Global warming and rational agricultural lands use in the Baikal Nature Territory

Y M Ilyin¹, A A Ayurzhanaev¹, M V Semenova², B V Sodnomov¹ and B Z Tsydypov¹

¹Baikal Institute of Nature Management SB RAS, Ulan-Ude, 670047, Russia
²Buryat State Academy of Agriculture after Philippov VR, Ulan-Ude, 670024, Russia

E-mail: mariai87@mail.ru

Abstract. A comparative assessment of moisture deficiency in the root zone of the soil based on its water properties has been made. The frequency of precipitation was determined. A reduction in the area of arable land with their transfer to deposits, hayfields and pastures has been proposed. It is shown that the risks of the agricultural sector need to be leveled by irrigated agriculture.

1. Introduction
Nowadays, many studies are devoted to climate change, many of them are coordinated by an intergovernmental panel on climate change. Global warming as direct impact to nature system components is express in a force of aridization and desertification processes. Aridization as a function of climate warming is supported by an increase in solar radiation fluxes due to sunny cloudless days. As a rule, clouds reflect 24% and disperse 7% of solar radiation. This effect forms in the soils an exudation regime and active water absorption by plant communities. To external the regulator of positive feedback is a reduction in the amount of precipitation (more than 5 mm / day) and an increase in the frequency of extreme low precipitation. So, droughts are becoming one of the main indicators of land aridization.

Thus, positive feedback as a measure of potential instability contributes to an increase in anomalies of microclimate elements during background climate fluctuations [1].

Climatic changes in the Baikal lake basin, first of all, its temperature characteristics and the amount of precipitation have been confirmed by many authors [2-11].

Climate change is confirmed by multi-year observations of the World Meteorological Organization (WMO) station network and national networks. According to the data obtained, from 1860 to 1998, the global increase in air temperature was 0.8°C [12]. On average in Russia in the 20th century an increase in air temperature is estimated from 0.9°C [13] to 1.1°C [14] is more evident than on the planet as a whole.

As a rule, the air temperature increase is directly related to the amount of precipitation. For example, in the Baikal and Transbaikalia (the Lake Baikal basin), it has been experiencing a dry period for two [15, 16]. The basin of Lake Baikal is located in arid and semi-arid areas on the border of the arid belt of Asia and classified as extremely vulnerable to environmental climate change [17]. The warming, the long dry period and the increasing rates of anthropogenic activity led to an increase in the area of deserts, reduction of forest and soil degradation [10] This, in turn, leads to environmental
aridization, disruption of the carbon/oxygen balance, dehumidification of soil systems, land degradation, etc.

Global warming and anthropogenesis together create a synergistic effect that definitely and directionally affects the environment, destroying its landscapes. At this stage, the system of interaction between the biosphere and humans does not show negative feedbacks that compensate and counteract the occurrence of chaos in the soil cover - the basic component of natural landscapes.

It should be noted, arid systems and deserts existed in past climatic epochs, which were successfully overcome by biotic communities, adapting to the new environmental situations of a changed world environment. Hence, at present, the main destabilizing factor in the life of the biosphere is human anthropogenic technologies. The peculiarity of the modern stage of aridization and desertification is to increase the role of society.

The fresh water preservation of Lake Baikal is the priority in accordance with the legal framework in the Baikal section (Baikal lake basin) of the World Natural Heritage. In the context of this task, the issue of agricultural production in the central ecological and buffer zones of the Baikal Nature territory (BNT) is relevant. Strictly speaking, the greening of BNT is aimed at reducing the anthropogenic load on its natural systems.

In work [18] it is noted that 95.7% of the agricultural land of the Republic of Buryatia is located in the BNT. Of the 3149.3 thousand hectares of agricultural land, 88.7% are constantly used in the central ecological and buffer zones of the BNT for the production of agricultural products.

However, in the last 5-10 years, agricultural producers in the conditions of aridization of the climate have been forced to write off the crop areas of crops, incurring multimillion-dollar losses. Thus, due to the drought in the territory of the BNT (the Republic of Buryatia) in 2014-2016, 13.5-52.3% of agricultural crops were written off [19].

This practice is, if not the norm, then a clearly emerging trend. In this regard, there is a need to revise the existing structure of sown areas and technologies used in the cultivation of crops.

The consequence of a decrease in precipitation and an increase in air temperature in the basin of Lake Baikal is a decrease in moisture reserves in soil systems and the onset of droughts, which are one of the main signs of land aridization.

Thus, terrestrial ecosystems are forced to respond to climate change. The feedback reactions of ecosystems are diverse and are aimed at mitigating climate perturbations. But global warming has also caused such ecosystem responses, which were expressed in intensifying and aridization and desertification.

It is considered that, of the 45 identified causes of desertification, 87% are due to the irrational use of water, land, vegetation, wildlife and energy by humans, and only 13% are due to natural processes, i.e. on climatic desertification [20]. In this regard, the aim of the research is the development of methods for the rational use of agricultural lands in basin of Lake Baikal.

