FOOD AND AGRICULTURAL SYSTEM DEVELOPMENT INFORMATION AND KNOWLEDGE

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Summary

The evolution of agriculture involves essential contrasts through time and space between unsatisfied needs and abundance. A crucial point in relation to sustainability occurred after World War II, when wealthy countries implemented industrial, energy-intensive technology in farming. The altered social institutions and structures encouraged increasing production by means of technology, which later proved to be unsustainable. The alteration of structures and institutions was based upon a notion by which agriculture was interpreted as decoupled from natural life support systems. Production was increased by means of capital and heavy inputs of energy and

chemicals. These structures and institutions contain the basis for individual as well as social experience and knowledge. Thus, social arrangements have supported industrial nations in producing too much food—compared with their needs—at the expense of the environment and future generations, and presumably also at the expense of presently developing nations. However, new evolutionary tendencies introducing organic farming as a sustainable alternative might give rise to slight optimism in relation to redirecting agriculture in a sustainable direction. These tendencies could establish incentives and opportunities to recouple natural life support systems upon social structures and institutions. On the other hand, this might not provide sufficient support to solve another fundamental problem—global population growth beyond the earth's present carrying capacity—but neither might new industrial technologies be able to solve that problem.

1. Introduction

In relation to sustainability, agriculture is important for several reasons. First, along with fishing, forestry and mining, agriculture constitutes the social field where the natural capital is administered in an immediate sense. Second, agriculture provides the main part (97%) of one of the primary basic needs of human beings: food. Third, agriculture represents a social field where human dependence upon nature and its capabilities and limits is noticeable and inevitable. For these reasons it is obvious that the social organization of agriculture and its local and global impacts are crucial when sustainability is considered.

1.1 Agriculture as Complex Systems

Agriculture is more than farming. It involves a wide range of social activities referred to as agricultural systems. Thus, agriculture covers the provision of produce, the refining of produce to saleable foods, and distribution. Other supplementary activities can also be considered a part of agricultural systems; for instance, the provision of various inputs, such as energy and chemicals, and of knowledge, such as R&D and education. To study this complex, it is necessary to acknowledge that the social organization of agriculture varies over time and space. In the nineteenth century, most of the aforementioned activities were carried out on the farm or in the local community. In the meantime, an increasing number of activities have been sourced out to new industries and institutions: dairies refine milk, cooperatives provide distribution, industries manufacture and deliver material inputs, governmental institutions provide knowledge, and private industries develop seeds and equipment. This evolution has exhausted the functions at the farm level and transformed the farmer into a specialized producer integrated into an agro-industrial complex. Simultaneously, an agro-political complex has evolved to attend to the interests of the agro-industrial complex, as related to the comprehensive subsidy schemes and international trade agreements, for instance. However, the extent of specialization differs among nations. In developed countries specialization and outsourcing is very extensive, while in developing countries a wide range of activities is typically still carried out at farm level. However, agriculture in developing countries is affected by the internationalization of the agro-industrial and agro-political complexes of developed countries. Such effects are due to the transfer of technology in pursuit of "The Green Revolution," for instance, and due to the regulation of export opportunities in observance of international trade agreements.

Important differences in time and space are also indicated in Table 1. The relative economic importance of agriculture is declining worldwide; however, agriculture is still essential to low-income nations, while importance to high income nations at the beginning of the twenty-first century tends to be insignificant.

Income level	Agriculture as % of GDP		Rural population as % of total	
	1970	1997	1970	1997
Low	42	28	81	72
Middle	21	11	67	51
High	5	2	28	24

Note: Income level state the world divided into the three categories according to national income per capita.

Source: World Bank (1999). *World Development Indicators 1999*, p. 30.

Table 1. Economic importance of agriculture

1.2 Stating the Problem

In the WCED report *Our Common Future* (1987), food in general, and agriculture in particular, are presented as keys to understanding the present problems and future challenges concerning sustainability on a global level. The point of departure is that for several decades the incurred responsibilities for natural life support systems have been carried out in an improper and unsustainable manner, which in turn involve serious dangers to the future of humankind itself. The report states that the analysis of this unsustainable trajectory must be carried out on two separate—although closely interrelated—sets of problems. It follows that when there are two sets of problems there must also be two sets of causalities and two sets of adequate solutions to restore sustainability.

Agricultural policies in industrialized nations have been supporting and subsidizing a trajectory involving food surplus since World War II. This has been achieved via the application of environmentally inadequate technologies involving an increasing use of fossil fuels, chemicals, and industrial fertilizers. These technologies are regarded as threats to agricultural resources due to erosion, pollution of aquatic systems and drinking water, and the use of material that might affect human and animal health.

