PHD

Reciprocal Technologies: Enabling the Reciprocal Exchange of Voice in Small-Scale Farming Communities through the Transformation of Information and Communications Technologies

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Award date:
2016

Awarding institution:
University of Plymouth

Appendix E: The origins of agriculture and its *coevolution* with sociotechnical systems.

1. The origins of agriculture.

Agriculture is subjected to controversies about its origin and competing theories about its expansion. Situated theories that explain the origins and expansion of agriculture seem to be more fruitful than unified ones, given the vast diversity of cultures and ecosystems in which agriculture originated and extended. Crops were domesticated[1] in different geographical areas, known as *centers of origin*.[2] Regarding their expansion, two main hypotheses may be observed: the *demic* hypothesis, that explains the expansion of crops through the migration of people, and the *cultural* hypothesis, that attributes it to the development of tools, techniques and trade. Geneticist Luigi Luca Cavalli-Sforza observed that, while cultural diffusion tends to happen quickly and has no observable demographic effects, the diffusion of cereals such as wheat and barley in Europe, that originated in the Middle East, was not only a slow one, but was also correlated to significant increases in the population along its route (Cavalli-Sforza, 2000). However, although the *demic* hypothesis confirmed by Cavalli-Sforza's research[3] may adequately explain the diffusion of agriculture from the Middle East to Europe, it cannot be generalized to explain the expansion of agriculture in other parts of the world. In Mesoamerica, for example, maize expanded more quickly towards the Andean region than to the North most likely because of the higher environmental diversity found in its southern regions (Cavalli-Sforza, 2000). Studies that integrated genetic and linguistic methods showed that maize may have been introduced from Mexico to the Andean Region through migration. However, this migration was predominantly comprised of males and not as a result of a demographic expansion (Kemp et al., 2010), suggesting commerce or war, and supporting thus the *cultural* hypothesis. Similar methods also propose that *group-to-group* diffusion, and not long-distance migration, may explain the expansion of maize into North America (Merrill et al.,

1 Domestication is the process whereby human management brings about morphological changes in plants. The means through which plants are domesticated are selection and hybridization, both of which may be achieved through conscious or unconscious processes (Vasey, 1992).

2 The theory of centers of origin was developed by Dr. Nikolai Ivanovich Vavilov, who posited that plants were not originally domesticated in random places around the world, but rather in specific regions (Vavilov, 1935).

3 Cavalli-Sforza supported the demic hypothesis by analyzing specific genetic and linguistic traits of European populations, whose distribution was correlated with the route through which the Middle Eastern cereals entered Europe (Cavalli-Sforza, 2000).

2009). Thus, regardless of whether agriculture expanded through migration or trade, the different hypotheses seem to imply that this process was much more strengthened by the *reciprocal* exchange of knowledge than by technical innovation or mere commercial interests.

2. The *coevolution* of agriculture and sociotechnical systems.

2.1. The *coevolution* of agriculture and culture.

The development of cultures in different parts the world is often associated with the large concentration of populations in stable territories. This process, known as *sedentism*, is commonly attributed to the cultivation of cereals, as lands had to be permanently occupied in order to replant seeds. However, although the correlation between agriculture and sedentism may have existed, it not always conformed to a consistent sequence (Vasey, 1992). But as human groups and agriculture became more established, agriculture began to interweave with the cultures in which it was practiced be enriching them and making them more complex and sophisticated[4].

Philosopher Lewis Mumford described the botanical knowledge accumulated through the observation and cultivation of plants as a pre-scientific form of empiricism (Mumford, 2013). For example, the cultivation of maize together with beans and squash, known in Mexico as *milpa*, might have originated from the ancient observation of how these plants grew together forming a reciprocal system[5]. Mumford argued that the development of agricultural systems such as the *milpa* originated in the observation and preservation of what naturally grew in ancient gardens (Mumford, 2013). This pragmatic empiricism was transmitted orally (León, 1980), and was one of the factors that strengthened and enriched symbolic abstraction in specific cultures.

4 These cultures arose as early states and civilizations in which most of the population was formed by peasant farmers (Vasey, 1992). Therefore, it is possible to assume that knowledge associated to agriculture was one of their main pillars.

5 Modern botanical science has explained how each plant in the milpa performs an ecological role (Aguilar et al., 2007). Beans contribute to the proper nutrition of maize by helping to fix nitrogen in the soil, while the strong stems of maize plants provide support to the more fragile bean. Squash limits the growth of weeds and, thanks to its large leafs, helps to preserve soil moisture. Moreover, the combination of these three plants results in a rich and well balanced diet.

An additional example is provided by the solar calendar, a distinctive feature of Mesoamerican cultures and one of the most notable achievements related to agriculture (Matos, 2013). Moreover, the complex system of land ownership in ancient Mexico, in which clear divisions between city and country, as well as between social strata were specified, was also a feature of the reciprocal evolution, or *coevolution*, between agriculture and culture (Matos, 2013). In contemporary Mexico, the *culture of maize*, related to the historical examples presented above, still manifests itself both through tangible features, such as food or dress, and abstract ones, such as language, social structure and religion (Esteva, 2007a). While these examples refer to a specific geographic region, similar evidences of the *coevolution* of culture and agriculture may be found in different parts of the world.[6]

The *coevolution* of culture and agriculture suggests that agriculture may have evolved reciprocally with cultural traits such as technological innovation and trade, rather than being driven by those factors. However, I claim that this gradual and fragile process was disrupted by a shift towards the rationalities associated with Modernity.

