THE ROLE OF FOOD, AGRICULTURE, FORESTRY, AND FISHERIES IN HUMAN NUTRITION

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Summary

This article traces the extraordinary history of human colonization of the habitable world and is a chronicle of humankind's early communion with the underlying realities of the earth's physical environment, the eventual destruction of this harmonious relationship, and efforts to repair the damage. From the beginning of human history, a major part of humans' mental and physical energies has been devoted to the search for

food. Whether by hunting, fishing, or cultivation, people have sought to secure the means to sustain themselves through the cycle of the seasons. Human progress over the centuries has largely consisted of devising more efficient ways of securing food requirements so that more time could be devoted to satisfying the desire for other comforts and pleasures. Even today, the proportion of a nation's population engaged in agricultural pursuits is a reasonably reliable indicator of the general level of economic welfare attained by the country: the fewer in agriculture, the higher the level.

Progress toward the attainment of adequate food supplies with minimum effort has not been steady over the years and not uniform among countries. The reasons are many. Because rural activities are highly dependent on the climate, the adequacy of food supplies in any particular region in any particular year varies with the weather, which humans cannot control. Likewise, episodic upsurges in the virulence of plant and animal diseases, or ecologically based fluctuations in insect populations severely cut back yields. Even when modern transportation is available, it is often not practical to offset fully the effects of such vicissitudes by redistributing food from surplus to deficit areas.
Human health and well-being depend strongly on the production, quality, and availability of food. Agriculture, or cultivation of the soil—harvesting crops and raising livestock, which are the main sources of food—has no single origin. At different times and in numerous places, many plants and animals have been domesticated to provide food for humankind. Fishing, like farming, is a form of primary food production. Through food gathering, primitive humans first obtained fish and other aquatic products in the shallow waters of lakes and along the seashore, in areas with ebb tides, and in small streams.

The development of agriculture meant an intensification of the food extractive processes. More food could be obtained from a given area of land by encouraging plant and animal species that were useful and productive, and discouraging others. This provided for an increased population and gave better opportunity for settled life. The development of agriculture also enabled people to produce greater amounts of food on a more reliable basis, and from smaller areas of land. In time, to keep the agricultural soils productive, it was necessary to develop technologies of various kinds. Increasing dependence upon foods that could not be eaten raw generated the need for materials with which to cook. Thus, requirements for a wide variety of living and non-living natural resources developed along with the rise of agricultural lands and settled villages.

With the growth of civilization and the concentration of people into cities, natural resource requirements increased. It became essential to organize and direct agriculture, fisheries, and livestock over large areas to provide food for urban populations. As a consequence, the pressure on the earth's natural resources has increased steadily. Natural resource conservation is essential to human survival. Because life depends upon the proper functioning of the biosphere (the relatively narrow zone of air, water, soil, and rock in which all life on earth exists), the ultimate purpose of this resource conservation is to maintain the biosphere in a healthy, operating condition.

Also important to the concept of conservation is the recognition that natural resources have multiple uses. In addition to its value as livestock forage, grass, for example, also supports wild animal life, holds soil in place, maintains the productivity of soil, keeps

soil and water relationships in proper balance, and helps guarantee stream flow and yields of water to underground channels.

The various benefits humans get from land are usually compatible and often complementary, but are sometimes in conflict. Land management is aimed at maximizing the benefits and minimizing the disadvantages.

In the history of human development, from the time of their earliest agricultural activities humans have cleared the natural forests and woodlands to obtain building materials and fuelwood, and to provide land for domestic animals and crops. It is this aspect that will be the main focus of the theme. The authors in this theme will analyze and review the interactions between the utilization of natural resources and human nutrition. Much attention will focus on the specific contribution by agriculture (including livestock husbandry), forestry, and fisheries in meeting human needs. This overview assesses the pattern of past changes in the relationship between humans and the resource base on which their lives depend. Lessons learned, or still to be learned, are teased out and elaborated.

1. Introduction

Throughout human history the organization of food production, distribution, and consumption has had major influences on multiple aspects of social and cultural life. The processing and preparation of food, transforming it from its natural state into "food" that is regarded as acceptable for consumption, are central features of adaptive human ingenuity. The processes of adaptation, which involve the interactions of biological, social, and environmental factors, can be seen in the evolution of human food systems.

