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Out of the Woods
Food and Climate
A series of articles looking at the past, present and future of food production and climate change.
March 9, 2015

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of gender equality, of non-hierarchical grassroots organisation, and certainly, the focus on autonomous social reproduction through non-commodified food, housing, and healthcare provision, cannot be dismissed as merely the parochial perspective of petty commodity producers. But agroecology's prospects of a wider overcoming will necessitate a communising movement that encompasses urban struggles, refugee movements, and the selective repurposing of technologies bequeathed by capitalism, (re)inventing cyborg methods or reviving old ones, and unromantically finding what is adequate to the unfolding climate disaster.

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But the prospect of, for example, incorporating symbiotic nitrogen-fixing bacteria - currently limited to legumes - into staple crops is not to be dismissed lightly. For one thing, it would massively reduce dependence on synthetic fertilisers made with the energy-intensive Haber process. However, cyborg ecology is not an inherent preference for the 'high' tech. From the cyborg point of view, the assemblage peasant-ox-plough is no more or less a techno-natural mesh than the assemblage AI-drone-GMO. The point is that bricolage practically appropriates whatever materials are to hand. For example as the glaciers that provide billions of beings with freshwater retreat, even maintaining traditional agriculture may well require desalination technology and knowledge of fluid mechanics to maintain irrigation. Or a reprisal of 'archaic' stormwater collection and distribution systems could play that role. Or some combination of the two.

It is capitalist social relations which pit agricultural technology against agricultural workers, scientific knowledge against mētis. It is also this system of relations that makes local commodity production appear like the only alternative to global commodity production. They, not machines or transgenics per se, form the barrier to the kind of bricolage necessary to avoid the kind of hunger inevitable under market dynamics. Agrarian social movements are surely essential to overcoming such a barrier, but the perspective of petty commodity production also forms part of that barrier. Yet it is a perspective that is prevalent in the existing movements.

If asked to point to the project of overcoming of commodity relations, we would highlight the communal approach to production and *also distribution* - i.e. the *right to food* - that La Via Campesina sometimes speak of, along with many of the related activities of some of their affiliates and allies. The promotion

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den shocks that shouldn't exist." - see: Autonomisation, financialisation, neoliberalism.

varieties to preserve biodiversity - could overcome many of the technical ones. Transgenic techniques can, in principle, be proprietary or commons, used for profit-seeking or ecological ends.

Using GMOs may, of course, be unnecessary and expensive, since there are tried and tested 'traditional' methods for developing new crop varieties in a biodiverse manner.[34] However, the disaster of the 4, 5, or 6℃ world we can expect to inhabit by 2100 will be an agricultural situation unlike any humans have ever encountered. Our world will also likely be changing at a rate that may challenge traditional breeding techniques. True, GMOs are not as fast to develop as their boosters claim. And current investments in transgenics are driven by the prospect of monopoly rents through intellectual property, to which conventionally unobtainable, uniquely useful phenotypes are a secondary concern. Could GMOs be useful to us amid disaster? The point is largely moot under capitalist conditions, where the benefits of, for example, golden rice, are offset by the centralisation of capital, the dispossession, impoverishment and urbanisation of the rural population, and the extension of the very market dynamics which ensure mass hunger amidst plenty.[35]

[34] Commenting on the identification of the gene variants responsible for desirable traits in rice, Susan McCouch, a rice geneticist at Cornell University, said: "The breeders have already accomplished this; they don't need these people doing the molecular genetics." See: Marris (2015), Geneticists reveal what makes great rice, Nature News, 6 July 2015. Available at: http://www.nature.com/news/geneticists-reveal-what-makes-great-rice-1.17918

[35] Production for the world market drives financialisation of agriculture, as farmers hedge price volatility with credit, futures, and options, or are simply forced into debt, while the financial sector speculates on such assets. Such speculative dynamics were central to the 2007-8 world food price crisis. "Completely connected markets can generate feedback and loops which in turn create unexpected emergent behaviour (…) in increasing the autonomous flow of capital, directed by high frequency trading algorithms designed to expect static relationships, the markets create flash crashes, sud-

Climate, class, and the Neolithic revolution

When people think of the impacts of climate change, sea level rise is often the first that comes to mind. Two recent studies have concluded that the loss of large parts of West Antarctica is now a question of when not if, with sea level rises of around 3 metres as soon as the next couple of centuries. New research also suggests that both East Antarctica and Greenland are more vulnerable than previously thought. The prospect of coastal cities, like Norfolk, VA, abandoned to the sea stirs the apocalyptic imagination, but the timescale is centuries to millennia. Food may turn out to be a much more pressing issue.

The latest IPCC report suggests that climate change will reduce agricultural yields on average by up to 2% per decade in a context of demand rising by 14% each decade.[1] With higher amounts of warming – business as usual could mean 3℃ or more by 2100 – the prospects for agriculture get worse. And regional climate change can diverge quite significantly from the global average. With warming, things also get far less predictable, since anything above 2℃ is unprecedented in the last million years (human agriculture has existed for around 10,000 years).

IPCC AR5 WGII wrote:

> Under scenarios of high levels of warming [business as usual], leading to local mean temperature

[1] AR5 WGII.

> increases of 3-4℃ or higher, models based on current agricultural systems suggest large negative impacts on agricultural productivity and substantial risks to global food production and security.