2.2. The *coevolution* of technology and agriculture.

Even though Cavalli-Sforza acknowledged that tools and techniques had a role in his *demic* hypothesis, he nonetheless found that it was a marginal one. He suggested that ceramic implements used in Middle Eastern agriculture might have arrived from the Sahara region. However, the usage of ceramics in the Middle East was subsequent to the cultivation of wheat and barley, and not a prerequisite (Cavalli-Sforza, 2000). Therefore, technical innovation in agriculture prior to industrialization may have been characterized by the appropriation of previously existing tools and artifacts, and their subsequent transformation.

Tools and techniques have been regarded as being central to human evolution, as attested by the notion of *homo faber*[7]. However, Karl Marx recognized that the emphasis

6 For an account of the historical relationship between agriculture and oral tradition in Africa, see (Schmidt, 2006)

7 In 1958, philosopher Hannah Arendt identified the notion of *homo faber*, that corresponded to the humans' task of fabricating an artificial environment of things (Arendt, 1998). Work, governed by ends and intentions, generated a mode of activity according to which humanity could be depicted as *homo faber*: humans as makers of artifacts that separated them from nature and provided a stable material context (Arendt, 1998). Although Arendt later established

on *homo faber* was insufficient to describe the human condition, and argued that artifacts and tools were fabricated in imagination before they appeared in reality (Marx, 2010). In resonance, Mumford argued that the notion of *homo faber* was based on an erroneous interpretation of human evolution that claimed for the centrality of *making* in retrospect, as a result of technological rationality. Mumford posited that, because ancient tools were often the only material evidence with which archaeologists could develop their hypotheses, theories of human evolution tended to be materialistic and excessively reliant on the contemporary notion of technology (Mumford, 2013). Furthermore, Mumford posited that tools were not fundamental to the development of human mind and culture, but rather expressed their potential[8], and that technology, in general, implied a reciprocal exchange between the social milieu and the specific fabrications of inventors (Mumford, 2010).

With respect to agriculture, Mumford agreed with the hypotheses about the origins and expansion of agriculture, such as those posited by geneticist Luigi Luca Cavalli-Sforza[9], and claimed that its evolution was relatively independent of the tools commonly associated with it. He presented ceramic sickles found in the Middle East or stone mortars as examples of tools that were not originally created for agricultural purposes, but were later appropriated and applied to tasks such as harvesting or grinding cereals (Mumford, 2013). These processes of appropriation resonate with the the transformation of technologies discussed in chapter 2, as well as with the claim that a technological object becomes what it is through its uses (Ihde, 1990). It is precisely by this *becoming through usage* that technology may be understood as a sociotechnical system open to transformation, as well as part of a human-technology relativity. In agriculture, this relativity originally emerged

that the activity of *homo faber* could not equate with human freedom, and therefore could not wholly define the human condition (Yar, 2005), the notion had already been posited as an anthropological model. In defining human intelligence, philosopher Henri Bergson referred to *homo faber* in its original sense (*man the maker*) as the human faculties for self-transformation and fabrication of material things (Bergson, 2011).

8 "Of course man is a tool-making, utensil-shaping, machine-fabricating, environment-prospecting, technologically ingenious animal – at least that! But man is also – and quite as fundamentally – a dream-haunted, ritual-enacting, symbol-creating, speech-uttering, language-elaborating, self-organizing, institution-conserving, myth-driven, love-making, god- seeking being, and his technical achievements would have remained stunted if all these other autonomous attributes had not been highly developed." (Mumford, 1979, p. 469)

9 Geneticist Luigi Luca Cavalli-Sforza observed that, while cultural diffusion tends to happen quickly and has no observable demographic effects, the diffusion of cereals such as wheat and barley in Europe, which originated in the Middle East, was not only a slow one, but was also correlated to migration, evidenced by significant increases in the population along its route (Cavalli-Sforza, 2000). Even though Cavalli-Sforza acknowledged that tools and techniques had a role in his hypothesis, he nonetheless found that it was a marginal one. He suggested that ceramic implements used in Middle Eastern agriculture might have arrived from the Sahara region. However, the usage of ceramics in the Middle East was subsequent to the cultivation of wheat and barley, and not a prerequisite (Cavalli-Sforza, 2000).

both as a way to extend the bodily capacities of humans, as well as to transform the environment.

Tools and implements used in agriculture, such as axes and hoes, developed much more slowly than agriculture, and probably contributed to an increase in the size of plots, but not necessary to an increase of crop yields (Mumford, 2013). Mumford claimed that the possibility of cultivating larger plots encouraged the occupation of new territories, thus suggesting that technical development may have indirectly affected population dynamics. This suggestion contrasts with the theory of economist Ester Boserup, who claimed that the correlation between population growth and available food resources[10] determined agricultural innovation, and not the other way around, as previously proposed by economist Robert Malthus (Turchin, Nefedov, 2009). However, if both Mumford's and Boserup's views are correct to some extent, it might be possible to observe a feedback loop between them. Axes and hoes might have allowed populations to extend territorially and occupy new regions in which the lack of tropical abundance that favored food collection was compensated by agriculture. Yet, in parallel, the growth of population might have generated a greater need for food resources, and thus the development of novel agricultural techniques and tools. What this feedback loop may reveal is a strong interdependence between population dynamics, agriculture and technical elements. Rather than a series of causal relations, such interdependence may be better described as a process of *coevolution* between technical innovation and agriculture.

The theories of Mumford and Boserup usefully expose the overemphasis on technical innovation that may be frequently found in different theories about the origins and expansion of agriculture (Vasey, 1992). Furthermore, Mumford observed that the invention of new tools and techniques was situated and adapted to local contexts (Mumford, 2013). Therefore, it might be possible to describe the relation between early agriculture and technical innovation as *situated coevolution*.

10 This correlation is also known as "carrying capacity", understood as the maximum sustainable population size that can be supported without degrading the environment.

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