Theories about the commencement of agriculture in prehistoric societies: A critical evaluation

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1. *Introduction*

The shift from foraging to farming or the «First Neolithic Revolution», as coined by V.G. Childe (1936), was one of the major events in the evolution of human societies. At its roots was the shift from the reliance on wild plants and animals to domesticated plants and livestock. Domestication is the process by which humans are able to control the reproduction of plants and animals species and thus select for various desirable characteristics. Domestication first occurred in the Levant, around 10,000 BC and it marks the beginning of the archaeological period known as the «Neolithic».

However, the adoption of domestic plants and animals is only a single symptom of a major societal and economic transformation. Indeed, people changed their views of many things during the Neolithic period, including the returns expected from their quest for food, acceptable levels of risk, their ability to change their environment, residential stability and property rights, definitions of kinship and residential groupings, and the benefits of having more children. Most of these changes find their roots in the Mesolithic period, but they came together during the Neolithic to produce a dramatic change in society.

For more than one century, many explanations[1] of the Neolithic transition have been given by archaeologists, anthropologists and pre-historians, and even more recently, by economists. Although it is widely agreed that this episode was crucial in human history, there is no unique explanation or theory of the Neolithic transition. This transition to agriculture is often viewed as being the result

of factors that operated in the Levant at the onset of the Holocene. Climate change, human population pressure, and culturally driven alternatives, such as competitive feasting, are among numerous additional explanations proposed in the literature.

Because the transition to agriculture seems to have had a range of causes and consequences that are themselves multidimensional (economic, social, ecological, institutional, technical), its study has led to some major debates among scholars. It is the purpose of this paper to present these major debates and critically evaluate the main theories.

The paper is organized as follows. First theories are outlined and discussed which rely on food deprivation (as a result of different events) as a suggested force for the adoption of agriculture. This is followed by consideration of theories which link the start of agriculture to a food surplus. In the subsequent discussion, it is pointed out that in some cases the beginning of agriculture might not have been a result of either of these factors. The role of natural resources and institutions in facilitating the development of agriculture is examined before concluding.

2. *Childe's Climate Change Theory and Similar Theories*

Often the transition to food production is explained by human adaptation to external shocks. Many external shocks are possible (e.g. wild animal extinction due to disease) but the most popular one currently is climate change and the induced transformations of ecosystems. This explanation is probably the most popular because past prevailing climate and ecosystems are nowadays perfectly known by means of various techniques, such as radiocarbon dating. Others features of the past, such as the population size, the degree of competition among neighboring tribes [...] are at best hypothesized.

One of the first, and probably the most famous explanation of the Neolithic revolution based on climate change was proposed by R. Pumpelly (1908) and popularized by V.G. Childe (1936) and is named the «Oasis theory». In this theory, bands of hunter-gatherers (HG) were initially living in an environment able to satisfy their basic needs. However, a major climate change occurred; the transition from the Pleistocene to the Holocene, around

15 to 12 thousand years BC, was characterised by a global warming. With the end of the last ice age, some areas – like the Sahara, which was initially a savannah where bands of HG were living – became arid deserts unsuitable for HG to live in. HG were therefore forced to migrate to the Levant in places where life was still possible, i.e. in oasis and on the banks of large rivers.[2] In addition to humans, desiccation also forced plants and animals to congregate around oasis and other areas of permanent water. Here, their familiarity with animals and abundant wild plants allowed humans to easily understand their growth cycles while their relative crowding stimulated them to invent agriculture in order to maximize food production. In other words, in order to survive in these places, they adapted their way of living, developed a symbiotic relationship with certain plants and animals which eventually culminated in their domestication and thus, some of them – the Natufians – invented agriculture and pastoralism. The transition to agriculture results therefore, from a logical sequence having some similarities with biological evolution theory. There is an exogenous shock – climate change – and then a process of natural selection or adaptation that leads to agriculture, i.e. to the emergence of a new human society, more developed than the previous ones.

Even if this theory is quite seductive – and was innovative for its time – it does not explain why agriculture was not invented before this time. Indeed, many similar major climate changes have occurred since the appearance of *Homo sapiens* without initiating food production. Moreover, this theory implicitly assumes that prior to the Holocene, HG had no knowledge of plants and animals whereas there is plenty of evidence to the contrary. Another shortcoming of this theory is that in the Levant there is no evidence[3] of major climate change for the period considered by Childe. Given this criticism, it has been argued recently[4] that while the role of climate change in the evolution of human societies remains important, its contribution should be more qualified. It is argued that regions characterized by either high or low intertemporal climatic volatility evolve more slowly than those with moderate volatility and experience a late onset of farming. Indeed, under static climatic conditions, HG are not forced to take advantage of the productive potential of their respective habitats, and remain indefinitely in

a hunter-gatherer regime, as is assumed in the case of «affluent societies» of HG. In addition, occurrences of extreme environmental stress – e.g. a return to semi-glacial or arid conditions – by eliminating the potential for farming, erode any accumulated human capital useful for agriculture, further delaying its adoption. It is therefore suggested that intermediate levels of intertemporal climatic volatility fostered the transition from foraging to sedentary agriculture. However, this theory seems to be at odds with the early development of garden agriculture in New Guinea where most likely intertemporal climatic variability was low.