The specific challenges faced by human groups throughout our history have changed in relation to changing technologies of food acquisition, distribution, and consumption, as have the challenges presented by different environments. The dual nature of human nutrition—that food is a biological necessity and that social and cultural factors condition its availability and consumption—presents unique challenges and opportunities. At the same time, the challenges of adaptation in different physical and social environments, in interaction with cultural and social values, have produced a rich diversity in human selection of plant and animal species, both as dietary stables and as secondary components of dietary intake. These, in turn, are reflected in the details of food production, distribution, and consumption patterns across the world.

The human species (*Homo sapiens*) first appeared about 500,000 years ago, at the very last instant, as it were, of the planet's 4.5 billion year history. Despite the lack of recorded history, a great deal is known about the broad pattern of events. As hunter–gatherers began to move over the face of the earth, they also began to impact on many of the large animals and birds that they killed for food. When agriculture evolved independently in eastern Asia, the eastern Mediterranean, Mexico, and Peru 8,000–11,000 years ago, there were perhaps as few as 5 million people throughout the world. Of course they were not evenly distributed, and centers of population had relatively high densities whilst other areas were unoccupied. This population began to grow quickly. In

the early stages of the expansion of human populations there were few or moderate pressures on natural resources, and thus no overexploitation. Collecting food was obviously a major activity. The hunting/picking and gathering ways of nomadic life were probably sustainable, but provided limited returns. Food gathering permitted the collection of about fifteen calories of food per calorie of energy invested. For example, in a food search experiment conducted in Turkey in the 1960s to simulate conditions in Neolithic times, hand-harvesting of a mixed stand of wild relatives of barley, wheat, and oats resulted in the collection of about 1 kg of clean grain per hour. The calorific value of this was marginally greater than the energy expended to collect it. (Note: throughout this article, calories and calorific values will be used instead of Kilo joules(Kj). This is because the WHO and other international agencies cite calories as the standard measure for assessing nutritional status. The conversion of calories to Kj is 1 calorie = 4.184 Kj). From this we might conclude that human energy invested per hour of labor, rather than the unit of land, determined the yield. There was no conscious effort to increase food production *per se* until much later in human history. With the onset of more organized agriculture, the approach became very different: people began to till the soil, and intentionally selected the most desirable plants found in the fields. Domestication of animals and plants goes back to the earliest days of settled agriculture. Not all animals and cereals were domesticated at one time nor in the same region. Sheep were first herded before 7000 B.C. in the hilly flanks of the Zagros Mountains (Iran, Iraq) and in the Taurus Mountains (Turkey), where they had previously been hunted in the wild. Cattle and pigs followed between 7500 and 6500 B.C. in Anatolia and domestication continued locally in Europe from 6500 to 5500 B.C. The domesticated horse was unknown in the Near East and east-central Europe before the end of the fifth millennium B.C. although it was obviously used in the Far East and perhaps elsewhere. Much still remains to be learned about the origins of agriculture.

In fact it is impossible to really know how agriculture began, or why precisely it has come to be the dominating force. There is a body of opinion that suggests that organized agriculture existed long before this: as early as 30,000 B.P. (Before the Present), not in the Middle East but rather in the tropical forests with the simple planting of favored trees. If cultivation of this kind did indeed arise 30,000 years ago, then this solves the significant mystery of why it is that agriculture seemed to arise independently in many different locations at different times after 10,000 years B.P. It suggests that people were not inventing the skills from scratch. They knew perfectly well how to cultivate and had known for tens of thousands of years. Cultivation and perhaps husbandry skills were invoked when necessary. The apparent first appearance of farming in the archeological record of any particular place indicates merely that cultivation had become economically desirable at that particular time and so was being practiced on a scale that was at last large enough to leave some trace.

It is easy to see too, in a general way, how advanced Paleolithic hunting graded seamlessly into husbandry. The “beating” of game by war hoops and fire became indistinguishable from herding. Control of animal movements, and ultimately their breeding, led from a system of passive herding to animal husbandry. There is speculation as to why people took up farming. Clearly, the whole point of farming is that from any given area it produces more food suitable for human beings, and so the population increases. In general farming communities exploited the land more

efficiently, they turned more of the resources into their own flesh; they out-competed groups that were less efficient.

