ORIGINS, DEVELOPMENT AND DIFFERENTIATION OF WORLD AGRICULTURES

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Contents

Summary

Throughout almost its entire history, humankind, which has existed on the earth for the past 200 000 years, lived on vegetal products and wild animals obtained by gathering, hunting and fishing. Only in Neolithic times, less than 10 000 years ago, did a very few societies of sedentary hunter-gatherer-fishermen very gradually develop, through their own inherent genius, into societies of farmers.

Equipped with axes of polished stone and a few other tools, along with their recently-domesticated plants and animals, Neolithic farmers then set out to conquer the world, chiefly by developing pastoral animal-breeding in grassy environments and slash-and-burn cultivation in the greater part of the temperate and tropical wooded environments. Subsequently, with the increase in population, large-scale deforestation and the creation of the thitherto unknown ecological conditions which resulted from this, they evolved forms of agriculture which differed widely from region to region and later changed greatly over time, namely, hoe-based cultivation in inter-tropical and other savannalands, hydraulic cultivation in arid or well-watered regions, rainfed cropping associated with breeding first with, then without fallowing, motorized and chemical-dependent cultivation resulting from the agricultural revolutions of the twentieth century.

Several millennia of distinct and sometimes intertwining patterns of evolution have thus given rise to a wide diversity of contemporary forms of agriculture, fundamentally different and of vastly-varying degrees of productivity, which occupy a large part of the various exploitable environments on earth and employ 40% of the world's active population. However, faced with competition from the most competitive amongst them, many of these agricultural models are today in grave difficulty and the majority of the world's peasants suffer from poverty and malnutrition.

Nevertheless, all the different manifestations of this agrarian heritage and all the world's peasants are needed to provide for the food and other requirements of the whole of humankind in the twenty-first century.

1. Introduction

Life first appeared some 3.5 billion years ago, in a universe whose origins remain unknown but which has putatively been expanding for the last fifteen billion years, within a solar system and on a planet which formed about 4.5 billion years ago. Since then, evolution has produced millions of living species of plants and animals, many of which have disappeared over time, though hundreds of thousands have survived.

All living entities are made up of organic matter, water and other mineral compounds. Only chlorophyllous plants are *autotrophs,* capable, through photosynthesis, of creating by means of solar energy their own organic compounds (sugars, fats, proteins, nucleic acids) from water, carbonic gas and a number of mineral salts they find in the atmosphere and in the soil. Animals, as well as non-chlorophyllous plants like fungi, do not possess this capacity and are *heterotrophs*, feeding on organic matter produced

directly by plants or indirectly by animals which may be frugivores, herbivores or carnivores.

The great majority of animals are merely predators, content to appropriate their food from whatever wild species they exploit. However, evolution has also produced a number of species of ants and termites that transform their environment in order to promote the propagation of the species they exploit. Such species, exploited but also assisted, are called *domestic*. For instance, several species of ant in the tropical regions of the Americas each cultivate one particular species of domestic fungus. The ants build nests, galleries and underground chambers. They amass various forms of organic detritus (fragments of leaves, wood or roots) and fashion them into tiny mushroom beds, where they plant fragments of the fungus being cultivated. The ants then systematically eliminate any other species of mushroom which may have begun to grow and regularly prune the filaments of the species under cultivation, to promote the formation of the nodules which are their sole nourishment. There are other species of ant which each breed a particular species of domestic aphid. Some of these ants, which feed on the honeydew excreted by these aphids, dig cavities intended for them around the roots of plants from which the aphids can readily draw the sap on which they thrive.

In return for their efforts in managing their environment and lavishing attention upon domestic species, ants are rewarded with a plentiful food supply capable of supporting huge numbers of individuals. It should be noted that each species of cultivator or breeder ant or termite is associated with a single domestic species, which it cultivates or breeds with the anatomical tools (mandibles, forelegs) it possesses, in a manner and in keeping with a form of social organization that appears to have remained unchanged for millions of years.

Unlike these ants and termites, when *Homo sapiens* appeared about 200,000 years ago, these human beings were neither cultivators nor breeders. And throughout most of their history, they have survived by gathering plants and capturing the most readily-available animals. Only in the Neolithic era, less than 10 000 years ago, did a few societies of these hunter-gatherer-fishermen very gradually evolve, through their own talents, into societies of farmers. When they began to practice agriculture, there were no already-domesticated species in nature but they nevertheless domesticated large numbers of plants and animals. Nor did they possess anatomical tools that were especially fitted to agricultural tasks, but they devised increasingly-powerful implements of all kinds. Finally, no innate or revealed know-how dictated the best way to conduct farming activities, but through their own resourcefulness human beings succeeded in developing diverse cropping and breeding systems that were appropriate to the various environments they found on earth and evolved according to their needs and their tools.

