MANAGEMENT OF AGRICULTURAL, FORESTRY, AND FISHERIES ENTERPRISES

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Keywords: Agriculture, forestry, fisheries, food security, sustainable, development, rural, enterprise, policy, regulations, incentives, stakeholders, strategies, life-support, biodiversity

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Summary

Rising populations and expectations will create heavy demands for food, fiber, fuel, and all resources needed for a decent standard of living. Because the expansion of renewable natural resource industries has already strained life support systems, it is clear that gains will have to be made in different ways from those of the past. The answer presumably will come from a complex mix of new technologies, regulatory frameworks, international agreements, government policies, and incentive structures.

The main resource sectors are fisheries, forestry, and agriculture. Each makes major contributions not only to human needs for food and organic products but also to employment. Ocean fisheries have been most severely compromised by over-exploitation because of over-capitalization, the inherent complexity of fishing trophic webs, and the failure of timely and effective international agreements. Although tropical forests are still threatened, sustainable forest management has become increasingly pervasive and operational. The sustainability of agriculture presents some of the greatest challenges because of the desperate demands of the rural poor and, in more privileged areas, the effects of tradition, property rights, and image.

Increases in world food production were achieved by expanding cultivated and grazed areas until the middle of the twentieth century at the cost of wildlife habitat and biodiversity. As the agricultural landscape stabilized, further gains until the end of the millennium were achieved through superior crop varieties supported by heavy subsidies for water and fertilizer, and protected from weed competition, insects, and diseases with pesticides. Selective breeding of livestock responsive to intensive husbandry added to world food supplies. However, gains have slowed and this achievement threatens to degrade global life support systems. There have been hopes that biotechnology will maintain the necessary expansion of food production, but there are obvious limits to genetic modification and the market has expressed reluctance to accept the new products. The complexity of managing agricultural systems has increased greatly.

Beyond technological adaptation, human organizations reflect adaptation to changing markets and resource supplies. Communities managing common property resources were largely replaced with private resource ownership by family units. Vertically integrated corporate structures are replacing family farms and the co-operatives they formed to supply major markets and access resource inputs economically. The implications of these changes are not clear, particularly from the standpoint of sustainability.

1. Challenge of Food and Fiber Production

1.1. Populations and Expectations

Between 1960 and 1999, world population increased from 3 to 6 billion, and it is expected to double to 12 billion before leveling off sometime after 2080. For the next several decades, 75 million persons will augment the world population each year, resulting in 8 billion people by 2025. Along with rising expectations and purchasing power, this will greatly increase resource consumption, stretch production capacity, and stress global ecological life support systems.

Consumption trends and associated impacts on life support systems are related to basic needs such as nutrition, literacy and livelihoods, not merely by lifestyle preferences as believed by many people in western countries. Therefore, fisheries, forest and agricultural products, and hence terrestrial and aquatic resources are not easily substituted. It is difficult to expect long-range planning and restrained resource use by people who are challenged simply to survive another day. For this reason, socio-economic development must be an integral part of environmental management.

Nutritional demands increase in proportion to population and may at least double as the population increases, but economic demands are expected to triple food demands. Most of this will be met by crop and animal agriculture. The Food Policy Research Institute expects production of rice, wheat, and corn, staples of the human diet, to increase by 40 percent. World cereal consumption has doubled in the last thirty years and over 3 billion tonnes are forecast for 2025. In the past forty years, meat consumption has tripled, reaching 213 million tonnes, and may increase to 306 million tonnes by 2025.

Some of the rising food demands will be met by fisheries. Demand for food fish alone is expected to rise to 120 million tonnes by 2010. The demand for non-food fish will remain constant at 30 million tonnes. This exceeds the sustainable wild catch of 90 million tonnes and the 30 million tonne shortfall is expected to come from aquaculture. Aquaculture, now providing 25 percent of food fish, will have to expand massively to meet the demand. Despite impressive growth in the past decade, this goal will be increasingly constrained by availability of reliable water supplies for fresh water aquaculture and estuaries for marinculture.

