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Global Population Blow-up and After: The Demographic Revolution and Sustainable Development

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ABSTRACT. Of all the global problems looming on our common horizon that of population growth comes first. It sets the scene for considering major issues of social and economic development, of science, education and art, of growth and security. In dealing with these matters a new way has to be found to comprehend the challenge of change. For one has to go beyond the agenda of demography and economics, sociology and anthropology, and see mankind as an evolving system. Without a broad vision of our past it is impossible to understand the present predicament of mankind, the crisis now facing us in so many dimensions of life, and project our future development. In this New World, not dictated by numerical growth, education and science will become the main issues in a knowledge society of an information- dominated world. It is then, where the old outnumber the young, to be sustainable, a new system of values are to develop. *© 2009 Bull. Georg. Natl. Acad. Sci.*

Key words: *demography, global population, mathematical modelling, demographic revolution, information, education.*

1. Introduction

The world is now passing though an immense demographic revolution, for during this time of rapid changes the very meaning of our growth is challenged. But from the very beginning a straightforward question should be answered. What does this broad approach, with an extensive time scale – spanning a million years and encompassing all the people ever inhabiting our planet – really mean for each of us, our town or country, where we live. For do not the local circumstances provide all that matters for explaining the facts of life? That is why for many these studies may seem to be out of place and irrelevant to what is happening here and now. The answer is that all large-scale events of history, everything that occurred in our past does matter for the life and wellbeing of every one of us today, as these consequences are often subtle and indirect, the profound messages of history being slow in coming, but full of meaning. They deal with connections between generations, values, and the very sense of our existence. The intellectual tradition of Russia shows the power of this approach in our thinking and these signals are most in demand at a time of crisis. Thus we are dealing with an interdisciplinary problem in an attempt to describe the human experience right from its beginning.

Probably the first to apply mathematical reasoning to social problems was Thomas Malthus. Malthus proposed the population principle – that resources set the limits to growth, and hunger limits the multiplication of people. His ideas have had singular influence on economists, political scientists and moral philosophers for the last two hundred years. Interest in his legacy has been aroused by the reports to the Club of Rome suggesting that the 'limits to growth' are due to limits in resources.

The following study refutes these Malthusian concepts and indicates that in an open, evolving and self-organising system of the global population, internal processes determine growth. Stated as the population imperative, this principle operates throughout the whole development of mankind. What determines global development is the growth and distribution of knowledge. That is why modern society is described as a knowledge or information society. To accept this, a new way for

describing our growth has to be worked out, taking into account the past, which is much closer than we think at the present critical stage of change.

2. Methods of Mathematical Modelling

Mathematical modelling, which to some may seem to be abstract and detached, mechanistic and lacking in human compassion provides for a quantitative description of our development. Now these methods are instrumental in developing the theory of global population growth [1,2]. These methods, with new metaphors, enlarge the scope of our thinking and vision. Most of these concepts come from physics are of a modern, non-linear vintage – like collective interactions, chaos and self-organisation with causality expressed in probabilistic terms. In developing the model by averaging the data and processes, the number of variables are reduced to a single one – to the global population. In this case the growth rate is seen to be proportional to the square of the total number of people on Earth expressing the network complexity of the entire population of the world, as a single dynamic system.

In this way one can get away from the 'curse of complexity', for Herbert Simon has noted that "Forty years of experience in modelling complex systems on computers, which every year have grown larger and faster, have taught us that brute force does not carry us along a royal road to understanding such systems. Modelling, then calls for some basic principles to manage this complexity."

The model is based on a holistic description by introducing a phenomenological interaction, which takes into account all relevant factors of social, economic, cultural, moral, ethnical and biological nature contributing to growth. This non-linear global co-operative interaction cannot be reduced by an addition of all partial factors and that is why reductionist models do not work. To this interaction we owe the stable hyperbolic blow-up of human numbers. For to date human beings have spread all over the globe and outnumber by five orders of magnitude – a 100 000 times, more than all other animals of comparable size and position in the food chain. Only domestic animals, husbanded by man,* are attached to the human population.

