

Forecast of the future of earthly civilization at the end of the current century

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Abstract: *Under the pressure of the inevitable threat of worsening natural living conditions on Earth, mankind will first try to redistribute the developed terrestrial territories and resources, and from the middle of the century will begin to create an artificial habitable territory on the Moon. To mobilize all resources for space exploration, the political unification of mankind will be completed and the military-industrial complex will be reoriented. Robots will be actively used in all industries. Robots will build habitable spaces on the moon. In the second half of the century, a transport system – an elevator – will be built between the Earth and the Moon, and a massive migration of people to the Moon will begin. The most important cultural values of humanity will be transported to the moon.*

¹ Professor Alexander V. Bagrov sent this article to Futuribili on August 13th 2020. On August 20th he passed away suddenly. The fact that the article was completed seven days before his death demonstrates that he was an active astronomer to the very end.

Prof. Alexander V. Bagrov was born on 30 June 1945 in Vladivostok. He graduated from Lomonosov Moscow State University in 1968, in 1987 he defended a PhD thesis, and in 2002 became a full doctor. From 1972 he was affiliated to Institute of Astronomy of the Russian Academy of Sciences (INASAM, before 1988 the Astronomical Council of the USSR/Russian Academy of Sciences). As an astronomer Alexander V. Bagrov studied minor bodies of our Solar System. Besides that he was the leader of a Russian team that worked on a space optical interferometer for precision measurements of stellar coordinates. When this project was cancelled due to lack of financial support, he proposed a conception of a single-satellite global positioning system for 1 mm accuracy geodesy and the improvement of the selenodetic coordinate frame. In the field of space technology he proposed an interstellar spaceship with a super-conductive magnet mirror, a lunar elevator, a method of non-rocket launching from Mars and a solar 3-D printer for lunar building. He honoured by the Russian Cosmonautic Federation as a “Space Technique Constructor”. A. V. Bagrov was the author of 12 inventions (supported by patents).

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Sommario: *Sotto la pressione dell'inesorabile minaccia del peggioramento delle naturali condizioni di vita sulla Terra, l'uomo innanzitutto cercherà di redistribuire i territori e le risorse sviluppati sulla terra, e dalla metà di questo secolo inizierà la creazione di un territorio abitabile sulla Luna. Per mobilitare tutte le risorse allo scopo dell'esplorazione dello spazio, ci sarà l'unificazione politica dell'umanità e il riorientamento del complesso militare-industriale. I robot saranno attivamente usati in tutte le industrie. I robot costruiranno spazi abitabili sulla luna. Nella seconda metà del secolo un sistema di trasporto – un ascensore – sarà costruito per collegare la Terra alla Luna, e avrà inizio una migrazione di massa verso la Luna. I più importanti valori culturali dell'umanità saranno “trasportati” sulla Luna.*

Parole chiave: *Spazio, luna, Terra, trasporto, colonizzazione, trasferita della civiltà umana, previsione del futuro.*

Foresight as a need

The desire to know their future is characteristic of all people. Such knowledge allows them to build their activities in such a way as to come to this future if desired with minimal costs, or to do everything to avoid future troubles. Until now, it has not been possible to develop scientific approaches to forecasting the future so that scientifically based forecasts meet the hopes and needs of people. This is widely used by charlatans who pass off their shamanic or astrological forecasts as sacred truth. For want of anything better, people are ready to believe in the predictions of Nostradamus, Vanga or other “prophets”. What alternative can science offer them?

Time constraints on the scientific forecast of the future

Let's start with the fact that science has reason to assert that the development of the world and human society occurs according to natural laws, despite all

kinds of accidents that can accelerate or slow down the ongoing changes. If you know these laws, then on their basis it is possible to make reasonable forecasts of the results of ongoing changes for a certain period of time into the future. The laws of the evolution of nature as a result of cause-and-effect relationships between interacting objects are studied by natural sciences, and very successfully. All technological progress of mankind is based on the knowledge of these laws.

Human society is much more complex than inanimate matter. The laws of the evolution of society have to be isolated from complex and sometimes confusing collisions. Therefore, the alignment of events taking place in society in a historical line is only one side of history. Its main task lies elsewhere.

