

GLOBAL SUSTAINABILITY AND REGIONAL DEVELOPMENT

Susumu Iai¹

¹Director, 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 basics of global sustainability, including the concept of limits to growth, strong and weak sustainability, an index called ecological footprint, and climate change. Based on these reviews, the paper proposes the conceptual framework 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 system and natural resources is essential to establish harmonic societies. Finding the relations between the social system and technological strategy is also important. Since the humanity's burden on the earth has already exceeded the earth's biological capacity, increasing number of the regional systems may face the critical condition. Studying the vulnerability and robustness of the social and ecosystems is important to find 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 the 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 system should be applied as an integral part of the study that aims 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 further 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 basics of the 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 materials enough to suggest the specific aspects of the approaches required in the sustainability science.

In particular, the paper points out the needs to uncover the system dynamics that may not be automatically identified by simple overlay of two maps as often adopted in the basic practice in geo-informatics.

2 SUSTAINABLE DEVELOPMENT

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

"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. Underlying notion behind this definition is the awareness that our planet is limited and hence unlimited development is impossible. Much earlier, a series of computer simulations of human growth on our planet were run by a 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.

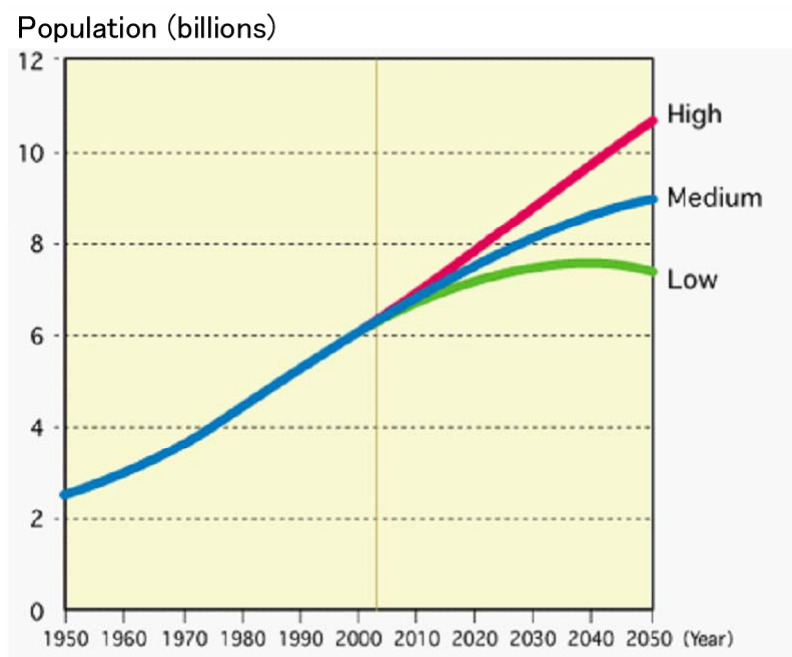


Figure 1 World Population Projections, 1950 – 2050 (United_Nations, 2003)

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

The global temperature change predicted by IPCC is shown in Figure 3. The results indicate that even though human manages to reduce the CO₂ emission to a certain target level in 50 years using an appropriate mechanism such as Kyoto Protocol, CO₂ concentration and temperature rise continues more than 100 years. More alarming is the sea level rise due to ice melting, continuing over several millennia (IPCC, 2001).

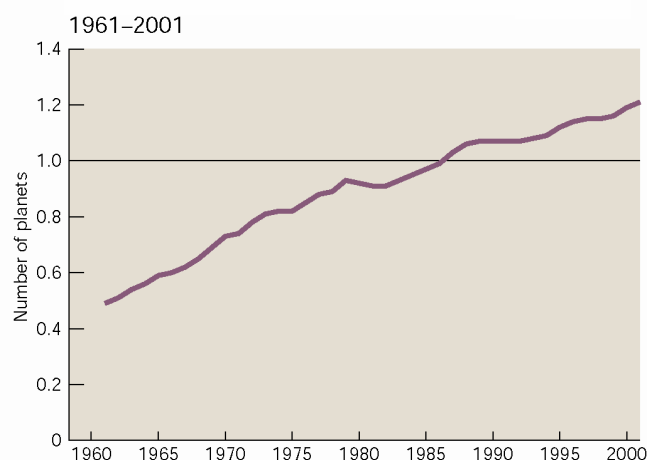


Figure 2 Ecological footprint, 1961-2001 (WWF, 2004)