What is remarkable that growth, in the first approximation, is for more than a million years dynamically self-similar and scales. By introducing the human life span of 45 years the limits of scaling may be determined. This provides for a very plausible estimate for the beginning of the human story 4 – 5 million years

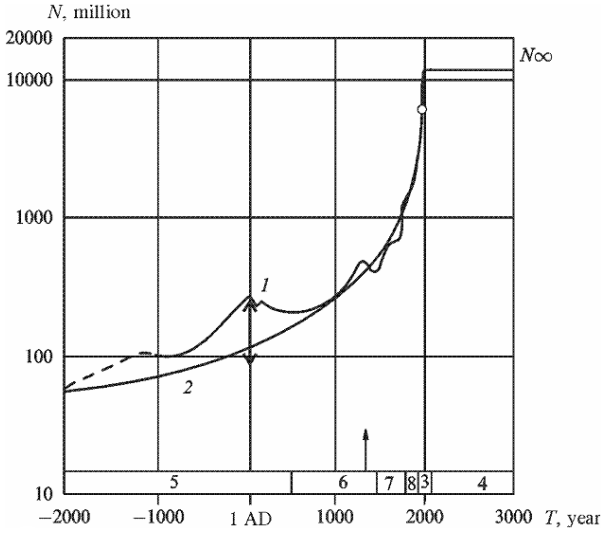

Fig. 1. World population from 2000 BC to 3000 AD. Asymptotic limit of global population N_∞=10 – 12 billions.
1 – data for global population [4], 2 – blow-up model of growth, 3 – demographic transition, 4 – stabilized population, 5 – Ancient world, 6 – Middle Ages, 7 – Modernity, 8 – Recent history, ↑ – the Plague, ↕ – error bar, ◦ – T_1=2000, N_1=6 billion. On a semi-logarithmic plot exponential growth will appear as a straight line and at no time can describe the growth of the global population. As the demographic transition is approached, the time of history and development is compressed, with 9 billion people living through each historic period indicated. See Table 1.

ago and describes the passage through the demographic transition. Up to the transition growth follows a hyperbolic curve, going off to infinity, as it approaches T_1 = 2000, when an abrupt change in the pattern of growth takes place. The global population levels off at 10 – 12 billion in the foreseeable future, in effect doubling the recent population of N_1 = 6 billion in year 2000.

The model is justified not only by the extent to which the results of modelling correspond to the facts of life, but also by the fundamental principles of systemic growth. When depicting the overall process of development by an essentially non-linear model it should be kept in mind that it cannot be directly applied to local or regional growth, for we are dealing with a collective phenomenon. But the global process of development definitely does influence all of its parts by the connections and interactions implied in the model and acting in the world. Any part of the global system that is separated from the main body of mankind will inevitably lag in its growth and development.

The most important changes are due to the limits of an information-dominated society, the real limits to growth where of central importance become culture, science and education. For during the demographic revolution the crisis is due not to a limit, real or imagined, of resources, but to the mismatch of our ideas and management of society at large. This should be of our main concern in

*In this text the term man and mankind refer to the genus *Homo*.

assessing the future of the world, as it enters its greatest crisis in the 21st century, breaking away from explosive growth to a constant population. Only after the demographic revolution, as a new equilibrium will be established, sustainable development could be sought for.

3. The Population Imperative and Time in History

Modelling global population growth is based on the ideas of synergetics [3]. The whole population of the world is treated as a system, a single entity, all the details of which and events are averaged and mixed up in its totality. The global population is both isolated and open, meaning that it can draw on the resources of the environment, of the outside world. The whole approach is essentially statistical and cannot be expected to take into account the details, however significant they may seem. Partial and chaotic events of current history should be seen against the backdrop of the total picture, where average growth is determined by the principle of the population imperative. Although the rate of growth is proportional to the square of the global population this implies a memory of the past for we really deal with the average values of the variables.

The factor driving the development of mankind is generalised information. The distribution and transfer of information from one generation to the next – knowledge and technology, customs and crafts, art and religion, and, finally, ideas and concepts of science – this is peculiar to humans and human society, and what makes us essentially different from all animals. Consider the very first steps of a human being, which are quite different from those of an animal. In this process education and training in all forms and varieties, including games, is a major part of human development. It begins with a long childhood, first learn-

Table 1.