In developing countries, on the other hand, food supply systems are inadequate to provide sufficient and stable amounts of food. Inadequate policies, technologies, and aid projects—as well as insufficient economic opportunities—cause this. The latter can be due to the insufficient performance of the economy as a whole, as well as to intranational inequity in economic distribution that leaves segments without the necessary means to acquire food. Simultaneously, the agricultural policies of industrialized countries have reinforced negative trajectories in developing countries by dumping subsidized food onto the world market, lowering world market price levels, and thereby also potential income from agriculture in developing countries.

Additionally, the increasing production in the industrialized nations has resulted in the import of agricultural produce and raw material. This has been an incentive to give priority to monocultural produce in favor of self-sufficiency in developing countries.

In industrial nations population growth is approaching zero level. In developing countries, by contrast, it seems very difficult to avoid rather high population growth rates. This problem enhances the double bindings in developing countries as their agricultural systems are already incapable of providing necessary nutrition for their populations or the necessary economic basis for sufficient import of food. Simultaneously, the population growth raises the issue as to whether the aggregate global population will exceed the maximum capacity of present global life support systems.

1.3 The Bottom Line: Two Crucial Questions

There are two questions to be faced: First, does humankind continue to undermine life support systems caused by the recent use of agro-technology? Second, does humankind now or in the future exceed the boundaries of life support systems caused by agro-technology and/or imbalance between growth in population and the capacity of life support systems relating to food? In the case of affirmative answers it must be asked: Can these problems be avoided by implementing new technologies and/or by distributional changes, especially by altering distribution between developed and developing nations? These two basic questions must be answered primarily on the basis of natural science, while social sciences must provide answers in relation to social causes and potential social solutions. The task of this article is to provide social scientific suggestions related to natural scientific answers to the former questions.

2. Contrasts in Agricultural Food Production and Consumption—Past and Present

The production and consumption of food is marked by distinct contrasts. The food evolution in several developed countries since the nineteenth century reveals a contrast between hunger and satiety. When developed countries are compared with the developing countries of the present day, a similar contrast between hunger and satiety comes to light. Thus, a contrast in time as well as in space is being faced that can be further depicted from several points of view.

Concerning demand, contrasts emerge in terms of overconsumption versus underconsumption. In the late nineteenth century most European nations were characterized by a social incapability to meet basic needs that contributed to vast emigration to the New World, as well as emigration from rural to urban areas. Consumers in wealthy countries are presently characterized by satiety as they tend to over-consume foods. Meanwhile, people in poor countries are to various degrees marked by hunger (famines or general undernutrition) caused by insufficient economic performance and the inadequate capability of national agricultural systems.

Table 2 reveals that developing nations—seen as one—have improved average nutrition greatly from 1970 to 1996; but the least developed have not. In the latter, the daily supply of calories is beneath the level (2200 calories) referred to as minimum to live a

healthy and normal life. In contrast, in industrial nations the daily supply, especially of fat, illustrates a tendency to exceed healthy limits.

Development level	Supply of calories daily per capita		Supply of protein daily (grams/%)		Supply of fat daily (grams/%)	
	1970	1996	1996	% change 1970–96	1996	% change 1970–96
Least developed	2090	2095	51.4	–3.3	33.3	24.3
All developing	2129	2628	66.4	30.1	57.7	92.9
Industrialized	2986	3377	104.8	14.0	133.1	24.6

Note: Indications are average per person.
Source: UNDP (1999). Human Development Report 1999, p. 214.

Table 2. Human nutrition in developing and industrialized countries

Seen from supply side, a contrast emerges in terms of overproduction versus underproduction. Since the late nineteenth century, new agricultural technologies have been developed in industrialized countries related to the intensification of livestock production, for example. Since the mid-twentieth century, farm production has become steadily more industrialized through the application of industrial techniques and industrial inputs such as pesticides, chemical fertilizers, and antibiotics. This increase has also entailed an import of produce, such as tapioca and soya beans, often from developing countries. In the latter, the production of food simultaneously tends to be insufficient to meet the basic needs of the population. This part of the problem could eventually be offset if the surplus produced in industrialized nations could be directed to developing countries, but efficient institutions to ensure such redistribution have not yet been established.

Income level	Arable land hectare per capita		Fertilizer 100 g per hectare		Tractors per 1000 workers		Food production Total amount based on index 1989–91 = 100	
	1979–81	1994–96	1979–81	1995–97	1979–81	1994–96	1979–91	1995–97
Low	0.25	0.19	753	1105	2	4	72.5	120.3
Middle	0.19	0.23	1542	1463	7	11	72.1	141.7
High	0.46	0.40	1949[a]	2343[a]	429	756	92.2	107.9

Note: Fertilizer state industrial fertilizers per hectare arable land. Tractors per 1000 agricultural workers; [a] figures only relate to members of the European Union.
Source: World Bank (1999). *World Development Indicators 1999*, pp. 126 and 130.