2. Models and methods

Field experiments were laid by standard methods [21]. Determination of the basic physical, water-physical and agrochemical properties of the soil are performed by generally accepted methods [22,23]. Studies were conducted in Southern Siberia, the Trans-Baikal province of the lowlands and middle mountains, the region of Selenginskaya Dauria.

The objects of study are alluvial meadow soil and various agroecosystems of the Ivolginsk depression, which are part of the Selenginsk Dauria basin of Lake Baikal. The Ivolginsk Basin is typical for the territory of the Baikal Basin in a part of the Trans-Baikal Province.

Climate change assessment in the Baikal Basin was carried out on the basis of the Buryat weather control and environmental monitoring service (UGMS) and Internet resources [24, 25].

The most important characteristics of climatic conditions are temperature and air precipitation. These characteristics determine the characteristics of agriculture and the natural environment. The monitoring of surface air and the soil system as a function of climate plays a crucial role in the life of crops cultivated by human.
3. Results and discussion
Currently, about 700.2 thousand hectares of rainfed arable land are exploited for the needs of agricultural production in the basin of Lake Baikal. Productivity of arable land is directly dependent on the weather conditions of the natural environment. They are also the main disintegrator of the landscapes of Lake Baikal. As a rule, arable land is confined to floodplains and river valleys, where alluvial meadow soils occupy vast spaces.

Data analyses of agrochemical properties indicates of alluvial meadow soil a fairly good performance. In the accumulative humus horizon, the content of organic matter varies from 4.19 to 5.68 % and has a weakly alkaline reaction. According to [17] grouped by the values of indicators of water properties of the soil, the studied soil has the optimum minimum moisture capacity in a layer of 0-50 cm (167.3 mm). Moisture reserves of minimum water capacity are 194.9 mm for 0.6 and 96.9 mm for 0.3 m of the soil layer, and for wilting moisture they are 112.3 and 56.4 mm, respectively. Agrocenoses consisted of dropping of oats “Rovesnik” variety and alfalfa “Nakhodka” variety. The objects of the research are located in Southern Siberia, the Trans-Baikal province of the lowlands and middle mountains, the region of the Selenginskaya Dauria and are included in the buffer zone of the Baikal nature territory.

Field experiments conducted in the Ivolginsk Basin of the BNT buffer zone show that 2018 236.5 mm of precipitation fell in May-September. During this period, marked 28 single precipitations. The loss of one-time rainfall, which is less than 5 mm/day, which are not taken into account in irrigated agriculture, is 50% of the total amount (Figure 1).

![Figure 1. Single precipitation.](image-url)

An analysis of the chronology of precipitation shows that May is rainless, June with rarely falling rain. The maximum amount of precipitation falls in July - 108 mm. In August, there are two peaks in precipitation, September is characterized by a decrease in precipitation. The vegetation period of the year by the amount of precipitation is equal to the average multiyear norm - 234 mm.

The average air temperature during May-September varies from 18.0 to 25.3 °C and higher than the average multiyear by 8.9 °C. The highest air temperatures reached 28.0-38.5 °C and as a result of high air temperatures the upper soil horizons (0-5; 5-10 cm) warmed up well to 28.5 °C.

Determination of moisture reserves as of May 16, 2018 amounted to 27.2 for 0.3 m and 63.1 mm for 0.6 m of the soil layer on the variants prepared for oats (Table 1). The field prepared for sowing alfalfa has the same moisture reserves in the indicated soil layers (Table 1).

Analysis of the tabular material shows that the initial moisture reserves in the soil layer of 0.3 m are 2 times lower than the wilting moisture (56.4 mm). Soil drought in combination with high air temperatures, lack of precipitation in the first half of summer leads to uncertainty, which subsequently results in the absence of seedlings.
Table 1. Initial soil moisture reserves, mm.

| Culture | 0-30 moisture deficit | 0-60 moisture deficit |
|---------|-----------------------|-----------------------|
| Oat     | -69.7                 | -131.8                |
| Alfalfa | -72.3                 | -121.2                |

Note: the numerator is moisture reserves on 05/16/2018. The denominator is the soil moisture reserves of 70% minimum water capacity.

Therefore, it is necessary to carry out pre-sowing irrigation with a norm of at least 131.8 mm or 1,318 m$^3$/ha for 0.6 m of the soil layer. In order to save water and energy resources, it is necessary to soil the soil layer with a norm of 69.7 mm (697 m$^3$/ha) with the minimum water capacity equal to 969 m$^3$/ha.

According to [20] in Transbaikalia (BNT), the evaporation potential for a 100-year period increased by 37-45 mm. From this it follows that due to the deficit of evaporation, the climatic rate of irrigation must be taken on 370-450 m$^3$/ha more than the existing ones.

At a rate of irrigation of alluvial meadow soil of 290 m$^3$/ha, it is additionally necessary to give water of at least 400 m$^3$/ha with a calculated soil layer of 0.3 m. However, for the root zone of the soil (0.6 m), the irrigation rate increases by 734 m$^3$/ha with a natural irrigation rate of 584 m$^3$/ha. This means theoretical calculations [20] comparable with practical indicators of moisture reserves in field experience for a 0.3 m soil layer. In the root zone of the soil (0.6 m) draining is 1.3-2.0 times higher than theoretical calculations.

