which will change in the coming decades due to climate change. Therefore, the results of the evolution of the simulated levels and the mineralization of the water in the lake serve to illustrate their sensitivity to climate change scenarios (greenhouse gas emission trends) rather than to the actual prediction of the lake water level and mineralization.

Scientifically substantiated recommendations of possible management decisions of further water management use of the reservoir aimed at maintenance and restoration of natural resources of the lake.

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RELEVANCE OF THE USE OF CLIMATE SERVICES IN THE DEVELOPMENT OF HORSEMANRY OF SOUTHERN UKRAINE

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World experience shows that climate change has never been as rapid as in the past 30 years. For example, 2016-2019 was the hottest year in the history of meteorological observations in the world. In addition to increasing temperatures, there is the problem of changing rainfall. During the period 2014-2018 in 10 regions of Ukraine, the average annual rainfall was 7-12% less than normal, there is a tendency to increase the area with insufficient rainfall (less than 400 mm) in the warm period [1].

According to the meteorological service of Ukraine, for the previous ten years an average of 170 per year was recorded. Every 10 years, the number of natural disasters in Ukraine increases by about 4% [2]. Southern regions of Ukraine are becoming more vulnerable to climate change, due to increasing aridity, climate is projected to reduce the yield of almost all crops in the range from 10 to 20%, in the case of a more severe scenario - from 25% to 50% by 2050 [3] . In the South of Ukraine, deviations of climatic conditions from optimal in recent years cause disturbances of homeostatic balance in the body, resulting in changes in the level of consumption and use of feed, energy metabolism and the level of productivity of animals [4]. One of the options for adjusting the management of pasture and fodder crop rotations in horse breeding is their adaptation to changes - the involvement of drought-resistant grasses and fodder crops for use in pasture and raw material conveyors, the use of optimal structure of sown areas, focused on reducing fodder production [5]. To reduce climate risks in animal husbandry, it is necessary to understand how potential environmental stressors can directly affect the functioning of animals and their health, the realization of genetic potential. In addition, in the conditions of the South of Ukraine the problem of thermal stress is extremely relevant [6].

Due to the effects of climate stressors, staff in weather-dependent sectors of the economy must have sufficient knowledge of the local environment and its impact on their activities. Due to suboptimal management decisions, ignoring them, significant damage and loss of profit can be inevitable [7]. An example of such a meteorological industry is horse breeding, which directly depends on the state of the pasture economy. It is the grazing of horses that best meets their physiological needs, it is green fodder in its chemical composition and nutrients are the most valuable for feeding horses. Thus, the best conditions for horse breeding are created in those countries that have the most favorable climatic conditions for the functioning of pasture biocenoses.

For example, in the conditions of Kherson region during 2000-2014 the average annual temperature increased by 1.3 ºC, during the growing season - by 1.7 ºC. The opposite processes were characteristic of the dynamics of precipitation: the amount of which fell by 73.53 mm on average per year and by 79.8 mm on average during the growing season. Such climate change can lead to a shift in vegetation zones; increase in the area of desert and semi-desert pastures (up to 30%); loss of spring-autumn pastures (up to 70%); reduction of pasture productivity; reducing the stability of the pasture system as a whole [8]. Based on the above, in the current realities of climate change in southern Ukraine, there are dangers to the functioning of pasture farming, which requires adjustment of technologies for keeping, using and breeding horses. In turn, the high degree of meteorological dependence of the horse breeding industry requires taking into account changes in weather conditions and the use of modern climatic services.

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CLIMATE SERVICES IN THE REPUBLIC OF BELARUS

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Dangerous weather events annually cause an average of $ 2.18 million in damage to the Republic of Belarus [1], the largest share of which is accounted for very heavy rains and rain showers, as well as very strong winds – 67,3 and 27,5 %, respectively. Droughts in 1992, 1994-1997, 1999, 2001 and 2002, as well as severe floods in the southern regions of the country in 1974, 1979, 1993 and 1999 had significant consequences for the state's economy [2]. In recent years due to the increase in the number and intensity of adverse and dangerous weather events the economic losses of the country have increased even more, the complete dependence of economic objects on the impact of natural factors is revealed. It is established that the greatest losses are incurred by agriculture (42 %), the share of the fuel and energy sector accounts for 19 %, construction –13 %, housing and utilities – 8 %, transport – 7 %, etc.

The hydrometeorological service of the Republic of Belarus provides climate services to consumers in accordance with the provisions and goals approved by the WMO Congress within the Global Framework for Climate Services (GFCS). First of all, information activities are carried out, which are aimed at minimizing economic and social losses in the country. The main attention is paid to the close interaction of consumers and producers of hydrometeorological information for the effectively solve this problem.

In the Republic of Belarus there is a developed network of hydrometeorological observations, which provides the necessary climatic characteristics. According to the data for 2021, there were 68 automatic stations operating in the country, performing ground-based meteorological observations. In the capital, weather data is received from 9 automatic stations. The MRL operating network in Belarus includes 5 radars. Aerological sounding of the atmosphere in the country is carried out in 3 points – Minsk, Brest and Gomel.

Hydrometeorological information helps business entities choose the right development strategy and take timely protective measures to prevent damage from dangerous hydrometeorological events. Consumers are provided with information that takes into account the specifics of their activities and production interests as much as possible. In the Republic of Belarus, the following types of specialized hydrometeorological forecasts are developed at the request of organizations and enterprises in various sectors of the economy: air temperatures for 6, 12, 18, 24 and 36 hours in the cities of Belarus; visibility and weather

conditions along routes and cargo transportation; average daily air temperature in the areas where energy facilities are located; fire danger of forests in the territory of the republic; average regional productivity and gross harvest of main agricultural crops; spring water inflow to reservoirs; terms of water release to the floodplain; terms of release of floodplain lands from water. To expand the circle of consumers of hydrometeorological products, advertising and marketing activities are carried out, the features of the production activities of economic sectors and the influence of hydrometeorological conditions on it are studied.

Along with the traditional forms of providing climate information to consumers – reference books, monthlies, yearbooks, reviews, bulletins, references, etc., more and more attention has recently been paid to the assessment of climate changes in the territory of Belarus, their impacts on economic sectors, and the development of measures to adapt to these impacts.

The State Program "Environmental Protection and Sustainable Use of Natural Resources" was approved for the period 2021-2025, which provides for the implementation of sub-program 2 «Hydrometeorological activities, protection of natural resources in the context of climate change» [3]. It is planned to perform the following tasks: introduction of modern technologies of hydrometeorological observations, further technical re-equipment of the state network of hydrometeorological observations; mitigation of the impact on the climate and adaptation to climate change, including in terms of water resources management. The implementation of subprogram 2 will contribute to the implementation of Belarus' international obligations under the Paris Agreement of December 12, 2015, and to obtaining new results of model calculations of changes in climate characteristics and forecast estimates of the future climate.

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MEASURES TO MITIGATE CLIMATE CHANGE FROM CIVIL AVIATION IMPACT

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Aviation impacts on the global climate through both CO_2 and non-CO_2 (such as ozone, methane, water vapors, nitrogen oxides, contrail formation) induced effects. According to the report of the Intergovernmental Panel on Climate Change (IPCC) [1] the contribution of aviation sector is approximately 2% of global CO_2 emissions produced by human activity. The International aviation accounts 1.3%.

The Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) is aimed "to strengthen the global response to the threat of climate change". While all domestic GHG emissions are dealt with under the UNFCCC, GHG emissions associated with international aviation are to be dealt with under ICAO. The ICAO Assembly defined a basket of measures designed to achieve the global goals to keep the global net CO_2 emissions from international aviation from 2020 at the same level (so-called "carbon neutral growth from 2020", fig. 1 [2].

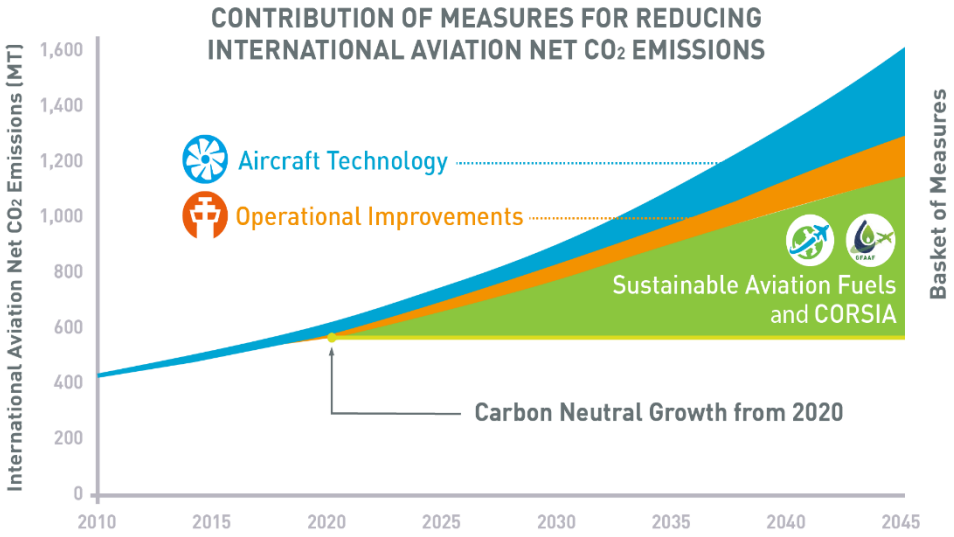

Fig.1. Measures of aviation emissions reduction

The European aeronautic community determined the key towards to achieve climate-neutral aviation goals by 2050 due to:

- development and maturing the zero- and low-emission technology improvements to reduce energy needs and fuel consumption;
- development and application of sustainable aviation fuels;
- implementation of green air operations and networks;
- creation the suitable conditions for transforming aviation by steering policies and global regulatory framework.

Ambitious zero- and low-emission technologies will be presented by hybrid-electric solutions for regional and short-range flights and ultra-efficient aircraft with engine adapted for sustainable aviation fuels (SAF) including a hydrogen for medium and long-range flights. Synergy of ambitious low-emission technologies and adaptation of SAFs predicts a 90% improvements in carbon efficiency at 2050 compared to today's fleet. The aviation sector can meet the Air Transport Action Group's (ATAG) [3] of CO_2 emissions in 2050 in comparison with 2005 levels, while maintaining its forecast growth.

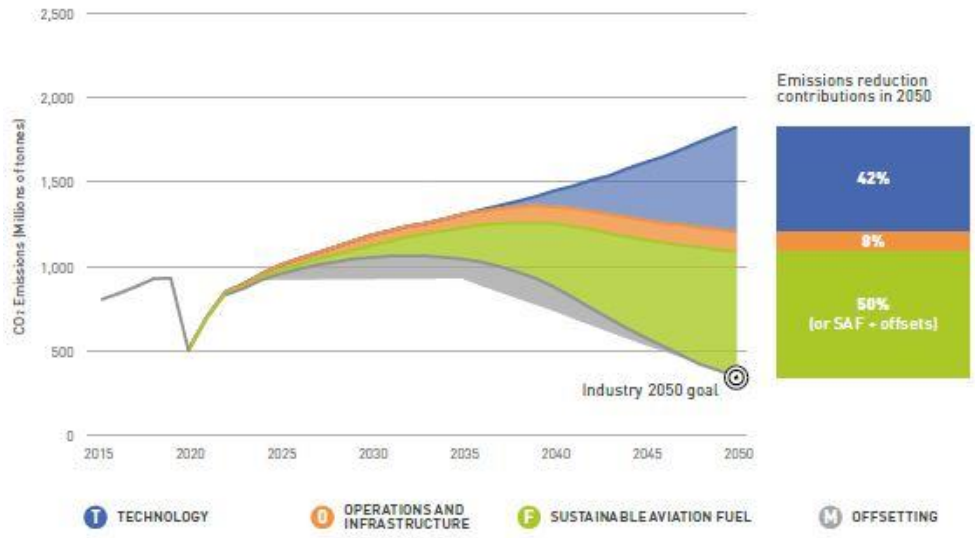

Fig. 2. Schematic of the ATAG goals and change drivers

Due to the predictions of aviation emission increase in comparison with ACARE goals, technological and operational measures are currently not sufficient to stabilize the growing impact of the aviation sector on climate change. Thus market-based measures are designed to mitigate climate change through in-sector emission reductions or through promotion efforts outside of the aviation sector.

In 2016, at the 39th session of the ICAO Assembly, Ukraine passed resolution 39-3 "Global System of Market-based Measures" with the introduction of Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The approach for CORSIA is based on comparing the total CO_2 emissions for a year (from 2021 onwards) against a baseline level of CO_2 emissions, which is defined as the average of CO_2 emissions from international aviation covered by the CORSIA for the years 2019 and 2020. Ukraine participates voluntarily in the experimental (2021-2023) and the first mandatory (2024-2026) stages of the CORSIA program.

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EUMETSAT'S PROTOTYPE DATA CUBE FOR DROUGHT AND VEGETATION MONITORING

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EUMETSAT is providing a prototype Data Cube for Drought and Vegetation Monitoring (D&V Cube).

This prototype contains a collection of gridded data records which are relevant for drought and vegetation monitoring, such as vegetation and solar radiation parameter, evapotranspiration, soil moisture and precipitation, to mention a few. These data records are taken from the portfolio of EUMETSATs Satellite Application Facilities (SAF) on Climate Monitoring (CM), Land Surface Applications (LSA) and Support to Hydrology and Water Management (H), as well as other data from other providers. All data records are provided on a regular latitude / longitude grid and in CF-compliant netCDF via a THREDDS server.

The presentation will provide an overview on the D&V Data Cube, report about the lessons learnt as regards the creation of data cubes and inform about how to participate in the exploration of this prototype data cube.

COMPOSTING OF ORGANIC WASTE - AN EFFECTIVE METHOD OF THEIR DISPOSAL AND A PROSPECTIVE FACTOR OF SLOWING CLIMATE CHANGE (ON THE EXAMPLE OF LVIV)

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Today the dominant method of solid waste management (MSW) in Ukraine is their removal and disposal in landfills and dumps. As a result of accumulation of solid waste in landfills and dumps is pollution of the atmosphere and hydrosphere, provoking climate change, disruption of ecosystems; a significant increase in the area of land allocated for waste storage. Therefore, the involvement of the organic part of solid waste in composting technology is very prospective. It will let to achieve the following goals:

1. Change the environmental load due to the reduction of total waste volume.
2. Receive a valuable product for agrotechnology (in case of absence in raw materials, and accordingly of presence in ready compost of heavy metals and harmful elements) or for biological reclamation. This will reduce the volume of mineral fertilizers used for these purposes.

Achieving both goals will ultimately help to reduce carbon dioxide emissions into the planet's atmosphere and reduce the dynamics of climate change.

Solutions for MSW management require a systematic approach: they must be financially sustainable, technically feasible, socially acceptable and environmentally friendly. It is necessary to create a balanced waste management system, identify long-term strategic priorities that will combine environmental efficiency and rational consumption of material and energy resources. That is why the policy of the European Union (EU) in the field of MSW management is aimed at building the most environmentally friendly waste management system. According to EU Directive № 2008/98/EU solving problems in the field of solid waste management, avoiding the deepening of the environmental crisis and aggravation of the socio-economic situation in society necessitated the development of a Waste Management Strategy. Its goal is to create a comprehensive waste management system to ensure efficient operation in this area, the use of waste as a raw material for recycling and energy production. The choice of solid waste management methods is based on the principle of waste hierarchy, namely: waste prevention, reuse, waste recycling, other types of disposals (for example with energy recovery) and disposal.

We considered the problem of expanding the use of the organic part of solid waste in composting technologies on the example of Lviv. The study of waste morphology is part of the preparation of the city's strategy for waste management methods and makes it possible to determine the optimal collection system for the recycling of municipal waste. The morphological composition of solid waste in Lviv consists of the following fractions: food waste - 31%, garden waste - 7%, paper - 2.4%, cardboard - 2.9%, composite materials - 1.4%, textile materials - 1.1%, sanitary textile materials - 11%, plastics - 13%, glass - 10%, metals - 1.5%, hazardous waste - 1.8%, small elements - 15%. In 2020 the first composting station in Ukraine started operating in Lviv. The operator of this station is Utility Company “Zelene Misto”. Advantages of its implementation include reduction of the waste amount that falls into landfills which saved almost UAH 2.6 million. Waste at the station comes from residents, utility companies and businesses. At the composting site there are four sections for aeration and storage of waste with their preliminary analysis on each section to prevent inorganic waste. The obtained high-quality compost can be used for fertilizing trees and in agriculture. During the first year of operation the composting station processed more than 2,500 tons of organic waste and received a profit for composting organic in the amount of UAH 300,000. It is foreseen that every year the capacity of the station will increase and it will process about 30 thousand tons of waste per year.

It would be promising to include sewage sludge in the raw material mixture, which is accumulated in large quantities in Ukraine and which poses a significant environmental threat. The total volume of sewage sludge, which is created as a result of urban wastewater treatment at sewage treatment plants, is 0.5–1.0% of the amount of treated wall water for sludge moisture, respectively 97–98%. It is created on average about 1 m3 of sediments with a humidity of 97% per one equivalent inhabitant during the year. Based on the total actual productivity of sewage treatment plants about 40-50 million m3 of sewage sludge with a moisture content of 97% or 1.2–1.5 million tons of sludge in terms of dry matter are created in Ukraine every year.

In order to study the possibility of involving sewage sludge in the composition of the raw material mixture for composting we designed an installation for the study of optimal composting regimes. The installation consists of 4 thermostated tanks in which temperature is supported in the set interval. Periodically, the contents of the tank were mixed to simulate the actual composting process. Raw materials of a given composition were loaded into each of the tanks. In the composting process, the composition of the gas phase and the composting temperature were controlled. Different types of raw materials, different composition of the raw material mixture and different composting regimes were studied. The obtained compost was tested by the method of bioindication.

CLIMATE CHARACTERISTICS OF THE HEATING PERIOD IN THE PRESENT TIME AND IN THE FUTURE

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Climate change and variability on our planet can now be considered an established fact. There is every reason to believe that they may have some negative and unpredictable impact on various areas of human activity, especially at the economic and social levels. Along with these changes, the recurrence and intensity of climatic and weather anomalies in recent years in the world is growing, so the main tasks today are the correct consumption of natural resources, the use of alternative energy, providing new population data to prevent economic losses, after all, the main resource of any country of the XXI century is its capital. Therefore, the need for information on possible climate change, which is calculated in various climate models, is more than relevant.

Using the data of scenarios RCP-4,5 and RCP-8,5 the changes of energy resources of Ukraine, namely dates of the beginning and the end of the heating season, duration of the heating season, the sum of degree-days of heating for the heating season are investigated. Such data make it possible to analyze as much as possible sharp jumps in changing the characteristics of the heating season, which are the most dangerous, as well as to calculate the risk of possible future economic losses.

Global climate models are the main tools used to design the duration and intensity of climate change in the future. At the same time, climatic models of various levels of complexity are used, from simple climatic to models of transitional complexity, full climatic models, and models of all terrestrial climatic systems. These models calculate future climatic regimes based on a number of scenarios of anthropogenic change. A new set of scenarios, namely Representative Concentration Pathways (RCP), is used for new climate calculations performed under the Coupled Model Intercomparison Project Phase 5 (CMIP5) of the World Climate Research Program.

The study developed two Representative Concentration Pathways scenarios, namely RCP-4.5 and RCP-8.5. The trajectories of these scenarios show an increase in the world average temperature of 2.6 ° C (RCP 4.5) and 4.8 ° C (RCP 8.5) compared to the period of industrial development in 1850.

The names of the RCP curves indicate the amount of radioactive energy in watts per square meter (V / m²). RCP curves show an increase of 4.5 and 8.5 V / m² in 2100 in comparison with 1850.

Having calculated forecast data from 2011 to 2050 for 32 stations of Ukraine according to the RCP-4,5 scenario, the dates of the beginning (POP) and the end (KOP) of the heating season were found, the dynamics of changes in the duration of the heating season (TOP) and the sum of degree days were considered heating by OP, for a clearer example, maps and graphs were built.

Analyzing the changes in the TOP and the number of degree-days of heating for OP under the scenario RCP-4.5 for the presented period, it is important to note that the TOP and the amount of degree-days of heating for OP, in most Ukraine has a uniform zonal distribution and only in some regions, particularly in the area of the Podil Upland, it has a meridional character and closed isolines.

Decreases in TOP are well traced between the respective periods, so on average in Ukraine the TOP decreases by 9 days, from 188 to 180 for the periods 2011-2031 and 2031-2050, respectively.

In the northern region, which is most exposed to the negative effects of temperature changes, the TOP decreases by an average of 9 days, for example, at Art. Semenivka on average decreases from 206 to 199 for the periods 2011-2031 and 2031-2050, respectively.

In the southern region, the TOP decreases by an average of 8 days, with a decrease is very uneven: in Art. Odessa TOP is reduced by 2 days from 160 to 158 for the periods 2011-2031 and 2031-2050, respectively, and in Art. Melitopol, this mark reaches 15 days from 177 to 162 for the periods 2011-2031 and 2031-2050, respectively, which is the maximum value of the differences between the two periods throughout Ukraine.

In the western part of Ukraine, on average, the TOP decreases by 10 days, the maximum difference between the periods is observed in Art. Ternopil and Art. Exactly, the TOP decreases by 12 days, from 200 to 188 and from 195 to 183 days, for the periods 2011-2031 and 2031-2050, respectively.

As a result of the study of the impact of climate variability on the characteristics of the OP for the period from 2011 to 2050 under the scenarios RCP-4,5 and RCP-8,5, the following conclusions can be drawn.

According to scenario data, the TOP in Ukraine by 2050 will decrease by an average of 6-8 days. According to the RCP-4.5 scenario, western Ukraine is most prone to changes in the TOP. According to the RCP-8.5 scenario, northern Ukraine is the most prone to changes in the TOP. The distribution of TOP and the amount of degree-days of heating OP in most of Ukraine has a uniform zonal distribution and only in some regions, in particular in the Podil Upland, has a meridional character. The analysis of scenario data confirmed an increase in the probability of days with extreme temperatures, and a decrease in the period between the transition from relatively warm to colder OP in each of the scenarios. The reduction of the TOP for the Odessa region is insignificant in each of the scenarios. On the example of Art. Odessa, the thermal regime of the southern region of Ukraine was considered according to the scenarios RCP-4,5 and RCP-8,5 in comparison with the data calculated for meteorological conditions for the period from 2011 to 2016 and it was obtained that the TOP is actually lower by 6 and 3 days, SGDOP in scenarios RCP-4,5, RCP-8,5 is lower than the actual data by an average of 141 ° C and 542,9 ° C, the average temperature of OP is higher than the actual data by 2,15 ° C and 0, 87 ° C according to each of the scenarios.

THE WORLD METEOROLOGICAL ORGANIZATION CLIMATE SERVICES INFORMATION SYSTEM: ADVANCES, CHALLENGES AND OPPORTUNITIES

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Credible climate information products and services are important elements in the decision-making matrix for effective climate risk management and support to adaptation. Such information is crucial for most countries and depend on sectoral assets in focus, particularly in the current context where climate change including variability threatens many facets of planetary habitability and human well-being. However, operationalizing the systematic use of climate information products and services requires a well-coordinated end-to-end institutional system that begins with monitoring and generation of climate information of high quality and ends with a community level response. Furthermore, agile approaches are required to translate research into operational services and inform decisions that can account for climate risks and opportunities.

This article outlines the World Meteorological Organization strategy for implementing the climate services information system (CSIS) at regional scale, highlighting linkages with research and operationalization efforts such as objective climate prediction and Multi-models (MM) ensembles that enable enhanced generation of regionally relevant climate information and emphasizes the importance of sustaining these efforts. CSIS is the primary mechanism to routinely collate, store, process information about past, present, and future climates and make it available from global to regional to national levels to support climate services around the world. It is supported the by development of global and regional systems architecture, mainly through WMO Global Producing Centres for Long Range Forecasts (GPCs-LRF), GPCs of Annual to Decadal Climate Prediction (GPCs-ADCP), Regional Climate Centres (RCCs), and Regional Climate Outlook Forums (RCOFs). Global and regional centres and National Meteorological and Hydrological Services (NMHSs) altogether provide climate information products and services to be used at the country level in support of more effective adaptation options.

