

The origins of industrial farming

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Agriculture has a long history. Starting at a time when its main source of energy was the sun and it provided food, energy, materials and fertilizers, it reached the current age of industrial agriculture, founded on the widespread use of non-renewable resources and chemicals, and largely reduced to food production.

Over the last two and a half centuries, human societies have undergone a series of profound changes in the name of modernization. These transitions, although extraneous, have revolutionized agriculture. As a result, agriculture has become embedded in what is often called the ‘industrial food system’. These changes can be traced back to three major interconnected transitions¹:

- The socioecological metabolism: It refers to the nature and scale of the energy and matter flows that permeate societies to sustain them in the long term. This socioecological metabolism transition involves a metabolic regime shift from the energy of the sun to fossil fuel use (Fischer-Kowalski and Haberl, 2007; Haberl et al., 2016). This major event in human history was triggered by the Industrial Revolution, which began in England in the mid-eighteenth century.

¹ The specific factors that underlie these three major transitions are beyond the scope of this chapter. The literature on food regimes – very popular in the English-speaking world and now also in the French-speaking world – tends to systematically attribute them to capitalism, itself seen as ‘always already in crisis’. The history of the twentieth century, spectacularly marked by the experience of real socialism, negates this interpretation. Real socialism was perfectly comfortable with the mining-dependent socio-metabolic regime and the division of labour. Instead of solely referring to capitalism, I therefore prefer to draw on richer perspectives, such as that of Ernest Gellner (1983, 1989), with his interpretation of industrialism, or that of Anthony Giddens (1990) and his four institutional dimensions of modernity – capitalism, of course, but also surveillance, industrialism and military power.

- The deepening division of labour: It spread within human communities and over large areas, with each individual becoming specialized in a particular activity and their existence depending on exchanges with others (Durkheim, 1933). As Adam Smith (1776) pointed out, the state of the division of labour – the driver of the ‘wealth of nations’ – is informed by the spatial and functional scope of the market. The way in which, over time, market transactions have spread to an increasing number of areas, activities and regions worldwide must be taken into account when analysing the deepening of the division of labour.
- ‘The Americanization of the world’: This refers to the series of political, economic and military events that turned the United States into the unrivalled hegemonic leader of the ‘concert of nations’ over the course of the twentieth century. It became the country that set the technical standards for production and consumption, and the locus for the emergence of a number of private and public institutions and bureaucratic frameworks that supported or superseded trade.

This chapter outlines the evolution of agriculture over the nineteenth and twentieth centuries, based on these three major simultaneous transition processes.

The mining-dependent socio-metabolic regime and agriculture

The socio-metabolic regime that was common to all societies prior to the Industrial Revolution of the eighteenth century was based on the energy of the sun and was characterized by material dependence on biomass (organic matter of plant, animal, bacterial or fungal origin). Biomass is a source of food and energy (Wrigley, 1988, 2004, 2010) and also a virtually unique source of raw materials. Within a socio-metabolic regime reliant on energy from the sun, agriculture (which produces biomass) generates more than just food. It also provides households with fuel for heating and lighting, fibres and hides for clothing, and much of the materials needed for housing and, through animals, most of the mechanical energy available to these households. Moreover, it plays an essential role in maintaining soil fertility, particularly through livestock farming.

Conversely, the mining-dependent socio-metabolic regime is characterized by the essential role of fossil resources. Coal, oil and natural gas (and to a lesser extent uranium) virtually became the sole sources of mechanical and thermal

energy from the Industrial Revolution onwards. The sourcing of materials was also profoundly altered by the use of ores (which could be mined and processed using the abundance of energy available) and by the replacement of biomass-derived products with synthetic ones. The development of organic chemistry played a key role in this regard. From the mid-nineteenth century, it facilitated the production of synthetic dyes, which in turn gave rise to the powerful chemical industry and its giant corporations (Bayer, BASF² etc.). This industry – always with a view to replacing natural resources deemed too expensive or with an unreliable supply – then started producing plastics, textile fibres, rubber and so on.

Within the mining-dependent socio-metabolic regime, the demand for agricultural products was no longer driven by a need for energy or materials, and food became the main outlet for agriculture. The emergence of the ‘agri-food’ and ‘food system’ concepts, which became self-evident in the twentieth century, clearly reflects this exceptional situation in the history of humankind. Our relationship with animals, especially cattle, is certainly the most illustrative example of this transformation. This livestock – once a source of horns and bones for making widely diverse objects, of fibres and hides for making garments, of tallow for lighting, of mechanical power for ploughing and transport, and of manure to fertilize fields – was then only reared for meat and milk, thus being reduced to a source of protein and lipids.

