GLOBAL SUSTAINABILITY AND REGIONAL DEVELOPMENT

Susumu Iai[1]

[1]Director, Institute of Sustainability Science/Professor, Disaster Prevention Research Institute,

Kyoto University, Gokasho, Uji 611-0011 Japan

Email: iai@geotech.dpri.kyoto-u.ac.jp

ABSTRACT

The paper reviews the fundamentals of global sustainability, including the concept of limits to growth, strong and weak sustainability, an index called ecological footprint, and the status of climate change. Based on this review, a conceptual framework is proposed that is required for the application of geo-informatics for regional sustainable development. The proposals made in this paper are as follows.

Differentiating the positive from the negative sequences could lead us to a strategy to achieve a sustainable society. Identifying the dynamics of concentration and dispersion of social systems and natural resources is essential to establish harmonic societies. Finding the relation between social systems and technological strategies is also important. Since humanity's burden on the earth has already exceeded the earth's biological capacity, an increasing number of regional systems may face the critical conditions. Studying the vulnerability and robustness of social networks and ecosystems is important to establish a strategy to achieve sustainable development.

A regional system is not a closed system. The impacts of inputs to and outputs from the regional system may be significant for regional sustainability. Except for solar energy, the global system is a closed system. Ultimately, study on the interaction between global and regional systems may be required.

The dynamics that governs the performance of a system may not automatically be understood by the simple overlay of two maps. In order to identify the dynamics of a system, geo-informatics should be applied as an integral part of the study aimed at identifying the sequence of events.

1 INTRODUCTION

After the creation of the Earth 4.6 billion years ago, chemical reactions produced organic molecules, which led to a crude form of a life four billion years ago. Human beings that evolved from primates four million years ago increased their population to five million by innovation of stone implements and later five hundred million by innovation of agriculture. During the ensuing ten thousand years, a period of little technological innovation, the population remained stable. The industrial revolution 200 years ago triggered a population explosion that reached six billion. Technological revolution in the 20th century led to further population growth, reaching ten billion within fifty years as shown in Figure 1. This growth, in turn, created an excessive burden on the limited earth resources and posed threats to sustainability of humans. The future of the earth and humans depends on our approach to solve these problems.

The objective of this paper is to review the fundamentals of sustainability science and to provide a basic conceptual framework useful for the application of geo-informatics to various aspects of sustainability. Although limited and minimal, the review will include sufficient materials to suggest specific approaches required in sustainability science. In particular, this paper underlines the need to uncover the system dynamics which may not be automatically identified by simply overlaying two maps as often used in geo-informatics.

2 SUSTAINABLE DEVELOPMENT

The term "sustainable development" was defined by the Brudtland Commision of the United Nations as (World_Commission_on_Environment_and_Development, 1987) as

"development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

This definition is most often quoted in the literature. The underlying notion behind this definition is the awareness that the resources of our planet are limited and hence unlimited development is impossible. Much earlier, a series of computer simulations of human growth for our planet were run by an MIT research team commissioned by the Club of Rome, culminated by the publication of "The Limits to Growth" that raised key questions about the sustainability of modern society. The primary findings from the simulation results were as follows (Meadows *et al*., 1972):

(1) If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one-hundred years. The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity.

(2) It is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future. The state of global equilibrium could be designed so that the basic material needs of each person on earth are satisfied and each person has an equal opportunity to realize his individual human potential.

(3) If people decide to strive for this second outcome rather than the first, the sooner they begin working to attain it, the greater will be their chances of success.