Adaptation and Resilience of Hunter-Gatherer Societies

Traditional climate forcing models[5] intended to explain the origins of agriculture in the Levant proposed that the shift to wild cereal cultivation was a solution to the failure of foraging systems due to Pleistocene Younger Dryas climatic deterioration. In doing so, they assumed that the Neolithic revolution was a response to the earliest well-documented example of social collapse, i.e. to the failure of forager economies in the wake of abrupt climatic change. However, this view has been challenged[6] in the case of HG societies[7] living in the Levant. It is contended that climatic fluctuations leading to changes in vegetation[8] only resulted in a shift in the resource focus of HGs rather than forcing a collapse of foraging economies. In other words, HG subsistence systems in the Levant were highly adaptable and resilient, and robust in terms of diversity of options and the mobility of HGs. HG societies had a broad range of economic strategies that enhanced their resilience. In the late Pleistocene or early Holocene, low-level predomestication cultivation may have occurred and would have been one of many options available to foragers. It is only well into the Holocene era, that cultivation did have a significant impact on foraging economies. Moreover, long-term social memory of accumulated experiences was crucial in these HG societies for preparing and responding to economic challenges. A further problem with correlating the Younger Dryas with the origins of agriculture is that during the last 40,000 years, there have been approximately nine other similar events, but agriculture developed only after the most recent one.

3. *Childe's Proto-Agriculture Theory and Braidwood's Nuclear Zones About How Agriculture Developed*

In addition to his Oasis theory, Childe indicates that agriculture may have developed from a form of proto-agriculture in some Eurasian and North African places where it first began. He states (1936, pp. 73-74): «the most suitable land for cultivation is often found on the alluvial soils deposited where intermittent torrents flow out from the hills onto the plains and in the valleys of rivers that periodically overflow their banks. [...] And so in the Eastern Sudan, the Hadendoa scattered millet seeds on the wet mud left by the Nile flood every autumn and just waited for the crop to sprout».

Horticulture is a process by which a plot of soil is prepared for the planting of seeds, tubers, or cuttings. It is tended to control competition from intrusive plants (weeds), and protected from predatory animals including humans. The crop is harvested, processed, and usually stored in specialized containers or structures. Some produce, often a significant quantity, is eaten during the growing season, but an important element is having the wherewithal to store food for future consumption, trade or ceremonies. A garden, being a more or less permanent location, forces those who tend and harvest the garden to settle down in its vicinity. Garden produce has value, so a group of humans must cooperate to the extent that they can protect themselves and their produce from those who would wish to steal it. It is telling that many of the earliest horticulturalists also lived in fortified communities. In some cases, garden agriculture might (in our view) have been developed as a supplement to meet the challenges of variability in HG supplies. There are often seasonal or other variations in the abundance of HG resources resulting in periodic food shortages. In some cases, agriculture helps to address this problem, especially if storage of the product is possible, as with cereals. Moreover, the adoption of proto-agriculture and primitive garden agriculture probably was accelerated in many cases by external events such as loss of tribal territory due to invaders, and in some cases, climate change.

Even if agriculture evolved from a type of proto-agriculture, the reason for, or the driver of this development of the proto-agriculture to settled agriculture

is not suggested by Childe. In other words, Childe explains the «how» but not the «why» of the transition to agriculture.

The Nuclear Zones Theory

Braidwood (1960) believes that domestication must have arisen in natural habitats – the so-called nuclear zones or hilly flanks – of wild ancestors of domesticated plants and animals. These were located in hilly regions adjacent to the Fertile Crescent (Zagros, Anatolia). He excavated Jarmo[9] to prove this and to test Childe's Oasis theory. Also, through multi-disciplinary research (botany, geology, zoology), Braidwood believed that he had established that the climatic crisis of Childe did not in fact occur, thus undermining the Oasis Theory. However, Braidwood did not explain why this development occurred. He just described the setting for its emergence. Thus, even if Braidwood's purpose was initially to contradict Childe's Oasis theory, he didn't provide an alternative theory; his «Nuclear Zones theory» only explains how (and where) agriculture first took place, but not the underlying reasons for its development.

4. *Population Pressure Theories*

Building on the ideas of E. Boserup (1965), who proposed that a growing population provided the impetus for the development of intensive agriculture, some archaeologists[10] have long argued that hunter-gatherer economies continually evolved to accommodate growing populations. The ever-expanding need for increased food supplies as a result of population growth eventually led to the adoption of farming.