The future of food production therefore faces much uncertainty due to climate change. For many, the go-to common sense is Malthusian - overpopulation. There's simply too many of us, so someone [black, brown, poor, elsewhere] has to go hungry. For others, the solution lies in the extension of capitalist property regimes through the privatisation of agrarian commons, and the accelerated application of biotechnology to agriculture. For the peasant international La Via Campesina and their Western NGO allies, the solution lies in 'food sovereignty', empowering subsistence producers on the land. To address the future of food, it will first be helpful to consider the past. A long historical view offers important perspective on the relationship between climate, agriculture, and class society.

Ancient history

The genus *Homo* emerged around 5 million years ago, while the species *Homo sapiens*, our own, the sole extant species of the genus, emerged around 200,000 years ago. Agriculture emerged only around 10,000 years ago. This transition, which took place independently in at least six global centres, is known as the *Neolithic revolution*. What relevance does ancient history, or strictly speaking, prehistory, have to today?

We think there are two main points of relevance. First, the Neolithic revolution represents a dramatic, and ultimately global transformation of the mode of (social re)production, induced in part by climate change. As we face even bigger climate change, we think there are some important lessons about how such transitions take place. Second, there is a common association between the spread of agriculture and

life-ending non-organic agriculture. The mētis practices of cyborg ecology are likely to defy simplistic distinctions between the modern and the earth-friendly. For example, selective application of insecticides, to minimise worker-exposure, may be best carried out by drones. Such ostensibly 'un-holistic' practices could exist side-by-side with more traditional methods, as appropriate.

It is to petty commodity producers that the strict delineation of organic agriculture *makes sense*. Their livelihoods require them to seek the highest market price for their commodities, and an 'organic' label is more marketable than a 'pesticides as a last resort' one.[33] It is in this context that much of the activism of La Via Campesina, the MST, and Navdanya takes place. This is also a limit to the autonomy of the EZLN: one can escape the wage relation locally, to an extent, but not generalised commodity production.

Shiva is right to emphasise the importance of self-organisation by agrarian producers, but wrong to translate this into championing local markets. Note that petty commodity production is always confronted by technology *as the centralisation of capital* (i.e. the threat of being squeezed out by more highly capitalised rivals). Its perspective often seeks to promote commons and cooperatives as alternative forms of production, yet misses the potentials for bricolage from newer technologies, including labour-saving ones, since those technologies come as a threat to the livelihoods of smaller producers. Agricultural bricolage could even include transgenics: treating GMOs as part of the genetic commons overcomes many of the economic objections; developing climate-resilient, low-input strains - conventionally cross-bred with existing

[33] However, it is a common misconception that organic crops are necessarily pesticide free. Some traditional but highly toxic, persistent, and broad spectrum synthetic pesticides - such as copper sulphate - are often allowed, as is the 'natural' Bacillus thuringiensis bacterium (from which transgenic Bt maize's toxins are derived).

ban poverty, rather than relief from drudgery and a multiplier of communal wealth? Under what conditions does scientific knowledge confront the mētis of producers on the land as the vanguard of capitalist dispossession, and when can it, instead, form one of the stock of materials available for bricolage? To what extent can traditional techniques be combined with modern technology to boost yields, reduce toil, and maintain ecological relations at the same time? One such practice is Integrated Pest Management (IPM):

> Although IPM approaches have always included insecticide tools, there are other approaches that can be effectively incorporated with IPM giving chemicals the position of the last resort in the chain of preferred options that need be applied first. Note that the current practice of seed treatment is the opposite: it applies chemicals as the first applied option instead of the last resort. The preferred options include organic farming, diversifying and altering crops and their rotations, inter-row planting, planting timing, tillage and irrigation, using less sensitive crop species in infested areas, using trap crops, applying biological control agents, and selective use of alternative reduced-risk insecticides.[32]

Mētis, bricolage, and disaster communism

Integrated Pest Management is one of many possibilities occluded by the rhetorical binary between life-giving organic and

[32] van der Sluijs et al (2015), Conclusions of the Worldwide Integrated Assessment on the risks of neonicotinoids and fipronil to biodiversity and ecosystem functioning. Environmental Science and Pollution Research. January 2015, Volume 22, Issue 1, pp 148-154. Available at: http://dx.doi.org/10.1007/s11356-014-3229-5

the rise of class society. We wish to challenge the 'common sense', promoted by popular writers like Jared Diamond, that we can have agriculture or egalitarianism, but not both.

For the avoidance of any doubt, we do not discuss the transition to agriculture out of any desire to return to a hunter-gatherer mode of subsistence. Historically, such a mode of subsistence supported only around 5 million people, far short of the 10-11 billion likely to populate the Earth by the end of the century.[2] A return to pre-agricultural living is neither possible nor desirable. But a long historical view puts contemporary questions of climate, food, and class society into the proper perspective.

The rise of agriculture

Jared Diamond's bestseller 'Guns, Germs, and Steel' tells the story of the emergence and spread of agriculture from the fertile crescent, the region between the Tigris and Euphrates rivers in modern day Iraq and the Nile of modern day Egypt. However, there were at least six independent centres of agriculture. The near east centre (Syria-Palestine) emerged around 9-10,000 years ago; the central American centre (southern Mexico) about 4-9,000 years ago; the Chinese centre (Yellow River) about 8,500 years ago; the New Guinean centre (Papua New Guinea) about 10,000 years ago; the south American centre (Peruvian-Ecuadorian Andes) about 6,000 years ago; and the north American centre (Mississippi basin) between 2-4,000 years ago.[3]

The question is then, why did agriculture emerge independently in so many distant centres in a relatively narrow window of time? Anthropologists and archaeologists disagree

[2] This estimate comes from Mazoyer & Roudart (2006), *A history of world agriculture: from the Neolithic age to the current crisis*, Earthscan, p.65.

