THE MANAGEMENT OF NATURAL RESOURCES IN SATISFYING THE NEEDS OF HUMAN LIFE: THE ROLE OF AGRICULTURE, FORESTRY, AND FISHERIES

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Summary

Human beings have been living in close association with forests and the sea for the purpose of hunting, gathering, and catching fish for a very long time. These activities have been continuous since the earliest recorded date of human history, going back as far as 4 million years ago. Consequently, the association of humans with forests and the sea has had a much longer history than that of the cultivation of arable land for agriculture.

Primitive agriculture began around 10,000 B.C. and continued to evolve successfully, eventually leading to an increased food supply. Because of this there was also an increase in population growth. At the end of the eighteenth century Thomas Robert Malthus warned that the production of food could not match this rapid increase of population growth. Indeed, the rate of population growth was remarkably fast after the Industrial Revolution.

However, humankind has never been seriously affected by worldwide hunger, as was first predicted by Malthus. In fact, humanity has successfully overcome the issues presented by Malthus with the fruit of modern science and further innovations of technology. The basic policy for modern agricultural production has long been “high input and high return.” This policy has also been adopted in forestry and fisheries, as may be clearly observed in the mechanized management technology in forestry and in the mass catching technology in fisheries. In the latter half of the twentieth century,

humankind has began to realize that the practice of "high input and high return" in agriculture, forestry, and fisheries might also create various other kinds of problems on local and global scales. The pollution of atmospheric air, soil, and sea water by inorganic and organic pollutants from industry, human lifestyles, and livestock raising, attracted the attention not only of scientists, but also of the general citizen.

Another serious issue that human beings now face is climate change. In particular, this problem is the result of a rise in temperature due to an increase of atmospheric carbon dioxide concentration, caused by the excesses of industrialization. In the latter half of the twentieth century, these issues became highly visible. Yet, we remain optimistic. Why is this? Is it partly because we are confident that we will be able to find new ways of "low input, sustainable, alternative, extensive, or environment friendly" production in agriculture, forestry, and fisheries in the twenty-first century?

The aim of this essay is to help us first to come to understand the present situation of our agriculture, forestry, and fisheries; second, to help to predict the impact of environmental change on these same industries; and finally, to present a few ideas on how we might compromise productivity and sustainability in agriculture, forestry, and fisheries. This knowledge will allow us to meet any future situations of increased population growth and the necessary maintenance of a sustainable environment.

1. Introduction: A Brief History of Human Evolution and Agriculture, Forestry, and Fisheries

Agriculture, forestry, and fisheries have been playing a tremendously important role in the history of humankind by producing food and other materials essential for its survival and development. In addition to their role in production, agriculture, forestry, and fisheries are sometimes referred to as biological industries in that they also make an important contribution to the stabilization of the environment, including land, atmospheric air, and water, not only on a local, but also on a global level. However, currently, agriculture, forestry, and fisheries are facing serious problems that have arisen from population increase and environmental deterioration caused by industrialization and also by agriculture, forestry, and fisheries themselves. World population is predicted to reach nearly 10 billion during the twenty-first century. Environmental deterioration is also proceeding at a very high rate. If environmental deterioration in cultivated lands proceeds at the same pace as it is at the present time, it is predicted that no more than 7 billion people can continue to live on the earth due to the limited production of food and other products of agriculture, forestry, and fisheries.

Evolution of human beings. The earth has had a long history—it is 4.6 billion years since its birth—but the earliest recorded history of human beings is short: just a mere 4 million years. Our oldest ancestors with upright, bipedal walking, such as *Australopithecus afarensis* and *Australopithecus africanus*, who are conventionally called ape-men, appeared on the earth about 4 million years ago in Africa. About 2 million years ago our tool-making ancestors belonging to the genus *Homo* appeared also in Africa. Some of them succeeded in leaving the African continent and eventually reached east Asia. The world population at that time is estimated to have been about 150,000. In the period 1–1.5 million years ago, humans, who then still lived in Africa,