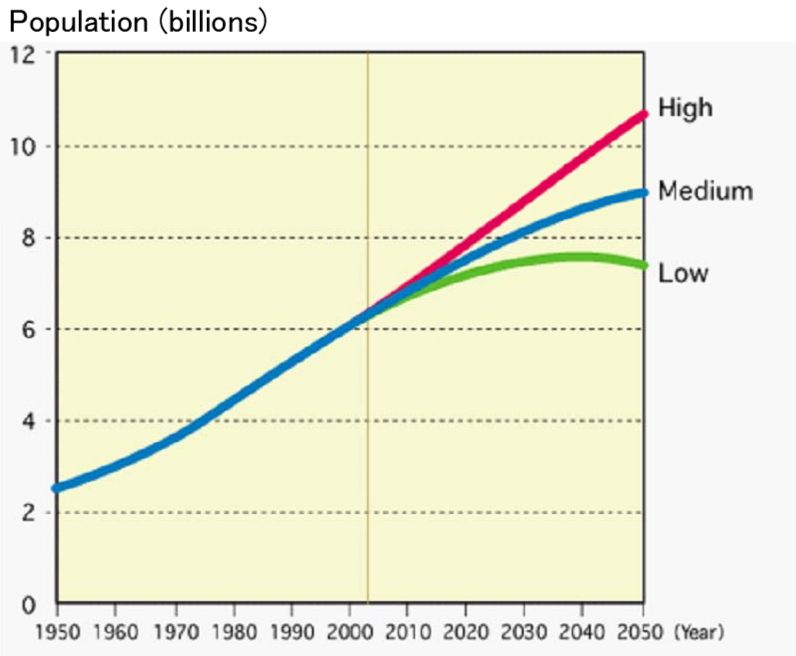

Figure 1 World Population Projections, 1950 – 2050 (United_Nations, 2003)

The most significant implication among these findings is the awareness that, even before reaching the physical limits of resources of this planet, a sudden and uncontrollable change in our society is expected to occur.

The protection of natural capital, including its ability to renew or regenerate itself, represents a core aspect of sustainability. Strong (narrow) sustainability stands for maintaining natural capital independent of the development of human-made forms of capital. Rather than giving special attention to maintaining natural capital, weak (broad) sustainability aims at preserving the value of all combined assets including the substitute produced by technology for lost ecological services (Pearce *et al*., 1989).

Whether a society pursues weak or strong sustainability, both paths need metrics to keep track of the various forms of capital. "Ecological Footprint" has received much attention in both academic and political societies. The ecological footprint is the measure of the global ecosystem's capacity to reproduce natural (biomass) resources and provide waste absorbing functions (Wackernagel *et al*., 2005). The ecological footprint is calculated based on the following seven areas using the equivalence factors, as of 2001, given in the parentheses (global hectares/ha):

(1) cropland (overall=2.1; primary =2.2; marginal =1.8)
(2) pasture (=0.5)
(3) forest (=1.4)
(4) fisheries (=0.4)
(5) built-up area (=2.2) (built-up area is assumed to be located mostly on prime agricultural land and hence built-up area has the same equivalence factor as primary cropland.)
(6) hydropower area (=1.0)
(7) fossil fuels (forest) (=1.4)

The ecological footprint calculated for our planet over the period from 1961 to 2001 is shown in Figure 2 (WWF, 2004). In 2001, human burden on the global ecosystem is 2.5 times of that in 1961 and exceeded the earth's biological capacity by twenty percent. Although this dramatic increase does not imply an immediate collapse of the sustainability of our planet, it sends us an alarming signal related to our ability to achieve sustainable development.

The global temperature change predicted by IPCC is shown in Figure 3. The results indicate that even though we can reduce the CO_2 emission to certain target levels in 50 years using appropriate mechanisms, such as Kyoto Protocol, CO_2 concentrations and related temperature increases will continue for more than 100 years. More alarming is the sea level rise due to ice melting, continuing over several millennia (IPCC, 2001).

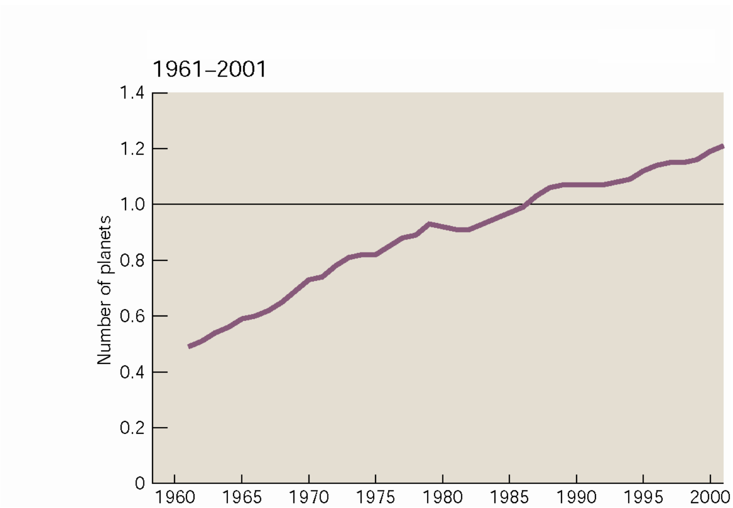

Figure 2 Ecological footprint, 1961-2001 (WWF, 2004)

3 FROM GLOBAL SUSTAINABILITY TO REGIONAL DEVELOPMENT

The current status of global sustainability reviewed in the previous section is an average over our planet. Underlying mechanisms of these trends are functions of the regional activities. For example, ecological footprint is not uniformly distributed over the planet and shows a drastic variation from region to region (Figure 4).