Demands for forest products are expected to grow somewhat less quickly than population. In 1997, the world consumed 3.4 billion m^3 of wood, of which more than half was burned as fuel. FAO's Global Fiber Supply Model predicts that demand for roundwood will grow to perhaps 4.6 billion m^3 by 2010, most of the demand arising from a doubling of fuelwood consumption. Demand for industrial roundwood is directly related to incomes whereas demand for fuelwood is related to the numbers of rural poor and hence is inversely related to income.

1.2. Sustainability and Life Support Systems

As compelling as the need for an increasing flow of products is the recognition that the gains of the past are not uniformly sustainable. Per capita availability of arable land

declined from 0.32 to 0.25 hectares between 1976 and 1992 and is declining slightly more rapidly than expected from population growth. Tropical forests declined by over 15 million hectares annually in the 1980s in the face of shifting cultivation, agroindustrial use, livestock grazing, forest harvesting, fuelwood collection, mining, and hydroelectric development. Estuaries, surface water, and ground water are being contaminated by extravagant fertilizer and pesticide application. The warming global climate has been attributed to both greenhouse gas emissions and declining carbon sequestration by oceans, soils, and forests. Global trade has increased the threat of spread of diseases and pests. The integrity of ecological life support systems is already strained.

Faced with these realities, world attention has turned from issues of sustained growth to sustainable growth. The 1987 Brundtland Report summarizes the concept of sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." It requires a balance among social, economic, and environmental factors: the development triangle. The concept appears in many international agreements such as the World Trade Organization Agreement and the Climate Change Convention, and the Biodiversity Convention arising from the 1992 UN Conference on Environment and Development (UNCED or Earth Summit). The Earth Summit offered *Agenda 21* as an umbrella under which specific conventions, protocols and agreements are negotiated.

Some of the most critical challenges are soil degradation, global warming, eutrophication, declining and degrading water supplies, environmental contaminants, and impoverished biodiversity.

1.2.1. Soil Erosion and Desertification

Soil degradation is proceeding at about 5–12 million hectares per annum, and over 500 million hectares of arable land ultimately could be lost. About 20 percent of irrigated land has been degraded through water-logging or salinization, and perhaps a million hectares continue to be lost annually. Desertification claims 60,000 km^2 of agricultural land each year and reduces the productive potential of another 200,000 km^2.

1.2.2. Carbon Cycles and Global Warming

Although the massive extent to which humanity was appropriating the Earth's primary productive resources was realized in the late 1970s, it was not viewed with alarm until the connection with global climate change was made. Anthropogenic sources of greenhouse gasses (carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons), along with impairment of the ability of vegetation to sequester carbon, threaten significant global warming in the near future. Rising temperature of only a few degrees threatens to alter weather patterns and coastal shorelines dramatically.

Agriculture not only has replaced forests and natural vegetation but also remains an important contributor to the world's energy consumption, estimated to be in the order of 360,000 gigajoules (GJ). Fertilizer production accounts for about 4,400 GJ. The production, processing, and transportation of food raise energy use by the agri-food

sector to about 10 percent of total annual energy demand in the developed world.

However, more urgent than the consumption of non-renewable energy sources is the impact of fuel combustion on climate. The Kyoto Protocol set a schedule for reducing greenhouse gas emissions. Its significance is that international action on a global crisis is possible and it offers encouragement for similar action on such threats as nitrogen cycles and biodiversity.

1.2.3. Nitrogen Cycles and Eutrophication

The next major global initiative must be regulation of human impacts on the global nitrogen cycle. Human activity is now fixing nitrogen faster than natural terrestrial processes (210 versus 140 million tonnes per year) and agriculture accounts for 86 percent of anthropogenic sources. Oxidized forms of nitrogen (nitrates and oxides) acidify and degrade ecosystems and contaminate drinking water. The reduced form (ammonium) fertilizes ecosystems and increases their productivity, but in excess can cause toxic algal blooms, oxygen depletion, and other expressions of eutrophication.