[3] Mazoyer & Roudart, p.75.

on the details. There is no disagreement however that climate change played a major role. 12,000 years ago marked the beginning of the Holocene epoch, and the end of the last ice age (the glacial-interglacial cycle is a natural climate variation driven by variations in the Earth's orbit known as Milankovitch cycles). For example, in the near east centre ('the fertile crescent'):

Mazoyer & Roudart, p.76 wrote:

> ...the post-glacial warming up of the climate entailed a progressive shift from a cold steppe ecosystem, characterised by the dominance of artemisia to a savanna ecosystem characterised by the dominance of oaks and pistachios, rich in wild grains (barley, spelt, emmer wheat, etc) and also other exploitable plant resources (lentils, peas, vetch, and other legumes), as well as various game animals (wild boars, deer, gazelles, aurochs, wild sheep, wild goats, rabbits, hares, birds, etc) and in some places fish.

However, this abundance created only the potential, but not the necessity for a transition to agriculture. In fact, it is believed that agriculture would have initially meant longer and harder work than hunter-gathering. For hunter-gatherers, there was no distinction between work and play, and in fecund environments at least, only a few hours hunting or foraging each day was sufficient for a band to reproduce itself. For this reason, hunter-gatherers have been dubbed 'the original affluent society', since leisure was abundant and the work-play distinction absent. So why did they take up agriculture?

It would be a mistake to generalise, since this process happened independently in widely dispersed places. Candidate factors include population growth exceeding the capacity of the environment or coercion. However, it would also be a

and also inaccurate. As scholar of agrarian studies James C Scott insists:

> The term 'traditional' (...) is a misnomer. (...) The apparent spread of variolation across four continents is a further instance of how 'traditional peoples' will embrace techniques that solve vital problems. Examples could be multiplied. Sewing machines, matches, flashlights, kerosene, plastic bowls, and antibiotics are only a tiny sample of the products that solved vital problems or eliminated great drudgery and were thus readily accepted.[30]

For Scott, so-called 'traditional agriculture' is dynamic and plastic, the work of *bricoleurs* who make use of whatever materials and techniques are to hand, including selective use of the products of science and technology. The practical knowledge thus acquired - which he calls mētis - often runs ahead of scientific knowledge since it is based in trial-and-error experimentation and tinkering. Bricoleurs may know *that* something works before they know *how* it works, albeit at higher risk of inferential errors (false positives/negatives). Therefore, rather than affirm the traditional side of the traditional-modern binary we should inquire into, and seek to overcome, *the conditions under which it makes sense.*[31]

That is, what conditions are necessary for labour-saving agricultural technology to be experienced as dispossession and ur-

[30] James C Scott, Seeing Like a State, p.331.

[31] This framing is based on Fred Moten's reading of Frantz Fanon: "Fanon, according to Moten, wants not the end of colonialism but the end of the standpoint from which colonialism makes sense." Moten & Harney (2013), The Undercommons: Fugitive Planning & Black Study, Minor Compositions, p.8. It also reflects Glen Coulthard's argument in Red Skin, White Masks that the aim of indigenous resurgence is not to reify traditional practices and culture but to build something new, alternative to settler-capitalism informed by indigenous values.

Shiva's claim that "to be organic means to be whole and wholesome",[26] and the corresponding sharp binary distinction between "authentic organic farming [which] gives life [and] pseudo-organic farming [which] ends life."[27] For Shiva, the organic 'whole' includes a need to "respect physical work, give it dignity". She insists:

> We need to shift the way we define and perceive physical work. Replacing people has been defined as liberating people from work. Physical work has been defined as drudgery and as degrading (…) In fact, it is being without work that is degrading.[28]

From our perspective, this association between labour intensivity and 'dignity' is to be rejected in the first instance. We suspect that Shiva would agree in most instances with Camus when he said "the machine is bad only in the way that it is now employed."[29] Further, the corresponding binary between a traditional, 'natural', stable, life-giving, low-tech agriculture - based on fulfilling hard work - on the one hand, and modern, 'synthetic', dynamic, high-tech, capital-intensive agriculture - that is toxic, part-automated and degrading - on the other, is itself part of the problem to be overcome. A story about two starkly opposed sides, it is of a piece with the self-image of colonial-capitalist modernity, in which good things like progress and modernization occur when dynamic Europe meets the people without history. Affirming the traditional side of this binary against capitalism is inadequate,

[26] Vandana Shiva, Soil Not Oil, p.124.

[27] Vandana Shiva, Soil Not Oil, p.126.

[28] Vandana Shiva, Soil Not Oil, p.139.