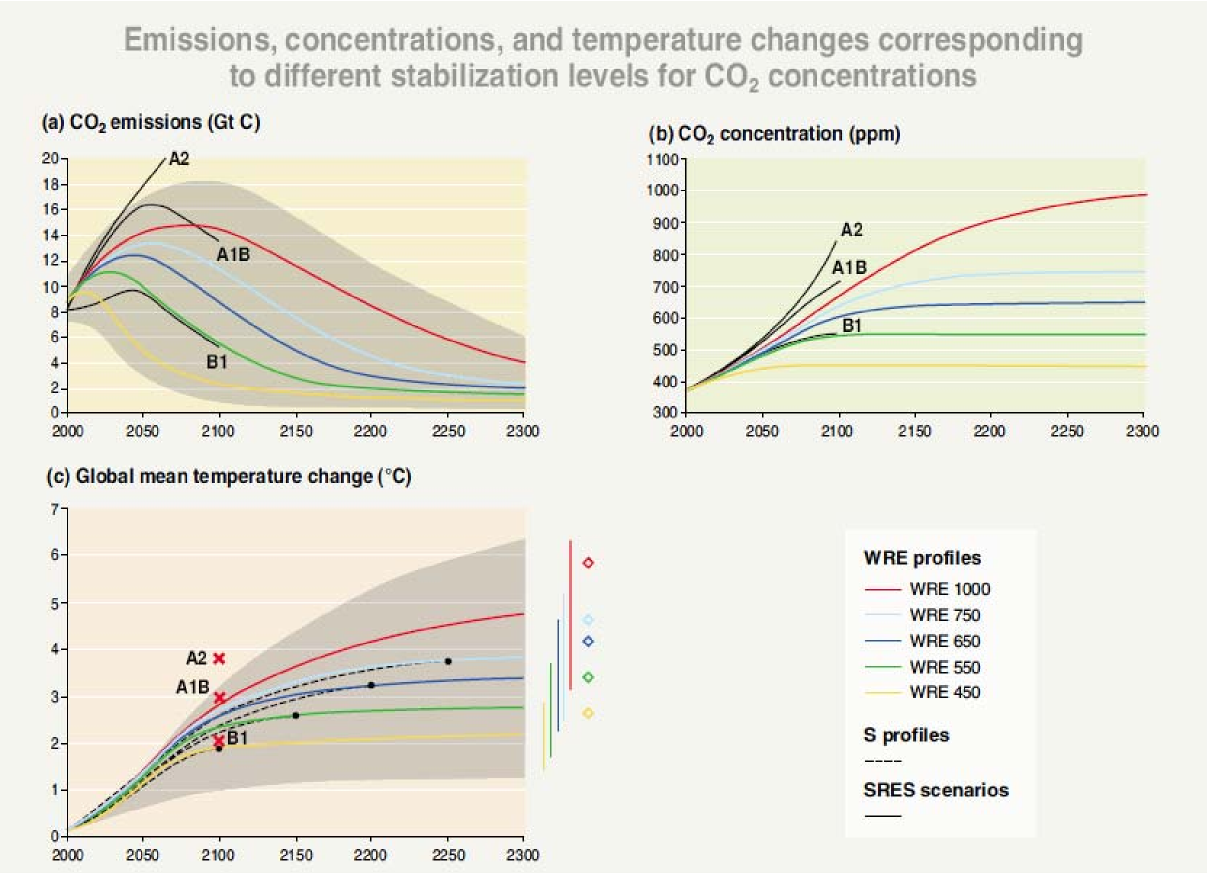

Figure 3 CO_2 emissions and global temperature change (IPCC, 2001)