The Marginal Zone Theory

Binford (1968) explains the emergence of agriculture as response to cyclical population pressure on the edges of the Nuclear Zones. This is a systemic theory that focuses on the relationship between population pressure, environment and subsistence strategies. The theory assumes

that human groups normally exist in balanced equilibrium with their physical environment. They don't normally intensify their food supplies and live normally in a state of systemic balance where change is the exception. Thus they keep their numbers below the carrying capacity of their food resources. By 10,000 BC the Nuclear Zones were comfortably full of intensive hunter-gatherers. They then experienced population growth because of local environmental disruption. This development forced migration into areas of less optimum food resources – the Hilly Flanks or Marginal Zones. This overpopulation created a systemic imbalance in these zones where there were inadequate wild food resources for the expanded populations. The invention of agriculture occurred in these regions to reinstate systemic equilibrium based on different means of subsistence and organizational structure of society.

An Infinite and Irreversible Evolution

All approaches highlighting the role of population pressure in explaining the evolution of human societies are closely related to biological evolution theory. This affiliation is obvious in many publications.[11] In order to illustrate it, we may consider two stages in the economic development of any human society. The first one is the economy of subsistence traditionally associated with HG. People are nomads, they get their food from hunting and gathering. Their main (unique) objective is to get enough food resources to satisfy their basic needs – survival and reproduction – and, of course, to minimize their effort in doing so. They do not try to maximize their food procurement because their basic needs are satisfied and excess food resources would be wasted anyway (storage is not consistent with their nomadic way of life). If there is no population pressure, nothing changes. A society may remain at this stage of economic development forever. However, according to T. Malthus, human population tends to grow at a faster rate than the availability of food. Population increase outpaces the scope for hunting and gathering to feed this increasing population. Therefore, more productive methods are required, such as those involved in agriculture.

The Possible Impact of Hunter-Gatherers' Migration

An alternative push-type theory (which we suggest) which could help explain the evolution of agriculture is that possibly tribes living in areas where proto-agriculture began in Southwest Asia and North Africa had some of their hunting and gathering territories taken away by invading tribes. This reduced their access to HG resources and so they gradually increased their dependence on proto-agriculture which subsequently developed to garden agriculture. It seems that Northeast Africa and Southwest Asia were important migratory routes for people from Africa. As they migrated, they most likely displaced local peopled or reduced their territory. However, this process could also occur as a result of migrants coming from other areas than Africa and going into Southwest Asia.

Is Food Deprivation a Necessary Condition for Agriculture's Commencement?

The various theories of the Neolithic transition illustrated above are based on push factors, either on climate change[12] or on population pressure,[13] share a common thread: transition to agriculture occurs when there is food deprivation, i.e. an excess demand for food resources. The latter can result from the negative impact of climate change on environment. It may also appear when population levels exceed the carrying capacity of environment. We therefore see that despite the varied contributions of the economics literature in explaining the Neolithic Revolution, population pressure, in most cases, is the ultimate driving force behind the transition to agriculture.

Population pressure critics argue that because many societies possess methods for controlling fertility via delayed marriage, prolonged lactation, induced abortion, infanticide, etc., a group's population level need never reach any Malthusian limits, exceed carrying capacity, or feel any of the supposed effects of an imbalance of persons to resources. Some authors[14] maintain that population pressure alone could not have played a critical role since there is no archaeological evidence of food crises prior to the development of agriculture. By contrast to what Cohen (1977, p. 279) claimed[15] – one of the leaders of the

population paradigm – around 10,000 BC, the world was not saturated with HG groups and there is no explanation of why HG groups would have over stretched their resource base in the first place.[16]

As Childe assumed, the rise of agriculture could be humanity's response to a climate change resulting in a worse environment (altering the availability of food for humans). In that case, the resulting ecosystems are worse than before, with greater scarcity of food resources, for example, as a result of a drought. In order to survive, i.e. to avoid starvation and death, HG must find new ways to get food and this may have led to the start of agriculture.[17] However, the rise of agriculture could alternatively be humanity's response to a climate change resulting in a better environment. In that case, the resulting ecosystems support more abundant and diverse plants and animals. As a result, food procurement is easier for HG who therefore have more time for leisure and for experimenting with cultivation and the domestication of plants and animals. They may settle and have more children.[18] These simple alternatives show that the start of agriculture can be the result of various external shocks (positive or negative) even when these shocks all arise from climate changes. More fundamentally, these alternatives demonstrate that in social evolution, opposite causes – a negative or a positive shock – may have the same consequence, i.e. may lead to the same evolution of human societies.