INCREASING THE PRODUCTION AND USE OF BIOGAS USING HYDROBIONTS AS RAW MATERIALS – AN EFFECTIVE WAY TO REDUCE CLIMATE DYNAMICS

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The development of renewable energy is an important aspect of slowing down climate change. After all, energy production is not accompanied by the creation of additional carbon dioxide, as is the case with the use of traditional energy sources. Carbon emissions during combustion are balanced with carbon, which is absorbed by biological objects during their development and accumulation of biomass. Therefore, the use of biomass in both direct combustion technologies and biogas synthesis technologies is promising for reducing the dynamics of climate change. The used gibrobionts are a strategically important raw material for biogas synthesis due to the rapid growth of biomass. In addition, aquatic organisms can be used in technologies for purification of polluted aquatic environments by the method of biological conveyor. In this case, the utilization of biomass becomes a limiting stage in the implementation of such technology.

We conducted research to establish the effect of cavitation treatment and the introduction of fermentation seed - the initiator of biodegradation on the intensity and completeness of biodegradation of biomass of aquatic organisms. Studies of the effect of cavitation treatment were performed using cyanobacteria as biomass raw materials. As the most promising type of cavitation treatment, vibration resonance cavitation is used. The study was performed on the biomass of cyanobacteria Microcystis aeruginosa, freshwater cyanobacteria that cause eutrophication of water bodies, harmful from an ecological and economic point of view. The experiments were performed with aqueous suspensions of cyanobacterial concentrate selected at the Kremenchug Reservoir in Svitlovodsk (Ukraine).

The content of the organic part of cyanobacteria was determined by burning a portion of dried cyanobacteria in an oven at 550 ^{o}C for 15 minutes. According to the results of research, the organic part was 94 % by weight of the dry matter of cyanobacteria, the dry matter content was 17.1 g/dm^3.

Pre-treatment of cyanobacteria was performed on a vibration-resonant cavitator. After vibro cavitation treatment, the sample was used in the future to study the effectiveness of anaerobic fermentation.

We studied the kinetics of biogas formation on a specially designed plant.

Reed biomass was used as an initiator of biodegradation to study the effect on the methanogenesis of fermentation seed application. Reed samples were taken

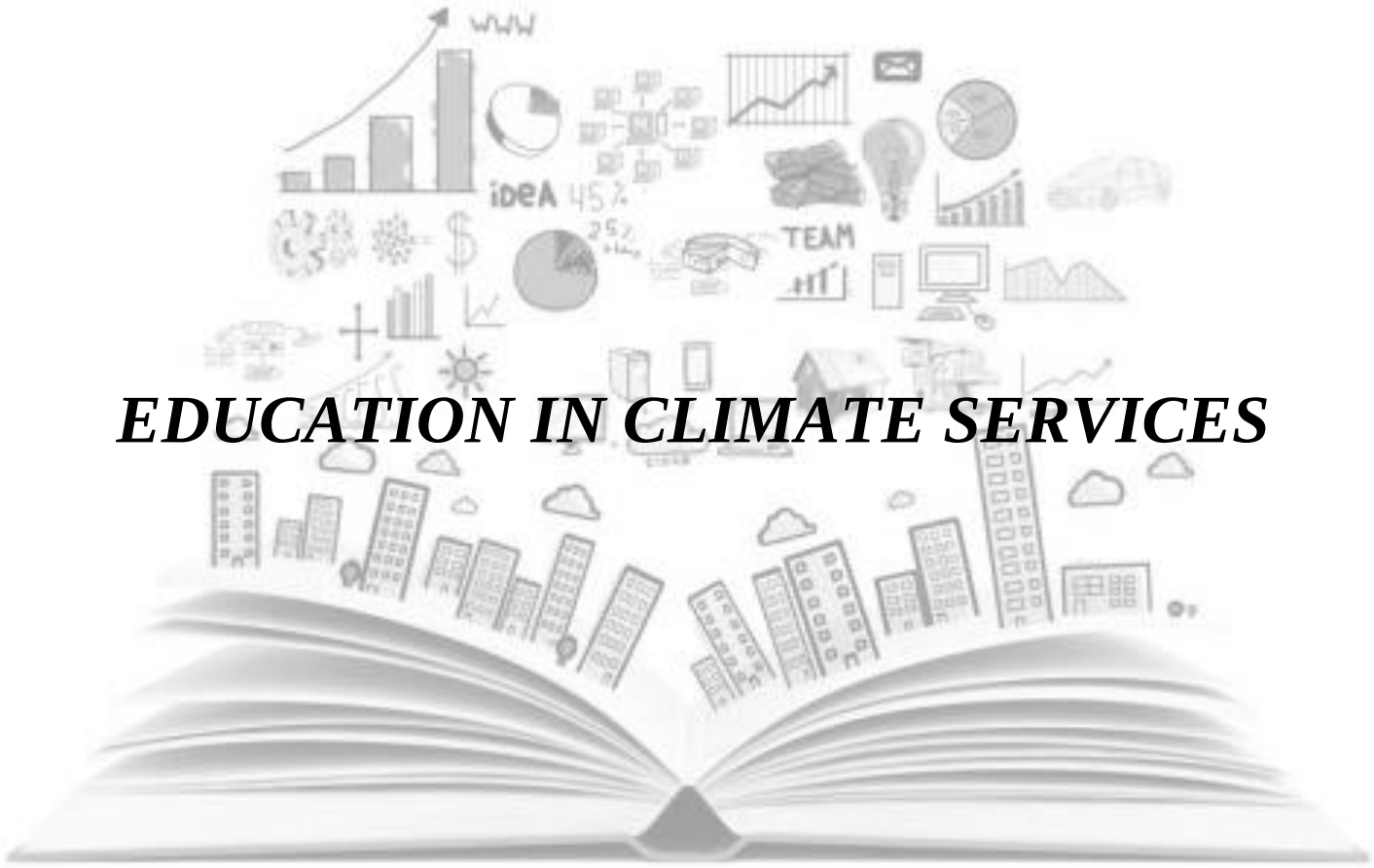
from the swampy part of Lake Yaniv (Lviv region, Ukraine). The selected sample was crushed in a blender, the dry matter content was determined, which averaged 15 %. Anaerobic microbiocenosis selected from methane tanks of plant "ENZYME", the main products of which are different types of yeast, was used as a seed. The dry matter content in the anaerobic microbiocenosis of the fermentation seed averaged 5 %, methanogenic activity - 0.46 kg of COD/kg of organic biomass per day.

As a result of the performed experimental researches it is established that for the purpose of opening of surfaces of mass transfer for intensification of biochemical reactions of process of mesophilic anaerobic fermentation it is expedient to carry out preliminary processing of biomass of aquatic organisms. Processing in the field of hydrodynamic cavitation may be suitable for practical use, but vibrocavitation treatment is the most effective. The technological advantage of such treatment is the possibility of implementing the process of processing biomass in a continuous mode in the flow. A mathematical model for describing the anaerobic fermentation process, which is based on the assumption that the kinetics of biogas release from cyanobacterial suspensions is described by chain biochemical reactions, and the biogas yield in the system is directly proportional to the concentration of active biochemical reaction centers. The obtained experimental results confirm the adequacy of the final equation of the mathematical model, which is structurally similar to the Michaelis-Menten equation.

For the experimental conditions, the values of complex kinetic constants of biogas yield for different durations of preliminary vibrocavitation treatment in the range from 5 min. up to 15 minutes

The results of studies on the influence of pre-vibrocavitation treatment on the methanogenesis show that vibro cavitation treatment can significantly increase the rate of biogas output, as well as increase the volume of its formation. Thus, with increasing time of vibrocavitation processing, respectively, from 5 minutes up to 10 minutes and then up to 15 minutes the amount of biogas obtained increased 1.5 and 1.7 times, respectively.

Analysis of the results of studies on the impact on the methanogenesis of the introduction of fermentation seed into the biomass of aquatic organisms before their anaerobic fermentation under mesophilic conditions suggests the viability of such an approach. The result of seed application is an increase in both the rate of methanogenesis and the total amount of biogas obtained. For a suspension with a dry matter content of CP_c = 0,1 and a mass fraction of dry matter of seed X_E = 0,2, the specific biogas yield was obtained 3.92 times higher than for a suspension with CP_c = 0,05 and X_E = 0,05.



EDUCATION IN CLIMATE SERVICES

TRAINING COURSE FOR EXPERTS IN CLIMATOLOGY AND METEOROLOGY "INTRODUCTION TO CLIMATE CHANGE"

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Climate change is one of the deepest and complex issues affecting our society and economy change may turn out to be even more serious than previously thought. Despite the continuing uncertainty about the detailed relationships, extreme weather events are increasingly associated with human intervention, and there is growing emphasis on the need to prepare for and adapt to climate change. To gain an understanding of the impacts of climate change, it is important to identify the vulnerabilities and opportunities for the region.

This course (https://re.climed.network/course/view.php?id=5&section=3) will be of interest to all staff in meteorological services organizations, especially managers and liders who are responsible for understanding the challenges of climate change, its impact on the environment and its associated risks. Government officials, civil society wishing to learn about the issue of climate change were also welcomed.

The aim of this course is to educate meteorological professionals, senior and mid-level meteorological leaders, and empower them to gain a deeper understanding of climate change processes for forecast and warning services in a way that will allow users to fully understand the impact of hazardous extreme weather events as well possible adoption of appropriate mitigation measures.

At the end of the course, students will be able to:

1. Analyze causes and effects of climate change
2. Use knowledge about the physical mechanisms of climate system formation and scenarios of its development to assess the possible consequences of climate change.
3. Use research databases on climate time series.
4. Provide consumers with information on hazardous weather conditions and risk factors for decision-making.

The main target of this training - to give an introduction to climate change, its impacts on the natural environment and human societies, and possible strategies for mitigation and adaptation. On completion of this course, students will be able to:

The course has the following contents:

1. Introduction to Climate Science and Climate Change:
   - The climate system and its components.
   - The Carbon cycle.

- Climate variability and climate change.
- *Climate change scenarios and pathways.*
-Trends in global and regional climate.

2. Causes of Climate Changes and Intensification.
   - Past climate investigations and tools to detect its change over time
   - Natural causes and factors contributing to climate change.
   - Human activities contributing to climate change.
   - Climate Intensification: floods, droughts, heat waves, rainfalls ets.
3. Impacts of Climate Change on People and Environment
   - Adaptation to climate change at various levels.
   - Climate change and biodiversity.
   - Climate change and agriculture.
   - The economics of climate change.
   - IPCC Assessment Reports and mitigation strategies.

Classroom course is for the main topics of lectures and practices. Some of the practical exercises the students may do at home or in groups in the classrooms helping each other. Reading materials will be distributed online and the lecturer will be available online at the dedicated time for consultation.

Learning activities will mainly consist of theoretical lectures (in group, may be online) and classroom practice exercises and case studies that will be done individually or as a group study.Case studies will be used past, real-time and future time series to let the students get the spatiotemporal distribution on climate indicators to analyze the climate extremes and climate changes.

Practice exercises will be suggest to retrieve climate data from different sources and generate special purpose time series (e.g. using Climate Explorer database). Main tasks in exercises will be devoted to computation of the basic climate products, such as normals, anomalies and climate Indices, such as those defined by the WMO. Students will be use the software applications for produce graphics, maps and reports based on the climate forecasts and projections.

In the first lesson planned Online Test Input Control, which will be used to identify the level of participants. This test task will be one option, which will contain 10 questions for each topic of the course.

At the end of each topic (3 topics), there will be an oral interview of students and a discussion on problematic topics. At the end of the training, Control Tests are conducted on each topic. Both theoretical and practical questions will be included in the testing.

The course will be conducted by blended learning. Online test input control, which will be used to identify the level of participants. The theoretical course will be carried out online for availability of training materials and student mobility.

In order to help us better evaluate the effectiveness of the training curriculum and improve our training activities, students will invite to complete the Post-Training Questionnaire.

"CO-CREATION OF CLIMATE SERVICES WITH LOCAL AGENTS" COURSE: ADAPTING WMO CLIMATE SERVICE COMPETENCIES IN THE FRAME OF BACHELOR DEGREE ON GEOGRAPHY OF ROVIRA I VIRGILI UNIVERSITY

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This communication aims to explain the basic aspects of the course "Co-Creation of Climate Services" that is developed in the degree of Geography, Territorial Analysis and Sustainability of the Universitat Rovira i Virgili (URV). It will explain the process of the course, its relation with the main competencies of the WMO as well as the evaluation process of the participating students.

Using a participatory methodology based on co-creation and user engagement (Font et al. 2021; Aguilar et al. 2019), students carry out a workflow in which they work on different competencies defined in the WMO framework for climate services (WMO, 2019) in a different way to their usual process (see Figure 1). This workflow starts with the performance criteria of competencies C4 and C5; then, students develop skills framed in competency C1 and C2 to finally develop skills defined in the performance criteria of competency C5. More specifically, the students, starting from a participatory workshop (C4 and C5), build and organize a climate database (C1), define a series of climate products (C2), and finally design an effective communication strategy for these products (C5).

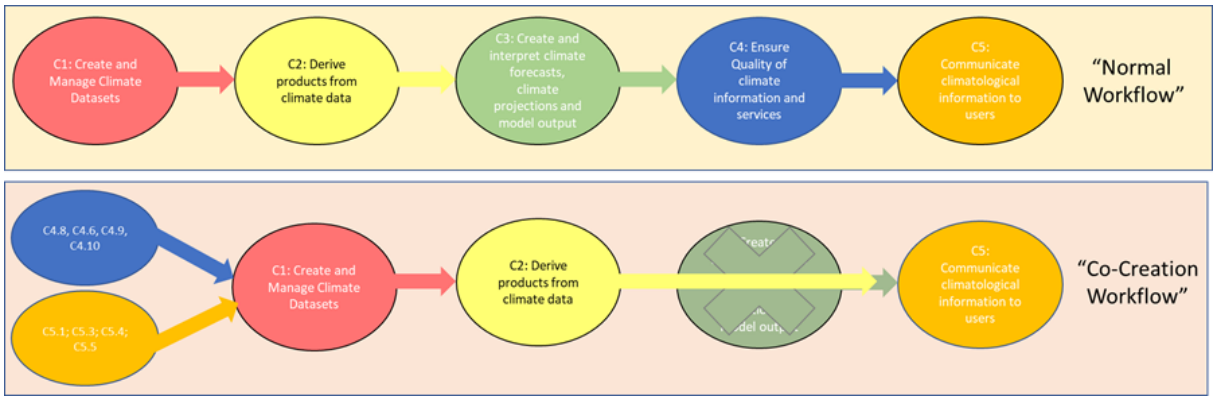

Fig. 1. "Normal Workflow" approach vs "Co-Creation Workflow" approach to define Climate Services

Progress is evaluated based on the achievement of different learning outcomes for each of the competencies developed. The workshop (C4 and C5) is

evaluated based on its development and the information obtained; the creation of the database based on the achievement of the data and its organization (C1); the numerical index based on its construction process (C2); and the communicative strategy (C5) based on the defined proposals, taking into account both its usability and creativity. Globally, the presentation of the climate service is also evaluated, as well as a written report of the service.

The work to be done by the students, to enhance their motivation, is open: they can choose the field of work that best suits their knowledge/interests.

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INTERNSHIP OF ERASMUS+ "INTENSE" FOR EVALUATION OF GREEN INFRASTRUCTURE AND ECOSYSTEM SERVICES OF FORESTY LANDSCAPES IN LVIV

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In the framework of the ERASMUS+ project "Integrated Doctoral Program for Environmental Policy, Management and Technology – INTENSE" was created the National Doctoral School. The main goal is to improve the quality of training of environmental specialists of a PhD level, using the resources of various universities and scientific institutes in Ukraine. The project provides the support of scientific internships for graduate students in partner organizations.

During the internship of ERASMUS+ project "Integrated Doctoral Program for Environmental Policy, Management and Technology – INTENSE" was conducted the studies of green infrastructure and ecosystem services of forest landscapes in Lviv, Institute of Ecology of The Carpathians.

The program of the internship included:

- visit the Department of ecology and nature resources of Lviv city council;
- research of management of the green areas in Lviv;
- fieldwork in the park "Zalizna Voda" with NGO "Plato", "EkoTerra", "Permaculture";
- research of green infrastructure of Lviv, square, functional zoning and governance;
- research of ecosystem services of forest landscape in Lviv and in Skole Beskids National Park;
- visit the first city eco-trail;
- fieldwork in Skole Beskids National Park: waterfall "Kamianka", Parashka mount, wildwood, State Historical and Cultural Reserve Tustan'.

During the internship was studied the management of green areas of Lviv, in particular parks – "Zalizna Voda", "Stryiskyi Park", Regional Landscape Park "Znesinnya ", "Park of Holy Pope Ivana Pavla II", "Ivana Franko Park".

The green infrastructure of the city includes parks, gardens, squares; green roofs; greenery of private territories; linear plantings along roads and plantations at central islands (refuge halfway across).

Most of the studied parks and squares are objects of public use and belong to the Nature Reserve Fund of Ukraine. Green roofs were found mainly on private or municipal buildings (building of the Ukrainian Catholic University) and belong to the green areas for restricted use. Linear plantings along roads and plantations at central islands belong to the green areas for special purposes.

It is established that the area of green zones corresponds to the current norms of city landscaping. The total area of the studied parks of Lviv is about 5% of the city territory. However, there is an expansion and restoration of green zones, there is a reserve land of about 100 hectares. One example is the inclusion of 1 hectare of land to the territory of park "Zalizna Voda".

It was found that the green areas in the city are subordinated to Lviv Municipal Enterprise "Green Lviv", and only the Regional Landscape Park "Znesinnya" has own directorate and subordinates to the Lviv City Council.

Among the main ecosystem services provided by the green infrastructure of the city are the following:

- regulatory: air purification, flood regulation, water supply, climate regulation, carbon deposition, biodiversity conservation, soil erosion prevention;
- cultural: tourism and recreation;
- support: ensuring the main ecosystem processes.

For further research, were taken samples of cores of trees *Aesculus hippocastanum* at the territory of the Regional Landscape Park "Znesinnya".

During the second stage of the internship in the Skole Beskids National Park researched the characteristics of the park and information about the projects that already have been implemented in the park and future projects.

One of the future initiative is the creation of glamping, according to European experience. This approach will stimulate the development of recreational activities of the park and will increase the number of visitors.

For the evaluating of ecosystem services were taken the samples cores of trees *Fagus sylvatica* at the territory of the park.

The ecosystem services of the park are climate regulating (absorption of carbon dioxide), soil protection, hydrological regulation, biodiversity conservation.

The problems of the park include overgrowing mountain meadows with tree plantations. As a result, the unique shrubby-grass cover of the meadow (with the Red List species) is replaced by species that grow in the forest. Another problem is the significant recreational load on certain areas of the park.

Therefore, during the internship it was found that the practice of landscaping and management has its own characteristics in Lviv. The samples of trees' cores were taken within the city and within the Skole Beskids National Park will be compared with each other and will be analyzed the radial growth of wood to assess the impact of anthropogenic load on wood formation.

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WAYS OF IMPLEMENTING NON-FORMAL CLIMATE EDUCATION FOR YOUNG PEOPLE

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Climate change is one of the global challenges of our time. It cannot be solved through legislation or economic approaches alone, as climate change raises a number of methodological, epistemological and ethical issues, in addition to environmental and socio-economic threats. Society today needs environmentally educated, literate and well cultured people. Ecological knowledge, skills, beliefs are especially needed for the education of a new value attitude towards nature, the development of a human worldview consciousness.

Research shows that one of the important tools for adapting to global climate change are education and communication programs, i.e. didactic and informative methods of involving the public in the problem. Climate communications can act as a stimulus to a deeper understanding of the urgency of the threat and contribute to changing the attitudes and behaviors of everyone on Earth.

The specific target group for climate communications is young people of different ages, who are in the process of active socialization — at the stage of assimilation of life values and behavioral norms, including those related to the environment. The involvement of young people in environmental decision-making is low in Ukraine compared to other countries. Knowledge and skills to be effective and powerful agents of change are mainly acquired by young people through formal education. In addition to formal environmental education, which is implemented by educational institutions, a significant role in the formation of an environmentally stable society is played by non-formal education, which is implemented through public environmental associations, volunteer activities, the implementation of environmental projects, and the media.

Non-governmental environmental youth organizations can promptly, effectively and as widely as possible disseminate information on environmental issues, including those related to global climate change, in the form of online courses, trainings, conferences, forums, discussions, lectures, creation of interesting videos and graphic content. As the international experience shows, non-formal environmental education through public organizations contributes to promotion of environmental movement in the country, formation of environmental culture of the nation and conscious civil society on the principles of sustainable development.

We examine the implementation of non-formal climate education in the activities of youth NGOs through their common practice with educational

institutions in creation of environmental education space, organization of climate change education, project and volunteering activities.

Courses, trainings, summer schools, workshops (eco-, photo-, art, etc.) are activities that the educational institutions can practice together with youth NGOs in order to create a "climatic" educational space. Examples of the successful implementation of such projects include trainings under the program SPARE ENERGY HUB, which aims to create eco-hubs in Ukraine on climate change and energy conservation [1], the annual forums "Climate Education" [2], etc.

Education in the field of climate change consists in dissemination of information about the role of anthropogenic factors in the global climate change, the negative socio-economic consequences of extreme hydro-meteorological phenomena, and adaptation to new conditions of various industries. As part of educational activities in the area of climate change, information and methodological materials are prepared, informational and educational audio- and video-materials are created, and social and advertising products are placed. Young people are involved in the dissemination of messages in blogging platforms, groups of public organizations like Ukrainian Climate Network [3] and other resources of the Internet space.

Numerous international and national programs now focus on providing new opportunities and engaging young people in communities to implement climate projects. Projects that aim to enable young people to implement innovative local initiatives and practices, such as the creation of "green jobs", supporting young entrepreneurs applying energy efficient technologies, providing vocational training in renewable energy, conducting energy audits etc., are financially supported. NGOs contribute to providing young people with theoretical knowledge and practical skills on project activities, tools of fundraising for project implementation and examples of successfully implemented projects.

Young people have the opportunity to volunteer by becoming, for example, a climate activist at NGO "Ekodia" and participating in various environmental activities such as climate marches [4] and in advisory activities.

Thus, non-formal climate education for young people can be successfully implemented through the activities of environmental NGOs, including in cooperation with educational institutions. An effective model for shaping environmental awareness and organizing environmentally-oriented activities among young people is the creation of "climatic" education space, implementation of public education, project and volunteering activities in the field of climate change.

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ABOUT THE POSSIBILITY OF AUTOMATED MONITORING OF ENVIRONMENTAL-CHEMICAL INDICES OF ATMOSPHERE PRECIPITATION

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The quality of surface and groundwater is significantly influenced by the dynamics and chemical composition of atmospheric precipitation. The rainfall regime has changed dramatically in recent years due to the processes of global warming. During 2015-2018, we conducted research on the dynamics and chemical composition of atmospheric precipitation in Lutsk and Volhynia region and made sure that information from the official network of meteorological stations is often insufficient to study their regime. For example, there are only 6 meteorological stations in our Volyn region. Not every administrative district has its own station. At the same time, precipitation is a volatile and localized phenomenon. Sometimes the rain falls in one of the microdistricts of Lutsk, and the sun shines in the other one. Therefore, we have developed a project of a non-state network of observations on sediments, whose work is proposed to attract geography teachers and the secondary school students. Observations will be carried out with the help of the automated module for controlling the ecological and chemical parameters of precipitation "RAIN-CONTROL".

The purpose of the work is to analyze the changes in the rainfall dynamics in Volyn due to the global warming and the development of a device for the automated control of precipitation and their ecological and chemical indicators. The tasks of this research and research work are: (1) studies of changes in the dynamics of precipitation (their repetition and number) that have fallen in Volyn in the last decade; (2) analysis of the chemical composition and precipitation acidity during 2015-2018; (3) development of a module for automated monitoring of ecological and chemical parameters of atmospheric precipitation "RAIN-CONTROL".