3 FROM GLOBAL SUSTAINABILITY TO REGIONAL DEVELOPMENT

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

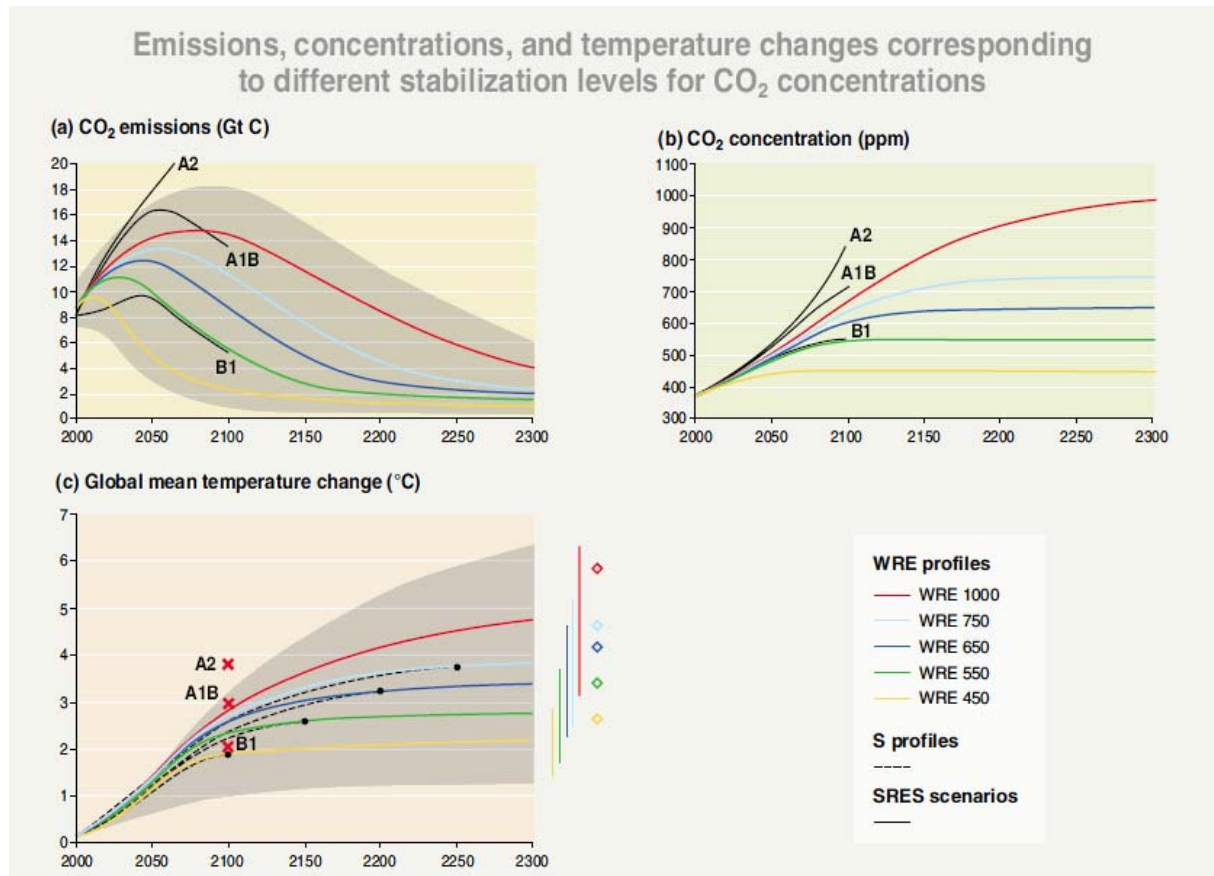


Figure 3 CO₂ emissions and global temperature change(IPCC, 2001)