5. *Abundance and Social Rivalry Stimulate Agriculture Development*

The commencement of agriculture may have been a lifestyle choice, i.e. an excess demand for food can exist even if there is no population pressure. Indeed, it is well known from Engel's laws about consumption that when the income increases, consumption shifts from primary to luxury goods. Such transformation may have occurred during the early Holocene. During that period, postglacial environmental transformations[19] have led to the diversification of food resources, i.e. to the so-called «Broad-spectrum revolution».[20] With more abundant and diverse food resources provided by the nature, HG may have chosen to consume more «luxury or prestige» goods,

be these food resources or non food resources.[21] However, the production of these prestigious goods required more labor and therefore led to an excess demand for (primary) food resources. In others words, social competition for prestige in HG societies occurred endogenously, without climate constraints and it led, by means of conscious adaptation, to the rise of agriculture.[22]

However, there are several major problems with this theory about the Neolithic transition. The first one is that without explaining the underlying causes of competitive feasting, it fails to explain the development of agriculture and simply describes the process. Second, the surpluses needed for competitive feasting only became available as an outcome of food production, not before, i.e. there is a problem of causality. Third, this theory considers that farming was highly desirable from the earlier stages of agriculture development. Indeed, it is often believed that the initial effect of the shift from hunting-gathering to agriculture was an increase in food production. Societies that adopted agriculture were able to produce far more food in a given territory than those that relied on foraging. This increase in productivity could be used either to expand the economic surplus or expand population, with both usually occurring. Moreover, recent studies have challenged this vision, demonstrating that, compared to foraging, agriculture in its early stages was an activity with low returns and involving high risks.

The Low Attractiveness of the Farming Way of Life

In Mesolithic Europe, for example, and as illustrated by the Ertebølle[23] culture, HG were not mobile and nor were their societies organizationally simple.[24] On the contrary, they tended towards socio-economic complexity, including sedentism. Similarly, Neolithic European farmers, as illustrated by the LBK[25] culture, were not super-productive and sedentary. On the contrary, they were often mobile and had a mixed-economy, i.e. an economy combining hunting-gathering and farming. The cultural diffusion of the Neolithic revolution, i.e. the deliberate choice of HG to switch to agriculture, finds therefore little support.

On the other hand, it was often believed that farmers were affluent and HG were poor. From the 1960s, the

latter part of this vision was challenged by the results of ethnological studies[26] of HG societies. Indeed, it appeared that some modern HG societies (mainly! Kung and Hadza, both located in Africa) were very different from the usual description of HG societies. Indeed, these societies did not experience scarcity of food and individuals had to do little work to satisfy their limited ends. Therefore, they were labelled as the «original affluent society».[27] Thus, the former part of the vision mentioned above has also been challenged. The first agriculturalists are now believed to have put in more rather than less labor to attain subsistence. As pointed out by J.L. Weisdorf (2005, p. 562) «Traditional scholarship has regarded farming as highly desirable. Scholars of human history long assumed that once humans recognized the impressive gains from cultivation and domestication, they would immediately take up farming. However, more recent studies have indicated that early farming was indeed back breaking, time consuming, and labour-intensive». J.R. Harlan (1992) also asked «Why farm? Why give up the 20-hour work week and the fun of hunting in order to toil in the sun? Why work harder, for food less nutritious and a supply more capricious? Why invite famine, plague, pestilence and crowded living conditions?».

In other words, early agriculturists had to work more hours than foragers did. They were also more prone to lethal disease and malnutrition,[28] as a result of the shift towards dependence on one or a few domesticated plants, with a diet based predominantly on complex carbohydrates. Increasing sedentism and living in close proximity to domestic animals leads to poor sanitation and an increase prevalence of zoonotic disease. They also had to endure less egalitarian social structures than hunter-gatherer societies. Since there are almost no indications of increased standards of living immediately after the agricultural transition, why complex HG should have decided to give up their way of life in order to adopt agriculture?

The low attractiveness of agriculture is also confirmed by some cases of reversion from agriculture to hunting and gathering, depending on opportunity costs. Some examples of reversion in North America are well documented.[29] In this area, the (re)-introduction of horses by conquistadors caused some north-American native Indians tribes[30] to revert to hunting as a permanent way of life. Another

example of reversion concerns the Levant and is about the well-known Natufians. Indeed, it appeared that the late Natufians reverted to a higher degree of mobility after having adopted a settled life. Decreases in site size, the decline of architecture, as well as changes in the burial record have been seen as indicators of increased mobility. It is suggested that the reason for higher mobility during the late Natufians was the climatic deterioration which occurred with the onset of the Younger Dryas, which depleted available resources. This, in turn, resulted in a dispersal of populations across the region to maximize their returns from different areas and alleviate risk.

6. *Livestock and Agricultural Development*

Childe (1936, p. 82) states «It must be remembered too that food-production does not at once supersede food-gathering. [...] At first hunting, fowling, fishing, the collection of fruits, snails and grubs continued to be essential activities in the food-quest of any food-processing group. [...] Only slowly did it win the status of an independent and ultimately predominant industry». Childe's (1936) seminal work, archaeological records and studies have contributed to reinforce his initial view. Even in the case of domestication of animals, the process was probably slow, except in the case of the dogs. However, dogs for a long time probably remained tame but undomesticated. The husbandry of livestock may have evolved from the capture of suitable wild animals, and their initial holding for some time for slaughter. In some societies, the keeping of livestock preceded the growing of crops but not in all cases. This also resulted in some differences in patterns of agricultural development.