The initial data for the statistical part of the work were the archival data of 6 meteorological stations of Volyn region for the period of 2011-2018, the data of the electronic weather archive rp5.ru , the results of the own measurements of the amount, acidity and total mineralization of precipitation that we had collected in Lutsk and the chemical analysis of the sampled samples . Literary and the Internet sources devoted to descriptive methods of constructing portable weather stations based on ArduinoMicro microcontroller were analyzed for the development of the automated module "RAIN-CONTROL".

The main results of the study:

– we calculated the average monthly rainfall amounts for every weather station of Volyn (Lutsk, Svityaz, Manevichi, Kovel, Lyubeshiv, Volodymyr-

Volynsky), the average rainfall for the warm season of the year (IV - X months) and the cold season of the year (XI - III months), average rainfall for every year and for the entire surveyed period (2011-2018). It also determined the number of days with precipitation for each year, the warm and cold period of each year, the average values of this indicator. According to these data, graphs, diagrams and cartograms were constructed, which clearly represent the dynamics of atmospheric precipitation in our region during the studied period.

– on the basis of the calculated indicators with the GS Surfer program, we have constructed 3 maps of the geographical distribution of precipitation amounts in the territory of the Volyn region during the investigated period (annual amounts, amounts for the warm and cold period of the year). When comparing them with maps of the period of the twentieth century wegad estimated the current growth of rainfall in Volyn.

– We had developed the automated module "RAIN-CONTROL". It is a small specialized meteorological station, created on the basis of the microcontroller ArduinoMicro and the set of the sensors.This device will allow automatic measurement of the main parameters characterizing atmospheric precipitation, namely:

– the duration of precipitation;

– the amount of fallen precipitation;

– the temperature of rain (mist snow) water;

– pH of the precipitation; the mineralization of precipitation;

– the CO2 content in the air (to assess the dynamics of the formation of the pH indicator because carbon dioxide significantly influences on it).

The control of the ecological parameters of water released in the form of atmospheric precipitation is very important for human, his health and quality of life. Therefore, in the future, after testing our module "RAIN-CONTROL", we plan to develop a methodology and justify the necessity of creating a network of automated monitoring of precipitation for Ukraine as a whole.

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ECOLOGICAL SECURITY AND SUSTAINABLE DEVELOPMENT AS ONE OF THE PLATFORMS OF NATIONAL REVIVAL IN THE MODERN EDUCATION SPACE

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Today, the problem of education in the interests of environmental security and sustainable development is relevant in most countries.

The determining factor in achieving ecological interaction of citizens with the natural environment today is the organization of such a structure of human life, which will ensure full coordination of any actions with the natural environment, its integrity, ability to self-reproduction and minimize consumption of non-renewable natural resources.

Such a restructuring of human activity is possible under the condition of a clearly structured greening of the living space of society and each individual in particular. This is especially true of educational space (a component of living space), the priority of which should be the ethical and environmental orientation of education in general [1].

Bridging the gap between the provision of climate services should be done through the education sector, where the growing individual, who in the future will become a full citizen of the country, will have a basic life strategy - selfless care and preservation of the earth's nature.

Today modern philosophy of education, according to the new program sets tasks that have important educational content, in particular, to form the worldview of the man of the future, who, having acquired knowledge, will seek to understand the cultural development of the nation to achieve high goals.

A new person with a new type of thinking must have the right values, which are natural to the created world and interdependent with the laws of the universe.

High worldview knowledge of the universe recorded by our ancestors in symbols and folklore texts, customs, traditions, rites, ie in ethnography, has a high potential to form in a growing personality ideas about the world, natural relationships and processes which are basis of human existence.

Therefore, the educational process should be based on the principles of folk pedagogy through the transition from specialized to worldview knowledge, which means deep penetration into the relations occurring in all phenomena, processes, states of man, society, nature, the universe independently of us according to the laws of the universe.

An important factor is the awareness of personal significance, ie one's own subjectivity, so that the new generation can be thinking, free, have the right to choose and can develop creatively.

In addition, human nature itself remains unchanged: human individuality seeks to reproduce in a person what is inherent in him genetically, that is, he always remains a bio-socio-cultural-spiritual being. Even in the conditions of the greatest social and economic well-being and everyday comfort, a person always subconsciously strives for unity with his cultural and spiritual heritage, without which he will never feel inner harmony and emotional comfort.

Today's globalization processes, economic, political and environmental imbalances do not cause positive changes in the field of national education. Therefore, there is a need to introduce a nation-building vector of nationally oriented educational program based on ethnography, which will be a reliable basis for Ukrainian children to understand themselves as conscious Ukrainians, with a strong national identity and national-cultural identity.

The platform for national revival should be an educational ethnographic program that provides one of the cross-cutting content lines as environmental security and sustainable development.

The educational trajectory should be focused on the formation of the growing personality of the notion of the value attitude of our ancestors to nature, land, water in connection with the world-creating processes. And also to form understanding on the basis of national sources about the special relation to water resources on the basis of deep penetration into properties of water, in particular, in interrelation of human water balance and the nature, ability of water to photograph, store information, improving properties of pure water and healing power of consecrated water, which aims to be more critical of the purity and preservation of water in the environment.

It is important to develop national consciousness and national-cultural identity in the spectrum of studying a wide arsenal of natural properties of flora, which once our ancestors took to help, revealing the great folk wisdom and refined sense of nature, to get acquainted with plants-symbols, which due to their unique properties in itself the essence of a phenomenon.

An important factor in the educational process must be the value basis of the educational process, where the ethnographic branch, according to the requirements of the State Standard, will emphasize the moral component, which should have an undeniable impact on the education of highly spiritual personality.

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MEDICAL EDUCATION IN THE CONDITIONS OF DISTANCE LEARNING

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Large-scale advances in medicine and the associated rapid increase in the professional information needed to train physicians raise the question of innovation in higher medical education. Taking into account all these conditions, current trends in the development of European medical education provide for the widespread introduction of high-tech information educational process in education. This is especially true of Ukraine, which, in the conditions of opening borders between states, is undergoing a process of full-fledged entry into the single European educational space.

The widespread introduction of distance education, due to the spread of the COVID-19 pandemic and the need to comply with all quarantine measures to preserve the health and lives of all participants in the educational process, posed new challenges to higher education, which must be overcome by joint efforts of all stakeholders. with the involvement of the latest interactive platforms, and increase the motivational factor in the acquisition of new knowledge.

The main factor in ensuring the European level of quality of higher medical education in Ukraine is the "transformation of medical education through Decentralized Training Platforms" and the introduction of e-learning (e-learning) in the educational process. In modern conditions, where the younger generation lives, the most relevant is communication and learning online, which best ensures the assimilation of educational and methodological material, composed in accordance with the latest information and communication technologies. Thus, the classical classroom training of a medical student, which now exists, in e-learning can be supplemented by online-learning or, if necessary, completely replaced by online-learning.

Taking into account all the above, e-learning should be structured and provided with the involvement of: e-student and / or e-community, e-teacher, e-logistics, e-administration, e-assessment. The potential source of practice-oriented e-content is the Internet and, if necessary, the e-librarian. The effectiveness of e-learning with the proper use of innovative virtual technologies creates unique opportunities for the formation and improvement of professional knowledge, skills and abilities of medical students in the absence of patients, but with the use of computer programs with e-patients and simulators virtual reality of diagnostic examinations with the help of modern devices and equipment, as well as various medical medical interventions (for example - in a virtual operating room).

Also, in e-learning there is an opportunity not only to gain a thorough knowledge of the theoretical aspects of medicine, but also to learn the technique of manipulation skills needed to work on modern diagnostic and medical equipment, which will soon get to medical institutions in Ukraine. Involvement of leading European physicians in e-teaching enables Ukrainian medical students to get acquainted with the protocols of modern medical care in Europe, acquire skills of standardization of decision-making and diagnosis, learn the principles of management in the medical field, emotionally feel competitive and ready to provide medical services European level.

The best organized and filled with appropriate quality content of medical and diagnostic direction of e-learning in a particular section of the discipline can be used for fully individualized independent extracurricular work of students on the principle of smart education (smart education). Smart education includes a wide range of tools for extensive delivery of basic and additional content, as well as provides a comfortable environment for e-student communication with e-teacher and e-administration. Smart education involves the creation of various learning platforms and constant updating of the virtual educational environment, which favors flexible highly communicative and easy to use educational programs, implemented with the involvement of teaching and online communication of the best representatives of the European and Ukrainian professional community.

In addition, interactive communication between teacher and student is provided through e-mail correspondence, ZOOM platform. With the help of e-mail

the teacher sends theoretical materials on the topic, questions for self-examination,

links to electronic resources and receives the results of independent work of students. urgent problems, answer questions, timely adjust the learning process. Such communication allows to maintain a constant connection between teacher and student.

Thus, the introduction of smart education and the formation of decentralized online learning platforms is one of the main and moving steps towards increasing opportunities for self-realization of students and teachers; establishing direct contacts with specialized clinical medical institutions and institutions of higher medical education in Europe, which should lead to an even greater expansion of the network of exchange programs for students, graduate students, teachers; concluding agreements on cooperation in various fields of medicine. Under these circumstances, it becomes possible to address the issue of staff shortages in Ukraine, when in the conditions of smart education an educational community is formed, which includes qualified and socially responsible teachers with a modern global worldview of European health professionals.

ONLINE APPROACHES FOR CLIMATE-ORIENTED EDUCATION

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The Erasmus+ ClimEd (2021-2023; http://climed.network; "Multilevel Local, Nation- and Regionwide Education and Training in Climate Services, Climate Change Adaptation and Mitigation") European-Ukrainian project is aimed at development of competency-based curricula for continuous comprehensive training of specialists in the field of climate services and additional education in climate change for decision-makers, experts in climate-dependent economic sectors, and public.

The ClimEd Trainings (http://climed.network/events/climed-trainings), in total 7, will be carried out during project and will be focused on training the faculty/ teaching/ research staff and postgraduates at the ClimEd partner institutions and collaborating organizations in advanced educational and information-and-communication technologies for building a flexible multi-level integrated practice-based education system in the field of Climate Services, Climate Change Adaptation and Mitigation.

Due to covid pandemic situation, the originally planned face-to-face trainings were converted into online training. Such online trainings were divided into 3 consecutive blocks: (i) online lecturing, (ii) home-work-assignments (HWAs) as group projects, and (iii) final oral presentations (projects' defences) of HWAs with evaluation and feedbacks, discussions, and awarding certificates (corresponding to ECTS credits). Trainings also include questionnaires distributed among participants: evaluation of the training, and evaluation of own learning outcomes. Technically, the Moodle system, Zoom-hosting, e-evaluations, etc. are actively utilized in such trainings.

The outcomes of the online approach will be presented and discussed for recent ClimEd 1st training (Fig. 1) - "Competence-Based Approach to Curriculum Development for Climate Education" (19 Apr – 12 May 2021; http://climed.network/events/climed-trainings/climed-training-1-online); 2nd – "Adaptation of the Competency Framework for Climate Services to conditions of Ukraine" (29 Jun – 26 Aug 2021; http://climed.network/events/climed-

trainings/climed-training-2-online); and planned for Oct-Nov 2021 the 3rd – "Digital tools and datasets for climate change education".

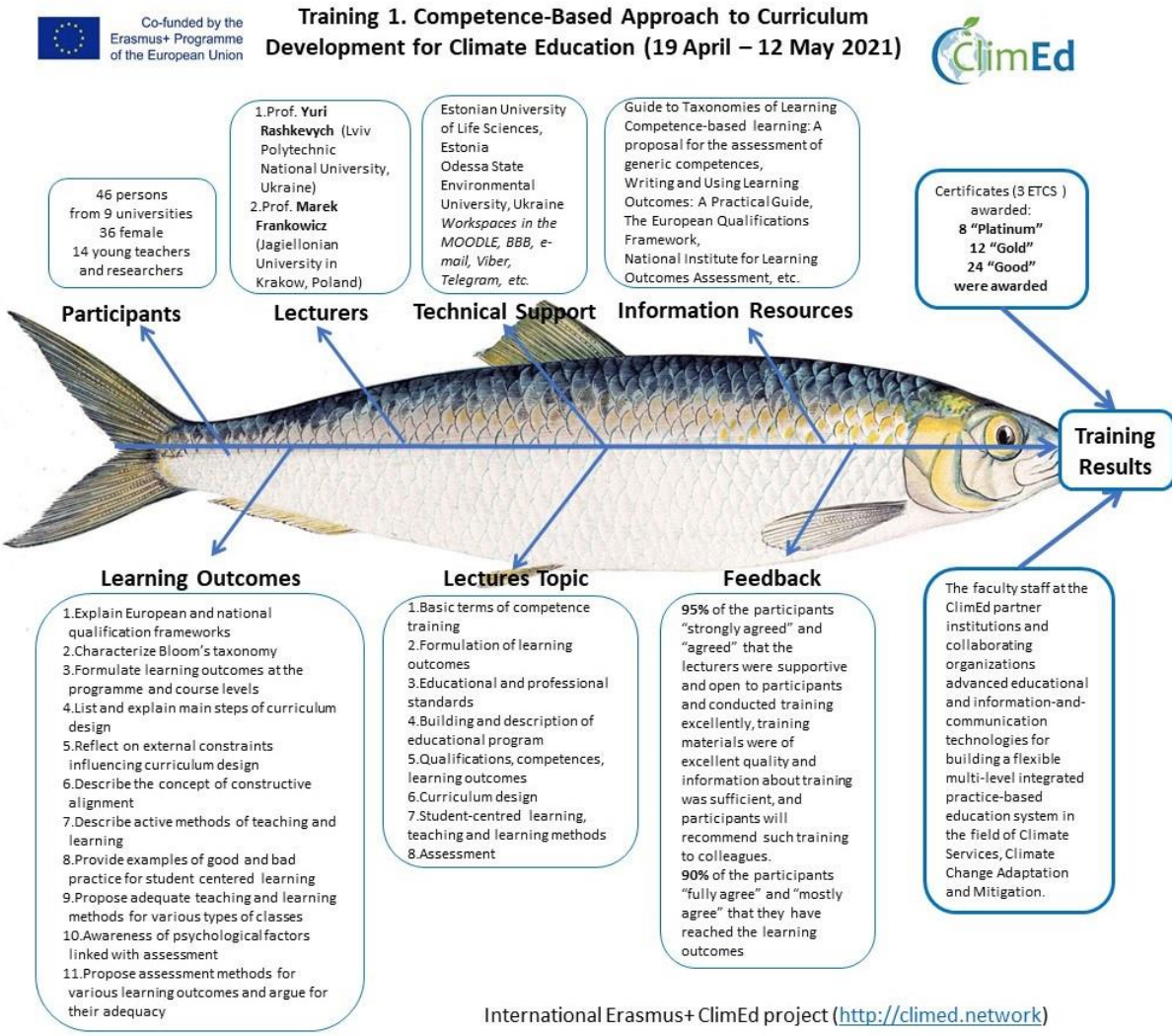

Fig. 1. Summary/ outcomes of the 1st ClimEd Training on the "Competence-Based Approach to Curriculum Development for Climate Education" (following Ishikawa diagram).

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INTER-FACULTY COURSE «WEATHER AND CLIMATE: GLOBAL WARMING» AS A PART OF BASIC EDUCATION FOR CLIMATE SERVICES

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Current level of meteorological, climatological or in general, geographical knowledge of the population in Ukraine is very low. That is why there are many questions about the causes and consequences of certain weather phenomena. At the same time, if certain meteorological processes are too difficult for understanding for non-specialists, a significant volume of climatological information is easy to assimilate, integrate and use in our everyday life. To achieve that, a person can be involved into self-education, but the infinity of information in paper and Internet does not guarantee the high quality of knowledge. As an alternative to self-education, students have the opportunity to develop individual educational trajectories (or individual education plans), in which, in addition to professional knowledge, they obtain additional knowledge and skills from other fields. According to the "Regulations on the organization of the educational process at V.N. Karazin Kharkiv National University " [1], on the 2nd and 3rd year of study students have the opportunity to listen to inter-faculty elective courses on humanitarian, socio-economic and/or basic fields. These courses are offered annually by all Schools (faculties) and institutes of Karazin University for all students. It is this segment of the individual plan that the student has the opportunity to study the "Weather and Climate: Global Warming" course, which is offered by the authors as a basic education in the field of climate services.

According to [1], the volume of inter-faculty elective course is 3 ECTS (90 academic hours), including 33% (30 hours) of in-classes lectures, the final semester control is conducted in the form of a test. Students who receive higher education at the Bachelor's level on any educational program may select for study the inter-faculty elective course "Weather and Climate: Global Warming" in the third, the fourth, fifth and sixth semesters and increase their basic knowledge in meteorology and climatology.

To ensure the conscious choice of inter-faculty courses, the Department of Education Quality at Karazin University up-load all summaries on the University web-site. For the 2021-2022 academic year the authors have submitted a summary of the "Weather and Climate: Global Warming" course (Table 1), which was selected for study in the autumn semester by students from different schools (group of 20 students). In parallel, an e-course is being developed on University Moodle platform; after its testing and certification it will be modified into the Open Online Course and can be studied by anyone individually under the moderation of an Karazin University academic staff. In this way, it is possible to increase the general meteorological literacy of the population.

Table 1. Summary of the inter-faculty course "Weather and Climate: Global Warming"

Aim	To develop a system of knowledge on climate services, basics of climatology, climate-therapy, features of climate in various parts of the Earth and acclimatization to them as well as to manifestations of global warming
Learning outcomes	Learning outcomes for students will include the following competencies: - To obtain ability to characterize the climate of various parts of the Earth and to assess it in terms of providing climate services. - To understand and make assessment of the borders of ecological and climatic comfort of the territory. - To know the ways of acclimatization for different types of climate. - To understand and explain the manifestations of global warming.
Topics	**Section 1. Weather:** T.1.1. General properties of the atmosphere. T.1.2. Basic meteorological elements T.1.3. Vertical heterogeneity of the atmosphere. T.1.4. Horizontal heterogeneity of the atmosphere. T.1.5. Water vapor in the atmosphere. T.1.6. Thermal regime of the atmosphere. **Section 2. Climate:** T.2.1. General patterns of climate development. T.2.2. General atmosphere circulation. Weather service. T.2.3. Climate classifications. T.2.4. Climate-therapy. Problems of recreation and climate. T.2.5. Weather modes for recreation, tourism and sports. T.2.6. Features of climatopathic reactions and seasonality of diseases. **Section 3. Global Warming:** T.3.1. Atmospheric air pollution as a factor of global warming. T.3.2. Climate dynamics. T.3.3. The nature of the greenhouse effect. T.3.4. Possible scenarios for the development of the climatic situation on the Earth.
Methods for control of learning outcomes	During the study of the "Weather and Climate: Global Warming" course the following methods of control are used: during the semester and at the end of the semester. Control during the semester is carried out by the staff in the form of an oral interview at lectures. The final semester control on the course (final test) is a mandatory form of assessment of learning outcomes and is conducted within the timeframe set by the schedule of the educational process and in the amount of educational material defined by the program of the course.
Working program (syllabus)	Syllabus is up-loaded to the web-site of the Department of Environmental Monitoring and Protected Areas Management https://drive.google.com/drive/folders/1bEbi7seX8-b8OlNlqTVmFRDdKOS0tRWj
Academic staff	Prof. Maksymenko Nadiya

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THE EDUCATIONAL CONTENT FOR THE LEARNING ENVIRONMENT IN ECONOMIC, METEOROLOGICAL AND AGRICULTURAL SCIENCES

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The main purpose of educational technology - forecasting the development of educational systems, their design, planning and factors that meet educational goals. We can say that this is a special kind of social technologies, which are conceptually united by priority educational goals and are interconnected tasks and content, forms and methods of organizing the learned process, where each element of this system leaves an imprint on all other elements [1,2].

An example of the widespread introduction of innovations in the educational process is the participation in the EU Erasmus + program of three higher educational institutions of Ukraine, namely, Odessa State Ecological University, Taras Shevchenko National University of Kyiv and Kherson State Agrarian University. Full name of the project "Adaptive learning environment to ensure competence in the field of the impact of local weather conditions, air quality and climate on the economy and society 561975-EPP-1-2015-1-FI-EPPKA2-CBHE-JP" (www. E-impact. net), abbreviated "ECOIMPACT" [3]. Grant Coordinator Professor S.S. Zilitinkevych, (Helsinki, Finland), partners - universities from Bulgaria, Slovakia, Russia. In the period 2017-2019, the goal of the project was achieved - to develop the capacity of educational institutions to improve the educational level of various segments of society in the field of local weather, air quality and climate change on modern life towards more sustainable socio-economic development. Tasks have been completed: development of educational content for the learning environment in the field of economic and social consequences of local weather, air and climate quality, aimed at students of higher education institutions, specialists in hydrometeorology and managers of meteorological enterprises and government agencies; development of hardware and software components of the learning environment and their integration with the learning content; testing of the integrated learning environment at the university, in refresher courses and retraining; development of commercialization strategies for an adaptive learning environment system.

Interactive training courses on sheep breeding, city ecology, transport, etc. have been created, as well as individual profiles of each student - his personal learning environment.

Interactive learning takes place under the condition of constant, active interaction of all participants of the educational process. The methodological feature of interactive technologies is the structuring of content and form, which would arouse the interest of students, contribute to their optimal development and education. Compared to the usual lesson, lessons with the use of interactive technologies stimulates cognitive independence, creative initiative of students [4].

Active forms of control of learning material with the use of Bloom's methodological approach were used [5].

The Ecoimpact training courses created in this way are not only relevant from the point of view of popularization of meteorology in the agricultural sector, medicine, logistics, etc., but also demonstrate a new approach in the formation of students' curricula and can be offered as an element of dual education.

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ERASMUS+ PROJECT "INTEGRATED DOCTORAL PROGRAM FOR ENVIRONMENTAL POLICY, MANAGEMENT AND TECHNOLOGY – INTENSE": KARAZIN UNIVERSITY TEAM COURSES

Kateryna Utkina, PhD., Assoc. Prof., Ganna Titenko, PhD, Assoc. Prof., Nadiya Maksymenko, Sc.D., Prof., , Alla Nekos, Sc.D. Prof., , Andriy Achasov, Sc.D., Prof., , Anatoliy Kucher, , Sc.D., Assoc. Prof., Inna Bodak, Olena Chernikova

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Erasmus+ project "Integrated Doctoral Program for Environmental Policy, Management and Technology – INTENSE" started in 2017 and will finish in 2021.

In 2020 UA national and international INTENSE Doctoral Schools were launched. In 2020 curriculum was approved and the first students entered the School at Karazin University. For the proper functioning Karazin University team has done a huge amount of work.

Ten new courses were developed or updated:

1. Philosophy of Science
2. Science Methodology
3. Natural Resource Science
4. Environmental Policy and Management
5. Geomatics and Modelling
6. Practice Learning in University Teaching
7. Environmental Projects Development and Management
8. Models for Environmental Risk Assessment
9. Sustainable Development
10. Environmental Management Practices

For each course the following documents were developed: working program (according to UA requirements), syllabuses, presentation of the course, reviews (2 national and 1 international one), Teaching and Learning Materials, QA of the course. All these documents are uploaded to the INTENSE web-site (http://intense.network) and on INTENSE web-page at Karazin University (http://ecology.karazin.ua/mizhnarodna-dijalnist/intense-integrated-doctora/navchalno-metodichnij-komponent/).

All courses are developed also for online on Karazin University Karazin University – https://moodle.karazin.ua/.

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MOOC "PRECAUTIONARY PRINCIPLE AND SUSTAINABILITY TRANSITION": UP-DATED STRUCTURE AND CONTENT

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Erasmus+ project "Integrated Doctoral Program for Environmental Policy, Management and Technology – INTENSE" started in 2017 and the list of deliverables includes development of four Massive Open Online Courses (MOOCs).

A Massive Open Online Course is an online course aimed at unlimited participation and open access via the Web. "MOOCs are usually non-credit-bearing courses typically offered for free by numerous universities and organizations to anyone interested in enrolling in these courses. Distinct features of MOOCs are that they are designed for 'massive' participation – thousands, even hundreds of thousands can participate in a MOOC – and students do not need to be enrolled in or even affiliated with the sponsoring organization offering the MOOC to register". [1].

V.N. Karazin Kharkiv National University is the leader of MOOC "Precautionary Principle and Sustainability Transition". The aim of the MOOC is to provide information about modern approaches concerning early warnings, precautionary principle, sustainable development and sustainability transition.