Human agriculture has therefore been a paramount factor in the transformation of the ecosphere. It has led to a huge increase in the quantities of food available, making possible the extraordinary rise in the earth's human population, which has grown from about five million individuals 10 000 years ago to almost seven billion today (see Figure 1).

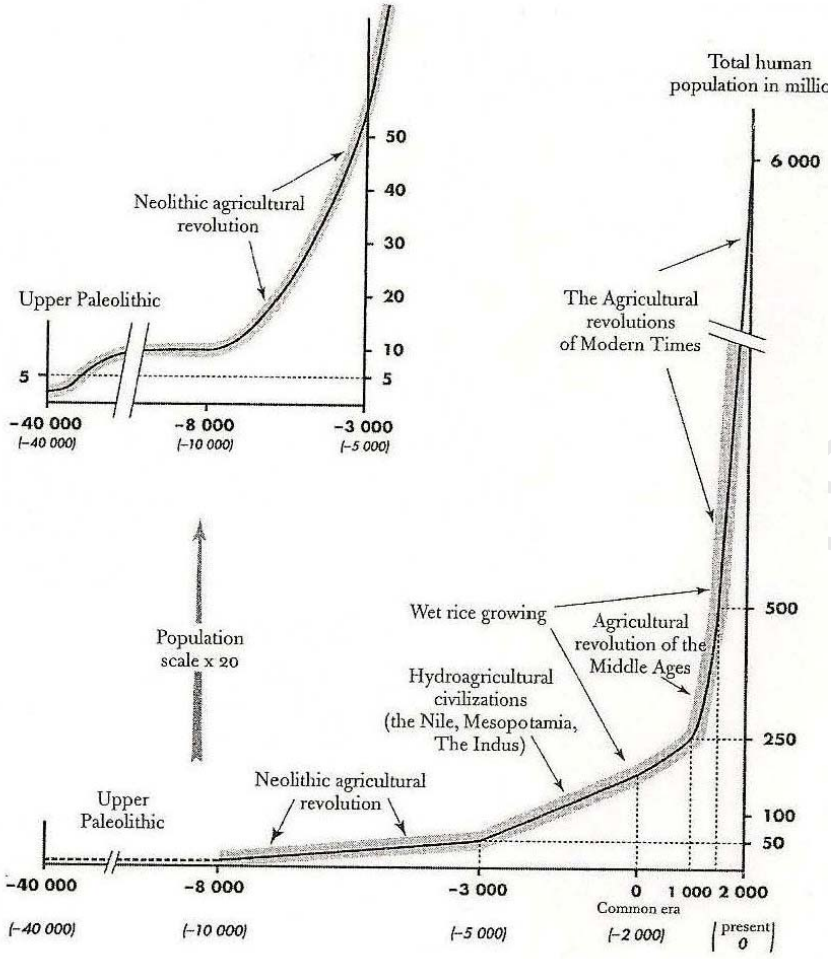

Figure 1. The Growth of Human Population in Connection with the Development of Agrarian Systems throughout the World (Source: Mazoyer M. and L. Roudart (2006). *A History of World Agriculture. From the Neolithic Age to the Current Crisis*, 528 pp. London: Earthscan, New York: Columbia University Press.)

In this chapter, we shall firstly introduce the different guiding principles, definitions and concepts involved in human agriculture, in the analysis of agriculture as an agrarian system, in its historical development and in its geographical variations. Then we shall recall the epic progress from the earliest forms of Neolithic agriculture to the extremely varied types of agriculture we know today. Finally, we shall assess the prospects for food and agriculture in about 2050.