The task of history is to forecast the future. It is only necessary to separate extrapolations *within the limits* of the identified historical trends from extrapolations *beyond such limits*. The fact is that some tendencies can persist for centuries and everywhere, and some appear for a short time and in a limited area. For example, navigation has been a means of communication throughout the history of mankind among all coastal peoples, and the development of shipbuilding technology effectively affected their development. But steam engines existed for less than three centuries, and their use had a very strong impact on the development of only a European-type civilization. Therefore, the identification of the laws of human development is often hampered by geographical boundaries.

Long-term factors of evolution

Nevertheless, there are certain trends that shape the development of human society everywhere and always.

Human history shows that the size of social structures must be consistent with the ability to control and manage them. As the latter developed, the number of people in social associations increased: clan – tribe – people – state – union of states. Now humanity is at the stage of social globalization – the unification of existing states into a single humanity. Rollbacks to separatism are possible, especially for competitive reasons, but the trend towards the globalization of the human community will persist until its complete unification.

Another determinant of the evolutionary changes of mankind is the state of the environment, including the availability of its resources. For several tens of centuries, mankind has settled in all territories with favourable conditions, but there still remain practically uninhabited territories of the planet with scarce resources and unfavourable conditions. This trend is also a permanent factor. If favourable conditions appear somewhere, people develop these territories, and where conditions become completely unfavourable, people stop living. Most often, people leave the inhabited areas if their main resource runs out – drinking water or food production (agriculture, animal husbandry) become unavailable or impossible in sufficient quantities.

History shows that the development of human communities proceeded in parallel with the development of new territories and new resources. Now all the territories of the planet have been developed, new resources are unlikely to appear in the near future. So the development of new territories on Earth has been suspended due to the lack of undeveloped territories with favourable conditions. Therefore, the struggle between countries for existing resources and territories is inevitable. Direct military action can be replaced by economic mechanisms and sanctions, but the struggle will remain a struggle until humanity unites into a single structure.

Further development of terrestrial civilization will be in the development of extraterrestrial territories. This task is only for united humanity; even powerful superpowers may not be economically ready for fully-fledged space exploration.

Considering the main factors determining the evolution of mankind, we can conclude that the future of mankind will be its unification into a planetary civilization and the development of extraterrestrial territories by it.

This conclusion determines only the vector of evolution, but on the condition that other factors that can influence the evolution of human civilization remain unchanged and will not exert their influence in a different direction. And such factors exist, and they are capable of nullifying a fully compiled forecast.

Changes in environmental conditions

We are talking about the stability of favourable conditions in the developed territories of the Earth.

The history of the Earth as a planet shows the existence of dramatic changes in conditions on its surface. In antiquity there were times of a planetary tropical climate, and there were periods of global glaciations. Often the rate of change was very high, and living forms did not have time to adapt to them. Then there were great extinctions. The species best adapted to the conditions of a particular environment died when these conditions changed greatly.

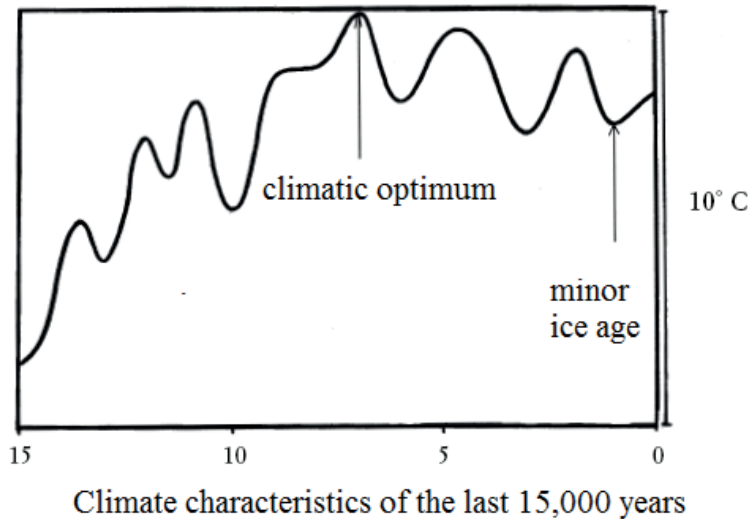
The reasons for the changes in living conditions could be very different. For example, even a slight increase in volcanic activity could cause long-term dusting of the earth's atmosphere and a strong decrease in the flow of solar heat to the planet's surface. They would inevitably lead to global glaciations. On the other hand, the accumulation of carbon dioxide in the atmosphere emitted by the same volcanoes, over time, would lead to an increase in planetary temperature due to the greenhouse effect and melting of ice. In addition, the planet's temperature balance is influenced by global ocean currents and the ability of plants to absorb atmospheric carbon dioxide. All these cyclically manifested reasons are natural, and the energy flows that control these processes exceed by many orders of magnitude the ability of humanity to influence them.