1.1. A History of Feast and Famine

Humankind has a history of alternating successes and failures in providing food, and the record reveals major periods of starvation in several parts of the world. Biblical records indicate successive feast and famine in ancient Egypt. Famines were common in some regions in Asia until recently. In the late 1990s famine was reported from North Korea. Post-harvest losses from insects, rodents, food spoilage, and so on have been—and in some regions still are—a serious impediment to achieving food security. Diseases and plague insects such as locusts have wiped out crops and livestock.

There have been natural disasters such as flood, fire, drought, and unseasonable weather that have exacerbated the problem of maintaining food stock. The last great perturbation, and one that profoundly affected the course of human history, was the last Ice Age. The Northern Hemisphere experienced four intense glaciations in the Pleistocene, the most recent about 8,000 to 10,000 years ago. These glaciations covered at least half of North America and Europe.

As the ice receded, the colonization of almost the entire habitable world was achieved by people who subsisted entirely on forms of hunting, fishing, and plant gathering. Great changes occurred to human societies at the onset of the Neothermal (*c*. 16,000 to 20,000 years ago). As the ice sheet of the late Pleistocene melted, sea levels rose and large freshwater lakes were formed as the glaciers retreated or turned into rivers. Human settlements became concentrated on river courses and around numerous lakes. The milder climatic conditions during the eighth millennium B.C., resulting from the rapid rise of sea level, had a strong influence on plant and food resources for humans and animals. In the coastal regions and along inland lakes, marshes and peat areas were created that spawned a rich habitat for fish, mollusks, shellfish, and water birds.

1.2. Domestication: The Chosen Few

Of the approximately 300,000 plant species, some 3,000 provide food; twenty provide 90 percent of the world's calorie intake and three alone (maize, wheat, and rice) supply almost 60 percent of the calories and protein in the human diet. Modern agriculture still reflects its Neolithic origins. There is a heavy dependence on the twenty or so plant species and ten animal species domesticated by humans 10,000 years ago. Yet there are at least 3,000 plant species which have been used for food by human communities at one time or another.

A further 75,000 plants, almost one in three of all species, are known to be edible but only 150 have ever been cultivated on a large scale. Anthropological and ethnobiological studies in South America and Africa show that in the past food and livelihood security of local populations depended upon more than 1,000 plant species—not all of them food plants. The same limited number of species has served humans for millennia. Many potential food resources remain unexploited in a hungry world. There is clearly scope for diversification based on further domestication and the promotion of

so-called neglected and under-utilized crops, not only for food but also as pharmaceuticals.

According to the World Health Organization (WHO), approximately 80 percent of the world's people rely on traditional medicine for their primary health care needs; an estimated 85 percent of traditional remedies are derived from plant extracts. Plants and other organisms are natural biochemical factories. More than 60 percent of the world's people depend directly on plants for their medicines: the Chinese use more than 5,000 of the estimated 30,000 species in their country for medicinal purposes. Moreover, the great majority of Western medicines owe their existence to research on natural products that organisms produce. Relatively few of the 300,000 kinds of plants in the world have been fully examined for their potential therapeutic properties.

1.3. Fish as Food

Fishing, like farming, is a form of primary food production. Through food gathering, primitive humans first obtained fish and other aquatic products in the shallow waters of lakes and along the seashore, in areas with ebb tides, and in small streams. Traditional societies gathered the seeds of plants growing at the ocean's edge, garnering much of their food from the land to supplement and complement the food derived from the sea.

As humans settled along the edges of rivers and lakes after the retreat of the glaciers, great emphasis was placed on fishing as a food supplement. Technologies were developed to catch the fish and to preserve it over the winter months. It wasn't until relatively recent times that alarms began to be sounded about the sustainability of fishing in most of the world's waters. Coupled with the problems of pollution of waterways and destruction of coastal (estuarine) spawning grounds is the harnessing of rivers for hydroelectric facilities and for irrigation. These factors have contributed to the demise of fishing in some regions of the world.

Fish farming of both freshwater and marine species has developed to a high degree. Throughout China and other Asian countries the intensive production of fish in ponds and reservoirs has been perfected over centuries. In Israel, the United States, and some other regions, the use of highly intensive methods has resulted in the development of a desert aquaculture system that uses saline waters and freshwater fish such as catfish.