Growth and development of mankind shown on a logarithmic time scale

Epoch	Cycle Phase	Date year	Number of people	Cultural period	ΔT years	Events in history, culture and technology
		2200	11×10^9	Stabilising global		Global population limit $10–12\times10^9$ Changing age distribution
C		2050	9×10^9	Population		Globalisation
	T_1	2000	6×10^9	Global demographic revolution	45	Urbanisation, Internet
	11	1955	3×10^9		45	Biotechnology Computers, Nuclear energy
	10	1840	1×10^9	Recent	125	World Wars Electric power
	9	1500		Modernity	340	Industrial revolution Printing, Universities
	8	500 AD		Middle Ages	1 000	Geographic discoveries Fall of Rome
	7	2000 BC	10^8	Ancient World	2 500	Christ, Muhammad Greek civilisation, Axial time, China, Confucius, India, Buddha
B	6	9000		Neolithic	7 000	Mesopotamia, Egypt Writing, Cities Domestication, Agriculture
	5	29 000	10^7	Mesolithic	20 000	Bronze Microliths
	4	80 000		Moustier	51 000	America populated Shamanism, Language
	3	220 000	10^6	Acheulean	140 000	*Homo sapiens* Speech, Fire domesticated
	2	600 000		Chelles	380 000	Europe and Asia populated Hand axes
	1	1 600 000	10^5	Olduvai	1 000 000	Choppers *Homo habilis*
A	T_0	4 – 5 Ma	(1)	Anthropogene	3 000 000	Hominida separate from Hominoids

ing to speak and mastering language, being brought up, taught and educated in the making of a man, to use an old expression, as a member of society. This now takes 20 to 30 years and is essential for every human being. At the same time this postpones the child-baring age to its limits. Information is multiplied and transmitted by a chain reaction vertically between generations establishing links with the past deeply entrenched in the personality of each person. Information is also transferred horizontally – in the space of the global informational interaction, synchronizing the grand periods of development, seen throughout the ages in the global population system.

An important outcome of the model is the logarithmic transformation of time of social development, as quadratic growth accelerates over the ages. Growth is not exponential, although at any moment in the past an instantaneous exponential time of growth may be worked out. This exponential time is equal to the time reckoned from the high point of the global demographic transition – from year $T_1 = 2000$, or to the time before present. In this case the compression of time makes the time from the end of a past cycle equal to half of the cycle's duration. Thus the Lower Paleolithic lasted a million years, leaving half a million for all future development. The Middle Ages lasted a thousand years and ended 500 years ago. Approaching the present the rates of growth and development can be compressed no more. The population blows up and enters the period of the global demographic transition, which is only 90 years long leading to a constant global population. The results of modelling are all shown in Table 1. Major cycles of global history, observed in our past, are interpreted as phases, punctuated by transitions and indicating the gross stability of growth.

In this Table dates are taken from the generally accepted sources and they follow, within acceptable errors, those calculated. It has to be noted that the Neolithic revolution, when a marked change happened in our development, is right in the middle of our past, if seen on a logarithmic scale, indicating the singularity of this event.

4. The Global Demographic Revolution

Demographic data and the model indicate that mankind is now rapidly passing through a critical period of the demographic transition. This is a veritable revolution, drastically changing our long-established pattern of growth and development. For more than a million years man was concerned with numerical growth. Growth on all counts – more children, more food, more space, more arms, more power in all dimensions of life. At present this paradigm of growth is changing, a change never experienced before.

It is well established that all countries pass through a maximum growth rate at the demographic transition and, hopefully, head for a stable population. This has been observed for all developed countries and is now being seen in countries of the developing world. The global demographic transition is shown in Fig. 2. During the transition death and birth rates rapidly change, beginning with an initial decrease in the death rate. The consequent fall in the birth rate starts later, and is accompanied by economic development, an increase in standard of life and the development of health services, leading to a longer life expectancy. Due to the interaction of these two factors, the growth rate passes through its maximum value.

For any specific country migration may modify this idealised description, but globally emigration does not enter into the growth rate since the population is limited to our planet. This sequence of events shows that the whole change is rapid and at no point is the population in any state of relative equilibrium. We are dealing with a non-equilibrium phase transition, centred on year 2000 – a veritable shock that could hardly happen faster. As a result of the transition the population ceases to grow and a marked change in the age distribution of the population develops. This is the last in the sequence of events and a very significant transformation to happen in a society. These processes are accompanied by urbanisation, with vast movements of rural populations to towns. As the population of the world acts as a truly global community, undergoing a common transformation, the transition in the developed and developing countries is happening practically at the same time. They are separated by a mere 50 years, showing that in a