Precaution is one of the guiding principles of environmental laws in the European Union. "The precautionary principle enables decision-makers to adopt precautionary measures when scientific evidence about an environmental or human health hazard is uncertain and the stakes are high. The precautionary principle is closely linked to governance. This has three aspects: risk governance (risk assessment, management and communication), science-policy interfaces and the link between precaution and innovation." [2]

A sustainability transition is defined as a "radical transformation towards a sustainable society, as a response to a number of persistent problems confronting contemporary modern societies" [3, 4].

The structure and contents of the MOOC were discussed on coordination meetings and in online workshops. The following INTENSE project partners have made their contributions:

- V. N. Karazin Kharkiv National University, Ukraine
- Estonian University of Life Sciences, Estonia
- National University of Mongolia, Mongolia
- Hanoi University of Science and Technology, Vietnam
- Odessa State Environmental University, Ukraine
- Institute of Ecology of the Carpathians NAS of Ukraine, Ukraine
- HoChiMinh City University of Natural Resources and Environment, Vietnam

The structure of the MOOC "Precautionary Principle and Sustainability Transition" is as following:

Module 1 - Sustainability concept and precautionary principle

- Early warnings and the precautionary principle
- Sustainability indicators
- IT tools – Geoinformation technologies in planning sustainable development of territories
- Sustainable land management and climate change

Module 2 - Sustainable consumption and production

- Special protected area management and its sustainability
- Sustainable agriculture
- Sustainable Fisheries
- Sustainable Transport
- Sustainable Forestry
- Sustainable Tourism
- Sustainabliy of Pastoralism in Mongolia
- Delta Challenges
- Social conflicts during econetwork creation and development

For each topic, partners have provided lectures (moreover, in most cases video-lecture also), syllabus, presentation, list of questions for self-control, references. After testing and polishing MOOC "Precautionary Principle and Sustainability Transition" will be opened on the INTENSE project web-site: http://intense.network/ on Chamillo platform.

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YOU WILL HELP WATER – YOU WILL CAUSE TROUBLE AND THEN THE ECOLOGY OF THE EARTH WILL RISE AGAIN

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Today's spiritual condition in our country, the problems of national security and, accordingly, socio-political and economic development put on the agenda an extremely important task - the education of a man of the century, a spiritual citizen of Ukraine.

As the new program provides a socio-cultural content line with four key competencies: life-saving, civic position, financial and environmental literacy - in the current conditions of the formation of society in Ukraine, the shortcomings and gaps in education of the younger generation are becoming more and more acute.

In the context of environmental literacy requirements, the aim of our work is to cooperate with the Lviv Regional Meteorological Center to develop children's understanding of the integrity of unity with nature, to show the interdependent connections we have lost today, and thus to ensure environmental literacy.

Our ancestors' attitude to the Earth and water was built on high values, which was clearly reflected in the customary and traditional rituals. Endowed with a subtle sensory-emotional level of perception, which can be regarded as a close connection with nature, the ancestors showed a deep respect for the earth as the Footstool of the Lord's Throne, as the One who fed them from time immemorial, which determined their agricultural way of life. As for the properties of water, in particular the ability to photograph and store information that is already known to us through scientific experiments, they also knew: "When I go to the well, I'll get into the codes (tapes), so as not to know the whole body from the water damage." This is evidenced by the practice of their lives, as well as folklore texts. From Garafina Makovii's books we learn that the ancestors considered water to be the Lord's Eyes, no one dared to approach the water untidy, not to choke it up.

The water balance of the human body and nature is also known from scientific discoveries, and in folk wisdom we find: "You will help water - you will earn trouble." Convincing norms of folk morality have a full range of educational influences to achieve the educational goal of environmental literacy of our children, which can be a rescue strategy the imminent environmental catastrophe.

So, it is necessary to clean water sources as soon as possible, without waiting for someone to do it for us, for someone to develop projects and invest

the appropriate funds. It is necessary for all together and everyone in particular, to feel and, without wasting a minute, to change this dangerous situation.

It is the experience of ancestors that we use in our work, suitable for adaptation and establishment in our time.

The main reason for the destruction of the world is the spiritual and moral condition of people. The economic crisis is the result of the Fall and their alienation from God.

Destroying nature, man is on the verge of self-destruction.

Today, people need to reconsider their way of life and understand that the spiritual and physical health of man is inseparable from the health of nature. The crisis of the human soul has led to an ecological crisis. Therefore, the answers to questions about environmental problems lie in the plane of the human soul. The way out of the economic, ecological impasse can happen only through the spiritual rebirth of the human personality. And here the decisive factor is the "ecology of man", his spiritual world, faith and morality.

And for this purpose it is necessary to outline directions of work with all spheres of a society, beginning with preschool education that they were able to remember the vocation "to look after the Earth, to clear Water, to keep a soul pure".

In modern conditions, this is difficult to do, because society dictates its living and working conditions. But the vector of action must be directed in the right direction. It is a well-known fact that a person who does not remember the past will not have a future. Overcoming adverse circumstances may not be given to everyone. Only those who are strong in spirit, strong in faith. And whether we will be like that depends on ourselves.

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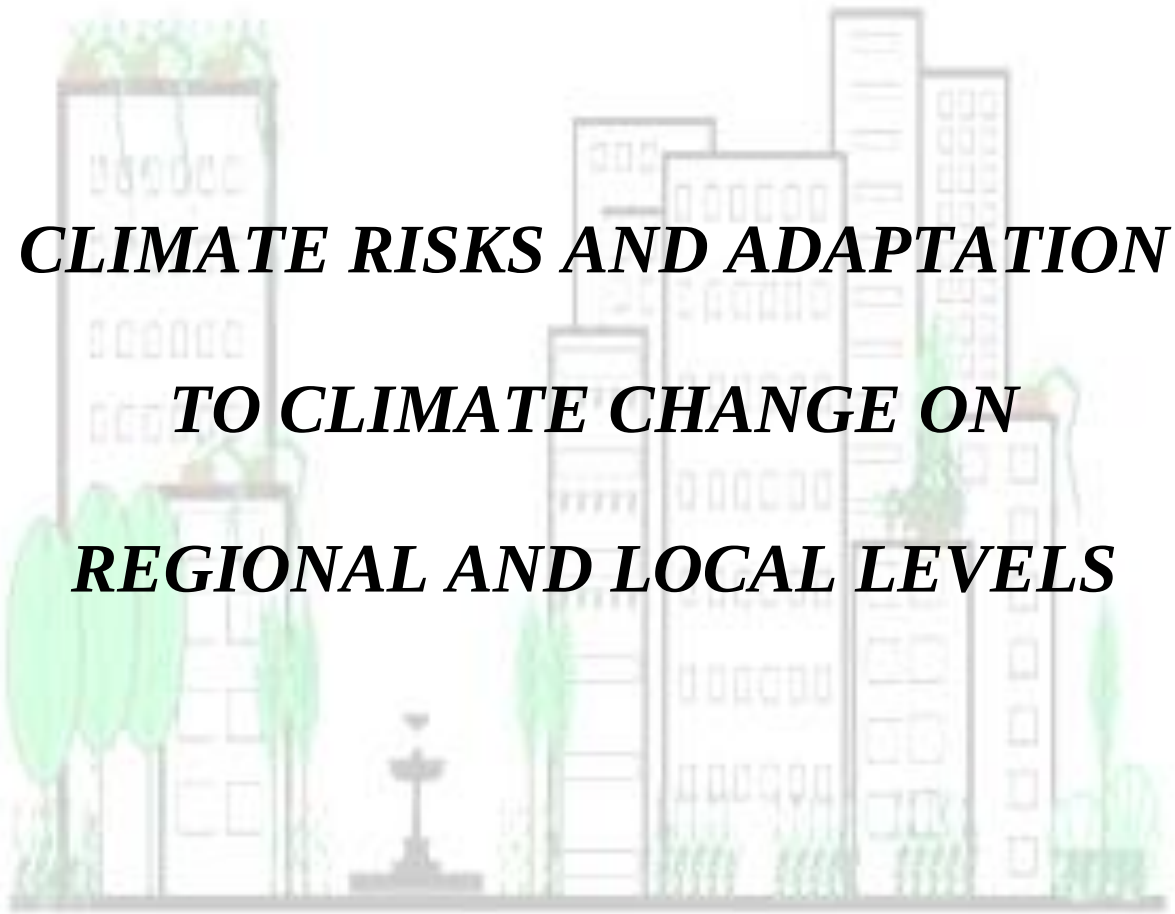

CLIMATE RISKS AND ADAPTATION TO CLIMATE CHANGE ON REGIONAL AND LOCAL LEVELS

LOW CARBON ROADMAP – THE CASE STUDY OF EGYPT

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Cement manufacturing is one of the key industries in Egypt, yet it is one of the highest fossil fuels and raw materials consumers. Resulting in depletion of non-renewable natural resources such as limestone, clay and Iron ore that are heavily consumed to produce clinker, the intermediate product to produce cement with subsequent evolution of CO_2 Emissions. This work represents a review on a case study of the development of the Egyptian Low carbon Roadmap with main focus on cement industry, highlighting the opportunities and challenges faced by the Egyptian cement Industry to become a role model in terms of application of Circular Economy Concept. Which is achievable via utilization of wastes as Alternative Raw Materials and Alternative Fuels (AFR). Potential Alternative Raw materials mainly are Construction and Demolition wastes, Slag from Iron and Steel Industry and Fly Ash from Coal Fired Power Plants. Regarding Thermal Substitution of non-renewable energy sources, Alternative Fuels to lower dependency on fossil fuels mainly are agriculture wastes, Refused Derived Fuels (RDF), Tires Derived Fuels (TDF). The recently developed roadmap indicates the CO_2 reduction strategies. It also highlights policies, regulations and standards that currently under modification by the relevant authorities in addition to the stakeholders' map and communication plan that needed to be followed to ensure sustainable inclusion of circular economy concept to the Egyptian Industry.

CLIMATE CHANGE AND THE FREQUENCY OF SQUALLS ON THE TERRITORY OF THE NORTH-WESTERN BLACK SEA REGION

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A squall is a sharp short-term increase in the wind, accompanied by changes in its direction and is a vortex with a horizontal axis developing under the influence of mesoscale atmospheric convection. Squalls are local and have a short-time influence, therefore they are difficult to register by standard methods. The fact of the phenomenon is often recorded only after its termination, with the help of data from remote sensing of the Earth from space. The accuracy of forecasting squalls by modern methods is still insufficient. In addition, there are practically no methods for forecasting disastrous squalls. Therefore, researches on squalls are continuing around the world, forecasting methods are being developed and perfected.

Most often squalls occur in the central part of a powerful thunderstorm cloud, with very high air humidity during the formation of precipitation [1]. The diagnosis of such local phenomena is quite difficult, especially when the phenomenon develops in a sparsely populated area, and even if a squall occurs in a densely populated area, most often the fact of its passage and intensity can be judged by the results of the damage caused.

Geographical position of the south of Ukraine, synoptic processes and a variety of climatic conditions contribute to the frequent occurrence of severe convective phenomena and creating the extraordinary complexity of their distribution in space and time. In recent years, due to significant climate change frequency of these events has increased. Despite the short duration of the impact, the squall causes significant damage to the economy, infrastructure and population.

Since the existing observational network in Ukraine is not enough for the diagnosis of convective phenomena and, in particular, a squall, it is necessary to equip the network with sensors for continuous registration of the meteorological situation. The most optimal instrument for determining the structure and physical characteristics of a squall line is a meteorological radar. World over, Doppler Weather Radar is recognized as the most versatile tool for squall analysis. On the basis of unambiguous and complex recognition criteria, radars in automatic mode allow not only to detect and recognize convective hazardous phenomena, but also to obtain information on the horizontal and vertical structure of the radar reflectivity of storms, the horizontal and vertical velocity of cloud particles and precipitation drops inside the cloud with a resolution of up to 1 km after 5-10 minutes.

One of the most squall-prone regions of Ukraine is the territory of the North-Western Black Sea. During the period from 2006 to 2020 there was an increase in

the number of squalls on the territory of the North-Western Black Sea region in comparison with previous years. If for fifteen years from 1991 to 2005, according to [2], an average of 28 squall cases were observed, then for 2006 -2020, according to the data of storm warnings from the HMC BAS it was 261.

The largest number of squalls in all three regions was observed in 2010 (43), the maximum number of squall situations per year was noted in 2013 in the Odessa region − 25 cases. The minimum recurrence rate of squalls falls on the Kherson region, where the maximum annual rates during the study period did not exceed 7 cases (2010). In the Nikolaev region, the frequency of squalls varied from 1 to 13 cases (2010) (Fig. 1).

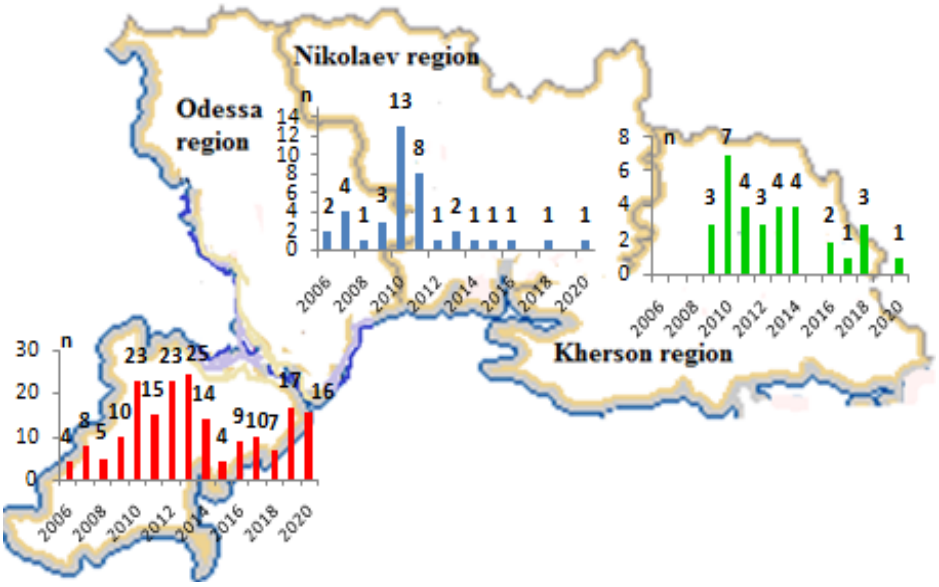

Fig. 1. The number of cases of squalls on the territory of Nikolaev, Odessa and Kherson regions by years. 2006-2020.

The increase in the number of squalls and, accordingly, the emerging risks associated with this phenomen are most likely associated with climate change, namely, with an increase in the meridional circulation. The penetration of warm air masses of subtropical anticyclones into high latitudes and cold arctic air into the southern regions leads to the formation of the most intense convective phenomena, including squalls.

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THE WMO VEGETATION FIRE AND SMOKE POLLUTION WARNING ADVISORY AND ASSESSMENT SYSTEM (VFSP-WAS): METHODOLOGY, CURRENT CAPABILITIES AND POSSIBLE APPLICATIONS FOR UKRAINE

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Vegetation fires – including the application of fire in land use, land-use change and uncontrolled wildfire – affect the functioning of the Earth System and impose significant threats to public health and security. This paper presents the concept of a newly developing Vegetation Fire and Smoke Pollution Warning Advisory and Assessment System (VFSP-WAS) [1,2]. It describes the scientific rationale for the system and provides guidance for addressing the issues of vegetation fire and smoke pollution, including key research challenges. The paper proposes the establishment of VFSP-WAS regional centers, describes the VFSP-WAS concept on examples of two existing regional centers (South-East Asia and North America) [3] and discusses opportunities and possible applications for Ukraine.

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CHARACTERISTICS OF EXTREME TEMPERATURE AND PRECIPITATION IN UKRAINE BASED ON ETCCDI INDICES

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Global warming caused by caused by an excess of greenhouse gas emissions in the atmosphere is undeniable, and over the last century the concentration of carbon dioxide has increased significantly, resulting in an increase in global average temperature by 0.85ºC from 1880 to 2012 [1]. Global warming has been accelerating and intensifying the water cycle of the world and increasing in the probability of occurrence of global abnormal extreme weather and climatic events, such as high temperature, heat waves, floods, hail, droughts, violent storms.

Important indicators of the state and changes in the climate system are climate indices [2]. The joint CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI) developed a suite of climate change indices primarily focusing on extremes [3]. Revealing the current and future trends of extreme indices helps to determine ways to climate change adaptation.

Study area and data. This study examines the trends and variations in 6 ETCCDI indices of daily extreme temperature and precipitation, namely annual and seasonal maxima value of daily maximum temperature (TXx), minima value of daily minimum temperature (TNn), number of days when daily maximum temperature >90th percentile (TX90p), maximum 1-day precipitation (RX1day), maximum consecutive 5-day precipitation (RX5day), maximum number of consecutive days when precipitation <1 mm (CDD), for 16 weather stations of Ukraine for all time periods where observations are available. The indices were retrieved from **http://www.ecad.eu/**.

Results. Non-parametric model was used to derive distribution of mean annual temperature and annual precipitation for the periods 1945–1980 and 1981–2018. Annual temperatures in all stations in question were above the average of 1945-1980 by about 1ºC. Since 1981 annual precipitation amounts have increased unevenly over the territory of Ukraine: the least amount of change in precipitation (2-5 mm) is observed in the Ukrainian West and there is the most increase (88 mm) in East Ukraine.

Empirical probability distributions of annual and seasonal indices based on data from 16 stations are obtained for the whole available time period. For Ukraine average, all annual extreme temperature indices grow strongly in the period of 1991-2018. Seasonal temperature indices also increase but change in distribution differs among seasons. The warming amplitude in TXx were higher in winter and summer than in spring and autumn. The TNn averaged over Ukraine the most intensively increase in spring than in other seasons. The TX90p significantly grows in spring from 24 in the beginning of the 20th century to 37 such days in the period of 1991-2018, though in other seasons warm days may be far greater (up to 45-50).

Maximum 1-day precipitation and maximum 5-day precipitation averaged over Ukraine show increasing trends in the period of 1991-2018. But in seasons RX1day and RX5day increase only in winter and spring, but in other seasons they decrease. The annual and seasonal CDD has been decreasing since the early 1960s.

For the weather stations where observations are available up to 2018 Mann-Kendal trend method and the Sen's slope method were applied to examine the climate variability for the period of 1945–2018. Spatially distributed trends of all indices are obtained in the study area for every season for the period of 1945-2018. In Ukraine, approximately 96% of the time series of TXx and TX90p and 100% of time series of TNn showed increasing trends. Among extreme precipitation indices, 90% of total time series disclosed strong evidence of increasing RX1day and RX5day over the whole study area in all seasons, except in the South of Ukraine where there is decrease in these indices in summer. All trend lines of CDD show downward trends in all seasons over most of the area in question, except summer where slight increase in CDD is observed over the whole territory of Ukraine.

A combination of harmonic regression and spectral analysis was applied to the time series for which the Mann-Kendal method revealed statistically significant trends, to predict annual and seasonal temperature and precipitation, TXx, TNn, RX1day and CDD up to 2050.

Annual temperature was predicted to increase in the study area, with an increasing rate of 0.3-0.5°C decade^{-1} in the next 30 years. Most increase in temperature was predicted for the Crimean Peninsula. Increasing rate of maxima value of daily maximum temperature is the same. Minima value of daily minimum temperature was predicted to increase the most from 0.44 to 0.62°C decade^{-1}. Seasonal values of all indices were predicted to grow, especially in summer and winter for TXx and in spring for TNn.

Precipitation is predicted to increase in range of 4 to 22 mm decade^{-1}, the most increasing rate will be observed in stations located in the western and central parts of Ukraine. For the period of 2019-2050 for the most of the territory of Ukraine time series of annual and seasonal RX1day showed slightly increasing trends while the annual and seasonal CDD is anticipated to decrease insignificantly.

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DISPLAYS OF CHANGES OF A CLIMATE IN BASINS OF THE WESTERN BUG AND PRIPYAT RIVERS

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Observed changes of a climate on globe cause redistribution of heat and a moisture on territory that leads places excessive dry the soils, and places to sudden strong flooding. Research of change of characteristics of a climate in space and time was spent and spent constantly and for various regions of globe and Ukraine including [1, 2, 6 et al.]. Results of these researches find application in various models and прогностических schemes of many reports and managements, as on forecasting consequences, and adaptation to them of territories and the population, etc. [4 et al.].

Changes of a climate in territory of Ukraine are shown in growth of temperature of air, quantity of atmospheric precipitation and evaporations, both from a water table, and from ground [5 et al.]. As a whole in Ukraine essential difference temperature-humidifying of a mode between decades of end XX and beginnings XXI item is marked [3 et al.].

Carried out researches show change, both average characteristics of a climate, and extreme (maximal and their minimal values). So, for example, on meteorological station Sarny growth of average temperature of air is more distinct (fig. 1a) while change of absolute maxima of temperature of air for a year shows presence of more distinct time cycles on a background of growth in time (fig. 1b). Absolute maximum and a minimum of temperature of air increase, and the difference between them decreases. Average and minimal relative humidity of air for a year, despite of growth of quantity of precipitation for a year decreases. The maximal daily quantity of atmospheric precipitation shows presence of some cyclicity and on the average small growth in time, and, in case of loss of a rain, for a day drops out deposits less than 50 mm in 80 % of cases. The maximal intensity of precipitation also has some cyclic fluctuations in time.

The action, capable to settle distribution of a moisture and heat on territory the existential organization of territory of land tenure or settlement can act. At flooding the special organization of territory does not allow water to flow down quickly in downturn of a relief and it reduces peak of a high water, i.e. smears a freshet wave, that in itself will lower a flood damage, the water distributed on a reservoir sates the top layer a ground and provides vegetation with a necessary moisture, in agrarian landscapes we promote a crop, and in settlements - a favorable microclimate from the wood landings, asphalt reducing heating - concrete designs and coverings.

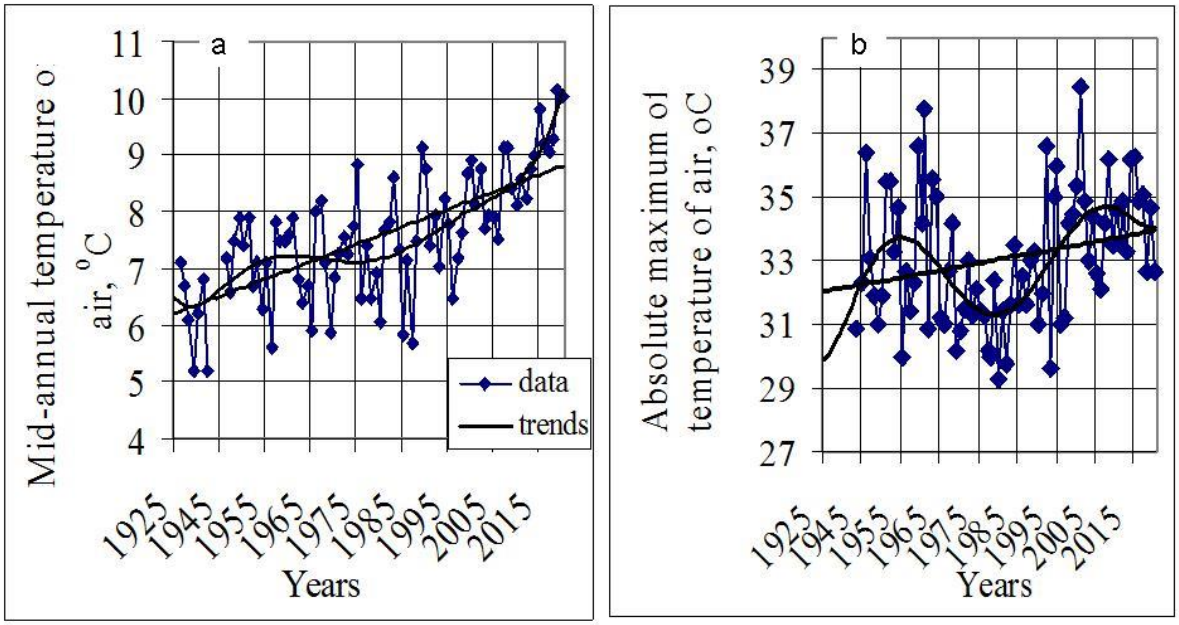

Fig. 1. Change of average (a) and maximal (b) temperatures of air on meteorological station Sarny

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PRODUCTIVITY FEATURES OF ROMANOV SHEEP IN KHERSON REGION CONDITIONS

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In June 2017 the flock of farm had 77 sheep, and it consisted of 3 breeding rams and 74 ewes, all animals up to 3 years old. Thus, all animals were of full-age and had productive characteristics at a level that met requirements of breed standard. Transportation of animals and formation of new flocks are stressful factors that determine changes in physiological state of animals and are traditionally characterized by a decrease in live weight. We evaluated live weight indicators of experimental animals in the autumn, after 2.5-3 months of adaptation to new conditions of keeping and care.