Looking at the emergence and the early stages of agriculture in the Neolithic era, we shall see where, when and how a number of predator societies evolved into farming societies. This was the basis on which Neolithic farmers set out to conquer the earth, developing two main forms of agriculture, namely, *pastoral breeding* systems on grasslands and *slash-and-burn* systems in the majority of temperate and tropical forest environments. Following this pioneering period, rising population caused deforestation in many originally wooded regions. We shall see how systems based on slash-and-burn

techniques ceased to be viable in these deforested regions by the end of the Neolithic period and gave way to new post-forest agrarian systems, which varied greatly from one climatic environment to another. In regions receiving moderate rainfall, deforestation resulted in the formation of *savanna grasslands* and the growth in various *hoe-based cropping systems*, whether or not in combination with herding. In arid regions, *hydraulic agrarian systems*, with floodwater farming or irrigation, were formed during early Antiquity in Mesopotamia, in the valleys of the Nile and the Indus, and later in the valleys and oases of the Inca Empire. In the humid tropical zones of Asia and Africa (Madagascar, the Guinea coast…), hydraulic systems based on *wet rice growing*, different in nature but comparable in scale, also developed in stages.

In the temperate regions of Europe, following deforestation, the agricultural revolution in Antiquity saw the advent of systems of *rainfed cereal cultivation with fallowing, combined with pasturing and breeding.* Centuries later, in the northern half of Europe, the agricultural revolution which occurred in the middle of the medieval period gave rise to *systems based on fallowing and animal-drawn cultivation*, with the use of plows and wagons. Subsequently, between the sixteenth and eighteenth centuries, the modern agricultural revolution led to *systems of cereal and fodder production without fallowing.*

Following the Era of Discovery, European agrarian systems were enriched by new plants from America (potatoes, maize, etc.) while themselves spreading to colonized lands in the temperate regions of the American continent, of southern Africa and of Oceania. Meanwhile, in tropical regions, agro-exporting plantations were created by settlers within the pre-existing systems, sometimes even replacing them and giving rise to new highly-specialized systems (sugar cane, cotton, coffee, cacao, palm oil, bananas, etc.)

Since the middle of the twentieth century, the second agricultural revolution of the modern era has been responsible for the motorized, mechanized, chemical-dependent and highly-specialized systems of cultivation and breeding now to be found in advanced countries and in limited sectors of developing nations. In many of these latter countries, the green revolution has resulted in systems where the degree of mechanization is often slight but where the use of high-yield seeds, mineral fertilizers and pesticides is high.

Several millennia of separate but often intertwined evolutionary processes have therefore given birth to a wide range of farming systems in the modern world, radically different and of widely-varying degrees of productivity, which occupy the diversity of exploitable environments the earth has to offer. All these forms of agriculture are constantly evolving and contributing to the creation of the modern world. And since industry is not yet in a position to synthesize human food on a large scale and will not be capable of doing so in the foreseeable future, all these different forms of agriculture will have a part to play if we set ourselves the target of guaranteeing the right to adequate food for every human being by the year 2050.

But before describing these multiple manifestations of agriculture, we shall now set forth the basic principles regarding the social activity of agricultural production and the analysis of this activity in terms of an agrarian system.

2. Principles, Definitions, Concepts

2.1. Agriculture and the Cultivated Ecosystem

Agriculture is an economic activity which consists in growing plants and raising animals in order to obtain from them useful products (foodstuffs, textiles, medicines, fuel, and other materials) and services. It is to be distinguished from industry, which entails the transformation of raw materials, whether mineral, vegetable or animal.

To cultivate a plant or breed an animal means firstly procuring this plant or animal, or else obtaining its seed, and establishing it in a location adapted for the purpose (field, pasture, shelter...). Next, it involves attending to the upkeep of this location and at the same time caring for the animal or plant so that it will provide the sought-after material or service. It also requires the collection of these products and the exploitation of these services, and finally it means renewing the agricultural tools and labor force, setting aside the seeds, plants or animals to be grown or reared the following season, and rehabilitating the locations where they will be established.

Cropping and herding therefore require a succession of operations involving plants, animals and their adopted environment, leading to the acquisition of the desired products and to the renewal of these operations year after year. These activities are totally distinct from the gathering of spontaneously-growing plants and the hunting of wild animals living in an environment that has scarcely, if at all, been modified for the purpose, since such operations are almost entirely restricted to the actual procurement of these products.

The ecosystem of a location is made up of the physical environment, or *biotope* (geological substratum, soil, atmosphere, climate) and the living environment, or *biocoenosis* (the plant and animal populations). An ecosystem is referred to as *virgin* when it has not been encroached upon by human beings, *natural* when it has not been altered by humans, or *artificial* once it has been transformed by some human activity (building, clearing, cropping...). A *cultivated* ecosystem is rendered artificial by a group of humans growing plants and/or breeding animals. It consists of a biotope that has been transformed to a greater or lesser degree (stone-clearing, terracing, soil enrichment, drainage, irrigation, enclosures, shelters, greenhouses, buildings...) and a modified biocoenosis (reduction in the quantity of natural vegetation or wild animals, introduction of domestic plants and animals...)