began to use fire. The use of fire then spread beyond Africa, becoming common 200,000–300,000 years ago when modern human beings, *Homo sapiens*, are supposed to have appeared on the earth. They then passed through a long period called the Paleolithic Age (or the Old Stone Age), until about 10,000 years ago when they went into the epoch-making era, called the New Stone Age. This is when agriculture first began. It should be noted that the entire history of agriculture, which is essentially an industry of controlling nature, is actually quite short: around 10,000 years. More than 99 percent of the total history of humankind was lived during an era when they depended entirely on nature for their nutritional needs. It is generally considered and accepted that our oldest ancestors initiated their evolution in the forest. This might be due to the fact that forests could protect them from various environmental stresses and hazards, such as heat, coldness, wind, drought, excess water, and strong solar radiation. They may have found protection under the huge roof of the tree canopy, and behind a long perimeter of trees. Forests have a great capacity to maintain the homeostasis of the environment, and can provide humans with a mild, safe, and comfortable environment. The second reason for humans to have initiated their evolution in the forest is that it protected them from attack by fierce animals or other human tribes, by hiding them from such dangers behind thick trees and dense bush. The third reason is that a large biological diversity existed within the forest itself. Many kinds of plants existed with wide variations, from mushrooms to tall arboreal plants. In addition, many different kinds of animals flourished, from the lowly worm in the soil to the higher animals that were also living and thriving in the forest. Biological diversity was well maintained in the forest by a stabilized ecosystem in which inorganic and organic matters, produced or introduced into the forest, recycled without undue loss or their escape from the forest's ecosystem itself.

Human beings were also involved in the ecosystem of the forest as another of its components. However, since they happened to be located at the top of the ecosystem, in terms of the food chain, they could also use the forest to obtain sufficient quantities of various food items by hunting and gathering in the forest, as well as by receiving various other products, such as skins, bones, and horns from animals, and flowers, leaves, roots, and stems from plants. These were utilized for clothes, medicines, and the various kinds of tools that were required for their survival. In addition to foods, human beings harvested wood from the forest, and used it to make weapons, traps, boats, and houses. However, it was perhaps the discovery of how to make fire with wood that was the greatest discovery by early human beings. It was not Prometheus, the Titan of Greek mythology, who introduced fire to humankind. The discovery of how to make fire might well have been the single most remarkable innovation in human evolution. It was undoubtedly an enormous epoch-making event during this period of human history. Fire was used for cooking and warming initially, though after a while it was also used for making earthenware and for the control of vegetation to develop new arable land. Owing to these functions of the forest, humans could successfully evolve and develop their history. These functions are still important for us even in the present age: the public services and multiple functions of the forest, along with the function of wood production will be discussed later.

A change of human lifestyle: the initiation of agriculture. The period commonly referred to as the Old Stone Age is characterized by a shifting lifestyle in which people

constantly changed their living places in order to obtain more food supplies or to have more comfortable and safe habitats for living. Hunting and gathering are unstable ways to obtain food, but people could not find any alternative lifestyle at that time, so they continued to shift from place to place in order to follow their hunting and gathering practices.

Incidentally, at a particular time and place on earth an absolute shortage of edible animals and plants must have occurred, so that our ancestors were forced to leave the forests and begin their search to live a more settled life. Living in caves, or in simple houses constructed on the flat lands near lakes, rivers, and seas, they were now able to catch fish and shellfish. Probably, these early people recognized that fishing was a more stable and easier way to obtain food than either hunting or plant gathering, because the life-cycle of fish is shorter than that of wild, terrestrial vertebrates, and thus the shortage of food occurred less often. The fact that shell mounds have been widely discovered in archaeological investigations near seashores or along riversides, is evidence of a more stable and settled life in these areas.

Around 10,000 B.C., humans came out of these caves into the open fields and plains, and lived there in pit houses made with logs harvested from the forest. This age is often called the Middle Stone Age, the transition era between the Old and New Stone Ages. Fine, curved stones were used for knife edges and arrowheads, which made hunting and cooking easier and more efficient. In this era, dogs were domesticated for hunting and guarding. Primitive agriculture was practiced through the cultivation of semi-domesticated plants and the raising of semi-domesticated animals. This form of primitive agriculture succeeded, eventually leading to an increased food supply for human beings, and because of this, also led to an increase in population growth.

The human population at that time is estimated to have been about 5 million. With an increasing population, the forest was exploited further in order to develop agricultural land and to obtain wood for fuel. This age is characterized by the use of polished stone tools, which contributed remarkably to the convenience of their life. Many kinds of agricultural tools such as the hoe and the sickle permitted easy and efficient land management for crop cultivation. The development of storage facilities made food supply even more stable. Due to these advancing technologies, people began to enjoy a more comfortable life. Significant progress was achieved not only in the production of food, but also in the manufacture of cloth. Knitting technology using hemp and wool staples were developed, leading to diversified clothing.