From Taming to Domestication: A Long-Term Process

Although often characterized as rapid and the result of explicit human intention, domestication is a complex process along a continuum of human, plant, animal relationships that often took place over a long period and was driven by a mix of ecological, biological and human cultural factors.[31] The relationship between humans and the nature

involves two polar cases: a behaviour in which human acts as a prey against the nature and on the other hand, the husbanding by domestication of plants and animals. Between these two polar cases, there exists a wide range of relationships, including taming. Taming encompasses commensalism/mutualism at a low-level of management, whereas directed control over reproduction is associated with domestication. Taming differs from domestication. By contrast with the latter, it does not imply morphological or biological modification of species. Bellwood (2005, p. 5) defines domestic crops as plants «[...] that show recognisable indications of morphological change from the wild phenotype, attributable to human interference in the genotype through cultivation». Although plants as well as animals were only domesticated in the Neolithic period, they were tamed[32] by hunter-gatherers before that period.

For plants, a wide range of «technologies» may be considered as 'taming', such as fire-stick agriculture[33] – to foster the growth of edible plants and to eliminate the others, and also to attract game in the resulting meadows – tending tubers, soil aeration, watering fields, semi-sowing or voluntary incomplete harvest of seeds.[34] Until recently, all these proto-agricultural technologies were still used in many hunter-gatherer societies. The dog was probably the first animal to be domesticated, even if it was not to provide food resources but mainly helped humans in their hunting activities. Many other animals have been tamed: sheep, goat, cattle, pig, horse, camel, llama [...]. The reindeer[35] is also a good example. During the Palaeolithic period, it provided 80% of human diet. With the global warming of the Holocene era, herds of reindeer migrated north to the arctic and subarctic regions where they are still living nowadays. In these regions, they have been tamed, providing meat, milk, hide and being also used for traction. However, they have never been domesticated; they may return to the wild easily and even they may interbreed with those still living in the wild. The taming of plants and animals also fostered the geographical dispersion of these species. For instance, the wild pig living in many European Islands[36] was introduced there by human during the Mesolithic period. All these taming activities by hunter-gatherers involving plants and animals are forms of a proto-agriculture.[37] In some places – the so-called nuclear zones[38] – some

of these taming activities led to domestication, i.e. they contributed to the Neolithic transition. It should however be noted that the process from taming to domestication was a very long one, as illustrated by Larson *et al.* (2014, p. 6142): «In wheat, barley and rice, it took 2,000-4,000 years to fix the nonshattering spikelet phenotype, a key indicator of cereal domestication». The evidence for a slow pace of domestication implies long cultural periods in which predomestication activities occurred. These periods lasted for many centuries and have been inferred from evidence in the Near East and China. Moreover, the length of this domestication process may be explained by the difference[39] between conscious and unconscious selection. Indeed, during the domestication stage, conscious selection meant that humans directly selected for desirable traits.[40] By contrast, in the farming stage the selection of non-shattering seed in cereals – a trait which took 2,000-4,000 years to develop – is thought to have arisen as a by-product of stalk-harvesting by sickles. This case illustrates unconscious selection, i.e. traits evolving as a by-product of growth and natural selection in field environments. Therefore, this highlights the gradual nature of transition to agriculture and suggests that it arose from a trial-and-error process rather than a major deliberative one.

A Mixed Economy Based on Foraging and Farming

The domestication of plants and animals does not in itself support a sharp transition from hunting and foraging to an economy fully-based on agriculture. Indeed, domestication can be seen as an important innovation but many other innovations were required for the whole human population to be fed by produce from agropastoralist activities. Therefore, the complete transition to agriculture was a slow process. It seems that early agriculturalists for a long time were also involved in hunting and gathering. As Childe (1936, p. 82) states «It must be remembered too that food-production does not at once supersede food-gathering. [...] Grain and milk began as mere supplements to a diet of game, fish, berries, nuts and ants' eggs. Probably at first cultivation was an incidental activity of the women while their lords were engaged in the really serious business of the chase. Only slowly did it win the status of

an independent and ultimately predominant industry». In the beginning, most likely little or no economic surplus was yielded by agriculture. It probably was in the nature of an income support measure, rather than a major addition to income. A major step forward in Mesopotamia was the development of irrigation around 5900 BC and around 4500 BC the plough (called the ard) pulled by draught animals (donkeys or oxen) was introduced and the wheel was invented and used both for transport and making pottery. Heat-tolerant strains of wheat and barley were also selected. It was only with these additional and more advanced innovations that Mesopotamian farmers were able to produce surplus food.