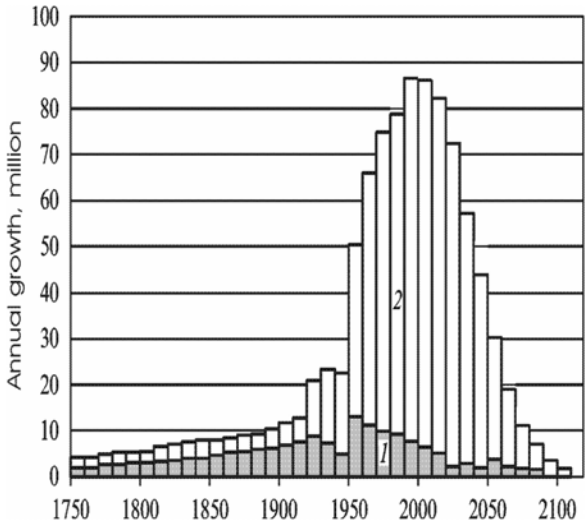

Fig. 2. The global demographic transition 1750 – 2100 Annual growth averaged over a decade: 1 – developed countries, 2 – developing countries. The global transition is remarkably short with a width of only 90 years, centred on year $T_1 = 2000$.

fundamental way these countries are not so different as usually assumed. Thus the transition is a powerful demonstration of the interaction between these sets of countries, leading to globalisation.

The global population transition takes only 90 years, and during this time, which is only 1/50 000 of all our history, a fundamental change in the mode of growth of mankind is to happen. A different image of the transition is seen, if we refer to the number of people – some 10 billion – who are to live through the demographic transition. This is 1/10th of the hundred billion people who ever lived, and is the chance for a human being to be caught into this critical period of rapid change.

5. The Sustainable World of the Future

The model equates the rate of growth to the development of the population system, seen as a function of the global population. The quadratic term was decisive in determining growth all through our history and expresses the contribution of the informational component to the global production factor. This can be seen as the domination of the 'software' of global development, input, which is associated with culture, science and all those factors like co-operation, communication, consciousness and memory in contributing to the meta-economic growth of mankind. As the principal factor of growth it indicates the primacy of the collective processes in society, which we owe to our highly developed brain and mind, the main and peculiar characteristic of a conscientious *H. sapiens.*

As the population of the world will grow no longer, the number of older people will outnumber the young. This is an essential result of the demographic transition, already seen in developed countries, where societies are getting much older. The restructuring of the age pyramid, a rapid and profound transition to a stable global population, will inevitably lead to far-reaching changes in many aspects of life, including global security, social and economic behaviour. Inevitably it will demand means to support the older generations, leading to greater expenditures for health services and social security. Probably one can expect that society could gainfully use the expertise of the old, re-establishing ties between generations in a family. Then the post-transition age structure will result in the development of new values in society, now lacking the inertia, memory of growth of human numbers.

After the Rio 1992 and Johannesburg 2002 International Conferences the concept of sustainable development has been put forward. The idea of sustainability was mainly developed in Gro Brundtland's report «Our Common Future» (1987) and is formulated as "meeting the demands of the present without infringing the rights of the next generation in satisfying its demands". The concept of sustainability should be seen in connection with the demographic imperative. All history has unequivocally shown that the growth of population had precedence over the environment. Mostly under economic pressure people moved and resettled, migrated to other parts of the world in search of space and resources. What really matters and creates social disparities and economic misery is not a global lack of basic resources, but inequity in their distribution – changes that can be expressed as the challenge in pursuit of a *quality of life* [4].

It is of interest to discuss the long-term changes that can be expected in the world as it passes into a new stage of development after the transition. Both demography and modelling, using different methods, show that the population of the world is to rapidly stabilise at 10 to 12 billion, although the latest revised forecasts of the UN Population Division indicate some 9 billion for year 2300. In practical terms all growth will happen in the developing world by the end of 21st century and will be accompanied by a drastic change in the age structure and a lowering of the total fertility rate. For at present, in developed countries the TFR is below 1.15 (1.07 for Spain). Thus these societies demographically are not sustainable and are doomed, if the TFR does not go up to 2.1 – 2.15 children for each woman. The low birth rates in all developed countries are a signal of a major crisis of prevalent values in these societies. These differences in the TFR are a source of great instability and in the coming years some large-scale migrations and social disruptions are to be expected. They are well be-