Table 3. Agricultural means of production and productivity: indicators

Table 3 displays a distinct inequity in the amount of productive factors, including the differences in the amount of arable land per capita, available to low- and high-income nations. The table also indicates that food production is increasing in low-income nations, but these increases are less impressive when the real levels of the numbers are kept in mind, which also means that these nations are still not able to supply enough food for their populations. While low-income nations are lacking factors of production, high-income nations are commanding a surplus of such factors.

The contrast between overconsumption and overproduction on the one hand, and underconsumption and underproduction on the other, is further reflected by severe differences in the population growth rates of rich and poor countries. Here a contrast is being faced between high versus zero population growth rates. The industrialization of farming led to an increase in food production in developed countries, while population growth in the same countries decreased and approached zero. Simultaneously the developing countries have maintained a high growth rate in population. This contrast reinforces distributional problems concerning current global production and consumption of food.

The differences in population growth rates are presented in Table 4. The implications are heavily underlined when economic indicators are involved. The least developed nations exhibit seriously low GNP per capita, negative annual growth rates and oppressive external debts. The annual growth rates in developing countries give rise to scenarios where the population in the mid-twenty-first century will exceed the earth's carrying capacity.

Development level	**Population growth rate % per year**		**GNP per capita**	**GNP per capita annual growth rate**	**External debts**
	1975–97	**1997–2015**	**1997**	**1975–95**	**1997**
Least developed	2.5	2.2	260	–0.2	92.3
All developing	2.0	1.4	1314	2.3	36.0
Industrialized	0.6	0.3	27174	1.9	--

Note: GNP per capita in US$. External debts as percentage of GNP.
Source: UNDP (1999). *Human Development Report 1999*, pp. 183, 196 and 200.

Table 4. Indicators of population growth rate and economic performance

From an environmental perspective, the aforementioned trajectories have given rise to increasing concerns for negative externalities related to emissions of polluting waste, soil erosion and loss of biodiversity. Such externalities represent a potential threat to the future of humankind. Agricultural use, directly and indirectly, of fossil fuels and other nonrenewable resources, along with environmental externalities, represent another distributive dimension: distribution between present and future generations. This is further underlined by concerns over the implementation of high-risk technologies that might cause irreversible alterations and chain reactions in nature. Table 5 indicates that

the consumption of resources (freshwater and energy) and outlet of emissions (CO_2) are very high in industrialized nations and very low in the least developed nations.

Development level	Annual freshwater withdrawals	Commercial energy use	CO_2 emissions
	Per capita 1987–95	Per capita 1996	Per capita 1996
Least developed	175	321	0.2
All developing	492	825	2.1
Industrialized	1058	5388	12.5

Note: Annual freshwater in cubic meters. Energy use kilogram oil equivalent. CO_2 emissions in metric tons.

Source: UNDP (1999). *Human Development Report 1999*, pp. 204 and 208.

Table 5. Indicators of environmental degradation

In terms of sustainability the contrasts can be briefly summarized in the assertion that the industrialized countries are characterized by overproduction and overconsumption that potentially comes at the expense of the developing nations and future generations.

3. Development of Agricultural Technology in Industrial Nations

The twentieth century involved tremendous changes in agricultural production systems in industrial nations: evolution from scarcity in peasant society, to industrial society with industrial farming and glut, to the outline of a post-industrial society where economic as well as political decision-makers seem interested in putting sustainability on the agenda.

3.1 The Peasant System of the Past

In the peasant production system the farm constituted an ecological unit that was part of a local, transparent cycle. The transparent reliance upon natural capital and nature's biological mechanisms provided the foundation for a cyclical common notion of nature as well as of society. This notion was often explicitly stated in terms of the property rights of future generations: the soil passed on to the next generation should be (at least) as fertile as when received by the present generations. This view was based on experience and knowledge; if the farmer managed livestock or soil contrary to the biological logic of ecological cycles a decrease in output would be experienced due to negative productive reactions from the livestock and soil. These negative reactions would further result in negative economic performance and ensuing economic pressure on the family. Of course the shortage of material opportunities could force families to act shortsightedly and ignore long-term considerations. However, without romanticizing the past it can be concluded that farming technology was ecological and that a functional integrity between labor (often the farmer and the farmer's family) and the local natural life support system was maintained.

The surplus from the ecological cycle—produced by means of photosynthesis, labor and natural capital (primarily soil)—could be exchanged with the external economy.

However, this exchange primarily took place at the local level, involving a relatively close relationship between producer and consumer. This meant that the social cycle was transparent and relatively horizontal—the consumer could personally experience the ecological cycles and the farmer could simultaneously face the consumer and receive reactions concerning the food supplied. This relationship provided a basis for mutual understanding and for directly sharing the related responsibilities. Similarly, the farmer could generally experience how possible spillover would affect the environs and how input to the farm was provided.

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Biographical Sketch

Prof. Jan Holm Ingemann was born in 1955 and is a graduate in economics with a Ph.D. in agricultural economics and policy. He is associate professor and research coordinator at the Department of Economics, Politics and Public Administration, Aalborg University, Denmark. He is cofounder and

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