At the same time, the switch to the mining-dependent socio-metabolic regime led to far-reaching changes in agricultural production, food processing and distribution methods (see Chapter 5). These changes occurred in two distinct stages. First, the agricultural supply process was mainly transformed by the sharp drop in transport costs – for both maritime and, especially, inland transport. Steam engines’ fundamental role in this respect cannot be overstated. For the first time in human history, this invention made it possible to convert thermal energy into mechanical energy, thereby completely redefining the question of transport and overcoming the so-called tyranny of distance. This was especially the case for inland transport as it had previously wholly relied on energy from humans and animals. Hinterlands could now be systematically tapped to supply faraway markets. The drop in transport costs also led to massive human migrations, enabling millions of Europeans, as well as Asians (mainly Chinese and Indians), to leave their homelands and ‘colonize’ distant lands. The steam engine thus helped link previously empty areas (or, more accurately,

² Abbreviation for the German industrial corporation *Badische Anilin und Soda-Fabrik*, a world leader in the chemical industry.

areas ‘emptied’ of their indigenous populations) to Europe, even when they were located thousands of kilometres away. A host of pioneer fronts sprang up in temperate and tropical regions during the second half of the nineteenth century and into the 1920s: the steppes north of the Black Sea, the Manchurian plains, the North American prairies, the Argentinian Pampas, the South African veldt, Brazil’s Mata Atlantica, the Sumatran forest and so on.

The second stage in the agricultural industrialization process began after the First World War and was characterized by the direct use of fossil fuels in agricultural production. Three innovations – hallmarks of industrial agriculture and directly linked to fossil fuel use – formed a ‘technical package’ that was first adopted in the United States before spreading to the rest of the world:³

- Tractors: Tractors became accessible from 1917, following the launch of the Fordson tractor in the United States, and replaced draught animals (oxen, horses and mules) within just a few decades, thereby prompting the widespread mechanization of agricultural tasks, a process that had been underway in the United States since the early nineteenth century. The tractor emerged as the symbol of the agricultural modernization project (Fitzgerald, 2003) and became central to the formatting of farm work, which it revolutionized.
- Synthetic nitrogen fertilizers: With the synthesis of ammonia through the Haber-Bosch process,⁴ fossil fuel use in agriculture took on an entirely new dimension. A milestone was reached in 1908 when Haber (working for BASF) perfected the process in the laboratory (Smil, 2001). The first manufacturing plant became operational in September 1913, a little less than a year before the First World War broke out. Ammonia synthesis using the Haber-Bosch process accounted for 16 per cent of the world’s nitrogen fertilizer production (in nitrogen equivalent) by 1920, 62 per cent by 1935 and 99 per cent by 1980. At the same time, the total quantity of nitrogen used for fertilizer increased tenfold.
- Pesticides: The chemical industry again played a key role in the development and dissemination of this new type of input. As Edmund Russell (2001) has shown, the first pesticides were a direct by-product of the First World War, for which the chemical industry was heavily mobilized.

³ One specific feature of hegemony is their ability to shape ideas and convince people that the general interest is the same as their own (Arrighi, 1994). This is how the United States has broadly set the stage for how problems and their solutions are understood, as also relayed by René Dumont, an agronomy professor renowned as a leading figure in ecology, in his book *Les leçons de l’agriculture américaine* (Dumont, 1949).

⁴ A chemical process for fixing atmospheric nitrogen gas into ammonia, used in particular to manufacture synthetic nitrogen fertilizers.

Phosphate mining began in the mid-nineteenth century, followed by potash mining in the early twentieth century. The use of these fossil resources offset the need to use recycled sludge and waste to fertilize soils depleted of these two minerals as a result of plant production.

The influence of the chemical industry has more recently extended to a crucial agricultural resource: seeds. Between 1996 and 2013, 200 seed companies were bought up by large chemical corporations (Howard, 2015). This massive chemical industry penetration into the seed business has led to enormous market concentration. The market share of the top five seed companies grew from 10 per cent in 1985 to 47 per cent in 2015, when four of these five leaders were chemical corporations (Monsanto, DuPont, Syngenta and Dow Chemical), with Limagrain being the only exception (Bonny, 2017).

These technical innovations have boosted crop production, with yields soaring as a result of the massive use of inputs and varietal selection geared towards producing varieties that perform well with these chemical inputs. Under the mining-dependent socio-metabolic regime, chemistry – both as a discipline and as an industrial sector – has thus gained a dominant role in dictating agricultural practices through the supply of inputs. From this point of view, so-called conventional agriculture should really be called ‘chemical agriculture’.