[29] From Camus' The Rebel. The passage reads: "it is useless to want to reverse the advance of technology. The age of the spinning-wheel is over and the dream of a civilization of artisans is vain. The machine is bad only in the way that it is now employed. Its benefits must be accepted even if its ravages are rejected (…) The real and inhuman excess lies in the division of labor."

mistake to dismiss agency, that is, choices to live differently. Agriculture did not emerge immediately following the post-glacial warming. The weakness of deterministic accounts is stressed by Mazoyer & Roudart, who insist that "as necessary as this revolution appears after the fact, nevertheless it cannot be explained by nor is it reducible to this necessity."[4] Furthermore, the knowledge, tools, and capacity for agriculture were present far before it was widely adopted. As David Cleveland writes, "it seems unlikely that a lack of basic knowledge prevented humans from taking up agriculture earlier."[5] In this respect, the Neolithic revolution was a break which occurred through the recombination of existing knowledge, tools, and social organisation into new forms of life.

Surplus calories and class society

Jared Diamond's popular account links the calorie surpluses made possible by agriculture with the emergence of non-producing social strata, that is to say, the stratification of society into classes. For Diamond, "with agriculture came the gross social and sexual inequality, the disease and despotism, that curse our existence."[6] However, calorie surpluses were possible even in hunter-gatherer societies, and as one critique of Diamond points out, "there are certainly many non-state horticultural and agricultural societies."[7] Diamond's determinist account is probably the most influential, but it also has strong similarities with many Marxist ones (via Engels

[4] Mazoyer & Roudart, p.98.

[5] Cleveland (2013), *Balancing on a planet: the future of food and agriculture*, University of California Press, p.55.

[6] Diamond (1987), *The worst mistake in the history of the human race*, Discover Magazine.

[7] Antrosio (2011), *The many origins of agriculture. Living Anthropologically*, http://www.livinganthropologically.com/anthropology/many-origins-of-agriculture/.

and Mumford), as well as primitivist or anti-civilisational perspectives (which accept the equation of civilisation with class society, and thus oppose both).

A powerful critique of the Marxist version of stagism is set out by Gilles Deleuze and Felix Guattari.[8] They draw on the work of anthropologist Pierre Clastres to reject the idea of history as a linear development from primitive to advanced stages.[9] Deleuze and Guattari's critique rests on three points: (1) development seems to 'zigzag' back and forth rather than pass gradually through successive stages; (2) the archaeological record and anthropological theory supports the existence of sudden breaks and discontinuities, i.e. the emergence of a state or city without passing through all the supposedly intermediate stages, and; (3) what they call 'reverse causality', that is, the ability of something which does not yet exist to exert causal force on the present.

It is this last point which is most original, but also, which requires the most explanation. The example they give is Pierre Clastres' concept of society against the state. For Clastres, non-state societies are not pre-state, that is they're not lacking in some way, or failures at linear development. Rather, egalitarian societies recognise the potential for the centralisation of power and stratification of the society – state formation – and develop material-cultural practices which ward off this potential. Thus even before it exists, the state exerts causal force on society.[10]

[8] See A thousand plateaus, proposition XI from page 427. They call this linear stagism 'evolutionism', meaning a gradual accumulation of small changes. This is in line with Darwin's view of evolutionary change. Writing in 1980 in French, Deleuze and Guattari were seemingly unaware of Eldredge and Gould's 1972 notion of punctuated equilibrium, which somewhat reconciles evolution with relatively rapid shifts at critical thresholds.

[9] By contrast, primitivism accepts this historiography, but performs a normative inversion where the 'primitive' is good and civilisation is bad.

[10] This kind of anticipatory causality features heavily in game theory, where not just present facts but future expectations structure decisions. A more contemporary example would be the fact the Cold War is incomprehen-

Cyborg ecology

> Imagine you're a rice plant. What do you want? You want to grow up and make babies before the insects who are your predators grow up and make babies to eat your tender shoots. So you divide your energy between growing as quickly as you can and producing toxins in your leaves to repel pests. Now let's say you're a researcher trying to wean the Californian farmer off pesticides. You're breeding rice plants that produce more alkaloid toxins in their leaves. If the pesticides are applied externally, they count as chemicals - and large amounts of them find their way into the bodies of illegal immigrants from Mexico who are hired to pick the crop. If they're inside the plant, they count as natural, but they may find their way into the bodies of the consumers who eat the rice.[25]

Donna Haraway's point is not just to note that 'natural' does not equal 'good', a fallacious appeal to nature all too common in environmental rhetoric. Crucially, her claim is that the neat distinction between 'natural' and 'artificial' itself does not withstand scrutiny. As Haraway puts it in the Cyborg Manifesto: "the certainty of what counts as nature — a source of insight and promise of innocence — is undermined, probably fatally." Riffing on Haraway, we call this insight *cyborg ecology*.

A cyborg suspicion of 'organic holism' - the notion of an original wholeness - and sharp binaries between natural and artificial, living and nonliving, can be productively applied to many aspects of the contemporary advocacy of organic farming. This perspective can generatively be contrasted to

[25] Donna Haraway http://archive.wired.com/wired/archive/5.02/ffharaway_pr.html

the emissions involved in synthetic fertiliser manufacture, emissions from transport and refrigeration, possibilities for soil-based carbon sequestration, and the pollution caused by agrichemical runoff are all taken into account, it does seem plausible that the narrow economic efficiency of capital-intensive agriculture may disappear using a wider ecological calculus.