According to breed standard, rams in adulthood have a live weight of 70 to 100 kg, and ewes have 45-50 kg [1,3]. In the first year of farm live weight of lambs was less than standard by 1.5 kg, and in following years it met the requirements. Variability of indicator was above average (Cv>17,0%) due to origin of animals from different farms. Total number of rams has doubled due to young animals and imports of animals.

Live weight of ewes meets requirements, feature is consolidated. Number of flocks increased by 2 - 3 times, thanks to introduction of young animals into the flock. The average live weight of animals increased by 2.0 kg during study period. Variability of indicator confirms prospects of breeding work.

Animals met breed standard, but according to monthly weighing, they lost 2.5 -3 kg of live weight during the first four months of their stay at the farm, and then returned to normal according to annual appraisal for growing and live weight assessments. Such fluctuations were associated with a natural reaction to stress of transportation and adaptation to new farm conditions.

The number of ewes has increased due to introduction of lambs into the group born in 2017 and 2018, respectively, in conditions of farm. Weight of animals increased by 2.3 kg, while variation of traits also changed in direction of traits growth.

Thus, within two years of management imported sheep adapted to conditions of farm during first 4-5 months. Indicators of live weight increased with age confirming adaptation of animals to conditions of farm. Preservation of productivity indicators and their growth are confirmation of Romanov sheep adaptation to conditions of Kherson region.

A good level of animal adaptation is traditionally proved by maintenance of productive traits at level inherent in breed. The Romanov breed of sheep is characterized by unique indicators of reproductive ability [1-3], so we have evaluated adaptation based on these characteristics/

Sheep mating was conducted in the autumn of 2017 and 2018, so lambing was held in the spring of 2018 and 2019.

Sheep were brought to the farm at the beginning of 2017, lambing took place in 2018. This breed differs of its polyestricity, so litter was obtained from almost all imported ewes. Multiplicity was 178%. At the same time, 32% of ewes gave birth to singles, others gave birth to twins and triples. Live weight of litter has biologically determined dependence on type of birth.

Lambs born in triplets had the smallest mass - less than 2.0 kg. The largest mass was characterized by lambs born as single - 2.07 kg ($P < 0.05$). Difference in live weight of lambs of different types of birth is 9.18%. Lambs born in multiple lambing were characterized not only by less live weight, but also by safety. Workers noted two cases of dead lambs in multiple lambing. Cases of lambing with more than three lambs were not observed.

Total number of lambs is 132 heads, and at the time of weaning is 123 heads. Preservation level of lambs at the farm is 93%, with the lowest preservation level in multiple lambing of 85%.

In 2019, number of ewes increased by 40%, and multiplicity increased by 25% and reached up to 203%, which corresponds to characteristic of the Romanov breed. The number of ewes has increased due to replenishment of group with their own young.

The number of ewes that gave birth to one lamb decreased to 20%, compared to 32% in 2018. The number of ewes that gave birth to two or more lambs increased proportionally. The number of lambs born in twins is the largest, more than 64% of total number litter. Average live weight of lambs in the second year of observation also increased: an average of 0.14kg by 6.7%. There is no significant difference in live weight between lambs of different birth types.

Preservation of lambs has increased by more than 96% and by 10% for lambs born in triplets in the farm. Birth *sex ratio* (table 3) is natural. At the time of birth, number of representatives of different sexes does not make a significant difference.

However, birth sex ratio in different types of birth is peculiar, in 2018, there were more male lambs than female lambs in multiple lambing, but difference is not significant.

This year the number of male lambs was born more often in singles and in twins. Satisfactory and good acclimatization of sheep to climatic conditions of Southern Ukraine is confirmed by birth of numerous healthy and viable offspring. In 2019 there is another dependency, total number of female lambs is higher.

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THE IMPACT OF CLIMATIC CHANGES ON THE WATER REGIME OF THE SIVERSKIY DONETS' BASIN

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This publication shows the main methodological provisions related to the study of the ecological status of the Siverskiy Donets river basin within the Kharkiv region for the period 1961-2020, the analysis of a number of characteristics. The state of water resources largely determines the living conditions of the population in a given area. Given the fact that the main source of water supply in the city of Kharkiv are watercourses and reservoirs of the Siverskiy Donets river basin, it is important to study the long-standing changes that have taken place and will take place. The main problem of the basin now is that during the 1990s and 2000s, the Kharkiv region, like Ukraine as a whole, underwent a process of deindustrialization, as a result of which most of the industrial enterprises that polluted the river closed. However, despite this, the condition of the river basin not only did not improve.

The history of studying the valley of the main river of Kharkiv region has more than one millennium. Thus, the first information about the nature of the current, the peculiarities of the water regime of the Siverskiy Donets are found in the work of Herodotus "History", dating from the V century BC. The chronicles of the times of Kievan Rus contain a description of the Siverskiy Donets along with a story about the lands of the Pechenegs, and later the Polovtsians (Kumans) [1]. The period when the territory of modern Kharkiv region was colonized, ie in the XVII-XVIII centuries, should also be singled out. During this period, the Siverskiy Donets, as well as the rivers Uda, Mzha, Oskil are mentioned in the "Book of the Great Drawing" (1627), "Description of the map of Tsarevich Fyodor Borisovich Godunov" (1605), "Topographic description of the Kharkiv governorship" (1785 p.) [1].

Given that the environmental assessment of any area should be multi-component, the presented study covers data on air and water pollution, as well as the degree of mineralization. Moreover, to obtain a more or less complete picture of the ecological status of the Donets basin, it will be advisable to consider not only watercourses but also reservoirs, ie the main lakes and reservoirs. Given the existing network of water quality monitoring, which includes 15 points within the basin in Kharkiv region, it will be possible to study the state of water pollution in the Pecheneg reservoir, and among the watercourses - Siverskiy Donets, Oskol, Kharkiv etc. Purely hydrological characteristics, which will also allow to characterize the changes that occur in the state of water bodies, will be obtained from hydroposts, of which there are 8 in the basin. 6 of them are on the Siverskiy Donets River, and 1 on the Vovcha and Oskil rivers. Climatological information for many years on the temperature and humidity in the basin will be obtained from the existing 7 meteostations, which are relatively evenly distributed throughout

the region, although most of they are close to the boundaries of the basin. However, this will allow interpolation to cover the entire territory of the pool using the software product ArcGIS Desktop.

In addition to all the above factors, attention should also be paid to the nature of the relief of the Donets basin, which largely determines the direction and density of the hydrographic grid. Since the tectonic basis of the basin is the Voronezh crystalline massif, the Dnieper-Donetsk depression and spurs of the Donetsk folded structure, the relief of the basin will be appropriate. Thus, in the north there are spurs of the Middle Upland, most of the basin is occupied by the Poltava Plain, and in the southeast there are spurs of the Donetsk Upland. To this is added the influence of flowing waters. All this affects both the condition of rivers and the condition of land. Thus, rivers contribute to the process of land erosion, as a result of which about a third of the basin is prone to erosion, and about 5% of soils are heavily washed away. Accordingly, it is necessary to afforest the slopes of ravines and gullies, as well as the right banks of the Donets.

Among the main components that determine the ecological status of the Donets basin are the state of the air and the peculiarities of the use and pollution of water resources. Given the closure of many hazardous industries in the Kharkiv region, the air situation has been almost stable over the past 30 years. After 2014, there are fluctuations in the number of emissions. Thus, after the start of hostilities in the Donbas, the thermal energy of the Kharkiv region suffered a devastating blow, and Zmiiv HES, one of the main air pollutants in the region, was threatened with closure. However, in addition to it, there are a number of enterprises (including Kharkiv Coke Plant), which continue to pollute the air more and more due to the lack of effective treatment systems. Regarding the use of water resources, the main industry here is industry, while the share of utilities is not high enough [2]. The volume of discharged water during 2014-2019 is characterized by stability, but there is a tendency to increase the share of polluted water, which indicates a decrease in the efficiency of treatment plants during this period.

Thus, a study of the ecological condition of the Siverskiy Donets basin showed that a third of the land is at risk of erosion, where the use of water resources is irrational and harmful to their condition.

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DETECTION OF THE CLIMATE CHANGE IMPACT ON THE RIVER RUNOFF OF SPRING FLOOD IN PIVDENNY BUG RIVER BASIN

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In this work the climate change impact on the river runoff of spring flood is detected and the regional methodology of long-term forecasts of characteristics of spring flood of the rivers in the Pivdenny Buh river basin is developed. The methodology forecasts based on the preliminary typification of floods by water content in choosing the main factors of spring runoff formation, establishing regional parameters (within the basin zoning by a set of hydrometeorological factors) for long-term forecasting of runoff layers and maximum discharge, determining their probabilistic values over many years in climate change conditions.

Researches of temporal trends and cyclicity in long-term series of maximum runoff characteristics of spring floods in the Pivdenny Buh basin showed that the decrease of spring runoff of rivers in recent decades is caused by climate change due to rising air temperature in cold period, deficiency of stable snow covers and significant reducing the depth of soil freezing (since 1989). There is a rescheduling tendency of maximum snow reserves and spring floods to earlier dates (Dokus, Shakirzanova, 2017).

The time series of the maximum discharge and runoff layers of spring floods are synchronous in terms of cyclical fluctuations, and from the end of the 1980s to 2015 the low-water phase was observed on the rivers.

Analysis of the total curves of runoff layers and maximum discharge of spring flood and their difference integral curves in the Pivdenny Buh river basin (at posts with the largest operating hydro-electric power stations on them) showed that in the modern period of spring flood formation in the basin, the impact of river control on the maximum runoff is not significant, the deviations on the total curves are mainly explained by natural cycles and the impact of climate change on river water content.

In the research using the methods of factor and cluster analyzes; hydrological zoning was performed under the conditions of spring flood of rivers in the basin of the Pivdenny Buh, which allowed to distinguish two hydrological regions (region I and region II with subregions IIa, IIb, IIc). The analyzed natural conditions have shown that within limits of the carried out hydrological zoning these regions have specific features of spring floods formation. Data from long-term meteorological, agrometeorological and hydrological observations in the Pivdenny Buh river basin (as of 2020) were used as input information for the development of the methodology forecasts, using data from observations in the Velykyi Kuyalnyk and Tiligul rivers.

To assess the impact of future climate change on the water regime of rivers in the spring flood period, climate change coefficients were calculated (according to IPCC climate models (CORDEX project) of RCP 4.5 scenario for the period 2021-2050), which were taken into account in determining the basic

characteristics of forecasting methods – average long-term runoff layers and maximum spring discharge rates; and modeling of spring runoff layers in the Pivdenny Buh basin in affected period was made.

The results showed that in the Pivdenny Buh basin in the region I in the period 2021-2050 was expected to reduce the long-term average characteristics of runoff (runoff layers and maximum water flow) of spring floods on average by 23 % ($k_{ch} = 0.77$), and in region II: sub-district IIa – by 37 % ($k_{ch} = 0.63$), sub-region IIб – by 51 % ($k_{ch} = 0.49$), sub-region IIв – by 75 % ($k_{ch} = 0.25$).

The layers of spring water runoff modeled according to climatic models in the period of 2021-2050 were expected to be lower than their long-term average value (established taking into account), which was 23 mm (fig. 1). The formation of catastrophically high floods in the period 2021-2050 according to the regional methodology of long-term forecasts of characteristics of spring flood of the rivers in the Pivdenny Buh river basin is not predicted.

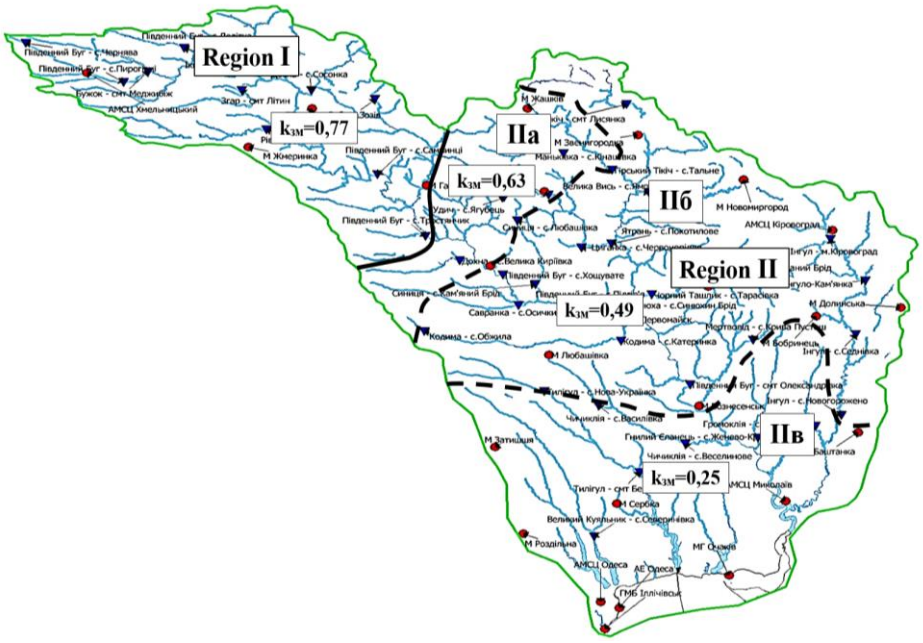

Fig. 1. Average values of climate change coefficients to the average long-term characteristics of the maximum runoff of spring flood (in the period 2021-2050) within the zoning of the Pivdenny Buh river basin under the conditions of spring flood formation

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USING ENSEMBLE OF REGIONAL CLIMATE MODELS FOR ASSESSMENT OF FUTURE CLIMATE IN NORTH-WESTERN COAST OF BLACK SEA

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Future climate change is one of the greatest challenges facing humanity in the current century. The need for information on climate change is necessary for an assessment of their impact on human wellbeing and natural systems in order to develop appropriate adaptation approaches and strategies to mitigate the negative effects of climate change at the national and regional levels. The main tool for future climate change assessment is global climate models. These models calculate future climatic regimes using the scenarios of anthropogenic impact on the global climatic system – so-called Representative Concentration Pathways – and are resulting in future coarse-scale spatial fields of hydrometeorological parameters. In order to obtain hydrometeorological fields with a horizontal resolution of several kilometers, regional climate models (RCMs) are used.

The framework for the impact of the climate-induced changes in meteorological parameters on hydrological and, consequently, hydroecological behaviors of "choked" lagoons in the north-western Black Sea coast is as follows: global warming leads to increased aridity of the regional climate, to increased evaporation from the catchment and/or lagoon surface (together with decreasing total precipitation), and reducing the inflow from rivers and streams into lagoons. This is resulting in an increasing deficit of annual freshwater balance.

This study aims to develop a methodology allowing determining the optimal simulation from the RCMS ensemble relatively to the north-western coast of the Black Sea. At the first stage, the CORDEX dataset was used to obtain future changes in temperature and precipitation.

Next, a database of meteorological parameters (monthly temperature, precipitation, relative humidity, wind speed, cloudiness) for the period 2021-2050 was created for 24 stations located in the north-western Black Sea coast and Moldova at the catchments of small rivers inflowing into the lagoons of the north-western Black Sea coast. The database consists of the outcomes from the 14 runs of different models for climate change scenarios RCP 4.5 and RCP 8.5 (Table 1).

A single simulation was selected, which best reproduces the annual course of temperature, precipitation and evaporation for each grid point and scenario from the ensemble in comparison with the ensemble mean values. The procedure for selecting the "best" run for each node and scenario is as follows:

Table 1. RCMs used in the study.

Run	Institution	RCM	Global model
CLMcom1	Climate Limited-area Modelling Community	CLMcom-CCLM4-8-17	CNRM-CM5
CLMcom2			ICHEC-EC-EARTH
CLMcom3			MOHC-HadGEM2-ES
CLMcom4			MPI-ESM-LR
DMI1	Danish Meteorological Institute	DMI-HIRHAM5	ICHEC-EC-EARTH
DMI2			NCC-NorESM1-M
KNMI1	Royal Netherlands Meteorological Institute	KNMI-RACMO22E	ICHEC-EC-EARTH
KNMI2			MOHC-HadGEM2-ES
MPI	Max Planck Institute for Meteorology	MPI-CSC-REMO2009	MPI-ESM-LR
SMHI1	Swedish Meteorological and Hydrological Institute	SMHI-RCA4	CNRM-CM5
SMHI2			ICHEC-EC-EARTH
SMHI3			IPSL-CM5A-MR
SMHI4			MOHC-HadGEM2-ES
SMHI5			MPI-ESM-LR

(i) for each month of the year, the ensemble mean is calculated as the average for the 30-year period;

(ii) absolute deviations for each run are calculated for each month of the year;

(iii) maximum values of absolute deviations are determined and relative deviations are calculated;

(iv) for each run, the sum of the average annual deviations for the temperature, precipitation and evaporation is calculated;

(v) the run with the minimum value of that sum is considered the best.

After the above mentioned procedure, the CLMcom4 run was be found as the best runs and it's outcomes are recommended as input parameters for modeling the hydrological and hydroecological regimes of lagoons in the north-western Black Sea coast and their catchments in the near future. Analysis of the expected changes showed that the trends observed during the current climate period will continue in the next 30 years.

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ANALYSIS OF PRECIPITATION AND THEIR EXTREMENESS ACCORDING TO OBSERVATION DATA AT ODESSA METEOROLOGICAL STATION FOR THE PERIOD 1976-2019

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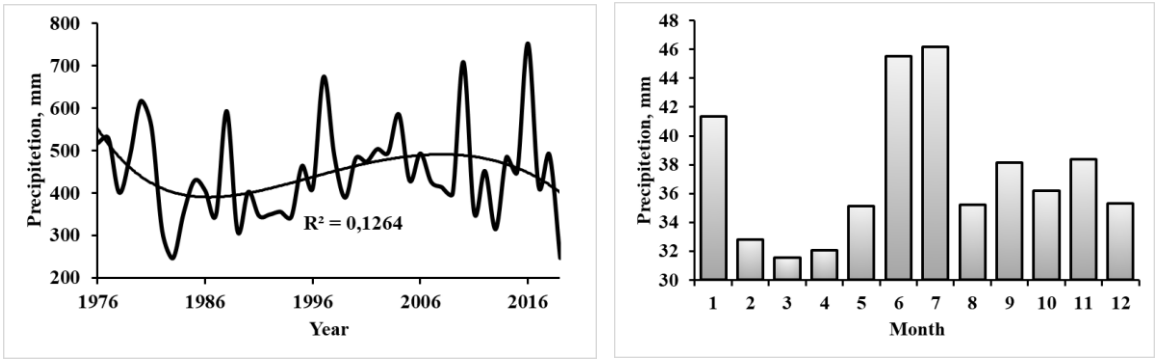
It is known that precipitation is the main source of moisture for the underlying surface; therefore, they largely determine its water balance. Both the lack of precipitation and their excessive amount are critical for human life. Precipitation is associated with such dangerous or disaster weather phenomena as droughts, floods, landslides, etc. Today, the results of scientific researches associate global climate changes, primarily with the redistribution of precipitation over the earth's surface, as a result of which territories with humid climate will become even more humid, and arid ones will suffer even more from moisture deficit in the future [2].

There are many works of scientists devoted to the analysis and forecast of atmospheric precipitation, however, it should be noted that global climate change requires scientists to conduct constant in-depth research at the regional level. The humidification regime is extremely relevant for the southern territories of Ukraine, because against the context of increased thermal background, they significantly depend from the amount of moisture, including that coming from the atmosphere. The issues of desertification of territories, soil degradation, etc. are important and relevant also.

It should be noted that the analysis of total annual precipitation at the Odessa meteorological station for the period from 1976 to 2019 shows the absence of a significant trend component. On the other hand, we can see a quasiperiodic variable (which is well demonstrated by the polynomial trend) against the background of an obvious increase in precipitation extremes in recent decades. The well-known 11-year and its overtone is a 5.5-year cycle, often found in the mode of meteorological values (the formation of an overtone can occur both under terrestrial conditions and be determined by the processes on the Sun themselves). This also includes the George Hale 22-year cycle (double 11-year) of magnetic phenomena, which in some places correspond to large amplitudes of temperature and precipitation fluctuations [1].

The above mentioned we can see on Fig. 1a, where the distribution of total amount of the atmospheric precipitation for the observation period 1976-2019 is shown. Seasonally, the maximum of precipitation is observed in summer (June-July) and in winter − in January, when 40-50 mm/month falls. The autumn months, as well as August, May and December, stand out in a separate group with

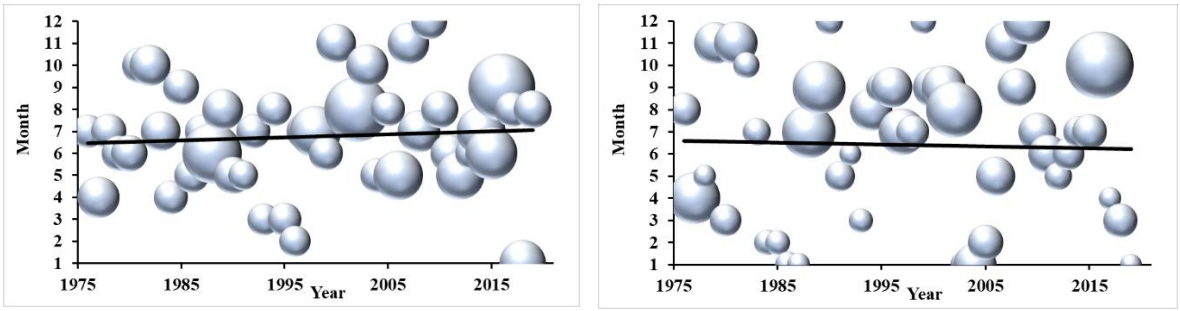
a monthly precipitation amount from 30 to 40 mm. The smallest amount of precipitation is observed from February to April − up to 30 mm/month (Fig. 1b).



a) b)

Fig. 1. Distribution of total amount of the atmospheric precipitation (a) and the annual course of precipitation (b) according to observation data at the Odessa meteorological station during 1976-2019.

The extremity of atmospheric precipitation can be estimated based by the analysis of modal component − Fig. 2. There is an increase of absolute value of the daily precipitation maximum over the past decades, as well as its shift to late summer and early autumn − Fig. 2a. By the monthly section, the following features should be noted: the precipitation monthly maximums are observed in the second half of year, although there is a tendency to shift them to late spring-early summer − Fig. 2b.



a) b)

Fig. 2. Modal component of distribution of the daily precipitation (a) and monthly precipitation (b) according to observations at the Odessa meteorological station for the period 1976-2019.

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AIR TEMPERATURE REGIME IN ODESSA IN PAST AND PRESENT

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The problem of climate change is one of the important issues of modern climatology. Its importance is due to the increased risks of negative consequences for the economies of different countries and changes in human conditions. One of the most significant characteristics of a country's climate is the long-term air temperature regime, therefore, using the example of Odessa, we will consider how the temperature has changed in the past and present time.

The aim of the work is to study the average monthly and annual air temperature for the past 120 years (1900-2020) with the definition of the trend and statistical characteristics.

In fig. 1 shows how the air temperature changed during the study period. For convenience, the period was divided into 4 time intervals of 30 years (climatic periods): (1931-1960), (1961-1990) and (1991-2020).