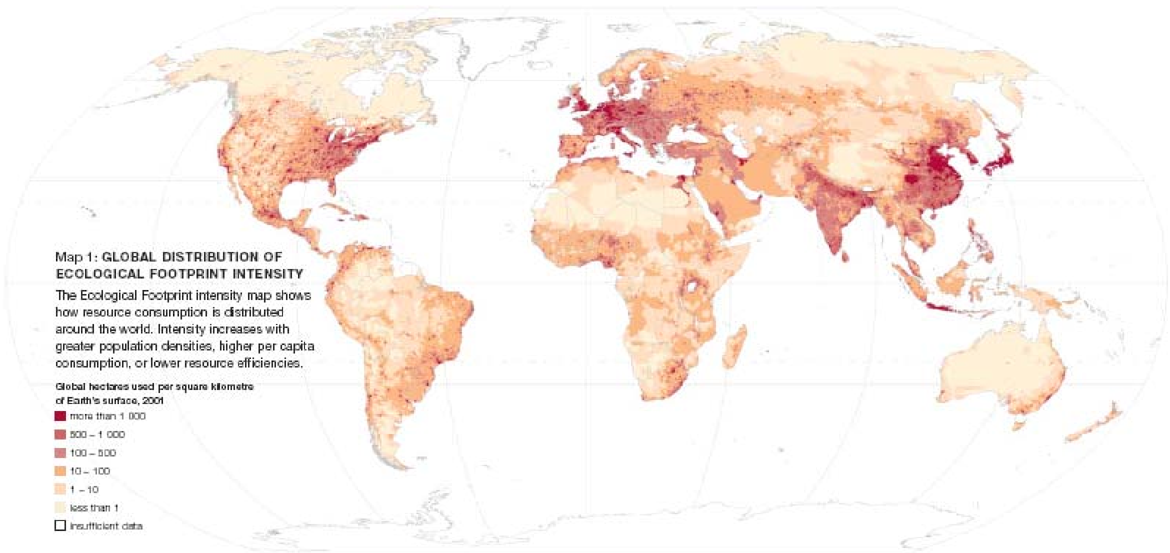

Figure 4 Distribution of ecological footprint (WWF, 2005)

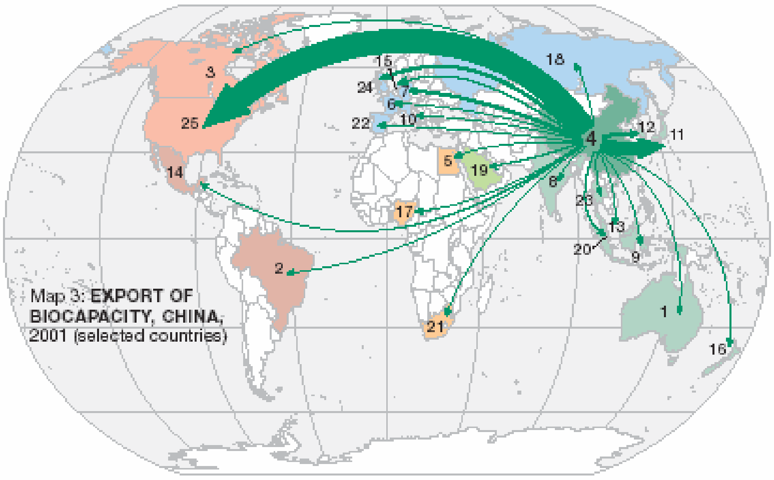

Figure 5 Export of Biocapacity, China (WWF, 2005)

More important are the dynamics not uncovered by the type of a map such as shown in Figure 4. Enormous amounts of natural resources are being transferred around our planet through import and export. As an example, export from China in 2001 is shown in Figure 5. With the rapid economic development in Asia, these flows of biocapacity will drastically change in the near future. When studying regional sustainable development, one should be aware of these dynamics at the global scale.

Regional systems are not closed. The impacts of inputs to and outputs from regional systems may be significant for the regional sustainability. The trend and change in the dynamics at the global scale may be closely related to regional sustainability. Ultimately, study of the interaction between global and regional systems may be required. If carefully applied, geo-informatics can be a powerful tool for uncovering the relationships between these systems.

With the aid of satellite and other remote sensing techniques, various sources of data are becoming available at the global scale. For example, natural resource data shown in Figure 6 are readily available in animation format from NASA. Various human statistics are available from the United Nations. A general global view of the earth is available through free software such as Google Earth. With the aid of internet sites, considerable amounts of information on sustainability at the global scale are available. These useful data sources have become available only recently and are encouraged to be shared. At least in the initial phase of the study of sustainability, these readily available data at the global scale can be useful to identify the general direction of the study.