7. *Diverse Reasons for Agriculture's Commencement in Different Centres*

The centers where the Neolithic revolution took place first are varied. The rise of farming and animal husbandry is clearly documented by archeological studies which demonstrate it occurred in a period spanning from 10,000 to 5,000 BC, the Neolithic revolution appeared independently in at least seven different locations worldwide: the Levant, North China, Mesoamerica, New Guinea, the Andes, North Africa and India. It is also widely accepted that animal husbandry appeared first in many of these centers, such as the Levant, but not all. The reason is that people were initially hunter-gatherers and therefore husbandry allowed them to produce and to store food – livestock – and also to keep their nomadic way of life. However, after few millennia, most of them gave up nomadism; they settled down and adopted agriculture. In these seven original centers, a great diversity occurred in the nature and number of plants and animals that were domesticated. In the case of plants, cereals (wheat, barley, rice, quinoa, maize) were the most common domesticates but were not present everywhere. In New Guinea, there were no cereals (the main domesticated plants were taro, bananas and later sugarcane). Similarly, the most common animals domesticated[41] were sheep, goats, cattle, pigs and chickens. However, in the Andes, only llamas were domesticated. Pigs and chickens were probably first domesticated in China and were then introduced to other

places. Substantial differences occurred in the availability of plants and animals where agriculture started. Indeed, there was little in common between the Mediterranean ecosystem of the Levant, the tropical forest of New Guinea and the highlands of Peru. Therefore, local ecogeographic conditions do not help us understand (as a global phenomenon) the transition from foraging and hunting to farming. Indeed, a precondition – or a necessary but not sufficient condition – for the development of agriculture and/or animal husbandry would be the presence of wild plants or animals suited to domestication and in the case of plants, climate conditions supportive of their cultivation. For example, neither agriculture nor animal husbandry were developed in Australia because there was a lack of plants suitable for domestication, no suitable animals for this purpose, and a climate unfavorable to agriculture.

8. *Natural Resources, Institutions and the Beginnings of Agriculture*

There is a debate among economists about whether economic development depends more on nature or on culture. This has led to the existence of two views or school of thoughts: for the first one, natural resource endowments (biogeographic and geographic conditions) are the prime determinants of economic development whereas institutions are central to the second theory. Each of these two views provides a different explanation of the Neolithic transition.

The Natural Resource Endowments View

After J. Diamond (1997), the various levels of economic development among societies were widely explained by differences in geographic and biogeographic conditions. Geographic conditions[42] include climate, latitude, soil, rain, orientation of continental axis [...]; biogeographic conditions consist of edible plants and animals suitable for domestication and cultivation. They mainly refer to, respectively, large-seeded grasses and large mammals. It should be noted that geographic and biogeographic conditions do not have separate influence; they have a combined influence on plants and animals. Indeed, every

plant or animal has certain habitat and environmental preferences. As such, they can only be cultivated and bred within their tolerance limits.[43] Environmental factors such as temperatures, precipitation, solar radiation during the growth season, the length of the vegetation period [...] had overall influence on the crops cultivated and the animals bred.

Many subsequent works following Diamond's publication have tried to verify the importance of these conditions as factors influencing the occurrence of the Neolithic transition and in promoting the further economic development of the regions concerned. Some of the necessary conditions for agriculture to emerge are more easily identified when the diffusion of agriculture is studied – rather than its origins. Indeed, in some areas the diffusion of agriculture has been hindered by geographical conditions (hills, mountains, rivers, seas). In some others areas, it has even been stopped by disease – in sub-Saharan Africa, cattle herding was not possible due to the presence of tsetse fly – or by ecological barriers such as the one that existed in the Carpathian Basin[44] where plants and animals reached in this place their tolerance limits and this stopped the diffusion of agriculture from the Balkans.

A central topic in several works[45] (following Diamond's publication) is about the influence of the timing of the transition to agriculture on further economic development. Implicitly or not, these works consider that institutions only have second-order effects on the economic development.

The Institution View

Following the definition given by D.C. North (1981, pp. 201-202), institutions are «a set of rules, compliance, procedures, and moral and ethical behavioral norms designed to constrain the behavior of individuals». In a later essay (North 1998, p. 81), he added: «If institutions are the rules of the game, organizations and their entrepreneurs are the players. Organizations are made up of groups of individuals bound together by some common purpose to achieve certain objectives. Organizations include political bodies, economic bodies, social bodies and educational bodies». On the basis of the previous definition, some authors[46] argue that the major impact of the environment

on economic development runs through its long-lasting impact on institutions.[47] In other words, tropics, germs, and crops do not affect country incomes directly other than through institutions. Among the various forms of the latter, the implementation of private property rights is considered[48] to be one of the main necessary condition for the Neolithic revolution to occur. To account for the difference of economic development among countries, various types of institutions have been defined:[49] inclusive ones favored economic growth whereas extractive ones lead to crisis, economic and social collapses after a while. However, many prehistoric and early historic societies were based on the extraction of an economic surplus and experienced economic growth, even if income per head remained low. The later are called «extractive» because such institutions are designed to extract incomes and wealth from one subset of society to benefit a different subset.