In addition, abrupt changes have occurred in conditions in the history of the Earth, resulting from the destructive falls of cosmic bodies on the planet. In these cases, changes in environmental conditions turned out to be so rapid and strong that up to 95% of the planet's biota died out.

Climate change threatening humanity

Global climate changes are now being observed. We must honestly admit that they are not caused by a human factor. Over the past 15,000 years, the average temperature of the planet has changed by almost 9 degrees (Fig. 1), and these changes are much higher than those attributed to industrial influences on nature.

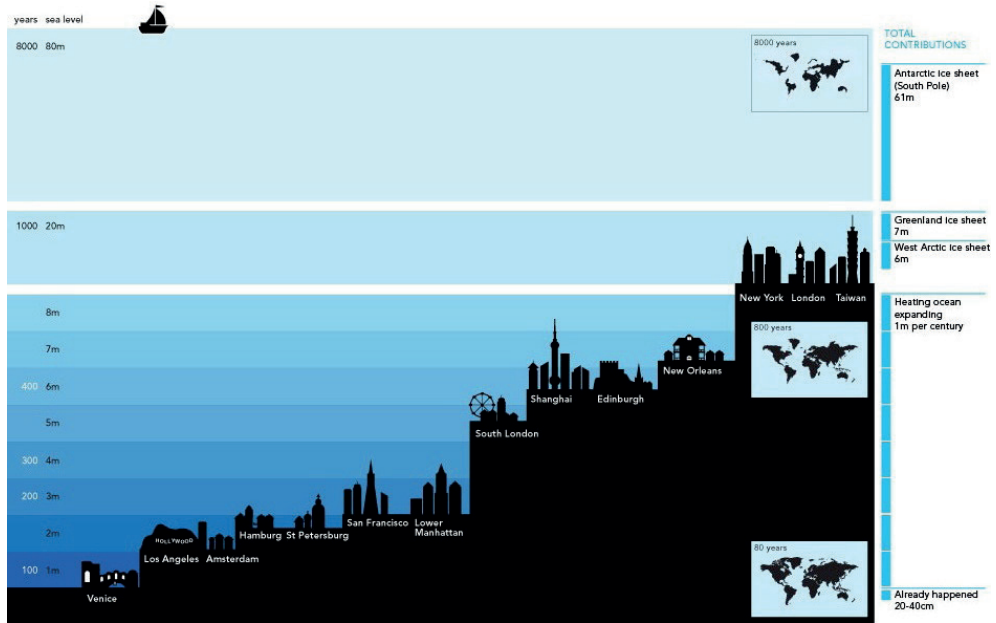
Fig.1. Changes in the temperature of the planet during the existence of people



Source: Mitchell D.M. A changing climate. // Energy and climate: collection. Leningrad: Gidrometeoizdat, 1991 (in Russian).

There are serious fears that existing global warming will lead to melting ice and rising sea levels (Figure 2). Even a slight rise in sea level of 1-2 metres, which may occur before the end of this century, will lead to the flooding of many populated areas and agricultural areas. We will have to relocate people from flooded cities and build housing for them elsewhere. We will have to develop new territories for farming without much confidence that the zoned agricultural crops will remain productive in the new place. In a word, the rise in sea level alone may require enormous efforts from mankind for the forced resettlement of peoples.

Fig. 2. Implications of rising sea levels for cities around the world.