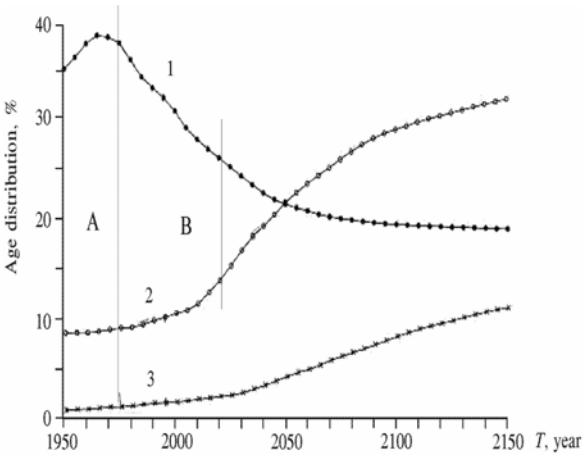

Fig. 3. Change in age distribution for the global population 1950 – 2150. (UN data).
1 – age group less than 14 years, 2 – group older than 65 years, 3 – age group older than 80 years. A – distribution in developing countries and B – distribution in developed countries in 2000.

yond the power of the states to be controlled by force alone, as seen with the rapid growth of the numbers of illegal migrants. These issues are frankly discussed by Patrick Buchanan in «The Death of the West. How Dying Populations and Immigrant Invasions Imperil our Country and Civilisation». New York, 2002.

In recent events one can discern the features of a future world with a stabilised population. In this world numerical growth, primarily expressed by population growth, will no longer dominate. The connection between population growth and the square of global population will cease to express development. In this case there are two alternatives – one is stagnation of development in a world of zero growth or even declining population. The other is finding a new dimension for development, and, as the quantitative growth of the past is gone, there is a possibility for qualitative growth and development. At present in developed countries there is a significant shift of the workforce from the production sector to services – health, education, science, and leisure indicating the shape of things to come.

These new processes of development are accompanied by an internationalisation of finance and technology. The rapid transfer of information and money has become the principal feature of globalisation. The recent and most powerful global information factor is now the Internet. With the mass media, these are the main instruments of change and influence. In a world where globalisation has become an imminent and dominant feature, the opposing trend of cultural diversification is manifest. This may be seen as the confrontation of the 'hardware' of civilisation with the 'software' of culture, which does not match the pace of progress. This present disparity in the growth and development of mankind should be resolved by a dialog, rather than a clash of civilisations.

Dynamics of population growth influence global security, the balance of economic and military power. In the foreseeable future armies will change. In countries that have passed through the transition there are fewer demographic resources to man by conscription the huge armies of the recent past. On the one hand, low growth rates and stagnant populations do not create conditions for conflict, for large-scale world wars, as happened in the recent past. On the other hand, science and high technology have changed the character of arms in modern warfare. Could the mission of these new armed forces be the containment of peace, controlling migration, fighting organized crime and terrorism, rather than war and operations leading to territorial gains and a New World Order? In fact, terrorism should be seen as a symptom of growing tensions and disparities rather than a danger itself.

The last sources of a real large-scale conflict are countries passing through the demographic transition at its explosive stage. Today, when in a world where the rate of numerical growth has reached its absolute maximum and mankind is passing a decisive threshold in its development, these strains and inequities could still lead to major conflicts within and with the rapidly developing countries. In these cases demographic factors may become critical indicators of growing disparities.

Humanity is now passing through the demographic revolution from an information-moderated society to an information-dominated global **knowledge society** [5]. The future in the post-industrial world will be determined not by the production of food or energy, by the 'hardware', but by the 'software' of our global population system. In this New World it will be not the volume of production that matters, but the way these results of the industry and cultural development are distributed. This is to happen in an economy with zero growth of human numbers in a society with a predominance of older people.

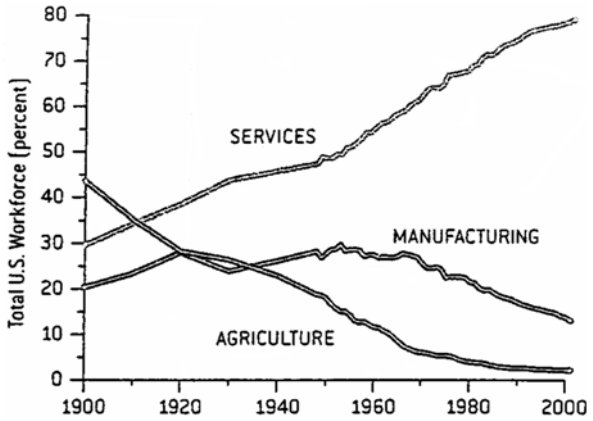

Fig. 4. Deindustrialization: Changes in total U.S. workforce in 20th century (in %).