Additionally, most comparisons between conventional and organic are under optimal conditions - precisely the kind of stable, predictable growing conditions threatened by climate chaos. "Extrapolations of future crop yields must take into account the high likelihood that climate disruptions will increase the incidence of droughts and flooding in which case (…) OA [organic agriculture] systems are likely to out-yield CA [conventional agriculture] systems."[22] This is because conventional high-yielding varieties are optimised for fairly specific growing conditions, including high water inputs, and for grains in particular, "temperatures over 30℃ cause an escalating pattern of damage."[23] However alternative practices can have greater climate resilience. For example, intercropping a taller crop can provide cooling partial shade, while organically farmed soils are often more resistant to water and wind erosion. Ecological efficiency should also include the effects of shifting from feeding cattle (feedstock)[24] and cars (biofuels) to feeding people, and measures to reduce massive food waste. It is precisely this reckoning with a multiplicity of incommensurable use-values which eludes capitalist commodity production.

[22] Lotter, D.W. (2003), Organic agriculture. J. Sustain. Agric. 21(4). Available at: http://donlotter.net/lotter_organicag.pdf

[23] Lynas (2008), op cit, p.157.

[24] As a rule of thumb, only about 10% of the energy consumed at one trophic level (cow eats grain) is available at the next trophic level (human eats cow). Therefore in general, shifting from meat to edible crop production increases the calories available to humans from a given area of land by an order of magnitude . See wikipedia on energy flow.

Together, zigzagging, breaks, and reverse causality make a linear, stagist account untenable. Consequently, Deleuze and Guattari also make a distinction between the rise of agriculture and settlement, and the rise of the state: "the 'urban revolution' and the 'state revolution' may coincide but do not meld." Rather there are simultaneous processes towards nomadism and settlement on the one hand, and social stratification and levelling on the other. Agriculture does not necessitate class society. This conclusion is supported by the more mainstream literature:

> While centralized control may be necessary for irrigation systems to function, it does not necessarily need to be in the form of social hierarchy (…) groups of users working co-operatively can successfully fulfil the same function.[11]

We can extend the notion of anticipatory causality to the present. Just as the state haunts non-state societies and must be continually warded off, the dissolution of hierarchy haunts state societies. It too must be warded off, if the state is to reproduce itself. The modern state is the capitalist state: guarantor of private property and a major agent of capitalist development. The state is haunted by communism – stateless, non-market self-organisation. This helps to explain the violent repression of seemingly harmless public square occupations and disaster communities, as well as the constant xenophobic demonization and repression of migrants and the hyping of terrorism, among other things, as existential threats to the national body. The state is never established once and for all, it must continually ward off the threat of communism which haunts it.

sible without World War III – the prospect of nuclear Armageddon exerted causal force even though it was never actualised.

[11] Cleveland, p.70.

Conclusions

The emergence of agriculture, and civilisation itself, was made possible by climate change at the end of the last ice age. A few degrees of warming dramatically transformed ecosystems. Agriculture emerged in at least six independent centres, and cannot be explained by a linear, stagist account. Societies chose to revolutionise their mode of subsistence, albeit under circumstances not of their choosing. This revolution made use of knowledge and tools already present in hunter-gatherer societies, but recombined them in a new mode of (social re)production. The emergence of settled agricultural civilisations and class society was sometimes contemporaneous, *but these were distinct processes.*

The earth only supported around 5 million hunter-gatherers and there is no going back. The challenge is to organise agriculture in a sustainable way to feed 10-11bn people. By sustainable, we mean a way which doesn't undermine its own conditions of production, for example by driving climate change, making pollinators extinct, or depleting the soil. Ecological science is indispensable here. In future posts we will look at the emergence of specifically capitalist agriculture through enclosures, colonialism, and plantation slavery. Then we will be in a position to look at the current problems and future possibilities for feeding the world under unprecedented conditions of climate chaos.

like-for-like comparison. However individual studies - rather than systematic reviews or meta-analyses - do exist. One 2007 study found that "for most food categories, the average yield ratio was slightly <1.0 for studies in the developed world and >1.0 for studies in the developing world."[18] As even the favourable studies don't find large superior organic yields, we are compelled to doubt Shiva's claims on this count.[19] However, Shiva also makes an important argument against a narrow focus on physical or economic yields:

> The promotion of so-called high-yielding varieties leads to the displacement of biodiversity. It also destroys the ecological functions of biodiversity. The loss of diverse outputs is never taken into account by the one-dimensional calculus of productivity. When the benefits of biodiversity are taken into account, biodiverse systems have higher output than monocultures.[20]

This claim is plausible so long as 'output' is understood broadly to include both negative and positive 'externalities'. Notwithstanding the problems with attempting to price so-called 'ecosystem services', estimates suggest they "contribute more than twice as much to human well-being as global GDP."[21] When factors such as the poisoning of essential pollinators by insecticides, the depletion of soil fertility and

[18] Badgley et al (2007), Organic agriculture and the global food supply, Renewable Agriculture and Food Systems: 22(2); 86-108. Available at: http://www.stopogm.net/sites/stopogm.net/files/Orgsupply.pdf

[19] Even more dramatic claims are made by partisans of permaculture, claiming physical yields 800% higher than conventional maximums! See: http://www.whale.to/a/blume.html

[20] Vandana Shiva, Soil Not Oil, p.113.