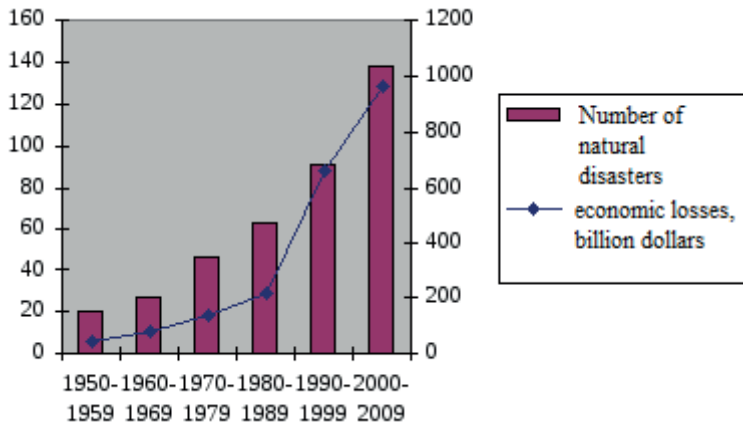


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None of the measures the public is urged to take to counter climate change will work. The Earth's climate will change, and it will always have an adverse effect on humanity. After all, any changes in the conditions to which people have adapted over the millennia will be unfavourable for them. Not only that, the average temperature on the planet's surface can change so much that warm-blooded organisms simply cannot tolerate it. Climate change will inevitably affect the transfer of heat and moisture on the planet. Somewhere, the amount of precipitation will greatly exceed their average values, and there will be floods, destructive for terrestrial species of animals and plants. And somewhere, on the contrary, precipitation will stop, and the former fertile territories will become deserts. With an increase in the temperature of the waters in the oceans, carbon dioxide from the atmosphere will dissolve worse in them, and algae, which bind carbon dioxide and supply the planet with free oxygen, will massively die from a lack of carbon dioxide necessary for photosynthesis. Already, there are dire signs of ocean warming and coral extinction.

Currently, humanity is faced with numerous natural disasters caused by climate change. Hurricanes, tornadoes, floods and droughts are increasingly occurring where they have never been. At the same time, the number of disasters with devastating consequences is growing from year to year (Fig. 3)

Fig.3. The observed increase in natural disasters and damage from it.



Humanity spends about 0.3% of world GDP on fighting the consequences of natural disasters. For third world countries, this value often exceeds their level of GDP growth, which not only excludes the development opportunities of these countries, but even causes a decrease in living standards. Ecological migration of the population from these countries to more prosperous regions is becoming commonplace.

Natural disasters on the entire planet will grow, and the elimination of damage from them will soon take away all resources from people. If the damage from natural disasters increases by only 10 times, it will reach 3% of world GDP, that is, recovery of damage from natural disasters will absorb the entire growth of world GDP, and all of humanity will move from a stage of slow development to a stage of slow regression. All this will lead to the fact that by the end of the century people will not be able to live in a changed climate, agriculture will be undermined, and the struggle for scarce living resources will take cruel forms.

Unfortunately, this bleak forecast of the near future of mankind is dictated by the tendencies of planetary changes that will persist for many centuries. Hopes to simply survive them as a series of “hungry years” are untenable. If territories with favourable conditions are not found, and people do not have time to move to them, then humanity on Earth is doomed to extinction or terrible degradation.

How to prevent the inevitable?

As any prediction, it is valid only if all evolutionary factors remain unchanged. The natural factors should not change, but human factors may change. Humanity, facing a real threat of its own demise, is able to mobilize all its forces to fight the threat.

First of all, one should analyze the prospects for the development of the productive forces of mankind. These prospects are very interesting. Just in our days, the Fourth Industrial Revolution has begun, which is based on the robotization of all types of production. Robots can very soon free up a large number of people who can be used to solve global problems. A particularly attractive point is that robots, which are required in large quantities, can be produced in robotic industries. And the liberated productive forces can be used to create favourable living conditions for people.

Such conditions cannot be created anywhere on Earth. It is possible, however, to use temporary oases with a climate suitable for life, and master them with the help of robots, but this will only be a temporary solution to the problem. A reliable solution to the problem of creating fully controlled living conditions must be sought in space.

The most suitable cosmic body for creating a place of salvation for humanity is the Moon. Now it is a completely lifeless body, but it has several advantages at once. The first is surprisingly stable conditions on the moon. Under the protection of a 2-meter layer of lunar rocks on the moon, there are no temperature drops, and there is no space radiation at all. If you build monolithic buildings from lunar basalt on the Moon, then you can even create an artificial atmosphere with the most favourable conditions in them using existing technology. The second is lunar gravity. It is 6 times lower than terrestrial

gravity, but it exists, and terrestrial organisms can adapt to it. The third is the huge territories that the Moon can provide for colonization. With low lunar gravity and the high strength of lunar basalts on the Moon, you can build monolithic buildings from basalts several thousand stories high. If the entire surface of the moon is turned into a single building with a height of 2,000 floors, then more than 1,000 billion people will be able to live in it, and each will have 1,000 square meters of usable area. This will be enough for people to live comfortably and for agricultural areas where the food they need will be grown. Finally, the Moon is the closest space body to Earth, and it will be easier to provide transport links with it.