4 IDENTIFYING THE DYNAMICS

With the recent industrialization and economic growth, Vietnam will soon be facing huge increases in energy demands, in particular the use of petroleum and natural gas. Infrastructure such as lifeline facilities will be rapidly constructed to accommodate the society's needs. These rapid changes in social and urban systems will pose a threat to the natural environment surrounding the urban areas and also to the global environment. As a whole, the social and urban systems will face a critical phase of vulnerability against external impacts such as natural disasters.

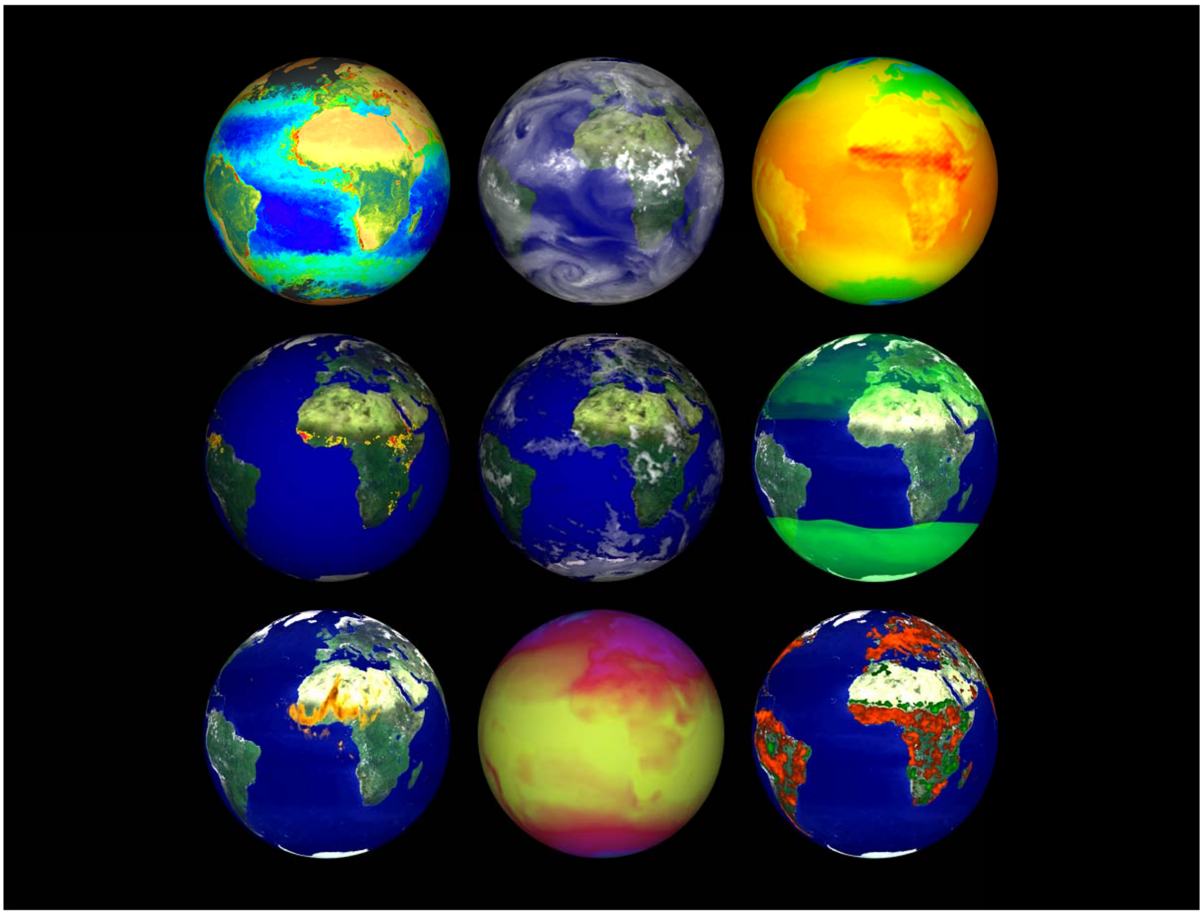

Figure 6 (left to right, top to bottom) Biosphere, water vapor, temperature, fires, clouds, methane, aerosols, radiant energy, vegetation index anomalies (NASA/Goddard Space Flight Center, The SeaWiFS Project and ORBIMAGE, Scientific Visualization Studio.)