[21] Costanza et al (2014), Changes in the global value of ecosystem services, Global Environmental Change Volume 26, May 2014, Pages 152–158. Available at: http://dx.doi.org/10.1016/j.gloenvcha.2014.04.002

legumes and perennials on weak-acidic to weak-alkaline soils), 13% lower yields (when best organic practices are used), to 34% lower yields (when the conventional and organic systems are most comparable)."[15] Shiva however, argues precisely against a like-for-like comparison, insisting that the alternative to high-input monoculture is low-input biodiversity (i.e. forms of polyculture).

A table presented by Shiva claims physical yield gaps of 23%, 66%, and 75% *in favour of* "biodiverse" vs "monoculture" production for three comparison sets.[16] However, the reference is to an unspecified "Navdanya study" (Navdanya is the NGO Shiva co-founded), not a peer-reviewed scientific publication. The claim is not as implausible as it may sound. Polyculture practices can fill more ecological niches in the same space, and can, in principle, therefore boost *physical* yields while preventing weeds and limiting pests. On the other hand, polycultures can be less amenable to mechanical harvesting, and so are often more labour-intensive and less *economically* productive. A study in the *Proceedings of the Royal Society* did find "that two agricultural diversification practices, multi-cropping and crop rotations, substantially reduce the yield gap (to 9±4% and 8±5%, respectively) when the methods were applied in only organic systems" (these same techniques also boosted non-organic production, maintaining a yield gap in like-for-like comparison).[17]

We have not been able to find any meta-analysis or systematic review in the peer-reviewed literature that shows yield gaps in favour of organic agriculture, especially in

[15] Seufert, V., Ramankutty, N. & Foley, J.A., 2012. Comparing the yields of organic and conventional agriculture. Nature, 485(7397), pp.229–232. Available at: http://dx.doi.org/10.1038/nature11069

[16] Vandana Shiva, Soil Not Oil, p.116.

[17] Ponisio LC, M'Gonigle LK, Mace KC, Palomino J, de Valpine P, Kremen C. 2015 Diversification practices reduce organic to conventional yield gap. Proc. R. Soc. B 282: 20141396. Available at: http://dx.doi.org/10.1098/rspb.2014.1396

Class struggles, climate change, and the origins of modern agriculture

> The last half-millennium of the Earth's natural history has been a time of dramatic and accelerating change. One has to look to the beginning of the Holocene, with the climatic amelioration after the last ice age and the Neolithic agricultural revolution, to find a period which produced changes of comparable significance for human-environmental relations.[1]

A diverse range of agricultural practices and social relations proliferated between the Neolithic origins of farming and the early modern period which began some 500 years ago. But in order to explore the future of food production under climate change, it is this transition to modern agriculture which is of most interest. This question is intimately bound up with the origins of capitalism. Here, climate change and class relations combined, and through a series of food crises led to the transformation of world agriculture through enclosures and colonialism.

[1] Neil Roberts (1997), The Holocene: an environmental history, Blackwell, p.155.

The Little Ice Age and global agrarian crises

The Little Ice Age of 1550-1850, while not a true ice age, was a period of global climatic cooling which was most pronounced in the northern hemisphere. Cold summers and freezing winters caused crop failures, chronic food crises, and famines across the world. In the Ottoman empire (centred in modern-day Turkey), this exacerbated conflicts over land, peasant rights, and agrarian taxation, and provoked flight to the towns and food riots.

In the Mughal empire (a Persian empire extending into most of modern-day India), the Little Ice Age saw a series of famines and food crises, the worst of which occurred in 1630-1632. The Shah (in)famously began building the Taj Mahal in 1631 to commemorate his dead wife, diverting huge resources which could have been used for famine relief. Mounting rebellions and rural conflicts weakened the Mughal hold on India, and contributed to the relative ease with which the British took control of the region from the mid 18th century.

Famines and peasant rebellions also wracked China during the late Ming dynasty:

> …in 1630, a famine in the central province of Shaanxi led peasants to support the peasant rebel leader Li Zicheng. During the 14 years of Li Zhicheng's rebellion, his forces equalised land between rich and poor in the provinces they controlled, killed many rich landlords, and plundered and destroyed many estates. His rebellion overthrew the Ming dynasty in 1644, but then lost power to the Manchu invasion a few years later.[2]

[2] Mark Tauger (2011), Agriculture in world history, Routledge, p.60.

movements, which "brings together millions of peasants, small and medium-size farmers, landless people, women farmers, indigenous people, migrants and agricultural workers."[11] Insofar as a common interest is found, it is that of petty commodity producers versus the big capital of agribusiness. But, as these remarks have already intimated, opposition to the centralisation of capital is not necessarily opposition to capitalist relations per se.[12]

The organic yield gap

Shiva claims that "organic farming produces more food and higher incomes."[13] The latter part of this statement is very likely true; many Western consumers are willing to pay a premium for largely imaginary health and nutrition benefits.[14] The first part of the statement, however, is more questionable; or at least, more complicated. A comprehensive meta-analysis published in Nature found "5% lower organic yields (rain-fed

[11] LVC: http://viacampesina.org/en/index.php/organisation-mainmenu-44

[12] "It is concentration of capitals already formed, destruction of their individual independence, expropriation of capitalist by capitalist, transformation of many small into few large capitals. (…) This is centralisation proper, as distinct from accumulation and concentration." Marx, Capital vol.1, chapter 25.

[13] Vandana Shiva, Soil Not Oil, p.110. In scientific terms 'organic' farming is meaningless, since pesticides like DDT are organic compounds from a chemistry point of view, but colloquially the term has become well established as a vague synonym for 'natural' (restrictions on pesticide use and GMO content). See discussion of cyborg ecology below.