These are the boundary conditions for the future. In this future, human ca-pital of an educated society will, hopefully, lead to establishing new norms of social values. It will be determined more than ever by education and the attitudes and values propagated by the mass media. The mass media, in the first place television, has yet to recognise its responsibility for its influence on social capital and in taking culture and morals seriously. Thus, a new set of values in the world could emerge, where numerical growth will cease to dominate our mentality. In a stabilised world with a slowing down of development, a new ecological and social consciousness may appear, with outspoken criticism of consumerism and capitalism.

In the post-transitional society education will take up more time and effort than at any other period in the his-

tory of humankind. For example, at present in developed countries lifelong education is expanding and the education industry is becoming a major sector of the economy. The extensive time devoted to education is a direct expression of the information crisis and indicates that humanity is definitely close to its capacity to train and educate the next generation. In fact, time spent on education is one of the reasons for low TFR' in developed countries.

Finally, fundamental science, which since the time of Copernicus, Galileo and Darwin has developed as a global cultural phenomenon, practised internationally, will now demand both support and a mandate to exercise its cultural and moral responsibilities as never before.

6. Conclusions

For the population of the world the theory provides a description of the gross features of the growth and evolution of mankind. Over the entire course of development a constant trend in the growth of human numbers is discerned, which follows a self-similar pattern of growth, expressing the dynamic invariance of development. Humanity, right from its beginning, is seen as an information society. Its growth is due to a direct transfer of acquired information, leading to a Lamarckian rather than a Darwinian mechanism of cultural inheritance and evolution. In this case economic growth and social development are non-linearly coupled and mutually determine the pace of history. At present its inherent limits, are determined not by resources or space, but by the 'limits to birth' in the 'war of the wombs'.

Global population dynamics has a drive and logic of its own, expressed by the population imperative. Only by reaching an in-depth and fundamental understanding of these complex interdisciplinary problems can we expect these universal issues to be faced and responsibly resolved by sensible social and economic policies.

The rapid demographic revolution is an event of great significance, and in the story of mankind it far surpasses the Neolithic revolution and all others known in history, ranking in its importance with the emergence of *Homo*, endowed with a mind and consciousness. Only a future anthropologist shall have a chance of understanding the magnitude of the transition, which mankind is now to experience. He will have to wait only 50 to 100 years – not the million years that have passed since the early stages of our origins, to assess the challenge of changes.

This period of rapid change is definitely responsible for much of the stress and strain of modern life, the great disruption now upsetting the long-established patterns of social development. For as the numbers, the 'hardware' of our world are changing faster than the social conditions, ideas, the global 'software' has no time to keep up, be it the pressure of the environment or folly of technological progress. The nature of this imminent transformation is yet to be fully understood and its consequences assessed. This can be seen as the intellectual challenge facing both the hard sciences and the humanities. Moreover, in a world where numerical growth is decoupled from development, it is not yet obvious whether humanity will take up the path of qualitative growth, or enter a pattern of slow development, even becoming stagnant and decaying as our civilisation passes into oblivion lacking long-term vision.

At this point it is appropriate to inquire what could be the next step in the evolution of mankind. Up to the present the biology of the human race has not changed and was determined by nature. Now there is a possibility to interfere and moderate the biology – the genetic make-up of mankind – as humanity itself can become a conscientious actor. It may well be that these factors are to limit the extent of the model and at the same time indicate the agents for change, which could ultimately set a new dimension for the development of mankind. In this case, if humanity is morally and ethically ready for such interference, it may become master of its evolution and will go beyond the limits set by the model, as its premises will no longer be valid. Although, with the sheer size of the world population and the rate of events, it is difficult to imagine how the world community can have a major effect on the population imperative with a pronounced lack of global governance.

As the fundamental understanding of growth is still rather limited, definitive advice for action is hard to provide – apart from very general recommendations, which lead to current demographic policies. The rate of change, the ultimate compression of the systemic Eigentime of history at the demographic transition, leaves no time for political decisions to be worked out and properly implemented. For it is now when the time-scale of history and politics merge.