Global fertilizer consumption is projected to rise from 134 million tonnes to 208 million tonnes by 2020. Only about half the applied fertilizer nitrogen is used by plants or otherwise captured in organic matter. The rest enters the atmosphere or water supplies. Indiscriminate use of nitrogen fertilizers and other soil amendments has caused eutrophication of estuaries, collapse of certain fisheries, and contamination of surface and ground water. In the United States, nearly 40 percent of the country's freshwater is too polluted for swimming or fishing, and agricultural run-off is a prime contributor. Also, an alarming 52 percent of estuaries show some degree of oxygen depletion and large dead zones have developed in places like the Mississippi discharge into the Gulf of Mexico.

1.2.4. Hydrologic Cycles

The impact of humans on hydrologic cycles threatens serious and persistent shortages of clean water. Indeed, control of water is anticipated to be one of the defining issues of the twenty-first century, replacing access to fossil fuels as one of the significant potential causes of war. Already 338 million people live in countries experiencing water stress (less than 1,600 m^3 of available water per capita) and this could leap to 3 billion people in over fifty countries by 2025.
Agriculture is a major user of water, accounting for about 70 percent of annual global consumption, leading industrial (18 percent) and domestic (13 percent) uses. The proportional use of water for irrigation approaches 90 percent in developing countries and less than 50 percent in developed countries.

1.2.5. Environmental Contaminants

Measures to control competition from weeds, pests, and diseases have been innovative and variably successful. Despite their value in reducing pre- and post-harvest losses, pesticides raise concerns about environmental contamination and food safety. Several agricultural chemicals are potentially carcinogenic and teratogenic but so are several of

the organisms they control.

Awareness of these issues has a long history starting symbolically with publication of Rachel Carson's *Silent Spring*. Developed nations have been cautioned about exporting unwanted technologies to developing nations where benefits to economy, nutrition, and control of disease are considered to outweigh risks of cancer and birth defects.

One of the emerging concerns beyond threats to human health is the impact of pesticides on biodiversity. Pesticides may cause collateral injury to beneficial organisms but the most pervasive effect is to replace management practices that encourage greater crop and landscape diversity.

1.2.6. Biodiversity

Over 1.4 million species have been identified worldwide but between 5 and 30 million may exist. Alarming rates of extinction and local extirpation are cause for concern. Communities of organisms comprise ecosystems and the deletion of certain elements may, under some circumstances, lead to profound changes and even disruption of ecosystem services. A rich biota is a storehouse of undiscovered drugs and genetic material to meet a variety of unanticipated future human needs.

The impacts of fisheries, forestry, and agriculture on biodiversity have come under increasing scrutiny. Over-harvesting is an obvious cause of declining stocks of target as well as non-target species. Exploitation of wild fisheries has unpredictable effects on complex food webs and collapse is a threat if not a too-frequent occurrence. But the indirect results of habitat change are considered ultimately more important effects of agriculture and forestry on wild biota.

Measures have been taken to include consideration of non-timber values, and considerable experience with working with multiple conflicting stakeholders has developed within the forest industry. Although protected by entrenched property rights on lands with a long history of use by small family enterprises, agriculture is coming under increasing scrutiny as a threat to biodiversity. A great deal has been done to provide incentives for landowners to manage in a manner that protects wildlife and habitat. But as the emergency intensifies, issues will sharpen and tighter measures will be needed.

1.3. Social Issues

Although threats to life support systems may be of ultimate importance, meeting near-term human needs, paradoxically to some, must be part of the solution. Social stability is strained by the ever widening gap between the rich and the poor. It has been noted that 225 persons control more than $1 trillion, equal to the annual income of 47 percent of the world's population.

Poor people starve. Despite increases in world food production, 135 million children under five years of age will be malnourished by 2020, a decline of only 15 percent. Over 5 million deaths can be traced to unclean water, and the proportion is expected to

rise rapidly. About 34 million people are infected with HIV and 14 million already have died of AIDS. Within twenty years, over 140 million will be infected. Most of these people will not benefit from anticipated medical breakthroughs.