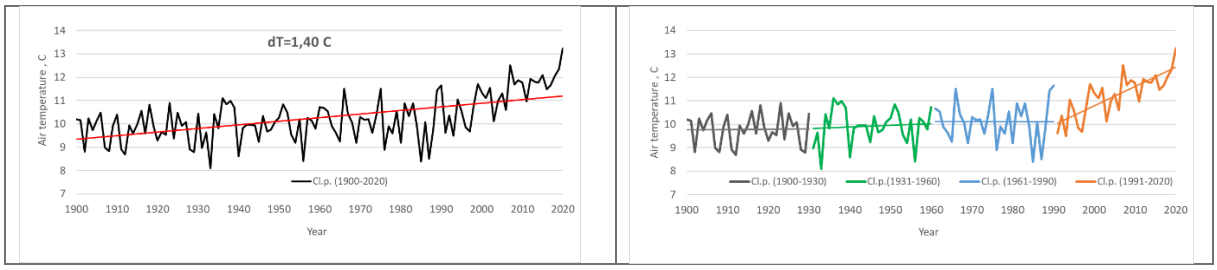


Fig. 1. Time variation of average annual air temperature for climatic periods 1900-1930, 1931-1960, 1961-1990, 1991-2020. and their trends.

Fig. 1 shows that the period from 1900 to 1930 characterized by insignificant fluctuations in annual temperature and practically no change in trend (dT=0.03°C). The annual amplitude of the air temperature was 24.8° C (tabl. 1), and the average annual temperature was 10.2°C, however, since 1930, this is probably due to the growth of industry, fluctuations in the average annual air temperature increased (A=27,6°C) and a positive temperature trend appeared (dT=+0.21°C), the average annual temperature during this period slightly decreased (9.9°C) due to the appearance of extremely low average annual temperatures up to 8.1°C. A characteristic feature of the third period is a negative trend in temperature change (dT=-0.03°C), the average annual temperature is 10.1°C. The most interesting is the fourth period, in which there was a sharp jump of temperature, well described by many authors and coincides with the general concept of global warming. This is primarily due to an emissions increase of the main greenhouse gas CO_2 and, as a consequence, a change in cyclonic activity in the atmosphere. Temperature rise for the current climatic period from 1990 to 2020 amounted to + 2.4°C, and the average temperature compared to the previous period increased by more than 1 degree and reached a value of 11.24°C.

Table 1. Main characteristics of climatic periods.

Characteristics	Cl.p. (1900-1930)	Cl.p. (1931-1960)	Cl.p. (1961-1990)	Cl.p. (1991-2020)
Aver. an. temp.	10,21	9,93	10,12	11,24
Amplitude	24.8	27.6	23.1	24,0

Studying the annual variation of average monthly air temperatures for these climatic periods, one can notice an increase in the temperature trend in winter and summer periods (Fig. 2), with the exception of the period from 1931 to 1960, when the air temperature decreased in the summer months. This is clearly seen in the difference between the previous and subsequent periods (Fig. 3). Comparing the current climatic norm (1990-2020) with the previous one (1961-1990), we can see an increase of the air temperature in all months of the year for the last period, however, the greatest increase of the temperature occurred due to the winter and summer months, when the difference reached 1, 5-2°C.

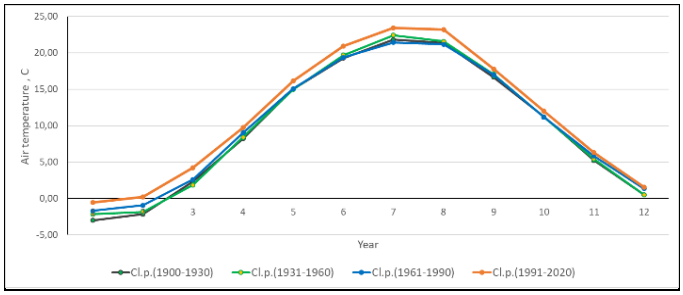
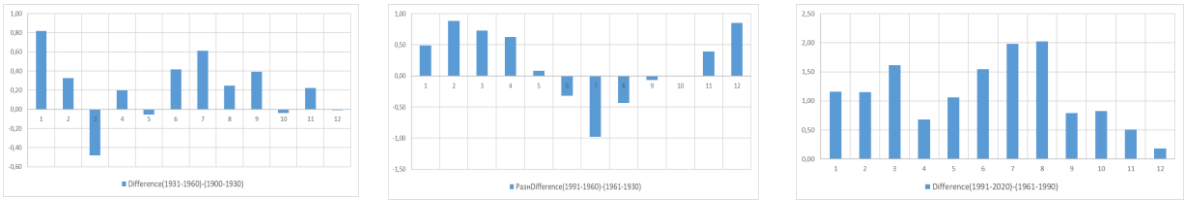


Fig. 2. Annual variation of average monthly air temperature for climatic periods 1900-1930, 1931-1960, 1961-1990, 1991-2020.



a b c

Fig. 3. Average air temperature differences between the climatic periods (1900-1930) and (1931-1960) (a), between (1931-1960) and (1961-1990)(b), between (1961-1990) and (1991-2020), (c).

Thus, we can conclude that for the past 120 years, the average annual temperature has increased by 1.4°C, the increase in temperature occurred mainly due to the summer and winter months.

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AIR TEMPERATURE REGIME IN ODESSA IN FUTURE

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In order to study the climate system on future climate forecasts, different climate models of different emission scenarios are used.

In our work, as forecast data (2021–2050), one used the daily average data of 14 models of the European Weather Forecasting Centers for scenarios RCP 2.6 and RCP 4.5, from which, according to the principle of proximity to the fact data and preservation of the temperature trend, 3 models: CLMcom4, MPI-CSC2, SMHI5 were selected and presented. According to the scenario RCP 4.5 (for convenience, the forecast period was divided into two periods: 2021-2035 and 2036-2050), the air temperature of all models will continue to increase until 2036, and then it will start to fall or slightly increase (MPI-CSC2) (fig. 1). As for the scenario RCP 2.6, the general trends for the entire period of the two models MPI-CSC2 and SMHI5 coincide and are aimed at a decrease in temperature, however, the trend of the CLMcom4 model is aimed at weak growth (Fig. 1).

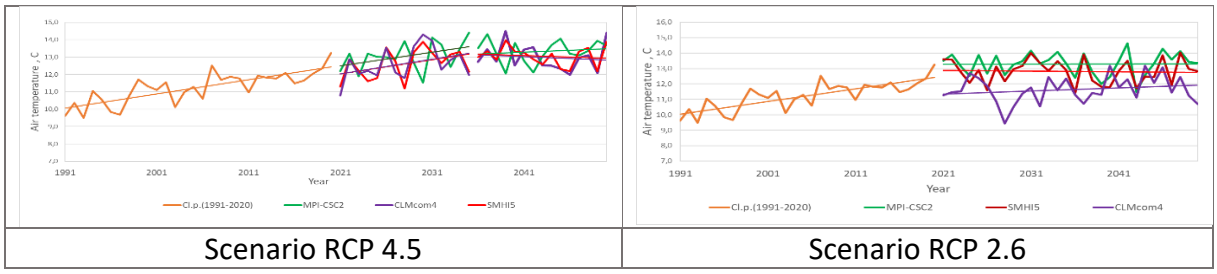


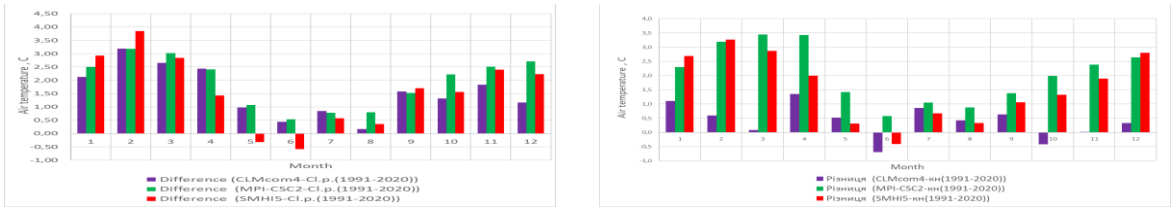
Fig. 1. Time variation of average annual air temperature for climatic and forecast periods

Studying the statistical characteristics (Table 1), it can be noted that the average temperature of the models CLMcom4 and SMHI5 for scenario RCP 4.5, compared with the climatic norm, it will increase by + 1.6°C and reach 12.8°C, and average temperature anomaly of the model MPI-CSC2 will be + 1.9°C and the temperature will increase to 13,2°C. The annual temperature amplitude, on the contrary, will decrease from 23.9°C (cl.n.) to 22.7°C (CLMcom4), to 22.2°C (MPI-CSC2) and to 21.6°C (SMHI5). The average temperature according to the scenario RCP2.6, for to the models MPI-CSC2, SMHI5 will be 13.3°C and 12.8°C, and the annual amplitude is 22.7°C and 22°C, respectively. As for the model CLMcom4, the lowest average long-term air temperature (11.6°C) and the highest amplitude (23.7°C) are expected.

In fig. 2 shows the monthly temperature anomaly. It can be seen that, according to both scenarios, the average monthly deviations from the climatic norm for almost all models are positive with maximum values in the cold half of the year (up to 3.8°C in February) and minimum values in the warm half (down to -0,6°C in June for model SMHI5), except for the model CLMcom4 of the scenario RCP 2.6, where such relationship no exists.

Table 1. Basic statistical characteristics of air temperature for models CLMcom4, MPI-CSC2, SMHI5

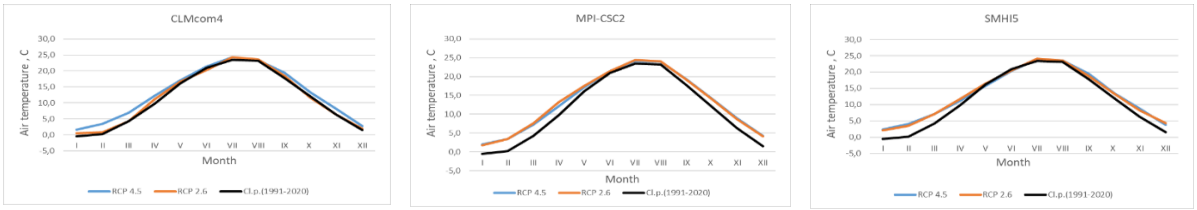
Characteristics		Scenario RCP 4.5			Scenario RCP 2.6		
	Cl.p. (1991-2020)	CLMcom4 (2021-2050)	SMHI5 (2021-2050)	MPI-CSC2 (2021-2050)	CLMcom4 (2021-2050)	SMHI5 (2021-2050)	MPI-CSC2 (2021-2050)
Aver. ann. temp.	11,24	12,80	12,83	13,18	11,24	11,64	12,81
Amplitude	24,0	22,6	21,6	22.2	24,0	23.7	21,9
Anomaly		1,56	1,58	1,94	0,40	1,57	2,06



Scenario RCP 4.5 Scenario RCP 2.6

Fig.2. Average monthly air temperature anomalies of the models CLMcom4, MPI-CSC2, SMHI5

Comparing the model data of the scenarios RCP4.5 and RCP2.6 with each other, it can be argued that the scenario RCP4.5 is a little more severe. The largest anomalies and, therefore, higher average air temperatures are shown by the model MPI-CSC2 (dT = 1.94°C for the scenario RCP4.5 and dT = 2.06°C for RCP2.6) (Table 1). With regard to the uniformity of the air temperature increase throughout the year, it is expected that according to all models and scenarios, in the warm period of the year, the monthly average values of air temperature will increase more slowly than in the cold period, and in some summer months even decrease in comparison with the climatic norm (Fig. 3).



CLMcom4 MPI-CSC2 SMHI5

Fig.3. Annual variation of the average air temperature for the scenarios RCP4.5 and RCP2.6

Thus, it can be argued, that there is a tendency for climate mitigation with the average annual air temperature growth up to 2036 due to temperature increase in the cold half of the year, and then, the air temperature will start to decrease slowly or increase weakly until 2050.

PAN-EURASIAN EXPERIMENT (PEEX) PROGRAM: CURRENT APPROACH AND COLLABORATION

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The scientific mission of the Pan-Eurasian Experiment (PEEX) program is to understand large-scale feedbacks and interactions between the Earth surface–atmosphere continuum in the changing climate of northern high latitudes. PEEX is also interested to understand and quantify the climate - air qaulity (AQ) interactions and AQ in megacities, especially in China. The PEEX Science Plan introduces scientific aims of the program. In addition PEEX programme provides education and training e.g. e-learning in atmospheric and Earth system sciences. PEEX is also promoting the research infrastructure framework GlobalSMEAR especially in Russia and China. The GlobalSMEAR is an approach towards integrated Global Earth observatory initiated by Academician Markku Kulmala and coordinated by Institute for Atmospheric and Earth System Research of University of Helsinki in Finland. We will discuss, what type of collaboration activities this kind of large scale research / research infrastructure / education / capacity building program can offer to the collaborattors and stakeholders.

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NATURAL FOCAL DISEASES OF THE ARCTIC REGION OF RUSSIA

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The Arctic region belongs to areas with an extreme natural environment. The most important components of the natural environment that determine its extremeness are geochemical, biotic, and climatic factors. At the same time, the climatic component of the extreme natural conditions is considered as prevailing in comparison with the others, since it affects human and animal organisms more intensively, as well as due to the scale of the territories it covers. The climate determines the structure of the incidence of both the indigenous and the non-indigenous populations, while the latter who moved to the northern regions from the south is more susceptible to various diseases, having no innate adaptations for living in high latitudes, in contrast to the indigenous peoples. In connection with the intensive development of natural resources in the Arctic, a special place is occupied by natural focal infections, the pathogens of which inhabit the natural environment.

The most important problems of the Arctic regions from a medico-geographical point of view are the following: (1) adaptation of indigenous people and newcomers to the harsh climatic conditions of the environment; (2) difficulties in supplying medicines and providing medical care in the hard-to-reach Arctic regions; (3) climate changes and associated landscape modifications, leading, inter alia, to changes in the spread of natural focal diseases, as well as diseases transmitted through food and water; (4) the emergence of new and recurring infections among indigenous and newcomers.

Thus, diseases caused by live pathogens play an important role in shaping the health level of the population of the Arctic regions. For them, the most important in the epidemiological and medico-geographical terms are brucellosis, tularemia, anthrax, trichinosis, opisthorchiasis, alveococcosis, and rabies. The question of the possible penetration of hemorrhagic fever with renal syndrome into the northern regions in connection with the advance of the bank vole range to the north, as well as tick-borne encephalitis and ixodid tick-borne borreliosis in connection with the possible expansion of the taiga tick range is discussed.

This research was performed according to the Development program of the Interdisciplinary Scientific and Educational School of M.V.Lomonosov Moscow State University «Future Planet and Global Environmental Change». The study was supported by the Russian Foundation for Basic Researches (Research Project 18-05-60037).

VARIATIONS OF ATMOSPHERIC CIRCULATION AND GEOMAGNETIC FIELD IN THE NORTH HEMISPHERE

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To understand the causes of climate change, it is necessary to consider the relationship between the various physical fields of our planet. The relationship between variations in atmospheric circulation and the magnetic field has received little attention. We studied changes in atmospheric circulation in the lower troposphere and geomagnetic fields in the Northern Hemisphere during the 20th and beginning of the 21st centuries to determine spatial-temporal relations between variations of these fields. Integral characteristics of atmospheric circulation and geomagnetic fields have been investigated in the latitudinal band 40-70^o N, applying the same approach. In the indicated latitudinal range, the main centers of action of the atmosphere in the Northern Hemisphere are located (Canadian and Siberian anticyclones, North Atlantic ridge, and Icelandic and Aleutian depressions and European trough), as well as global geomagnetic anomalies (Canadian and Siberian). For the analyzed period there is the most complete set of observational data, which ensures high reliability of the results obtained. The time diagrams were plotted for atmospheric circulation and magnetic field by their integral characteristics. Their comparison showed that the minima and maxima of the pressure field and the full vector of the geomagnetic field coincide quite well. This allows assuming that trends in changes in the geomagnetic field and atmospheric circulation, which were outlined at the beginning of this millennium, will continue in the coming decades. For the prediction of global changes in the air pressure and geomagnetic fields in the future, it is possible using the same methodology.

DEPENDENCE OF WOOL PRODUCTIVITY OF SHEEP AND CLIMATE

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To determine the spatio-temporal climatic conditionality of changes in productivity in sheep, the data are systematized and the links between changes in obtaining the amount of wool shearing per sheep depending on air temperature and precipitation in the Kherson region for 1995-2018 are established. Kherson region for the period 1990–2018 and actual observations of wool productivity of sheep.

The average value of wool shearing per sheep in the region during the study period was 3.73 kg, the maximum value - 4.70 kg (2004), the minimum - 2.80 kg (1996), the level of variation over the years was 15.75% . During the research period there is a pronounced cyclical component of changes in sheep productivity, which makes it possible to determine three time periods: in the first period (1990-2000) there was a rapid decrease and obtaining the minimum productivity of sheep; II period (2001–2010) - obtaining maximum productivity; in the third period (2010–2018) there was a trend-cyclic repetition of the conditions of the first period. Such trend-cyclical manifestations of changes in sheep productivity are significantly influenced by climate change, which is expressed in the favorable living conditions and the provision of fodder for farm animals.

Local observations confirm the presence of a trend-cyclic component of reducing the dynamics of wool shearing per sheep in different soil and climatic conditions of the Kherson region.

As a result of statistical analysis of these observations over the past 25 years, the influence of basic climatic conditions (air temperature and precipitation) on the change in the average annual value of wool shearing (HB) was determined.

For the calendar year of the study of the influence of climate on the productivity of sheep, the period of average values from the 5th to the 12th months of the previous year and from the 1st to the 4th months of the year of wool shearing is taken. To determine the patterns, the largest number of observations was taken in order to ensure the representativeness of research. The dependence is described by a nonlinear function:

$$HB = 0{,}0043x - 1{,}248\ 10^{-6}\ x^2 + 1{,}9285y - 0{,}0751y^2 - 0{,}0003xy - 5{,}348;$$
$$r = 0{,}87,\ r^2 = 0{,}76$$

where *x – is the sum of precipitation for the period of formation of wool productivity, mm; y – the average value of air temperature,* C^o.

According to the spatial diagram, it can be stated that the optimal climatic conditions for the period of formation of wool productivity of sheep and to obtain the maximum value of wool shearing is the average temperature of about 12 ° C, the amount of precipitation - 320-430 mm. As a result of research, a nonlinear dependence of wool productivity of sheep on economic and climatic conditions with a high degree of correlation - 0.87. This makes it possible to carry out simulation spatio-temporal prediction of wool shearing in the Kherson region with a fairly high degree of confidence, determined by the level of approximation of the obtained model - 0.76.

Using GIS-technologies and map algebra on the basis of the created mathematical model the simulation raster model of spatial distribution of wool productivity depending on economic and climatic conditions in the territory of the Kherson area is constructed.

It is determined that the most important natural factor that affects wool productivity is the temperature of the area. The impact of precipitation is underestimated due to significant human economic activity to increase the quantity and quality of feed base through its additional procurement for farm animals. Therefore, to adjust the raster spatial model, an additional coefficient of the natural agroclimatic potential of the Kherson region was introduced to minimize the artificial agricultural impact on the formation of the fodder base, which has a direct cross-correlation with wool productivity of sheep. To do this, using the algebra of maps, recalculated the agroclimatic raster of quality of perennial grasses (fodder base) and obtained an adjusted model of spatial distribution of wool shearing per sheep (STI) in the Kherson region, adjusted for agroclimatic conditions.

Thus reduced, but not completely excluded, the influence of economic activities on additional formation of wool productivity and as close as possible to the natural agroclimatic conditions of formation of wool cutting potential per one sheep. As a result of statistical and spatial geomodeling, raster models of economic and climatic and as close as possible agroclimatic of wool potential on the territory of Kherson region. It is established that under the economic and climatic influences of the potential wool shearing per sheep in the farms of the Kherson region wool potential is in the range 6,4-7,0 kg, its increase is reached from the south to the north. The potential of the territory of Kherson region, as much as possible approached to the natural agroclimatic conditions, provides an opportunity to obtain the wool fleece from 4,7 kg (in the south and south-eastern parts) to 6,6 kg (in the southern and south-eastern parts) to 6,6 kg (in the northern part of the region) per sheep.

AN INTEGRATED FRAMEWORK FOR ASSESSING CLIMATE RISKS TO POPULATION SUSTAINABILITY: A CASE STUDY IN HO CHI MINH CITY, VIETNAM

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Keywords: Sustainable development assessment; Population sustainability; Sustainable development index; Climate change; Ho Chi Minh City

Global warming is a serious and urgent issue facing the world today to achieving sustainable development, and it threatens to reverse millions of people into poverty. In this work, a simple and pragmatic framework for assessing the impact of climate change on sustainable development at local scale was reported according to the three-pillar conception of social, economic and environmental sustainability. This research was conducted to assesse the climate effects on sustainable development of population in the south of Ho Chi Minh City (HCMC), which is subdivided into five district-level subdivisions (District 7, District 8, Binh Tan District, Binh Chanh District, and Nha Be District) and each district possesses its own unique properties of natural resources and society. The average population growth rate of all five districts from 2005 to 2014 was approximately 5.17%, which was around two times higher than that of HCMC, at 2.97%. To the south of HCMC is a lowland area with an elevation of 0.8-1.5 m, as compared to that of HCMC. Also, the population growth rate in five districts was unsustainable under the influence of climate risks, with the sustainable development index of $0.280 \div 0.305$. In conclusion, the negative impacts of population growth affected by climate fluctuations in the southern part of HCMC may lead to potential consequences of population size and structure such as migration, poverty and family disruption.

THE IMPACT OF CLIMATE CHANGE ON THE PRODUCTIVITY OF DAIRY CATTLE

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To reduce climate risks in animal husbandry, it is necessary to study how potential environmental stressors (ambient temperature, humidity, heat radiation, wind speed) can directly affect the functioning of the animal and their health, the realization of genetic potential.

In order to maintain high productivity of farm animals it is necessary to protect them from extreme temperature fluctuations. Therefore, it is important to know the boundaries of the neutral temperature zone, in the middle of which biological processes in the body are normal.

The effect of temperature stress is: hypothermia or hyperthermia, and if these conditions last a long time, the animals die. If the temperature is below thermoneural, the animals are stressed by the cold.

Analysis of meteorological indicators shows that the animals are not in thermoneutral conditions.

During the period 2016-2020, the average annual temperature increased by 1.32ºC, while the minimum and maximum temperatures changed in a similar way. The level of humidity in the winter decreased to 88-84%, against 92-96%, proportionally and the amount of precipitation decreased. The average daily temperatures of the summer period increased from 32.3 to 24.6ºC. Showers during the grazing period have become commonplace, in some months the rainfall reaches 77 mm.

When organizing the production of milk from dairy cattle, the reaction to excess heat is manifested relatively quickly, even at temperatures that people feel as cool. In calves already at ambient temperatures of 15-20 ° C there is a rapid increase in ear temperature, as a sign of increased intensity of blood supply to the skin.

The air temperature of 41°C causes an increase in body temperature to 40°C, the animals clearly feel overloaded, have difficulty breathing, look sluggish. It was found that in a very hot environment the cattle rectal temperature rises above 42°C. At the same time, the frequency of breath sharply increases (to 160 64 respiratory movements per minute), especially at high relative humidity. This can lead to alkalosis, which raises the pH of the blood and lowers the level of carbon dioxide. The heart rate is relatively little affected by temperature.

The state of heat stress of cattle is observed at a respiratory rate of 59 breaths per minute and skin temperature of 35ºC. According to [1], the threshold

value of air temperature is 27.5ºC, for the stress index (temperature-humidity index THI) – 72 points.

According to our observations, the number of cases when the actual value of the indicator exceeded the threshold - for respiratory rate was 27.5% of all measurements; for the stress index - 45% of cases when keeping animals on the playground and 85.1% - indoors.

Observations indicate that the animals had heat stress. Moreover, in some animals the respiratory rate exceeded 100 breaths per minute, and the skin temperature rose to 34.2 ° C. The average respiratory rate does not exceed the threshold level, in contrast to stress indices. In our opinion, the data obtained indicate the need to establish stress thresholds for a particular herd.

Heat stress leads to a decrease in milk productivity and changes in milk quality. The tendency of higher milk yield in the cool period was clearly manifested in animals of high-yielding and low-yielding groups. In general, the number of animals in the cool period probably had a higher one-time hope (P> 0.999).