2. Humans Have Modified the Global Environment

Human-induced land degradation has taken place all through history, for example during the Mediterranean and Middle East civilizations, about 2,000 years ago, and during the time of European expansion in the Americas, Australia, Asia, and Africa. During the twentieth century however, land degradation has increased enormously in extent and severity, due to direct action of a strongly growing world population and its increased livelihood expectations and demands.

It has been calculated that the total net terrestrial primary production of the biosphere currently being appropriated for human consumption is around 40 percent. This does put the scale of human presence on the planet in perspective. The countless other

organisms with which humans share the planet need to be catered for. Survival of both humans and other species depends upon maintaining the resource base.

The environmental resource base on which all economic activity ultimately depends includes biological systems that produce a variety of services. There are three basic kinds of resources that humans derive from the resource base (including the terrestrial and aquatic ecosystems that are the focus of this theme). See Box 1 for more details. This resource base is finite. Finding a balance between increased food production and the conservation of the world's natural resources remains a major challenge. It is clear that food will have to be produced at less cost to the natural resource base than at present. This will be quite difficult if burgeoning populations are to be fed.

Everything that we need, want, use, abuse or consume comes from nature. Will it last? Ironically enough, the debate about resource depletion has shifted from concerns about non-renewable resources such as fossil fuels and minerals to fears that we will run out of renewable resources. There is a growing scarcity of renewable resources such as fresh water, food and fiber, forest products, fish and shellfish. As populations rise, we will need more of all these. In some regions there is a profound shortage of water and of arable land (see below).

1. Ecological services (or Conservation Values). Such values have long been recognized but have received increased interest lately. These boil down to the concept of sustainability of land use and continued benefits to human welfare. They include such benefits as clean water, protection of soil from erosion and nutrient loss, and conserving genetic resources and the like. Neither the landholder nor society usually derives direct monetary income from protection of these services, but it is recognized that they are in humanity's long-term best interest. Enlightened management for other values will usually, but not always, also provide for these values.

2. Non-commodity values and services. These uses of resources do not involve harvesting a "product" from the land, but the user receives a benefit. Examples include recreations such as hiking, and bird watching. People who participate in these receive a benefit (pleasure) for which they are sometimes willing to pay not only the landholder but also other sectors of society who facilitate access or transport to the site.

3. Commodity values. Production of food, fiber, fuel, and minerals provide an income to the landholder from sale or consumption) of these products and/or fees paid to remove them, and benefits society in the form of new wealth or taxes. These benefits constitute the primary production upon which society's ultimate welfare depends

Box 1: The three basic kinds of resources humans derive from the resource base

The rush to develop the world has damaged the natural systems that sustain renewable resources. Examples of this are seen in:

- land degradation and soil loss
- spread of salinized wastelands
- build-up of pollutants in the air, water, and soil
- damage to watersheds
- loss of biodiversity.

Sustainable use places the focus on two groups of disenfranchised people: the poor of today and the generations of tomorrow. The rapid degradation of the natural resource base of the rural poor is significantly worsening their condition. Many of the threats to the environment in the developing world occur as a result of poverty. Indeed, rural poverty and degradation of the environment are mutually reinforcing. When people's survival is at stake they are forced to over-cultivate marginal cropland, overstock fragile grazing lands, cut trees for firewood, and overuse ground waters.

Few aspects of development have been found to be so complex as the need to reconcile anti-poverty and pro-environment goals. The policy linkages and choices to be made have yet to be articulated. One pivotal point is that no long-term strategy of poverty alleviation can succeed in the face of environmental forces that promote persistent erosion of the natural resources upon which we all depend.

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Biographical Sketch

Dr Victor Squires is an Australian. He has undergraduate qualifications in agriculture, botany, and ecology, and a Ph.D. in range ecology from Utah State University, USA. He is a retired academic from the University of Adelaide, and currently an Adjunct Professor at the University of Arizona, USA. He is a consultant to FAO, UNDP, and UNEP, and has consulted for the World Bank and the Asian Development Bank in Africa, the Middle East, and Central Asia. Dr Squires was a researcher with the Australian government research organization (CSIRO) for twenty-two years before taking up the post of Dean of the Faculty of Natural Resources at Roseworthy Agricultural College. Dr Squires was Head of the Division of Land Resource Management and, later, Director of the National Key Center for Dryland Agriculture and Land Use Systems at the University of Adelaide. He is the author of over 100 scientific papers and three books.