Clearly, economic, social, and ecological sustainability are facets of the same problem.

2. Natural Resource Sectors

Today it is common to speak of fisheries, forestry, and agriculture as the three major renewable resource sectors. However, the distinction is relatively recent, reflecting the industrialization of renewable resource exploitation. For most of human history, resources were considered in terms of our needs (food, clothing, shelter and fuel) rather than the tools used for their extraction, and were understood in a more holistic way. For subsistence communities, resources of land, water, and forests are simply parts of a wider ecosystem that sustains them.

The sectoral distinction may again submerge as a growing proportion of the global supply of fish comes from aquaculture and fiber and fuel from plantation forests. Fish and trees will simply be seen as alternative livestock and crops, distinguished mainly by the equipment needed for their production and harvest. Crops will provide liquid fuels, fiber, and pharmaceutical products. Transgenic organisms will produce products associated with unrelated species. The distinction will also be blurred by further integration of these production systems in comprehensive sustainable resource management systems.

Of the renewable resource industries, fisheries and forestry have remained largely common property and are often open-access resources, whereas agriculture is based on privately owned land resources. However, wild plants and animals from the public domain still make significant contributions to human needs whereas fish and trees are increasingly farmed on private property by individuals or firms. The following sections briefly consider issues and trends in each sector.

2.1. Fisheries

Fishing is an important economic activity involving 12.5 million fishers operating 3 million vessels and landing 90 million tonnes of fish each year. Fish consumption has increased 57 percent since 1960, and fish now constitutes 16 percent of the animal protein consumed by humans globally. In 1996, fish harvests reached record highs of over 120 million tonnes, of which about 72 percent was marine catch, 6 percent was from inland fisheries, and over 22 percent came from aquaculture. About 25 percent of the annual catch is processed into fish meal and oil used mainly in animal feeds. (These figures do not include the one in four fish that are thrown back to the sea, many of which do not survive.)

However, several key fisheries have collapsed worldwide in response to this heavy harvest, and the annual wild catch is expected to stabilize well below the record catch in the mid-1990s. Wild catches peaked in the 1970s in the Atlantic, 1980s in the Pacific, and 1990s in the Indian Oceans. Perhaps 70 percent of the world's fisheries now need

urgent management and 30 percent are in serious decline or have collapsed, as in Atlantic cod, haddock, and bluefin tuna.

Fisheries are difficult to manage because of the inherently complex marine food webs. However, the main reason for collapse is overcapacity; the global fleet is 30 percent larger than required to sustainably harvest fish stocks. This overcapacity results largely from distorted economic incentives. Steps have been taken to buy back equipment but often this eliminates small-scale craft while subsidizing modernization of industrial fleets.

Technological advances have increased the impact of fishing. Benthic communities are disturbed by trawl nets and dredges dragged along the sea floor. This greatly adds to the persistent illegal use of explosives and poisons by small-scale fishers. Additional stress arises from pollution of estuaries and inland waters by sewage, industrial effluent and agricultural chemicals. There is considerable room for reduction of waste and reducing by-catch of non-target species. This is both a technological and methodological problem. Aquaculture has grown at 10 percent per year (compounded) since 1980 and has more than compensated for the declining wild catch. Although aquaculture promises to fill the gap between supply and demand, it may create its own environmental problems. Among these are loss of estuarine habitats (e.g. mangroves), competition for land and water by freshwater aquaculture, pollution arising from pond effluents, inadvertent introduction of competitors, predators, parasites, and diseases, and genetic modification of wild stocks by inevitable escapes.

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Biographical Sketch

Robert J. Hudson is Associate Dean (Academic and International Programs) of the Faculty of Agriculture, Forestry and Home Economics at the University of Alberta. His research and teaching are in the areas of sustainable agriculture with particular reference to livestock diversification. He has co-authored books on wildlife production system, bioenergetics and deer farming. Recent research projects have examined the role of tannins in diets of farmed deer and cumulative effects models of the effects of landscape change on populations of woodland caribou.