The indices used for discussing the global sustainability such as the temperature change (Figure 3) include both spatially and temporally averaged data. These data do not include annual, monthly, or daily variations and they do not show anomalies or extreme highs or lows. Also, they do not show extreme climatic events such as storms, typhoons, and high tides. In order to achieve sustainability in a system that is already progressing through a critical stage, response of a system and assessment of vulnerability to these extreme events should be studied because such extremes often trigger threshold responses (i.e. natural disasters).

Identifying sequences of events often leads to a reasonable understanding of the dynamics of social and natural systems. For example, a negative spiraling sequence of events can be recognized in natural disasters and poverty in society through the course of rapid industrialization and urbanization. Population growth in rural areas will push people to areas that have never been cultivated and are vulnerable to natural disasters. Disasters and resulting poverty in those areas will force the people to more isolated areas that are more vulnerable. If rapid industrial growth is in demand and in progress, cities require cheap labor and thus pushing people to urban areas. After young generations move to urban areas, only older generations remain in rural areas which decline in population.

A positive spiral of events is also possible. For example, poverty in rural areas has been the major social problem in Brazil. Since new technology to efficiently produce ethanol from sugar cane has been developed and put into practice, people in these areas are finding new jobs relating to ethanol production. The produced ethanol is then put into use as part of biomass energy, offsetting human burden on the environment in those areas.

The previous discussions can be summarized as follows. Differentiating the positive from the negative sequences could lead us to a strategy to achieve a sustainable society. Identifying the dynamics of concentration and dispersion of social systems and natural resources is essential to establish harmonic societies. Finding the relations between the social systems and technological strategy is also important. Since humanity's burden on the earth has already exceeded the earth's biological capacity, an increasing number of regional systems may face critical conditions. Studying the vulnerability and robustness of the social networks and ecosystems is important to establish a strategy to achieve sustainable development.

These dynamics may not be automatically identified by simply overlaying two maps as often adopted in the basic practice of geo-informatics. In order to solve this problem, geo-informatics systems should be applied as an integral part of the study that aims at identifying the system dynamics.

5 CONCLUSIONS

The fundamentals of global sustainability are reviewed. The review includes the concept of limits to growth, strong and weak sustainability, an index called ecological footprint, and the status of climate change. The following conclusions may serve as a conceptual framework for the application of geo-informatics to regional sustainable development.

(1) Differentiating positive from negative sequences could lead us to a strategy to achieve a sustainable society.

(2) Since humanity's burden on the earth has already exceeded the earth's biological capacity, an increasing number of regional systems may face critical condition. In particular, regions where rapid growth and social change occur often face vulnerability. Studying vulnerability and robustness of social networks and ecosystems is important to find a strategy to achieve sustainable development.

(3) Regional systems are not closed. The impacts of inputs to and outputs from regional systems may be significantly related to regional sustainability. Dynamics at the global scale may be closely related to regional sustainability.

(4) These dynamics may not be automatically identified simply overlaying two maps as often adopted in the basic practice in geo-informatics. In order to solve this problem, geo-informatics systems should be applied as an integral part of the study that aims at identifying the system dynamics.

6 REFERENCES

IPCC, 2001. *IPCC Third Assessment Report – Climate Change 2001*.

Meadows, D. H., Meadows, L. M., Randers, J., and Behrens III, W. W., 1972. *The Limits to Growth*: New York: Universe Books.

Pearce, D., Markandya, A., and Barbier, E., 1989. *Blueprint for a Green Economy*. London: Earthscan Publications Ltd.

United_Nations, 2003. *World Population Prospects: The 2002 Revision*. New York.
Wackernagel, M., Monfreda, C., Moran, D., Wermer, P., Goldfinger, S., Deumling, D., and Murray, M., 2005. National footprint and biocapacity accounts 2005: The underlying calculation method. *Global Footprint Network*, No.
World_Commission_on_Environment_and_Development, 1987. *Our Common Future*. Oxford: Oxford University Press. .
WWF, 2004. *Living Planet Report 2004*. Gland, Switzerland: WWF International.
WWF, 2005. *Ecological footprint and natural wealth Asia-Pacific 2005*: Living Planet.