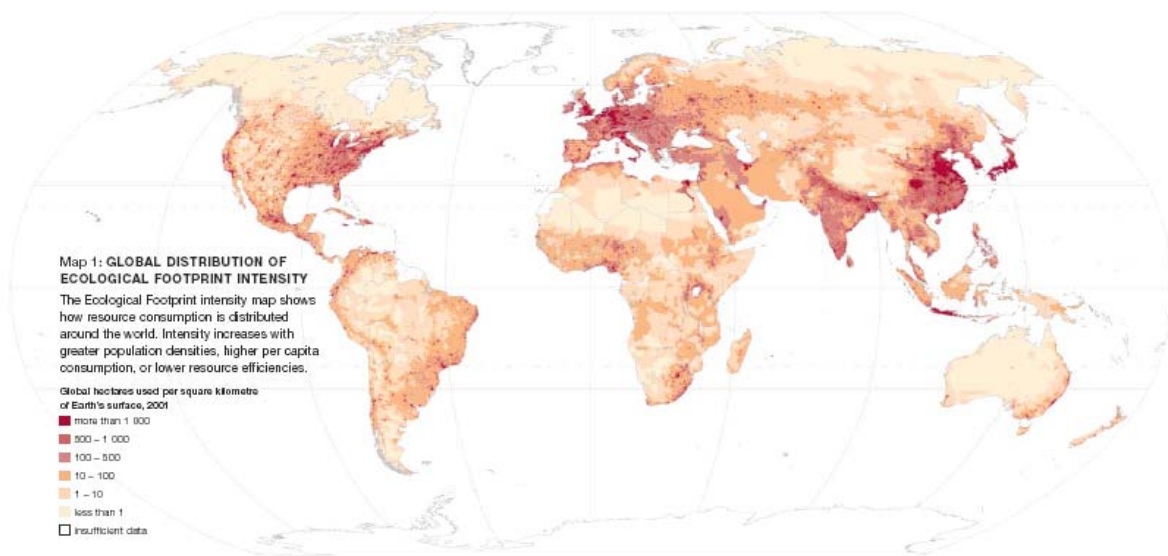


Figure 4 Distribution of ecological footprint (WWF, 2005)

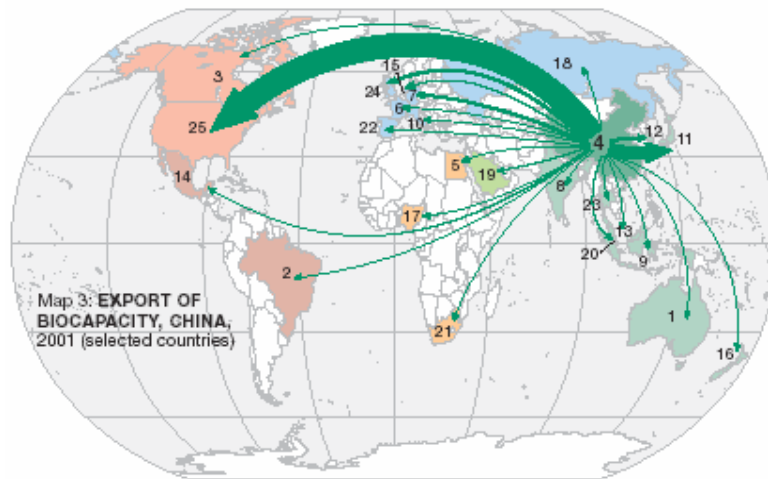


Figure 5 Export of Biocapacity, China (WWF, 2005)

More important is the dynamics that is not uncovered by the type of a map such as shown in Figure 4. Enormous amount of natural resources are moving 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 the regional sustainable development, one should be aware of these dynamics in the global scale.

Regional system is not a closed system. The impacts of inputs to and outputs from the regional system may be significant for the regional sustainability. The trend and change in the dynamics in the global scale may be closely related to the regional sustainability. Ultimately, study on 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 become available in 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 United Nations. General global view of the earth is available through free software such as Google earth. With the aid of internet sites, fair amount of information on sustainability in the global scale are available. These useful data sources have become available just in recent years and are encouraged to be shared. At least in the initial phase of the study for sustainability, these readily available data in 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 increase in the energy demand, 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 natural environment surrounding the urban areas and also in 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.