Development of agriculture, forestry and fisheries. Around 4000 B.C. in the Orient, metal tools were used for political ceremony and weapons, and for soil management in agriculture. The development of the metal plow particularly contributed to the remarkable increase of agricultural productivity, along with the development of irrigation systems. Around 3500 B.C. agriculture was further developed on the widely extended alluvial plains from Mesopotamia to the Nile Valley, and large villages and towns were formed. During the same era, along the Indus River of west India and the Yellow River of middle China, civilized societies began to appear. All of these civilized societies were formed primarily in inland regions in order to avoid salt damage to the soil by seawater. As civilization spread gradually to the surrounding areas with

agriculture, a cyclic series of an increase of agricultural production and an increase of population was formed, leading to the further development and enlargement of human society.

The high point of the Greek civilization, which goes back to around 500 B.C., owes much to the technological developments achieved in Mesopotamia and Egypt. Higher agricultural productivity was not achieved in Greece at that time, although the Greeks were quite active in research into the biological sciences. In contrast to the Greeks, the Romans showed great skill in the practice of agriculture, because agriculture was a vital part of the economy in Rome.

During the medieval era, productivity in agriculture, forestry, and fisheries stayed at relatively low levels, and there was little innovation in technology because the rate of population increase was still slow. However, the discovery of the American continent by Christopher Columbus opened an important door to a new history of agriculture. During this era, innovations in technology used to increase agricultural productivity were greatly stimulated by an increase in population, which gradually speeded up. New crops introduced from the New World in the sixteenth century contributed to a diversification of agricultural crops. In the seventeenth and eighteenth centuries—the transition period from the medieval to the modern era—technologies for the cultivation of crops, particularly innovative cropping systems, were greatly developed, bringing about a revolutionary change in agriculture. This period is sometimes called the Agricultural Revolution. As this era advanced into the eighteenth century population increases became rapid, and by the end of the century world population had reached about 1 billion.

Modern science's response to the increase in population. At the end of the eighteenth century the Industrial Revolution took place in England and spread to other European countries. This Industrial Revolution ignited yet another population explosion. In this sharp increase another innovation of technology in agriculture was necessary to accommodate it. In 1798, during the period when people in Europe were experiencing the Industrial Revolution, Thomas Robert Malthus, an English economist, published a book called *Essay on the Principle of Population*. In this he presented his theory that population increased in a geometrical ratio, but subsistence increased only in an arithmetical ratio. With this theory, he warned that the production of food could not match the rapid increase of population, leading to poverty, vice, war, and hunger caused by an unbalanced supply of food.

Indeed, the rate of population increase was remarkably fast after the Industrial Revolution. Though some million years or so from had been required for the world's population to reach 1 billion, in just 123 years after the publication of Malthus's book the population increased from 1 to 2 billion people. Once the population attained the level of billions, the rate of increase accelerated. It took only a further twenty-three years for the population to grow another 1 billion from 2 to 3 billion, then fourteen years and thirteen years for the population to reach 4 billion and 5 billion, respectively. However, humanity has never been seriously attacked by worldwide hunger as first predicted by Malthus.

We have successfully overcome the issues presented by Malthus with the application of modern science and with further innovations in technology. The basic policy for modern crop production is "high input and high return," where much fertilizer and agricultural chemicals, such as pesticides, insecticides, and herbicides are used to obtain high yields from crop plants. In addition, agricultural machines, such as tractors with various attachments, and plastic films, were invented for high and efficient production of food, fiber, and livestock feed. A similar policy to that used for crop production has been adopted in forestry and fisheries, as observed in the mechanized management technology in forestry and the mass catching technology in fisheries.

New arising issues in agriculture, forestry, and fisheries. As already mentioned, human beings evolved in close association with the forest, the sea, and arable land. It should be noted that humankind could not have survived to the present time, and will not survive into the future without further improvement of biological productivity in agriculture, forestry, and fisheries. However, humankind is facing various difficulties in improvement of biological productivity. In the latter half of the twentieth century, people began to realize that the policy of "high input and high return" in biological production might bring to human life various ecological problems on a local and a global scale. In 1962 an American, Rachel Carson, published a book entitled *Silent Spring*, in which she warned of the harmful effects of the excessive usage of DDT and other pesticides on wildlife and on human health. DDT, which is the abbreviated name of dichloro-diphenyl-trichloro-ethane, had contributed greatly to the control of plant-attacking insects and hence to an increase in production in agriculture and forestry, so that it was identified at the time as a "miracle insecticide." Since the book was published, environmental pollution by agricultural chemicals has attracted the attention not only of scientists, but also of the general public. Various agricultural chemicals with low toxicity were consequently developed, and a new technology for ecological pest control was exploited. This issue is discussed in more detail in the topic paper of agriculture," EOLSS on-line.