Agriculturalization, ‘sectorization’ and the division of labour

Local ‘traditional’ farming communities, which in France subsisted until the late nineteenth century (Weber, 1979), were involved in a broad range of activities on their farms that enabled them to produce most of the materials required for their agricultural work and for their daily lives. This system did not preclude a division of labour and specialization within farming households, based on the age and gender of individuals. These smallholders were sometimes also involved in various manufacturing activities (weaving, glove making, embroidery, nail making etc.), supplying regional industries.

In Europe, as in the United States, today’s farmers are a striking illustration of the division-of-labour approach. Working alone on their farms, these farmers specialize in growing a few crops or rearing a particular livestock species (Nicourt, 2013). They buy fertilizers, seeds, machinery and pesticides from specialist companies and sell raw materials. Meanwhile, their spouses work in neighbouring towns, and their cash earnings serve to buy virtually all of the

goods consumed by the household from a nearby supermarket. This situation can be seen as the result of a dual farm-specialization dynamic driven by a vertical (agriculturalization) and horizontal (sectorization) division of labour.

The agriculturalization of the peasant economy (Shanin, 1974), in other words the increased specialization of peasants in agricultural activities, was the first stage in the process of division of labour. The Industrial Revolution triggered this trend by reducing the price of manufactured goods and concentrating their production in urban areas. This led to the emergence of food processing industries, which performed (increasingly standardized) agricultural product-processing operations that had previously been carried out on farms at a low cost and on a more regular basis (albeit using a great deal of fossil fuel). For example, wine growers became wine producers, cheese makers became milk producers and so on. It is worth noting that the food industry also began taking on a growing number of tasks previously handled by households, right up to actual cooking, with the development, in the twentieth century, of ready-made canned, frozen or tray meals that could be reheated at home. The rise of agriculturalization also stemmed from the fact that it enabled farmers to gain income by engaging in the long-distance national and international trade of agricultural products (facilitated by the development of transport). The creation of standards and futures markets, which underpinned the status of primary commodities and, later, price stabilization policies, transformed the trading profession. Once protected from price risks, traders were able to step beyond their delivery or brokering role – never owning the product but merely organizing its circulation – and source the products directly in rural areas (Daviron, 2002).

At the same time, farms were specializing in a limited number of products. In Europe, one of the most visible signs of this was the demise of mixed farming and the separation of crop and livestock production. Synthetic chemical fertilizer treatments enabled farmers to grow crops year after year without manure. Moreover, as animal feed became readily available, farmers could rear livestock without land, or with the bare minimum of land necessary to spread the farm manure and slurry generated on the farm, which had become burdensome waste products. Mechanization was also a major driving force of specialization, forcing farmers to produce large quantities of a particular crop or livestock product in order to cushion the cost of specialized equipment. This also prevented, or severely restricted, the growing of mixed crops on the same plot of land.

A division of labour also emerged at national and international levels, as a result of the reduction in transport costs and the advent of new food preservation techniques (refrigeration, freezing). Some regions specialized in growing a certain crop or raising a particular type of livestock. Entire countries followed suit in the

late nineteenth and early twentieth centuries, with Argentina specializing in wheat, corn, beef and flax; Burma in rice; Brazil in coffee; and New Zealand in dairy products. Today, this trend is once again witnessed as part of the so-called second globalization, for instance, with soybeans being produced in Latin America and wheat and maize in Ukraine.

Industrial farming is thus now specialized and integrated, with upstream multinational chemical corporations supplying pesticides, fertilizers and seeds; feed mills supplying animal feed; banks providing credit; and specialized companies providing agricultural machinery. Likewise, large-scale cooperatives, traders and a handful of food companies and supermarkets prevail downstream. To complete the picture, it is also worth mentioning the host of organizations – cooperatives, whether private or public – offering services as well as technical and economic advice. Farmers are now just cogs in what has become the ‘industrial food system’, dependent on many other actors. Little is left of farming communities’ relative autonomy – understood here as their ability to set their own rules.

Americanization, liberalization and bureaucratization

Although the hegemony of the United States has repeatedly been proclaimed to be declining or dead, it never ceased to assert itself over the course of the twentieth century. However, it did not follow a linear trend; two defining moments stand out: the victory over Germany and Japan in 1945 and the victory over the USSR in 1989. Throughout the period in between, despite a sharp drop in its share of global wealth and radical shifts in economic policy, the United States has provided a model for the rest of the world, disseminating new ways of organizing production and trade.

The United States has played a pioneering role in the fields of agriculture and food since the nineteenth century. A diverse range of agricultural machines were invented in that country, which heralded the advent of motorization in the following century as well as the standardization of agricultural products and the invention of futures markets (Cronon, 1991) – almost perfect markets according to economics textbooks, with pure and perfect competition, perfect information, no uncertainty over the quality of the traded commodities and so on. It was also in the United States that the ‘visible hand of managers’ (Chandler, 1977) first took hold, with the rise of giant corporations (General Foods, Procter and Gamble, Massey Ferguson, Cargill etc.). These corporations could only prosper through bureaucratic abundance, with an army of white-collar workers responsible for planning, controlling, advising, negotiating and influencing, in addition to

many other functions in the so-called management domain – a process which Michel Foucault referred to as the ‘conduct of conduct’ of individuals (Dreyfus and Rabinow, 1982).