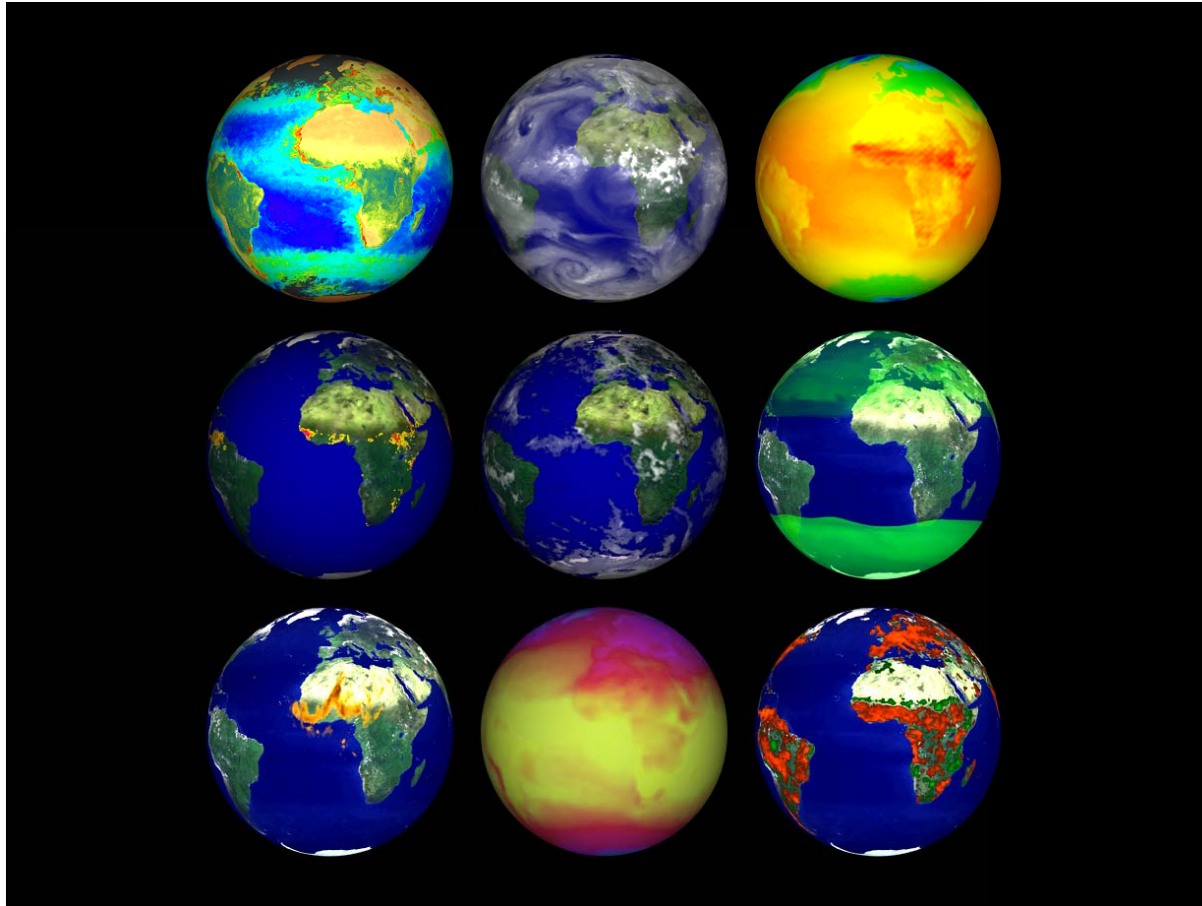


Figure 6 (left to right, top to bottom) Biosphere, water vapor, temperature, fires, clouds, methane, aerosols, radiant energy, vegetation index anomalies (NASA/Goddard Space Flight Center, The SeaWiFS Project and ORBIMAGE, Scientific Visualization Studio.)

The indexes used for discussing the global sustainability such as the temperature change shown Figure 3 are averages both in space and over certain time frame. They do not show variation in year, month, day or they do not show anomaly or extreme high or low events. 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 going through a critical stage, response of a system and assessment of vulnerability to these extreme events should be studied.

Identifying the sequence of events often leads to reasonable understanding of the dynamics of social and natural systems. For example, a negative spiral sequence of events can be recognized in natural disaster and poverty in society through the course of rapid industrialization and urbanization. Population growth in the rural areas will push the people to areas that have never been cultivated and 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, urban area needs cheap labor force and pushes the concentration of people to the urban areas. After young generation has gone to the urban areas, only aged generation remains in rural area with decrease in population.

A positive spiral sequence of events is also identified. For example, poverty in rural areas has been the major social problem in Brazil. Since the new technology for efficiently producing ethanol from sugar canes has been developed and put into use in practice, people in these areas find a new job relating to the ethanol production. Produced ethanol is then put into use as part of biomass energy and offsetting the aggravating environments in those areas.

Discussions made above may 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 system and natural resources is essential to establish harmonic societies. Finding the relations between the social system and technological strategy is also important. Since the humanity's burden on the earth has already exceeded the earth's biological capacity, increasing number of the regional systems may face the critical condition. Studying the vulnerability and robustness of the social and ecosystems is important to find a strategy to achieve sustainable development.

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

5 CONCLUSIONS

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

- (1) Differentiating the positive from the negative sequences could lead us to a strategy to achieve a sustainable society.
- (2) Since the humanity's burden on the earth has already exceeded the earth's biological capacity, increasing number of the regional systems may face the critical condition. In particular, the region where rapid growth and social change are occurring often faces the vulnerability. Studying the vulnerability and robustness of the social and ecosystems is important to find a strategy to achieve sustainable development.
- (3) Regional system is not a closed system. The impacts of inputs to and outputs from the regional system may be significant for the regional sustainability. The trend and change in the dynamics in the global scale may be closely related to the regional sustainability.
- (4) These dynamics may not be automatically identified by simple overlay of two maps as often adopted in the basic practice in geo-informatics. In order to solve this problem, geo-informatics system should be applied as an integral part of the study that aims at identifying the system dynamics.

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