High temperature and humidity have a negative effect on cattle, leading to reduced milk yield and disturbance of the general condition (general lethargy, reduced resistance). At low relative humidity, animals tolerate even high temperatures.

Analysis of milk productivity data of cows shows that 59.8% of animals had a higher milk yield in the cool period, and 40.2% - on the contrary, in the hot period.

Studies of the reproductive capacity of cows showed that the efficiency of insemination was lowest in summer and autumn, which indicates the negative impact of heat stress during this period. The ratio between the number of sexual hunts and calvings was 3.68 times less than in the spring.

It has been proven that animals that calved in summer came to sexual hunting and were successfully fertilized in autumn and winter. In winter, the effectiveness of insemination was the highest, which indirectly confirms the fact that the negative effects of heat stress have already ceased to exist.

The duration of stress in the experimental farm "Askaniyskoe" in the Kherson region is 1240 hours per year, which is similar to the figures of Ohio and California. Confirmation of the influence of thermal stress on the level of milk productivity and quality indicators of milk was obtained.

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INDEXES OF THE LIVE WEIGHT OF LAMBS OF DIFFERENT TYPES OF BIRTH

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According to the characteristics of the sheep of Taurian type of the Askanian fine-wool breed have multiple births of 110-130 100 head of young ewes [1,2]. We estimated the features of live weight at birth and weaning of the experimental ewes of different types of birth.

By the type of birth, more than 50% of the experimental young ewes were born singles, and less than 50% of the young ewes were obtained in large litters. The lambs of Group I have a high live weight (4.5 kg), which is 9.3% (0.38 kg) higher than the average value for the whole population. Lambs born in triplets have a minimum value of 3.1 kg, the significant average value is 24.6% (1.01 kg, $P \leq 0.05$). The variability of the value is less than 5%, this index is a common species biological trait. In general, the resulting offspring met the breed standards and the level of survival. All lambs were characterized by good physiological development, quickly brought to their feet and actively showed innate reflexes. Maternal qualities were characteristic of all the ewes.

The index of lamb survival at weaning time reaches 92% of the newborn livestock by experimental groups: for singles - 92.0%, in Group III decreased to 80.0%. According to the records, the loss of lambs was: the first group - 6 animals, the second group - 8 animals, and the third - 2 animals.

At the time of weaning the live weight was 34.6 ± 0,71kh (30.2 36,8kh ...). No significant difference by the trait was determined between the groups. The advantage of Group I over the average was 3.0 (1.01 kg), the advantage over the peers born in triplets was 12.7% (3.9 kg).

The variability of the trait is higher than 5.0% that indicates a significant influence of environmental factors. These factors include the level of milking capacity of the ewe, the composition and quantity of colostrum and milk consumption, and so on. Under such conditions, single lambs have an advantage over their peers, they receive all the nutrients from the mother's body.

At the time of weaning, the ewes had a well-developed wool cover, the average length of wool was 6.3 cm. This confirms the high potential level of wool productivity in the experimental livestock, regardless of the type of birth.

According to the technology, at the age of 4 months, lambs switch to full self-feeding, the pancreas and small and large intestines are actively formed. The live weight of lambs exceeds 30.0 kg.

Weaned lambs were put on fattening, the live weight was determined by monthly weighing. The second group included young ewes, born in single

lambing; the third group – young ewes, born in large litters. During the raising period, the loss of young animals of the experimental groups did not exceed 3%.

The control group included a group of young ewes of the previous year, at the time of birth these animals were 14 months old, therefore, to compare their actual live weight with the dynamics of growth of the experimental young ewes was considered incorrect.

The experimental young ewes of Group II (born singles) had a higher live weight, and significantly – by 14.5% (0.7 kg, $P < 0.01$) outweighed Group III (born in large litters). The difference is explained by the type of birth of young animals. Young animals of the experimental groups at the age of 1 month retained a significant difference of 12.5% (0.94 kg, $P < 0.01$). It decreased to 0.79 kg in the following months. At the time of weaning (4.5 months) it is equal to 0.42 kg.

The index of the live weight of young ewes born in large litters of lambs does not have a significant difference with the peers, as born in single litters. It is traditionally believed that this confirms the high genetic potential and ability to compensatory growth. After weaning, all young ewes ate food on their own, that also helped accelerate the growth of the lambs in Group III.

The most similar indexes of the live weight of experimental young animals were determined for the age of 6 and 8 months. According to the calendar of technological processes, this time occurs in August-September-October, when there is active motion and grazing on pastures. This promotes puberty, and the available live weight (from 38.0 kg, the difference between the groups is 0.31 kg) is a confirmation of their ability to reproduce early. It does not depend on the type of birth.

According to the technology, it is necessary to start preparing ewes for insemination not later than in July, increasing their diet by 10% due to concentrated feed. This preparation process is included in in our research.

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THE IMPACT OF CLIMATE CHANGE ON THE CONDITIONS OF GROWING VEGETABLE CROPS IN THE STEPPE ZONE OF UKRAINE

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At the present time, the warming of the climate is no longer in doubt. According to scientists, this warming will continue until 2100. Warming causes a significant change in the agro-climatic conditions of growth, development and the formation of crop yields. Taking in the account the inertial nature of agricultural production and the dependence of its efficiency on weather conditions, it is already necessary to make timely and adequate decisions to solve the complex problems arising from climate change. Warming causes a change in the radiation and moisture-temperature regimes of crops growing, increasing the heat supply of the growing season, reducing soil moisture, decreasing its fertility and increasing its degradation. In addition, the main feature of warming is the unevenness of precipitation in certain periods of the year. Future climate changes are calculated using climate models. In this case, climatic models of different degrees of complexity are used. With the help of models, future climate change is calculated based on a number of scenarios of changes in anthropogenic factors [1].

In the presented study a set of scenarios was used for climatic calculations, namely-Representative Concentration Pathways (RCP). They represent four scenarios, including the time series of emissions and concentrations of the entire set of greenhouse gases, aerosols and reactive gases. Two scenarios were used, as the most commonly used-RCP 4,5 and RCP 8,5.

As a theoretical basis for performing calculations and comparing the results obtained, Polevoi's A.N. models of the production process of agricultural crops were used [2].

The calculations were carried out on the basis of long-term observations of vegetations of vegetables and meteorological elements for the period from 1986 to 2010 year (base period) on the territory of the steppe zone of Ukraine. Calculations of changes in agroclimatic resources, with possible climate changes, were carried out from 2021 to 2050 year. At the same time, agroclimatic indicators were investigated: the average ten-day air temperature (T_c), the amount of precipitation (P), the deficit of air saturation (Das) (t.1), the total evaporation (E_f), the evaporation (E_o), the evaporation deficit (E_o-E_f),the hydrothermal coefficient of Selyaninov G.T. (GTK) (t.2).

The analysis of the calculations made it possible to conclude that the warming of the climate will favor the improvement of the heat supply of heat-loving vegetable crops.

Table 1. Comparison of average long-term agro-climatic indicators with those calculated according to the scenario RCP 4,5 and RCP 8,5

Indicator	Months and decades of the growing season										
	V	VI			VII			VIII			IX
	3	1	2	3	1	2	3	1	2	3	1
Tc	16,1	17,7	19,0	20,3	21,5	22,6	23,1	22,9	22,3	20,8	18,7
T4,5	16,4	17,2	18,8	21,4	23,1	24,4	24,1	23,4	22,1	22,3	18,4
T8,5	17,0	18,2	20,4	20,5	22,3	24,3	23,6	24,7	24,5	21,3	19,2
∑Pc	13	16	18	19	19	16	14	13	13	13	12
∑P4,5	15	23	21	13	5	1	6	7	9	2	8
∑P8,5	25	13	14	18	7	8	3	2	3	9	15
Дс	6,8	7,7	8,7	9,6	10,7	12,2	13,3	13,4	12,2	10,9	9,6
Д4,5	6,6	6,5	7,1	10,5	14,0	17,2	16,1	15,4	12,7	15,4	10,5
Д8,5	6,2	7,2	9,6	9,7	13,1	16,2	17,0	18,9	18,4	12,2	10,4

Table 2. Comparison of average long-term moisture indicators for the growing season with the calculated indicators for scenarios RCP4.5 and RCP8.5

Period	Precipitation amount (mm, %)	Total evaporation (Eф, mm)	Evaporativity (E_o, mm)	Volatility Relationship ($E_ф/E_o$)	Evaporation deficit, mm	Hydro-thermal coefficient of Selyaninov
1980-2010pp.	377	420,2	556,2	0,76	136,0	0,86
RCP 4.5	293	365	516	0,71	151,3	0,80
Difference	-84	-55,2	-40,2	-0,05	15,3	-0,06
RCP 8.5	290	367,1	543	0,68	173,0	0,79
Difference	-87,0	-53,1	-13,2	-0,08	37,0	-0,07

However, under both scenarios, a decrease in precipitation and an increase in aridity are expected, which will adversely affect the productivity of moisture-loving vegetable crops.

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POSSIBILITIES FOR COMPLEX STORM DETECTION AND FORECASTING OF SEVERE CONVECTIVE STRUCTURES BASED ON MODELING AND SATELLITE DATA

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The most important objective of the forecast is the prognosis of severe weather conditions in time. In summer period these are convection clouds, having rain, thunderstorms. It is very important to monitor and prevent these natural hazards by means of advanced techniques which must able to: detect the event as soon as possible, track the behavior of the event and predict the development of the event. For accuracy forecast it's important to use methods that based on data with high special and temporal resolutions.

The one of such methods that able to accomplish these requirements is MSG stratification. The data of global forecast model GFS and channels of geostationary satellite Meteosat were used in the method. The method includes to detect the area of severe convection structures and identify their intensity.

The satellite data, and different techniques of analysis applied IR 10.8 μm and WV 6.2 μm channels of satellites, are used for diagnostics of deep moist convection features from the high level troposphere to the low level stratosphere. Meteosat-11 is equipped with a high-resolution imaging radiometer in the visible and infrared channels, consisting 11 channels with special resolution 4 km and a temporal resolution 15 minutes [1]. The method used is based on IR 10.8 μm channel that observes cloud-top temperature, shape and phase and WV 6.2μm channel that observes contents of water vapor and cloud-top temperature. The important step of algorithm is comparison between cloud-top temperature and temperature tropopause. To identify the temperature of tropopause there are used the data of numerical model GFS with good spacial and temporary resolution [2].

The tools presented above have the objective of analyzing a deep convection storm with great detail. The algorithm includes parameters that produced from analyses IR 10.8 μm and WV 6.2 μm channels and numerical weather prediction fields, dividing into two levels, in order to better identify regions with deep convection. These parameters can be analyzed distinctively, highlighted or combined into an index that is used to classify the storms. A scheme of the approach is presented in Fig1.The first step (blue) is to analysis parameters on possibilities convection. The next step (red) is calculating of intensity convection if it's possible.

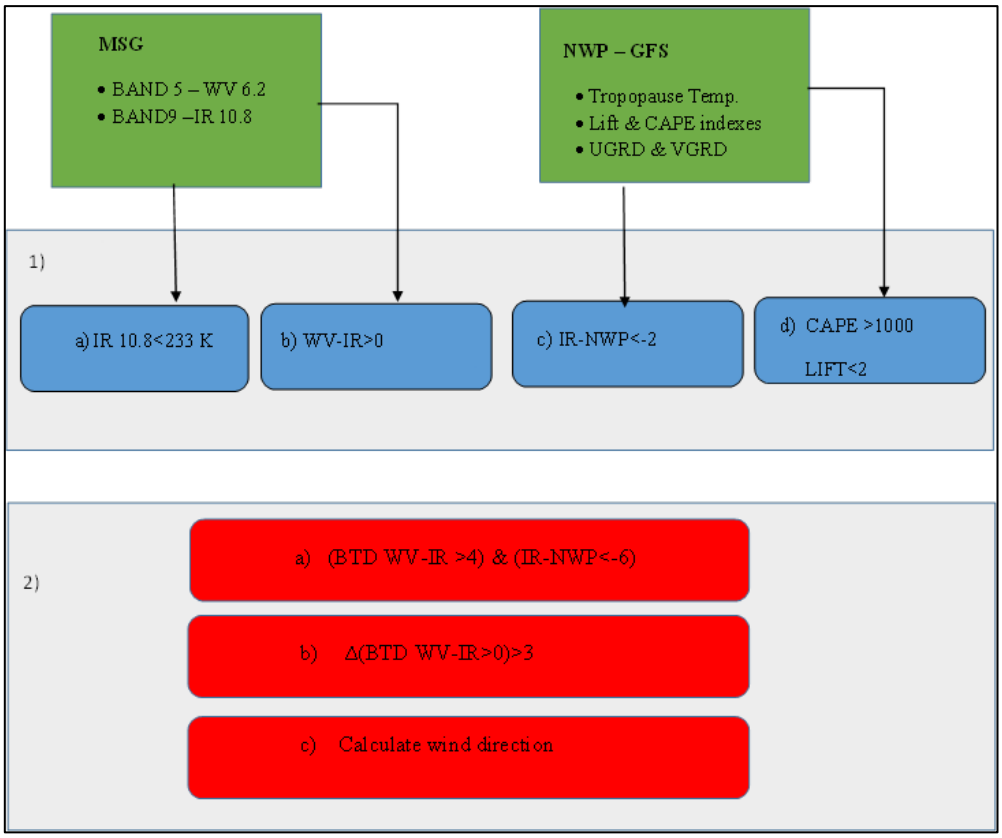

Fig. 1. Stratification approach algorithm scheme

The study period covered the time interval from March 2018 to September 2019. The method shows a good special and temporal frequency. For verification the results were companioned with radar data and satellite data. The results showed that the method has more accuracy for complex convective structures. Sometimes, in zones of active cyclones, along fronts, presumably in areas of large-scale removal of water vapor to the upper layers of the troposphere, there may be cases of false detection of areas of powerful convection. In this regard, to mask these false zones, an additional parameter was introduced into the methodology - the convective instability index. The results of research showed that the method can be quite satisfying when applied to large-scale systems that generate several convective storms with different intensities. Use of such products increase lead-time for storm nowcasting by 30 min – 2 hours.

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THE EFFECT OF PARTIAL DEFORESTATION ON SURFACE WIND SPEED

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It is known that canopy impacts climate characteristics via albedo, evaporation etc. Also, it affects wind speed through roughness and height. The forest influences the most via causing reduction in surface wind speed and provokes local circulation. And forests are the lungs of our planet which produce oxygen via taking in carbon dioxide, levels of which have increased dramatically recently due to mostly anthropogenic factor. Many years people have been planting windbreaks to prevent from extreme wind speeds, soil erosion and escaping of snow from fields etc. Nowadays, against the backdrop of climate change which causes extreme weather events and quantitative redistribution of climate characteristics, the mankind has been facing the deforestation for the last several decades. The deforestation is one of the factors that increases the risks of dust storms, soil degradation etc through wind speed acceleration. These problems attract a lot of attention of the world community and the one of the last reports of IPCC was dedicated to the most urgent problems of land degradation and management taking into account climate change and concerning different regions of our planet [1]. Also much research deal with climate issues and there are many global climate projects, for example, the Coupled Model Intercomparison Project Phase 6 (CMIP 6) [2] the purpose of which is to observe, model and analyze climate change in the past, current state and for the future. One part of this project is the Land Use Model Intercomparison Project (LUMIP) [3] that refers to the past. The aim of this experiment is to investigate the impact of partial deforestation with constant unchangeable anthropogenic impact via global climate models (GCM) for historical period 1850-1929. It is divided into two phases: 1) 1850-1899, defined as pre-industrial with gradual deforestation with a trend approximately 1%/year; 2) 1900-1929 with constant forest cover. Recent years a couple of publications have been published with results of analyzing only annual characteristics of air temperature and sum of precipitation on a global scale [4]. The purpose of the presented study is to assess the quantitative impact of partial deforestation on wind speed for the territory of Ukraine. Such characteristics as temperature, radiation and moisture regimes were analyzed previously. In our research data of retrospective modelling of 6 GCM were used that retrieved from [5]. They have different spatial resolution. For data analysis calculated the mean of wind speed for each month for base period 1850-1869 and found the difference (or anomaly) between a parameter in every month of the year and the corresponding month in the base period. For getting rid off the possible biases the obtained data series were smoothed by 5-year running mean and found correlations between deforestation and wind speed.

The obtained results have shown that all 6 GCMs demonstrated the increase of wind speed and negative correlations with mean and strong bond between forest cover reduction for all months. For the winter season, on the example of January, the correlations between deforestation and wind speed were -0.91…-0.4 in general, that causes the increase of wind speed with trend 0.1-0.2 m/s per 10 years. For the spring season, the correlations for all GCMs were -0.95… -0.4 and with growth of wind speed with value 0.04-0.2 m/s per 10 years. The strongest negative correlation and more significant changes (Fig.1) were found for GCM with more intense deforestation of 1.2-1.3%/year.

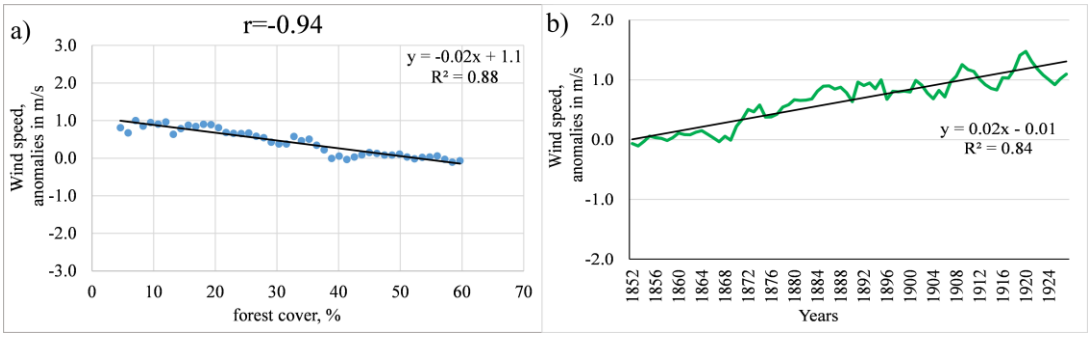

Fig. 1. The correlation between a partial deforestation (%) and changes in wind speed (m/s) (a); the trend of wind speed (m/s) (b) for April, North Ukraine

For July correlations were within -0.97…-0.4 that provoked wind increase up to 0.02-0.2 m/s per 10 years. Also, in autumn for October forest cover reduction triggered the growth of wind speed 0.04-0.3 m/s per 10 years that is supported strong and average correlations -0.97…-0.4. So, all GCMs have confirmed that partial deforestation increases wind speed and consequently, will increase risks connected with dust storms, soil erosion etc.

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TEMPERATURE REGIME AS A FACTOR OF INFLUENCE ON THE TERRITORY

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The reliability of the recorded changes allowed the IRSC to draw conclusions about further warming, which will continue due to the inertia of geosystems. It is expected that in 2050 there will be a change in global atmospheric circulation, which will lead to an increase in arid phenomena and an increase in the level of the oceans.

The consequences of changes in the thermal and water regimes of the planet will contribute to the restructuring of the world economic structure, especially agricultural production. With increasing temperature, there is a decrease in the potential for food production at the planetary level, increasing aridity. Increased droughts and floods will negatively affect regional crop and livestock production.

Analysis of temperature series at 25 meteorological stations, which are evenly distributed throughout Ukraine, allowed to establish the general patterns of spatial changes in temperature. Calculation of deviations of air temperature indicators from the standard climatic norm (1961-1990) allowed to reveal tendencies of these changes. The temperature regime during the year for the period 1882-1990 in relation to 1961-1990 underwent minor fluctuations (Fig. 1).

The analysis of climatic temperature series for the period 1991-2015 allowed to record the trend towards warming, which is characteristic of each research period. The southern and south-eastern territories have insignificant growth rates of air temperature: from 0,4 °C to 0,9°C.

Maximum air temperature growth rates are typical for the central and northern regions (from 1,0°C to 1,4°C). Since climate and temperature are the primary factors influencing agro-climatic resources, due to their direct impact on the agricultural complex, it is necessary to consider in detail their changes over time.

Temperature is a complex system due to spatial and temporal changes, it changes regionally and locally, but its changes are related to the global climate system and cover periods from decades to millennia. In the course of the study by histogram methods were obtained for each meteorological station indicators of the duration of the growing season for the three studied periods (1880-1990, 1991-2015).

The dates of the beginning and end of the growing season and active growing season were determined, which allowed to calculate their duration and determine the shift of the dates of the studied periods. During the period 1880-1990, the longest growing season was recorded in Simferopol (160 days) and the shortest in Sumy (131 days).

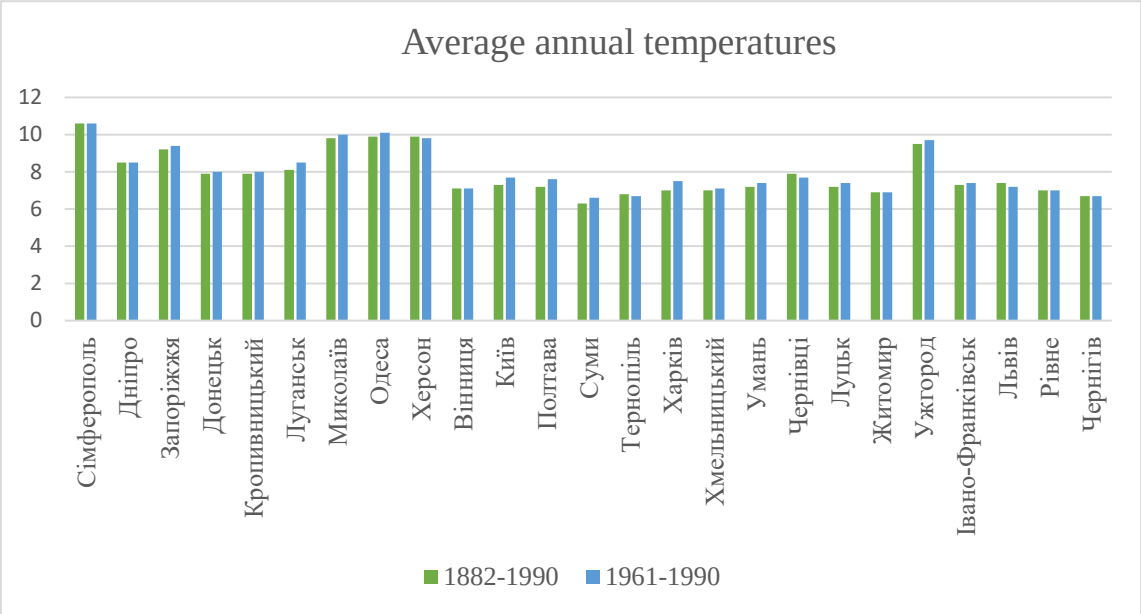

Fig. 1. Dynamics of average annual air temperatures

In general, the largest length of the growing season was recorded in the southern, southeastern and extreme western regions (140-157 days). This is due to orographic features, the influence of physical and geographical factors formed in the country. The shortest duration was recorded in the central and northern regions (131-136 days). The obtained results confirm the spatial variability of air temperature and latitudinal connections of the components of the climate system.

The period 1991-2015 is marked by an increase in the duration of the growing season: the largest indicators of duration are Simferopol (164 days) and Uzhgorod (163 days).

The largest deviations in the direction of increase are characteristic of such stations as Vinnytsia (13 days), Khmilnytsky (12 days), Donetsk and Uman (11 days).

At other meteorological stations the duration of the vegetation period increased from 4 to 10 days. Clear changes in the central, western and northern regions. The southern regions maintain consistently high rates. These trends are a kind of markers of spatio-temporal changes in air temperature in the country, which have a number of consequences.

You can set the impact of these changes on the territory of the three-point system: high (3 points), medium (2 points), low (1 point).

Thus, the vegetation period of 1991-2015 differed in duration and time limits from the period of 1882-1990 and requires further research.

THE ROLE OF SATELLITE MONITORING FOR CLIMATE SERVICES

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Climate services require data from observing and monitoring systems such as ground-based weather stations, ocean buoys, and Earth observation satellites. Satellite measurements of Earth's temperature, greenhouse gas emissions, sea levels, atmospheric gases, dwindling ice and forest cover etc, are essential for improving the understanding of climate change and predicting future of the Earth. Space-based Earth observation has reached a good level of maturity in performance and data-record length: some of the records span 40 years and sensor technologies are increasingly sophisticated and stable.