In the mid-twentieth century, in the wake of two world wars and an equally global economic crisis, the United States became the national economy par excellence, capable of producing everything it consumed and consuming everything it produced. It became a model, which six Western European countries sought to replicate by uniting within a community. Under the banner of ‘development’, this model also fascinated the rulers of Latin American countries and recently decolonized African and Asian countries. In the agricultural sector, the focus on the national market was largely underpinned by generalized state intervention. Franklin D. Roosevelt’s presidency had implemented this intervention strategy to tackle overproduction, which free market forces had not seemed capable of curbing. Surpluses built up again at the end of the Second World War and the Korean War (1951–3). Set-aside land, public stockpiling, support for the promotion of meat consumption, food aid, the opening up of oilseed and protein crop markets elsewhere in the world, and the subsequent support for biofuels were instruments deployed by US authorities to reduce these surpluses. In Europe, the Common Agricultural Policy (CAP) also introduced a wide range of instruments to regulate agricultural markets. French dreams of imperial self-sufficiency were abandoned in favour of a new dream: food self-sufficiency. Now so-called developing countries also embraced this slogan, even though agricultural taxation prevailed in the name of accelerated industrialization (Daviron, 2020).

In the late 1970s, neoliberalism emerged. State intervention in the market, though previously praised, became reviled. Margaret Thatcher was the first to negotiate this turn in the United Kingdom. Ronald Reagan soon followed suit in the United States, using resources on an entirely different scale (including the dollar) to offer the world a new economic policy standard. Compared to the liberalism of the eighteenth and nineteenth centuries, neoliberalism was marked by a vision of the market as an instrument of competition rather than cooperation. Liberalization became the watchword in agricultural markets. International negotiations under the General Agreement on Tariffs and Trade (GATT) – the forerunner of the World Trade Organization – and the structural adjustment programmes of the International Monetary Fund and the World Bank forced the dismantling of public market regulation systems at a pace and on a scale inversely proportional ‘to the wealth (and power) of nations’. In countries of the Organisation for Economic Co-operation and Development

(OECD), decoupled payments – direct aid paid to farmers irrespective of the volumes produced – were widely adopted. In African countries, the impacts of liberalization were tempered by their reduced participation in international trade. In China and India, countries with both a population and soon an amount of US Treasury bonds (loans issued by the US government) that have passed the billion mark, state intervention held firm.

True, honest and effective competition, however, cannot be achieved simply through the withdrawal of the state; it is also essential to monitor, control and accredit respect for this competition. Hence the new wave of bureaucracy on the horizon (Hibou, 2015): after being chased away together with the administrative machinery implemented to regulate agricultural market prices, bureaucracy is back in a new guise. Farmers now have to demonstrate the merits of their practices in order to benefit from certain types of support in the form of targeted public aid (second pillar of the CAP) or higher prices (organic products). These practices must therefore be monitored. Certification – like auditing in the world of joint-stock companies – is the preferred instrument to do so. Industrial agriculture has thus acquired a new component that is far from being conducive to farmers' autonomy.

Conclusion

This chapter has presented a brief history of industrial agriculture, up to and including recent developments. This is just a basic outline: although the different processes discussed above occurred almost worldwide, this does not imply uniformization or the emergence of a 'global food system'. The distinction between 'states' and 'trends' (Kautsky, 1988) is key here. Trends may potentially influence all countries, but their effects (the resulting states) may radically differ between areas due to the diverse range of baseline situations at stake and the different degrees of resistance and opposition encountered. Diversity prevails despite hegemony.

Finally, although industrialization has been the target of substantial well-founded social and environmental criticism (Chapter 7), it is important to keep in mind that this system has helped feed a global population whose numbers soared over the course of the twentieth century. Despite the downturn in agricultural commodity prices, this trend has also led to a very significant increase in farmers' incomes as a result of labour productivity increasing even faster than crop yields. I point this out not to defend industrial agriculture on

the grounds of its productive performance, but rather to highlight the challenges facing the different widely advocated agricultural and food alternatives (as described in other chapters of this book).

This chapter largely draws on the author's book *Biomasse – Une histoire de richesse et de puissance* (2020) and his contributions at the 2019 Master's training seminar organized by the UNESCO Chair in World Food Systems titled 'From solar energy to fossil fuels, a history of the role of agriculture in development'.

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