To master the Moon will require, first of all, the massive construction of premises on the Moon. Such construction can be performed by building construction robots (3-D printers), which will use a constant flow of solar energy to melt bedrock lunar rocks into monolithic walls and floors of buildings. The first batch of construction robots can be delivered to the Moon with the already available rocket means, and in the future the mass production of construction robots and tunnelling machines for tunnelling and basalt mining can be organized right on the Moon.

New technologies are the foundation of the path to a prosperous future

It may seem implausible to predict the exploration of the Moon in the near future as a “spare planet”. The most serious obstacle in this direction is the lack of reliable and inexpensive vehicles for the delivery of the necessary equipment to the moon and human flights. This obstacle will be overcome around the middle of this century. In two to three decades, technologies will be created for the production of ultra-strong carbon fibre and materials with superconducting properties at room temperatures. The most famous institutes and laboratories in the world are now working on these technologies, since there is great demand for them in industry. And as soon as these materials begin to be produced on an industrial scale, lifts between the Moon and the Earth will be built on their basis. Undoubtedly, the creation of high-capacity transport routes will lead to the rapid development of the Moon and the construction of a refuge for humanity on it.

Another new technology that will quickly resettle billions of people on the moon will be the monolithic construction of gas-tight buildings from lunar basalt. On the Moon, they can be smelted using solar heat at a rate that will determine the number of working 3-D printers, and they can be produced in robotic production in unlimited quantities. There are no factors on the moon that destroy buildings; once built, premises will stand without the need for repair for hundreds of millions of years. This will also speed up the construction of premises necessary to accommodate all the inhabitants of the Earth and all the necessary industries.

The most important vital resources for lunar settlements – water, oxygen and nitrogen for the atmosphere, carbon dioxide for plants – will be extracted in space from cometary bodies, which are there in unlimited quantities.

As for the energy supply of lunar settlements, with the mass production of solar cells and the transmission of energy through superconducting cables, the level of solar energy produced on the Moon alone will be hundreds of times higher than the level of earth's energy consumption today.

It is fundamentally impossible to make a more detailed forecast of the future by the end of this century. The fact is that the technologies mastered by civilization have an extremely strong influence on the development of mankind. It is clear that the emergence of the railway network had a huge impact on the economy of the entire planet. Mastering electricity, too. Undoubtedly, any forecast of the state of humanity in the twentieth century which did not take into account at least only these two factors, would be far from the truth. And it should be borne in mind that new technologies that can profoundly change the course of history appear every 30-50 years. Without imagining these technologies, we cannot imagine a world in which these technologies are determining the evolution of civilization. A long-term forecast can be made only for those changes in the destinies of the world that have been going on for centuries and which cannot be influenced by the efforts of mankind.

Conclusion

Proceeding from the fact that the observed global climate changes and natural disasters caused by them occur under the influence of irresistible natural

forces, it can be argued that the inevitability of fatal changes in the conditions of life on the planet arose before the advent of humanity. Perhaps the life of people on Earth will become impossible by the end of this century. The rate of fatal changes in conditions on the planet cannot be predicted; it is possible that they will continue in the next century, but the forecast that in the near future there will be no place for people on Earth is inevitable.

The only salvation for mankind can be the development of space territories, where it is possible to create completely controlled conditions for people and other forms of earthly life. The only territory of this level available in the solar system is the Moon. If, in the time remaining until the end of the century, mankind has time to solve the technical problems of creating inhabited settlements on the Moon, then earthly civilization will continue to exist in a new place.

The creation of habitable spaces on the lifeless moon will require united efforts from humanity. Therefore, the formation of a united humanity is an inevitable stage in its evolution; it will take place in the second half of the twenty-first century and will be accompanied by a re-profiling of enterprises producing military equipment into the production of means for the exploration of the moon.

In the next quarter of a century, we can expect a series of military-economic conflicts aimed at redistributing the existing territories and resources of the planet. Only the growth of climatic disasters will force economically developed countries to abandon the accumulation of military potential as less in demand than life support resources.