Probably the most important issue is by all means to ensure the stability and security of the world to be, as the prerequisite for resolving global problems. The rate of change itself leads to the absence of long-term commitments and socially relevant planning in society. This is all the more significant during the singular epoch of the demographic revolution, when these tensions are the greatest. This leads to the current loss of governance, law and order, corruption, criminality with moral decay and a rise of irrationality with decay in reason, seen on many levels of society and political structures of the world. It is how present crisis in the collapse of the global financial system should be seen as the loss of systemic stability.

These studies are the outcome of an attempt to develop interdisciplinary understanding by bridging ideas and methods coming from areas of research long separated by tradition and history. As the model is supported by further research and gains ground, the insight it provides should lead to greater understanding of the present state of world affairs. It may offer a common frame of reference for anthropology and history, demography and sociology, for studies in human evolution and genetics. For economists it provides a universal and general framework for assessing our growth and development. For doctors and politicians alike it can indicate the sources of stress and tension in this transient period, unique throughout all human development and affecting both the individual and society in terms of personal and global security and stability. In the emerging world of a stabilised global population there will be a lot of restructured time to resolve these problems of our own making, hopefully managing them without a major disruption, as the challenge of growth will cease to dominate our life. This may provide us with some optimism in facing the present predicament of mankind.

მოსახლეობის გლობალური აფეთქება და მისი შემდგომი პერიოდი: დემოგრაფიული რევოლუცია და მდგრადი განვითარება

სერგეი პ. კაპიცა

ფიზიკური პრობლემების ინსტიტუტი, მოსკოვი, რუსეთი

ყველა იმ გლობალურ პრობლემას შორის, რომლებიც უკვე გამოჩნდა ჩვენს საერთო ჰორიზონტზე, მოსახლეობის ზრდას პირველი ადგილი უჭირავს. მის ფონზე უნდა განიხილებოდეს სოციალური და ეკონომიკური განვითარების, მეცნიერების, განათლებისა და ხელოვნების, პროგრესისა და უშიშროების ძირითადი საკითხები. ამასთან დაკავშირებით უნდა გამოინახოს ახალი გზები, რომლებიც დაგვეხმარება, რათა ჩავწვდეთ გამოწვევებს, ამ ცვლილებებს თან რომ ახლავს. დღის წესრიგი უნდა სცდებოდეს დემოგრაფიის, ეკონომიკის, სოციოლოგიისა და ანთროპოლოგიის საკითხებს და კაცობრიობას განიხილავდეს როგორც მუდმივგანვითარებად სისტემას. ჩვენი წარსულის სრულყოფილი ხედვის გარეშე შეუძლებელია ჩავწვდეთ კაცობრიობის წინაშე ამჟამად არსებულ დაბრკოლებებს, კრიზისს, რომელიც ცხოვრების მრავალ განზომილებაში ვლინდება, და ვერ დავგეგმავთ ჩვენს სამომავლო განვითარებას. მოსახლეობის რიცხობრივი მატება აღარ განსაზღვრავს ახალი მსოფლიოს ბედს. განათლება და მეცნიერება იქნება ცოდნაზე ორიენტირებული საზოგადოების მთავარი პრიორიტეტი, რომელიც იარსებებს ისეთ მსოფლიოში, სადაც ინფორმაცია დომინანტურ როლს ითამაშებს. სწორედ მაშინ, როდესაც ხანდაზმულთა რიცხვი ახალგაზრდათა რიცხვს აღემატება, მდგრადობის შესანარჩუნებლად უნდა ჩამოყალიბდეს ფასეულობათა ახალი სისტემა.

REFERENCES

1. *S.P. Kapitza* (2003), The Statistical Theory of Global Population Growth. In «Formal Description of Evolving Systems» Eds. J. Nation et al., Kluwer Academic Publishers.
2. *S.P. Kapitza* (2007), Global Population Blow-up and After. The Demographic Revolution and Information Society. A Report to the Club of Rome, Hamburg, Moscow.
3. *H. Haken* (1983), Advanced Synergetics. Instability Hierarchies of Self-Organizing Systems and Devices, Springer: Berlin.
4. *J. Cohen* (1995), How many People can the Earth support? N.Y.
5. Towards knowledge societies (2005). Director Jerome Binde, Preface by Koichuro Matsuura: UNESCO, Paris.