Mutual Causation Between Both Factors

Even though natural endowments were important in enabling agriculture to become established, one should not conclude that geographic or biogeographic determinism existed. Indeed, some resources were crucial at one point of time and of less importance later, due to innovation[50] or because they became more abundant through trade. Similarly, when we talk about necessary ecogeographic conditions, we immediately think of edible plants and animals suitable for domestication. However, a critical resource may not necessarily be a food resource. For instance, during the Neolithic period agriculture was highly dependent on stone tools, especially on stone axes used for forest clearance. Although they were not a staple food, stone tools were therefore a critical resource for the agricultural system; indeed, some of these stones were traded on several hundred kilometres from their origin area[51] which confirms that they were highly valuable.

Therefore, resource endowments were important in enabling agriculture to become established, although they were not unimportant for its sustainability. Institutions assumed increasing importance after agriculture was established and were also important for continuing development. In other words, both factors were important

st[illegible]t their relative importance varied along the development er[illegible]th of the agricultural system. For instance, human th[illegible]pital accumulation and intergenerational transmission of att[illegible]owledge were also necessary conditions;[52] consequently a [illegible]mbol system[53] was required for that purpose.

it[illegible] According to a recent work,[54] this combined influence [illegible] f both views could be explained by the following s [illegible]echanism: if we consider any center (e.g. Eurasia) where [illegible]nitially agriculture emerged, we must distinguish between i[illegible]e core and the periphery of this region. In the core (e.g. a[illegible]e Levant), economic development was important at the beginning but slowed afterwards. This is because the [illegible]nstitutions implemented in the core were extractive. In the [illegible]eriphery (e.g. North Europe and Scandinavia), agriculture was adopted by diffusion and the resulting economic development (including the traits defining «civilization») [illegible]ccurred later. Despite their later start, these countries are [illegible]owadays more developed – compared to the Near East [illegible]ountries – because their institutions were inclusive from the [illegible]eginning. However, we do not want to judge the validity or [illegible]therwise of that theory here.

[illegible] Despite this, we believe that social evolution as suggested [illegible]y G. Myrdal (1957), involved mutual causation. In other words, particular types of economic growth facilitated the development of particular institutions and social structures. Suitable natural resource endowments and appropriate institutional arrangements were needed for agriculture to be established and to develop. As agriculture developed, institutional arrangements increased in importance and co-evolution[55] occurred in production methods and in institutions.

9. *Discussion*

There are many different explanations of how and why agriculture first commenced. Table 1 provides a list of reasons and causal factors that have been seen as resulting in the commencement of agriculture in prehistoric times. These different types of motivating forces are identified together with their possible causes. The list may not be exhaustive[56] but it gives an idea of the diversity of views about why agriculture first commenced and the underlying causes for its start.

TABLE 1. *A classification of reasons why agriculture first commenced*

Reason	Causal Factors
Responding to food shortages	– Climate change (e.g. Childe's Oasis Theory) – Climate and seasonal variability – Population growth – Loss (reduced area) of hunting and gathering resources due to invasion – Other environmental disasters – Loss of territory due to formation of new colonies (in existing territory) by some tribal members
Food abundance	– Results in food being produced for ostentatious feasting – Allows experimentation with proto-agriculture
Not related to food shortages or abundance	– Curiosity and experimentation even if food is not abundant – Some crops found easy to cultivate e.g. bananas – Agriculture not purposively developed but a result of chance incidents

In addition to the reasons given in the literature for the development of agriculture being diverse, many different views exist about how it was developed. We believe that not only did the reasons for agriculture's development differ between geographical regions but also the way in which it developed, appears to have been varied.

10. *Conclusions*

Given the varied ecogeographic areas in which agriculture independently developed, we suggest that different causes contribute to its development in different parts of the world and that the patterns of its development also varied somewhat. Of course, in some cases, there may have been similarities between agricultural development in different epicenters but we suggest this was not so in all cases. The reasons why agriculture developed in the Levant and in North Africa are unlikely to be the same as in New Guinea or in the Americas. Furthermore, the eventual way in which early agriculture evolved was not the same in all ecogeographic regions. For example, the urban revolution based on agriculture did not happen in New Guinea but it did happen in Southwest Asia. Therefore, a more diverse approach to considering the development of agriculture is needed than has been apparent in the past. Most theories of agricultural development have focused on Southwest

Asia's experience. Agricultural development (in our view) was globally heterogeneous in nature and in its causes rather than homogenous. Ultimately, the nature of agricultural development influenced the type of social institutions which emerged with the passage of time. These institutions co-evolved with changes in technology and in patterns of economic activity. In the beginning, the scope for economic development was dependent both on natural resources and cultural factors, but the former became less important as economic development proceeded.

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1 For a complete and recent survey of the anthropological and economic approaches to the Neolithic transition, see Weisdorf (2005).