Another serious issue which humankind is now facing is climate change, particularly the rise of temperature due to an increase of atmospheric carbon dioxide concentration, caused by the advance of industrialization. Climate change will have a great impact on biological production in agriculture, forestry, and fisheries, and this will be discussed in the topic paper "Impacts of global environment changes on agriculture, forestry, and fisheries," EOLSS on-line.

Response to the new issues. In the latter half of the twentieth century, various issues, such as the ones mentioned above, became highly visible. And yet we are still optimistic. This is partly because we have gained much more experience now in solving the important issues of food production through our successes and the so-called "Green Revolution" in rice and wheat. We are confident that we will be able to establish a new policy of food production in the twenty-first century. Biological production by agriculture, forestry, and fisheries should be done with the new concept of "low input," "sustainable," "alternative," "extensive," or "environment friendly" production. It is considered that to implement the practice of these new concepts in biological production will not be easy, but we have to meet this challenge with the new tools available.

Various aspects of agriculture, forestry, fisheries, and human nutrition will be discussed in depth in this theme in EOLSS on-line. We will focus on how to respond to the changes in the global environment and the rapid increases of population; increased biological production; and how to compromise productivity and sustainability in biological production for the performance of high productivity under sustainable conditions.

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Bibliography

Brookfield, H. 1995. United Nations University Collaborative Research Programme on People, Land Management and Environment Change. *Global Environmental Change*, No. 5, pp. 263–393.

Consultative Group on International Agricultural Research (CGIAR) 2001. The Challenge of Climate Change: Poor Farmers at Risk. *CGIAR Annual Report 2000*. Washington, CGIAR Secretariat, pp. 2–17.

Costanza, R. 2000. Social Goals and the Valuation of Ecosystem Services. *Ecosystems*, No. 3, pp. 4–10.

Costanza, R.; D'Arge, R.; De Groot, R.; Farber, S.; Grasso, M.; Hannon, B.; Limburg, K.; Naeem, S.; O'Neill, R. V.; Paruelo, J.; Raskin, R. G.; Sutton, P.; and Van den Belt, M. 1997. The Value of the World's Ecosystem Services and Natural Capital. *Nature*, No. 387, pp. 253–60.

Diamond, J. 1997. *Guns, Germs, and Steel. The Fates of Human Societies*. New York, W. W. Norton. 480 pp.

Evans, L. T. 1998. *Feeding the Ten Billion. Plants and Population Growth*. Cambridge, Cambridge University Press. 227 pp.

Food and Agricultural Organization of the United Nations (FAO) 2000. *FAO Year Book, Production of 1999*, Vol. 53, Rome, FAO. pp. 59–100.

——. 2001. *The State of World Fisheries and Aquaculture 2000*. Rome.

Janick, J.; Schery, R. W.; Woods, F. W.; and Ruttan, V. W. 1981. *Plant Science*. San Francisco, W. H. Freeman. 119 pp.

Lipton, M. 1999. *Reviving Global Poverty Reduction: What Role for Genetically Modified Plants?* Washington, CGIAR Secretariat. 41 pp.

Serageldin, I.; Perley, G. J. 2000. *Promethean Science, Agricultural Biotechnology, the Environment, and the Poor*. Washington, D.C. CGIAR Secretariat. 38 pp.

Soda, O. 2000. *Fundamental Agronomy*. [In Japanese.] Tokyo, Iwanami. 304 pp.

Wiersum, F. 1995. 200 Years of Sustainability in Forestry: Lessons from History. *Environmental Management*, No. 19, pp. 321–9.

Biographical Sketch

Ryuichi Ishii was born in 1940 in Beijing, China, of Japanese nationality. He graduated from the Department of Agricultural Biology, University of Tokyo, and started his scientific career as a Research Assistant in the Laboratory of Crop Science, University of Tokyo. He was promoted to Associate

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