To respond to UNFCCC (the United Nations Framework Convention on Climate Change) and GCOS (the Global Climate Observing System) need for climate data, the European Space Agency (ESA) has undertaken the Climate Change Initiative (CCI) programme [2]. The CCI is a research programme that exploits archived and emerging satellite observations to develop long-term, global data records that describe the evolution of key components of the Earth system, known as Essential Climate Variables (ECVs) including land cover, land surface temperature, soil moisture, fire, biomass, lakes, permafrost, snow, glaciers, ice sheets (Antarctica and Greenland), sea ice, sea level, sea state, sea surface salinity, ocean colour, sea surface temperature, greenhouse gases, water vapour, ozone, aerosol, and cloud. It ensures that full capital is derived from ongoing and planned ESA missions, including ERS, Envisat, the Earth Explorer missions, relevant ESA-managed archives of Third-Party Mission data and the Sentinel constellation.

Currently, there are around 170 satellites of different operators in-orbit that measure the various indicators related to climate change. Climate Data Records (CDRs) for ECVs are generally derived from a combination of satellite and *in-situ* observations, with satellite observations making a significant contribution for a majority of ECVs. New generation satellites have enhanced optical and temporal resolutions that have improved weather forecasting, climate modeling and the ability to obtain real-time details. Within the next five years, many new satellite missions will be launched, including Eumetsat's second-generation polar-orbiting satellites, third-generation Meteosats and Chinese satellites.

The Satellite Application Facility on Climate Monitoring (CM SAF) from EUMETSAT [3] generates and archives high-quality datasets for specific climate application areas, through the exploitation of satellite measurements with state-of-the-art algorithms, to derive information about the climate variables of the

Earth system. CM SAF is also engaged in training customers in the use of CM SAF products.

The demand for climate services has increased considerably over recent decades. The Global Framework for Climate Services (GFCS) provides a context for developing services, which are interests for insurance, agriculture, public health, energy and transportation. The provision of more and higher quality observational data, together with advances in climate science, will improve the prediction of extreme events such as droughts, floods and tropical cyclones.

Since the creation of the World Weather Watch (WWW) in 1963, some 240 environmental satellite missions have taken place as a major component of the global observing system. The various on-board instrument technologies have permitted observation of the Earth through a wide range of the electromagnetic spectra. The emerged necessity for a coordinated approach for observing climate and generating climate data from space resulted to the creation of Architecture for Climate Monitoring from Space (ACMS) [4]. The final report [1] focuses on satellite observations for climate monitoring and the need for an international architecture that ensures delivery of these observations over the time frames required for the long-term analysis of the Earth's climate system.

The strategy report describes the ACMS in terms of information flow and logical dependencies, which includes: measuring relevant quantities from satellites ("sensing"); the production of climate data records; and the application of those records by various end users, often for policy and decision making purposes (Fig. 1).

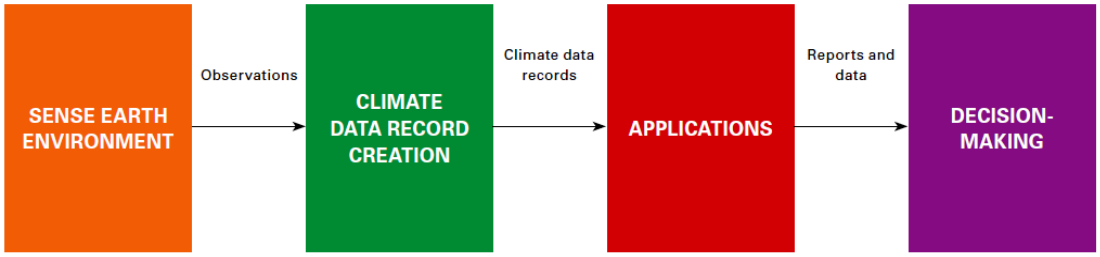

Fig. 1. Architecture for Climate Monitoring from Space [1]

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ECOLOGICAL EDUCATION AND ENVIRONMENTAL SAFETY ISSUES

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The relationship between man and nature is primordial, and it could only become a problem through man and his search for "new meaning". This topic is very multifaceted, but the conclusions of scientists can be summarized in the words: " We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide". And, of course, there are many ways out of this situation, because it is essential to reorganize technological, economic and social factors with all the paradigms, goals, and first of all values.

Evangelical – let's save the Earth and ourselves, it's time.

The competence of the Lviv RCGM includes conducting systematic actual observations and forecasting activities to provide public authorities and local governments, organizations and economic sectors and the population with information on weather conditions in the Lviv region and the city of Lviv. The need and importance of hydrometeorological support is determined by the significant dependence of almost all sectors of the economy on weather conditions and hydrological regime of water bodies, and timely warnings of natural disasters save the most expensive - human life.

The study of climatology and environmental safety does not belong to the scope of LRCGM, but using all available archival and actual information, our experts can not be indifferent, because they see real climate change in the Lviv region:

- increasing the maximum and minimum air temperature in winter, reducing the number of frosty days lead to a decrease in winter duration.

- a significant increase in air temperature causes an increase in the duration of the warm period and, with a possible shortage of moisture, an increase in aridity in the region and increase in level of fire danger.

- significantly increases the length of the growing season and the period of active vegetation, but the early beginning of the growing season can pose a threat of damage by late spring frosts.

The process of global warming is most traced to the example of long-term changes in air temperature and precipitation.

Among the most pressing problems of the ecological state is the insufficient efficiency of existing management systems for the protection and use of all natural resources, which is a consequence of gaps in the work of the educational space.

To love the native Earth given to us by God, to keep it pure and honorable, as our ancestors did, is a real action. Time ecology of the soul!

SCIENTIFIC, METHODOLOGICAL AND EDUCATIONAL ASPECTS OF CLIMATE CHANGE OF THE ANTARCTIC PENINSULA REGION

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Antarctica is a continent far from the centers of civilization, and it is assumed that its climate is formed primarily under the influence of natural factors, allowing to assess the contribution of each climate-making factor.

As well known, a characteristic feature of the recent climate at the end of 20th century at the Antarctic Peninsula (AP) region was an increase in the near-surface air temperature (SAT), which was considered as part of global changes and surpassed global warming by magnitude accompanying by accelerating glaciers' melting, reduction in the sea-ice, expansion of local ecosystems poleward etc. However, just after turn of millennia, in this region as well as in some other extratropical regions of the planet, the warming trend sign changes, with some alternative changes.

The problem of climate variability in polar regions is one of the priority scientific and practical problems of modern meteorology, climatology and environment sciences as the consequences can be expected everywhere on Earth.

In the context of Antarctic peninsula, influenced by both oceans and Antarctica, it is very instructive to study main episodes of climate change – e.g., the manifestation of a well-known climate shift in the mid-1970s due to transition of the El Niño-Southern Oscillation (ENSO) to positive phase and its consequences are still being felt.

Ongoing now climate episode with weak cooling but keeping air temperatures above the multiyear norm has been formed against the background of predominantly cold phase ENSO, although with significant interannual variability.

During the recent climatic period, Important conclusions were made about the influence of ENSO on the regional climate - during the 20th century, this influence has been increasing. Different atmospheric circulation patterns and wind transports were found for West Antarctic sector during the years of various El Niño events. For example, signal of ENSO spreading fast to the AP region, determining climate anomalies at regional stations. So, AP region is Important region in the assessment teleconnections from Equatorial to Antarctic latitudes, with issues to the seasonal forecast on the basis of important periodicities in the atmospheric motions. Atmosphere and ocean teleconnections as well as transitions between scales, from synoptic to regional are well-outlined including local winds and currents, sea-ice.

The influence of ENSO on regional circulation and weather at the Antarctic Peninsula region is displayed in the best way on time scales from monthly to half-

an-year after its mature phase in the behavior of the large-scale synoptic systems such as long-lived (blocking) anticyclones and circumpolar trough (annular mode) governing the intensity of cyclones.

Such a climate variability during the last 60 years is typical for the AP region, and was most pronounced by the data of Akademik Vernadsky station at the western coast of AP and is very convenient for studying climate-forming factors. Besides being the indicator of the regional warming, the Antarctic Peninsula and Vernadsky station is a characteristic point for the states of the atmospheric circulation and its local modifications, ozone anomaly, changes in local ecosystems, rising sea levels and sea ice. As Vernadsky base is close to the latitude of the low pressure belt in Antarctica, it is an indicator of the intensity of cyclones, and peculiarities of the local weather modifications due to the proximity to the AP mountain system and significant topographic diversity in the form of numerous islands (big and high-elevated and low-lying small ones), indented coastline, glaciers. In particular, foehn winds have an supplemented effect to increasing temperatures at Vernadsky station.

Following to the set of glaciological parameters established by prof. L.S. Govorukha in 1996, local small glacier is an Indicator of the state of local glaciation. A wide variety of marine and terrestrial ecosystems makes this area also as the most sensitive Indicator of the state of environment showing ways of adaptation to rapidly changing external conditions

The role of Vernadsky station at the margin of the “ozone hole" is important to show its poleward extent and the speed of wave transport within Circumpolar Vortex. Significant coupling in troposphere-stratosphere is registered, as well as geopotential fields with total ozone fields. Deepening of the ozone hole corresponds in time to the period of modern warming, along the deepening the circumpolar trough and cyclonic activity in Antarctica. Antarctic climate system is also convenient indicator of growing technogenic impact.

Climatic service for this area consists in seasonal forecasting to support Antarctic expeditions, as well as climate forecast, taking into account the fact that the station is located not much above sea level. As stronger variability of ENSO episodes is predicted by models, we should be ready to regional global climatic consequences as glaciers disintegration, sea level rise in Antarctica, and other extremes throughout the world.

Educational aspect of climate change at this region. The Antarctic Peninsula region – is one of the best natural tools for studies of the climate-making agents at the variety of spatial and temporal scales, starting from local and regional (mountains, glaciers, sea-ice and currents) to the larger-scale (atmosphere-ocean) and Cosmic scale (Earth rotation etc.), as well as for the study in the regional ecosystems, starting from krill – primary link in the food chain.

The Southern Hemisphere sets an example for the Northern Hemisphere in using the teleconnections and peculiarities in atmospheric circulation to make forecasts on different time leads.

ASSESSMENT OF CLIMATE CHANGE IMPACT ON PARAMETERS OF FRESHWATER BALANCE IN LAGOONS OF NORTH-WESTERN BLACK SEA COAST

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The study has been aimed to assess quantitatively the impact of regional climate change that occurred and expected in the near future on the freshwater balance of "choked" lagoons in the north-western Black Sea coast. These lagoons have no constant connection with the sea and are sporadically connected to the sea by artificially created channels or other waterworks. The ecosystems of the lagoons are the most sensitive and vulnerable to climate change. These include the Tylihulskyi, Dofinovskyi, Khadzhibeiskyi, Kuialnytskyi, Budakskyi limans, Tuzla lagoon group, and the Sasyk reservoir, which should be renaturalized in the future by restoring contact with the sea.

The incoming components of the freshwater balance for these "choked" lagoons include precipitation falling on the water surface of lagoons and the freshwater inflow from small and medium rivers, and the evaporation from the water surface of the lagoons is the component of expense. If during the year the amount of incoming components is less than the ones of the expense, then a deficit of annual water balance is observed. This deficit should be compensated by water from other external sources in order to prevent shallowing and salinization of a lagoon, deterioration of its water quality, ensuring the sustainable functioning of the ecosystem.

The climate changes of meteorological parameters in the north-western Black Sea coast, which determine the components of the lagoons' water balance, were assessed for the current period 2000-2018 and the near future 2021-2050, compared with the period 1961-1990 (according to the Climate Cadastre of Ukraine). Expected climatic conditions in the near future were determined by the results of the Euro-CORDEX project for two climate change scenarios RCP4.5 and RCP8.5. The 'best' run by the regional climate model CLMcom-CCLM4-8-17 was selected from the ensemble of 14 runs. This run provided the near-future monthly precipitation and evaporation from the lagoon water surface calculated by the data on temperature and relative humidity.

Using the changes in the meteorological parameters, it was revealed that from the beginning of the 21st century: (i) the air temperature is gradually increasing - the annual air temperature for 2000-2018 is 11-14% higher than for 1961-1990, and the expected temperature for 2021-2050 is 26- 28% higher; (ii) the relative humidity for 2021-2050 is reducing by 11-18%; (iii) the annual evaporation from the lagoons' water surface is increasing by 13-15% in 2000-2018 along the northern coast and by 7-9% along the west coast of the northwestern part of the Black Sea; the annual evaporation is increasing in 2021-2050 by 16-20% due to the rising air temperature only and by 33-56% considering

also the expected decrease in relative humidity; (iv) the annual precipitation is increasing by about 3% in 2000-2018 and is decreasing by 5% (up to 15% in the southern part) in 2021-2050 for the scenarios RCP4.5 and RCP8.5 as compared with 1961-1990.

The expected freshwater inflow from rivers into the lagoons in natural and disturbed water management conditions was estimated using the “climate-runoff” model using meteorological data of scenarios RCP4.5 and RCP8.5. It was revealed that in 2021-2050 as compared to the reference period 1990s, on average, the volume of freshwater inflow into the lagoons under natural conditions of runoff formation will decrease by 30% under the RCP4.5 scenario and by 49% under the RCP8.5 scenario.

These estimates indicate that climatic changes, which have already occurred and will be expected in the 21st century, are resulting in an increase in the deficit of the annual freshwater balance of "choked" lagoons in the north-western Black Sea coast; moreover, some lagoons can disappear (see Figure). According to the vulnerability to climate change due to a significant annual deficit of freshwater balance in the absence of other sources of water (e.g. from the Black Sea), the lagoons are ranked in the following order: Kuialnytskyi, Dofinovskyi, Budakskyi (in the absence of water from the Dniester estuary), Tuzla lagoon group, Sasyk, Tylihulskyi, Khadzhibeiskyi (in the absence of anthropogenic runoff). This requires the development of new strategies for their water and environmental management.

An effective solution to the problem of stabilizing the hydro-ecological regime of "choked" lagoons in the north-western Black Sea coast under the increasing deficit of freshwater balance due to climate change is to ensure constant year-round many-directional water exchange with the sea through artificial connecting channels with morphometric characteristics preventing salinization of lagoons in the long-term perspective.

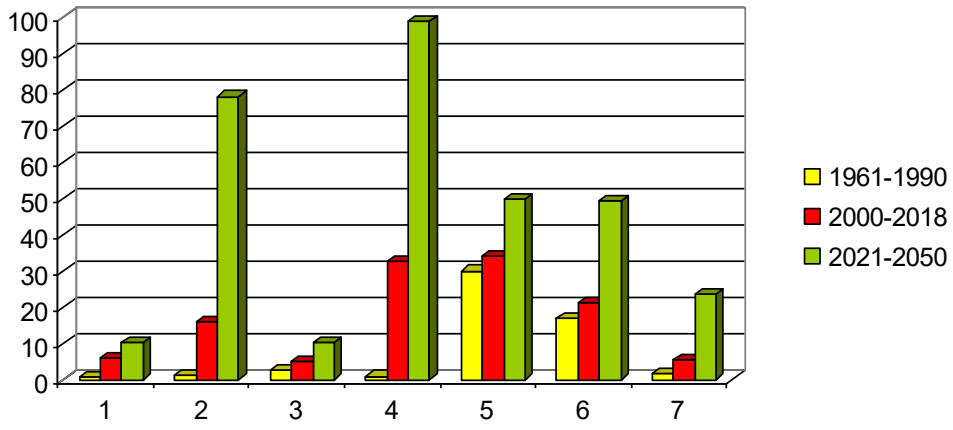

Fig. 1. Percentage of annual deficit of freshwater balance from the average annual volume of water in the "choked" lagoons in the north-western Black Sea coast under RCP8.5 scenario (1 - Tylihulskyi, 2 - Dofinovskyi, 3 - Khadzhibeiskyi, 4 - Kuialnytskyi, 5 - Budakskyi limans, 6 - Tuzla group, 7 - Sasyk).

RELATIONSHIP BETWEEN AIR POLLUTION, GLOBAL CLIMATE CHANGE AND DISTRIBUTION OF COVID-19

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Recently, the relationship between air pollution and global climate change has been carefully considered in the works of domestic and foreign authors [1,2,3, etc.]. Some authors have established the relationship between pollution of CO, NOx, CO_2, CHOH components (as primary and secondary pollution due to photochemical transformations in the air) and temperature conditions of the urban environment. For the conditions of Ukraine, long-term statistical trends were built on the basis of monitoring long-term observations of large cities according to the data of both the state system and other currently existing observation systems.

Urban air pollution is one of the reasons for the spread of disease among the population. Solid particles with a diameter of less than 2.5 μm in the city atmosphere are a significant predictor of the number of confirmed cases of COVID-19. As noted in the works of foreign authors, the expected number of cases of COVID-19 increases by 100% with an increase in the index of air pollution by 20%.

However, with regard to air pollution of urban areas by aerosol particles against the background of global climate change, these studies today need further study given the relationship between aerosol pollution from 0.1 to 001 microns of air in large cities and the spread of disease in Covid -19.

It should be noted that recent studies by foreign authors on this topic have found a potential link between air pollution by particulate matter (PM) and the spread of Covid-19 infection in Italy (Sedlmaier N., Despres V.R. et al)[[4,5]. In these studies, it is noted that the fractions PM2,5 and PM10 can serve as a carrier for several chemical and biological contaminants, including viruses. Viruses can be adsorbed by coagulation on solid particles consisting of solid and / or liquid particles and whose lifetime in the atmosphere is hours, days or weeks. Inactivation of the virus depends on certain environmental parameters: if on the one hand both high temperature and solar radiation can accelerate the rate of inactivation, on the other hand high relative humidity can contribute to the rate of diffusion.

The hypothesis of foreign authors was tested by the authors for the conditions of Ukraine on the example of the cities of Kyiv and Odessa.

The data of monitoring researches on the example of separate months 2020 – 2021 were taken from the data of the system of the international network of automatic solar photometers AERONET and the online system of LUN in Kyiv and in Odessa.

Assuming that measurements of suspended PM2.5 particles in the air also contain aerosols of thinner fractions, the authors considered it correct to use the

measurements of this fraction to construct statistical trends between measured concentrations, temperature conditions and cities and the number of daily increases in Covid -19.

Analysis of monitoring data from different systems showed the probabilistic nature of the distribution, so according to the research of Professor O.I. Pirumov, the integrated dispersion curves of aerosol particles in the probability-pre-arithmetic coordinate system have the form of a straight line.

The relationships between the air quality index AQIPM2.5 and the incidence of Covid -19 for April-June 2021 data in polynomial coordinates for the city of Kyiv and the city of Odessa were constructed. The number of infected was taken taking into account the 14-day incubation period.

The conducted researches give the basis to draw the following conclusions:

1. For the conditions of Ukraine, the hypothesis of the works of a number of foreign authors on the relationship between the presence of air pollution by aerosol particles in urban areas and the number of patients with Covid -19 was confirmed. On the example of the urban environment of Kyiv and Odesa, correlation dependences are obtained, which are linear in nature and directly depend on the temperature conditions of the environment.

2. These studies can be promising in the future to find ways to reduce the impact of aerosols in the air on the human body, as well as the appointment of finer cleaning in production processes and air exchange technologies in modern buildings and structures.

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ANNUAL DISTRIBUTION OF THE OKA RIVER FLOW IN KALUGA UNDER THE CONDITIONS OF CLIMATE CHANGE

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As is well known, the main element of renewable water resources is the river flow. The study of annual distribution of the river flow in the recent period is explained by the need to adapt a complex water management system to seasonal changes of flow under the conditions of climate change [1].

Information about an annual flow distribution is important for planning water supply to urban populations in order to provide environmental safety in changing climatic conditions. For instance, water supply in Kaluga and the Kaluga region is provided from underground and surface sources, but it is known that 50% of the total amount is the surface water intakes.

The real year method is used to calculate the annual flow distribution based on hydrological observations for the period 1987-2017 in this article. This method is in selecting from a few years the such year, which is the closest to the probability of exceedance for the year and for the limiting period (seasons) both. The part of year from June to February is taken for the limiting period, the periods from June to August and from December to February – for the limiting season, i.e. low-water periods. The probability of exceedance is set at 95% according to the drinking water supply type.

The parameters of probability distribution curves for the series of modular coefficients for the specified periods are determined by the maximum likelihood method (Table 1).

Table 1. Parameters of the probability distribution curves of flow.

Statistical parameters	Year	Limiting period	Limiting season	
			Summer-Winter	Summer-Autumn
C_v	0.24	0.21	0.23	0.26
C_s	0.38	0.74	0.84	1.02
C_s / C_v	1.59	3.55	3.61	3.95
σ_{Cv}	0.02	0.02	0.02	0.04
σ_{Cs}	0.39	0.43	0.43	0.46

The relative mean square error of the average long-term runoff value for all series is less than 5%, the relative mean square error of the coefficient of variation is within 10-15%.

Thus, the absolute values of flow of 95% probability of exceedance is 2227 $m^3 \cdot s^{-1}$ for the year, is 1216 $m^3 \cdot s^{-1}$ for the limiting period and is 835 $m^3 \cdot s^{-1}$ for the limiting season. Flow of the third (spring) season (or non-limiting period), which is not included in the limiting period, is 1011 $m^3 \cdot s^{-1}$. Flow for the non-limiting

season, which is included in the limiting period, is 382 $m^3 \cdot s^{-1}$.

Accordingly, the relative values of flow of 95% probability of exceedance increase to 54.6% of the annual one in the limiting period and they reduce to 45.4% in the non-limiting period for the low-water years. Besides the flow of probability of exceedance of 95% is 37.5% of the annual flow in spring and winter seasons. Such redistribution of the river flow is in the low-water years.

The seasonal distribution of runoff is calculated for a low-water group of years by the real year method. It is found that the real year is 2015-2016. Figure 1 shows the results of the monthly and the seasonal distribution of flow for the low-water year by the chosen actual one.

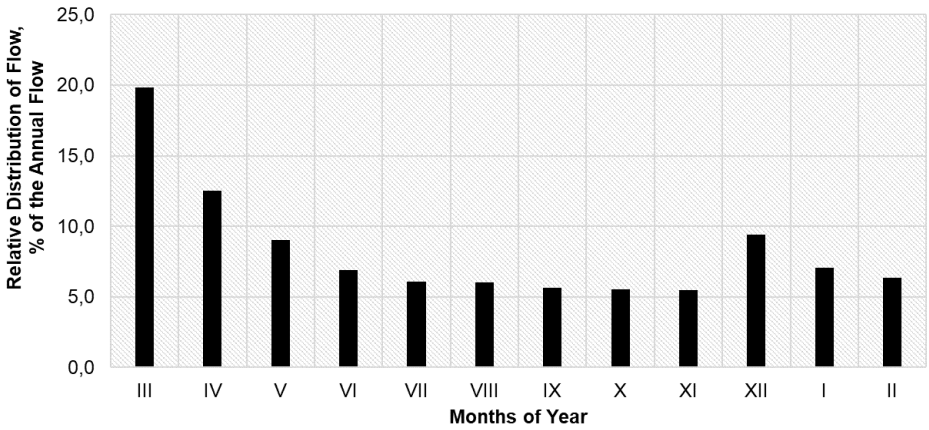

Fig. 1. Estimated distribution of the flow by month of 2015-2016 year.

Analysis of the season distribution of flow showed that 19.9% of the spring flow is in March, 6.9% of the summer flow is in June. The distribution of flow from July to November is almost unchanged and varies from 6.1% in July to 5.5% in November, the most value of the winter flow is 9.4% in December. In general, the relative distribution of the spring flow is 41.4%, of the summer-autumn is 35.7%, of the winter flow is 22.9%. Such distribution of runoff into the summer-autumn and winter periods indicates about sustainability of underground food.

These results prove the features of distribution of the annual flow of the Oka River basin noted by the authors [1], which are related to a decrease in the unevenness of distribution of the annual flow and an increase of the ratio of the low-water flow, especially in the winter. This circumstance should be considered when planning the use of water for various water management needs.

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AUTHOR INDEX

Наукове електронне видання

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