2 Such as the Nile, Euphrates and Tigris rivers.

3 See Braidwood (1960).

4 Ashraf, Michalopoulos (2011).

5 See for instance Dow, Reed, Olewiler (2009).

6 Rosen, Rivera-Collazo (2012).

7 Chronologically, these HG societies living in the Near East were: the Kebarans (21-17 ky/BP), the Geometric Kebarans (17-14,6 ky/BP), the early Natufians (14,8-13;1 ky/BP), and the late Natufians (13-11,5 ky/BP) who were coinciding with the Younger Dryas. It is during the Pre-Pottery Neolithic A (11,7-10,5 ky/BP) period that the cultivation of domesticated plants occurred.

8 The Levant is within the Mediterranean climatic zone where vegetation zones are complex: woodlands dominated the west and the north while grasses and other steppic plants are present in the east and the south. In this context, the vegetation respond to climatic changes by shifts in boundaries and shrinking or expanding within their respective zones.

9 Jarmo is an archaeological site located in northern Iraq on the foothills of Zagros Mountains.

10 Binford (1968), Cohen (1977).

11 E.g. in Johnson, Earle (2000).

12 E.g. V.G. Childe (1936) and his followers.

13 For instance Johnson, Earle (2000).

14 Harlan (1995).

15 Cohen (1977, p. 279) suggested that the nearly simultaneous adoption of agricultural economies throughout the world at the end of the Pleistocene can «only be accounted for by assuming that hunting and gathering societies populations had saturated the world approximately 10,000 years ago and had exhausted all possible strategies for increasing their food supply within the constraints of the hunting-gathering life-style».

16 If an analogy with recent HG groups is acceptable, one may recall that HG groups today tend to live in equilibrium with their environment.

[17] Childe (1936) and his «Oasis theory» is based on such scheme.

[18] This case can be illustrated by the way of life of complex HG (e.g. the Natufians).

[19] Roberts (2004).

[20] Flannery (1969).

[21] E.g. prestigious polished axes, furs of scarce animals, jewelry (made from amber or spondylus shell...).

[22] Many contributions in the literature are emphasizing the role of social competition or feasting to explain the Neolithic transition. See for instance Bender (1978) or Hayden (1990).

[23] The Ertebølle-Ellerbeck culture is the name given to the Late Mesolithic/Early Neolithic communities of Northern Europe-South Scandinavia, dated between 5400-3900 BC, consisting of fisher-hunter-gatherers who adopted pottery but not agriculture from their neighbors.

[24] Zvelebil (2001).

[25] The Linearbandkeramik Culture (also called Bandkeramik or Linear Pottery Ceramic Culture or simply abbreviated LBK) is the first true farming communities in Central Europe, dated between about 5400 and 4900 BC.

[26] Lee, DeVore (eds.) (1968).

[27] Sahlins (1974).

[28] See e.g. Stock, Pinhasi (2011).

[29] See Smith (1993, pp. 17-18).

[30] Cheyenne, Arapaho and Pawnee.

[31] See Diamond (2002) for an overview of the causes, evolution and consequences of plant and animal domestication.

[32] Zvelebil, Pluciennik (2003).

[33] In Australia, Aborigines used this technology since at least 9000 BC.

[34] In South California, once the seeds were harvested, the Kumeteyaay were burning the fields and thereafter they were sowing some of the seeds they had harvested.

[35] *Rangifer tarandus*.

[36] E.g. Ireland, the islands of the Baltic sea (Gotland, Bronholm and Saaremaa), Corsica and Sardinia.

[37] Pryor (2004).

[38] Braidwood (1960).

[39] Darwin was the first to make explicitly this distinction.

[40] E.g. some Asian cultures had consciously selected glutinous grains of rice for their cuisine-prized trait.

[41] We do not consider here the domestication of dog; it began earlier (during the Pleistocene) but was mainly motivated to ease human hunting activity rather than to provide food.

[42] Gallup, Sachs, Mellinger (1999).

[43] This phenomenon is called the minimum limiting factor; Liebig (1840).

[44] See Kertész, Sümegi (2001).

[45] Olsson, Hibbs (2004, 2005), Chanda, Putterman (2007), Putterman (2008).

[46] Easterly, Levine (2003).

[47] Including technologies.

[48] North, Thomas (1977), Bowles, Choi (2013).

[49] Acemoglu, Robinson (2012).

50 Some stones (e.g. flint or obsidian) were valuable during the Neolithic period and used to make tools and weapons. However, with the introduction of metal-working, they became less valuable.

51 Tykot (2004).

52 See e.g. Smith (1993).

53 It could be the spoken language and, for the elite, also the written language.

54 Olsson, Paik (2012).

55 For a discussion of co-evolution of social and economic systems in relation to the state of the environment and natural resources see Tisdell (2009, pp. 50-52).

56 An example of a theory about the origin of agriculture which, despite its importance, is not covered in this article is J. Cauvin's one (2000). This author argued that the Neolithic revolution was influenced by a change in thinking as much as changes in the environment. One of his most important themes was the «Revolution of the Symbols» and the birth of «religion» in the Neolithic.

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