[14] A systematic review in 2012 found that "The published literature lacks strong evidence that organic foods are significantly more nutritious than conventional foods. Consumption of organic foods may reduce exposure to pesticide residues and antibiotic-resistant bacteria." Smith-Spangler et al (2012), Are organic foods safer or healthier than conventional alternatives?: A systematic review. Ann Intern Med. 157:348-366. Available at: http://dx.doi.org/10.7326/0003-4819-157-5-20120904

can lock in the ecologically damaging aspects of industrial agriculture, such as workers' exposure to toxic chemicals, death of pollinators, and pollution of waterways by agrochemical runoff. Indeed, GMOs like Monsanto's *Roundup Ready* lines are specifically designed to lock-in monopolistic use of their accompanying agrochemicals. There is also the question of the 'ecological arms race' triggered by pest-resistant GMOs. For example, in 2014, it was found that Bt maize - genetically engineered to produce insecticidal toxins derived from the *Bacillus thuringiensis* (Bt) bacterium - had created selective pressure for Bt-resistant pest species.[7] Such an arms race, in turn, further locks-in monopoly control by big agribusiness, amplifying the economic grievances.

LVC's proposed alternative to the dominant 'food security' approach is 'food sovereignty', understood as the right to "healthy and culturally appropriate food", prioritising "local food production and consumption".[8] Similarly, Vandana Shiva's understanding of food sovereignty is that:

> Self-organized production rests on the principles of agroecology, and self-organized distribution rests on the the principles of localisation - local consumption through local markets.[9]

Shiva's advocacy of local markets here comes within pages of her decrying that "food has been reduced to a commodity", while at the same time advocating "fair trade".[10] This tension reflects the class composition of contemporary agrarian social

[7] Gassman et al (2014), Field-evolved resistance by western corn rootworm to multiple Bacillus thuringiensis toxins in transgenic maize, Proceedings of the National Academy of Sciences in the USA. Vol. 111 no. 14, 5141–5146. Available at: http://dx.doi.org/10.1073/pnas.1317179111

[8] LVC: http://viacampesina.org/en/index.php/organisation-mainmenu-44

[9] Vandana Shiva, Soil Not Oil, p.126.

[10] Vandana Shiva, Soil Not Oil, p.123 and p.125 respectively.

In the Americas, both the Aztec and Inca empires had developed sustainable agricultural systems, but imperial expansion overstretched their food production capacities. This provoked agrarian rebellions and internal political conflicts. When the Spanish arrived from the early 16th century, they encountered empires in crisis, wracked by civil wars. This greatly aided the conquistadors, who were able to ally with rebel factions before taking control.

In Europe, reactions to the Little Ice Age were polarised on an east-west axis. In the east, the balance of class forces favoured the landed aristocracy, who were able to reimpose a 'second serfdom' on the peasantry. Servile practices were reimposed, and "Russian nobles sold serfs just as American planters sold slaves."[3] But in the west, the balance of class forces was more favourable to the peasantry, who won emancipation in numerous kingdoms and republics. While Spain was busy constructing the largest slave-based agricultural system in history in its American colonies, its domestic peasantry and Moorish slaves won emancipation.

The Atlantic, American, and Pacific plantation complexes

The Western European maritime powers, principally the Spanish, Portuguese, and Dutch, followed by the British, French, and others, were busy constructing colonial empires across the globe from the late 15th/early 16th century. This involved the construction of plantation complexes oriented to cash crops for export. The interest-bearing and merchant's capital which funded these conquests belonged to what Marx called "the antediluvian forms of capital, which long precede the capitalist mode of production."[4] That is to say that in them-

[3] Tauger, op cit, p.68.

[4] Karl Marx, Capital volume 3.

selves, the circuits of colonial capital served to reproduce the feudal social relations of their home countries. The emergence of a distinctly capitalist mode of production would coalesce only later.

The Dutch were most active in colonising the Western Pacific. Where the colonialists encountered hierarchical social systems, they were often able to co-opt local elites and thus formally incorporate local labour into their trading empires. However, when they encountered more egalitarian societies, this option was not available. One such society was the Banda Islands in modern day Indonesia. Here, village life was governed via assemblies, which limited the power of would-be elites, the *orang kaya* ('moneymen'). When the orang kaya made contracts with the Dutch, the village assemblies promptly ignored them. The civilised Dutch set out to teach these savages a lesson in the rule of law, and proceeded to slaughter them.

> Through military action, the VOC [Dutch East India Company] killed most of the population in 1621. Of the population of approximately 15,000, only several hundred survived.[5]

This was a pattern often repeated, prompting Karl Marx to note that:

> ...wherever they set foot, devastation and depopulation followed. Banjuwangi, a province of Java, in 1750 numbered over 80,000 inhabitants, in 1811 only 18,000. Sweet commerce![6]

Genocide, through a combination of disease and intentional slaughter, was a recurring feature of European colonialism. The

[5] J L van Zanden (1993), The rise and decline of Holland's economy, University of Manchester Press, pp.76-77.

[6] Karl Marx, Capital volume 1.