2.2. Fertility

The *overall fertility* of an ecosystem is its capacity to produce annually a given mass of vegetal organic matter, or biomass. As a rule, overall fertility is much greater than *useful fertility*, which is the capacity of the ecosystem to produce on a sustainable basis vegetal biomass which may be used by human beings or by the animals they exploit.

The fertility of an ecosystem depends upon the temperature and the amount of sunshine prevailing over the entire year and the quantities of nutritive matter – carbon dioxide, water, mineral salts – the environment is capable of supplying to the plants. As there is usually no shortage of carbon dioxide, the growth and development of plants in a given

location with a given climate are determined in the last resort by the presence of water in the soil and by how richly this soil is endowed in dissolved nutritive mineral salts.

The soil is the topmost part of the earth's crust and is formed by the alteration of the geological bedrock, and by the *decomposition of litter*, i.e. the dead organic matter deriving from the living populations that grow on it.

Water comes from precipitation, from the surface (through runoff or irrigation) or from the underground (by capillary ascent or pumping). But a soil also loses moisture through evaporation, plant transpiration, surface runoff or drainage and also by seepage into the underground water table.

Mineral salts can have several origins. The first of these is the *breaking-up* of the parent rock into particles of various sizes (gravel, sand, alluvium, clay) followed by its *solubilization*: the parent rock releases its minerals in a form which is soluble in the soil's water and can be absorbed by the roots. These processes are carried out through the agency of several factors, which are climatic (temperature variations), chemical (water, oxygen, carbon dioxide, acids in the soil) and biological (micro-organisms, roots, earthworms…). The second major source of mineral salts is the fixation of atmospheric nitrogen by micro-organisms either present in the soil (*Azotobacter* bacteria) or existing in symbiosis in the roots of certain plants (*Rhizobium* bacteria with leguminous plants, for instance).The third source of mineral salts is the decomposition of litter, converted by the action of certain micro-organisms into *humus*, which is itself subsequently *mineralized* and oxidized by releasing the water, carbon dioxide and mineral salts it contains. In the process, the humus returns to the soil solution the minerals which had for a time been absorbed and fixed in the biomass. But while a soil is constantly being enriched in minerals, it is also undergoing losses. Salts are forced downwards by rainwater, in other words *leached* or indeed *drained* towards the water table, denitrifying bacteria decompose nitrogenous salts and return the nitrogen to the atmosphere, and where the soils are cultivated, the harvests taken from the biomass result in the exportation of minerals.

Over time, therefore, the balance between gains and losses may be positive or negative and the quantity of soluble mineral salts in the soil may increase or decline. In this respect, the humus in the soil plays a major role. The acids in the humus combine with fine particles of clay to give a *clay-humus complex*, which apart from creating a reserve of water and other nutritive elements, helps to loosen the soil, facilitate root penetration and promote the existence of those micro-organisms that are active in the solubilization of the parent rock. The soil's fertility therefore also has a humic component.

In many agrarian systems, the renewal of the cultivated soil's fertility is largely dependent upon organic and mineral resources to be found in the uncultivated part of the ecosystem, like fallow land, whether wooded or not, alternating with cropping, or pastureland and hay meadows, where the grass is consumed by animals with their excrement serving as manure, or else catchment areas providing water to irrigated land, etc. But in many currently-practiced systems, mineral or organic fertilizers or amendments are collected and produced outwith the cultivated ecosystem and then transported to manure the soil under cultivation.

Meanwhile, the clearing and containment of wild vegetation with the purpose of preserving the greater part of the soil's mineral salts and water for cultivated crops is one way of increasing useful fertility over the short term. In addition, humans also act upon temperature (greenhouses, sometimes heated), sunshine (the creation of shaded areas), the supply and management of water (irrigation, drainage, windbreaks, soil coverings to limit evaporation) and even the carbon dioxide content of the air (greenhouses with artificial atmospheres).

Once a soil is brought under cultivation, its useful fertility, though clearly determined by the climate and the parent rock, becomes a historical variable strongly influenced by the successive forms of agriculture which have already been practiced and by the cropping or herding activities that are currently being carried out. The useful fertility of a cultivated ecosystem viewed as a whole depends on the fertility of the cultivated lands themselves but also on how large a part they occupy within the ecosystem.

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