Irrigation melioration should be the conceptual basis for the rational use of arable land in the conditions of unstable wetting of the BNT. The transition to a model of sustainable agricultural development based on irrigated agriculture, the rational and environmentally sound use of agricultural land is dictated by the deterioration of the climate of the BNT territory towards aridization, environmental legislation, and widespread soil drought.

It is known that 1 hectare of irrigated arable land is equivalent to 4 hectares of non-irrigated and on agricultural lands it is possible to reduce from 700.2 to 175.0 thousand hectares. Currently, the area of irrigated arable land in the BNT is 36,405 hectares. Retiring arable land will need to be converted into deposits, hayfields and pastures in order to bring them closer to the close, natural state of wild biogeocenoses.

4. Conclusion

The risks of agricultural production in BNT are specific and are due to global warming and the associated drought in soil systems. This means that BNT refers to the zone of risky farming, where aridization of the environment is observed, which is characterized by unstable moistening and an increase in air temperature.

As a result of global warming during the growing season of plants, an increase in air temperature is observed, the amount of effective precipitation decreases (above 5 mm). In this regard, moisture reserves in the 0.3 cm soil layer below the wilting moisture.

Solving the problem of aridization of the environment is possible on the basis of reducing the area of arable land and transferring the main burden of agricultural agriculture to irrigated land. Releasing arable land should be used for hayfields, pastures and abandoned lands.

Soil drought as a consequence of global warming impedes the growth and development of crops. For this reason, 52.3% of the acreage is written off in the BNT.

The conceptual basis for the rational use of land (arable land, hayfields, pastures, abandoned lands) in the context of global warming and unstable wetting in Baikal Natural Territory should be irrigation melioration.
Acknowledgments

The reported study was funded by Russian Foundation for Basic Research according to the research project No. 18-016-00211

References

[1] Budyko M I 1971 Climate and life (Leningrad: Gidrometeoizdat) p 427
[2] Batima P, Natsagdorj L, Gombluudev P and Erdenetsetse B 2005 Observed climate change in Mongolia Assessments of impacts and Adaptations to Climate Change (AIACC) Working paper 12 26
[3] Ding Y, Wang Z and Sun Y 2008 Int Journal of Climatology 28 (9) 1139-61
[4] Shen C et al. Climate of the Past 5 (3) 129-41
[5] Berezhnykh T V, Marchenko O Yu, Abasov N V and Mordvinov V I 2012 Geography and Natural Resources 3b 61-8
[6] Tang Q and Leng G 2012 Environmental Research Letters 7 (1) 014004
[7] Schubert S D et al. 2014 Journal of Climate 27 (9) 3169-207
[8] Tornqvist R et al. 2014 Journal of Hydrology 519 1953-62
[9] Obyazov V A 2015 Doklady Earth sciences 461 (2) 375-8
[10] Sutyrina E N 2015 The Bulletin of Irkutsk State University. Series “Earth Sciences” 13 120-30
[11] Antokhina O Yu, Antokhin P N, Kochetkova O S and Mordvinov V I 2015 Atmospheric and Oceanic Optics 28 (1) 52-8
[12] The Intergovernmental Panel on Climate Change (IPCC) 2003 Climate change: a summary report ed Watson T (UNEP: Gris Arsenal) p 220
[13] Gruza G V, Rankova E Ya, Aristova L N and Kleshchenko L K Russian Meteorology and Hydrology 10 pp 5-25
[14] Anisimov O A, Lobanov V A and Reneva S A 2007 Russian Meteorology and Hydrology 10 20-30
[15] Bychkov I V and Nikitin V M 2015 Geography and Natural Resources 36 (3) 215-24
[16] Nikitin V M, Abasov N V, Berezhnykh T V and Osipchuk E N 2016 Geography and Natural Resources 5 29-38
[17] Karthe D et al. 2015 Water & Environment in Selenga-Baikal Basin ed Kapas M (Stuttgart: Ibedem-Verlag) p 366
[18] Ilyin Yu M 2014 Environmental management of agricultural land use of the Baikal region (Ulan-Ude: Publishing House of the Filippov V R BSAA) p 268
[19] Accounting Chamber of the Republic of Buryatia 2017 The result of expert and analytical activities “Evaluation of the effectiveness of state support for rural producers in the framework of the state program
[20] Ubugunov L L and Kulikov A I 2013 Bulletin of the Buryat Scientific Center SB RAS 4 (12) 243-58
[21] Dospekhov B A 1985 Field experience (Moscow: Agropromizdat) 351
[22] Dolgov S I et al. 1966 Agrophysical methods for soils studies (Moscow: Nauka) p 259
[23] Sokolov A V et al. 1966 Agrophysical methods for soils studies (Moscow: Nauka) p 656
[24] The Intergovernmental Panel on Climate Change, https://www.ipcc.ch/
[25] World Meteorological Organization, https://public.wmo.int/en