LVC member-groups have consistently organised against multinational agribusiness, and particularly against genetically modified crops. On international women's day in 2008, a large occupation by 1,000 MST and LVC activists destroyed GM corn, while as recently as March 2015 another 1,000 MST women destroyed GM eucalyptus. LVC has described GM crops in Mexico as "a crime against humanity". These actions have incurred violent repression, with assassinations of activists, including the murder of MST activist Valmir Mota de Oliveira, who was executed during an occupation of a Syngenta GM site in 2007.

An examination of the grievances with GM crops is instructive. These fall into two basic categories: economic and technical. Prominent among the economic grounds for opposition is the effect on trade, with MST activists citing cross-contamination as leading to loss of organic status, and subsequent loss of premium prices for their produce. This is a grievance that unites the various commodity-producing agrarian strata grouped under the category of peasantry. Another economic grievance is the effect of seed monopolies on input prices. For example, Vandana Shiva claims seed prices in India rose 71,000% after Monsanto cornered the market, and argues that seed patents represent an enclosure of the genetic commons.[6] This aspect of monopoly and enclosure raises a third economic objection; demands for local control versus the globalised centralisation of capital.

Technical grievances refer to the properties of specific transgenic crops, sometimes dubiously described as "poisonous": they are often designed to require high inputs of water, synthetic fertilisers, and insecticides (the monetary costs of which also constitute an economic grievance; though this high-input requirement is common to the non-GM high yielding varieties of the Green Revolution too). These factors

[6] See: http://vandanashiva.com/?p=105

Agribusiness and agrarian struggles

As we discussed in our previous article, there is no single class of 'peasants', but rather several heterogeneous strata of wage labourers, sharecroppers, petty commodity producers, patriarchal family farms, and small-scale capitalist farmers. Nonetheless, agrarian social movements have emerged from these strata to challenge aspects of capitalist agriculture, particularly dispossession from the land, and the use of transgenic crops. Among the more famous of these movements are the Landless Workers Movement (MST) in Brazil, and the Zapatista Army for National Liberation (ELZN) in Chiapas, Mexico. Both movements have organised land-takeovers and established growers' cooperatives, whilst also engaging in wider social movement struggles.

The MST and ELZN do not only recruit from the existing rural population, but also draw on a second generation of members returning to the land from the precarious, impoverished urban proletariat; an attempted 're-peasantization' or 'decolonial exodus' from the wage labour relation.[5] The MST is one of the more high-profile member-organisations of the 'peasant international' La Via Campesina (LVC), which claims to represent 200 million farmers. Both MST and other

[5] On re-peasantization, see: Vergara-Camus (2009), The MST and EZLN struggles for the land: new forms of peasant rebellions. Journal of Agrarian Change. Volume 9, Issue 3, pages 365–391, July 2009. Available at: http://10.1111/j.1471-0366.2009.00216.x

Post-autonomist thinker Paolo Virno defines exodus from the class relation thus: "Exodus is a committed withdrawal, the recourse to force is no longer gauged in terms of the conquest of State power in the land of the pharaohs, but in relation to the safeguarding of the forms of life and communitarian relations experienced en route." However, one of his main examples is explicitly settler-colonial - North American workers fleeing wage labour for the frontier "in order to colonize low-cost land". For Latin American land movements, especially in the case of the ELZN, this flight for autonomy from the state and the wage relation has an expressly decolonial aspect. Paolo Virno, Virtuosity and Revolution.

massive depopulation lead to the importation of slaves to work the land. In Portuguese Brazil:

> Smallpox killed so many natives that by the 1580s the planters shifted to African slaves. By 1620 the plantations relied almost exclusively on the labour of Africans or their American descendants.[7]

The net effect of the plantation complexes in the Atlantic, Americas, and Western Pacific, was dramatic depopulation and the replacement of subsistence modes of agriculture with cash crop production for the world market.

Capitalist agriculture

Meanwhile in Western Europe, class conflicts in the countryside were driving agrarian change. In England, the balance of class forces favoured the landed classes. Freed from their obligations to the peasantry, they evicted them from the land. Peasant emancipation here meant being 'freed' from the land through clearances and enclosures. Richer peasants became tenant farmers, and hired landless peasants as wage labourers to work the land. The landed nobility were transformed into capitalist landlords.[8]

Thus accumulated capital met landless workers, kick-starting a cycle or rural accumulation and dispossession which would provide both the labour force and some of the capital which fuelled the industrial revolution a century or so later. In effect, this transformation meant a shift from politically appropriated surpluses in kind or in taxes and tithes which sustained the feudal ruling class, to economically appropriated surpluses accruing to the owners of agricultural capital

[7] Tauger, op cit, p.76.

[8] For the classic account, see: Robert Brenner. Marx recounts this process here.

as surplus value - a shift synonymous with the emergence of the capitalist mode of production.

But this development was not simply an English peculiarity, or rather, this peculiarity was not a wholly English development. That is to say, the balance of class forces that favoured the emergence of free wage labour in England had an irreducibly geopolitical dimension. European geopolitics in the early modern period were significantly structured around the power of the Ottoman Empire. Europe's military powers were thus oriented to the east, with little heed paid to the English backwater.

It was "the upsurge in Euro-Ottoman trade [that] contributed to the preconditions of rural revolt and the primitive accumulation of capital in Northwest Europe."[9] Furthermore, it was the Ottoman control of trade routes to the east which drove the Atlantic powers to the sea in search of alternative routes. The rise of European banking and merchant capital was a side-effect of feudal war-making, but it was one which fuelled colonial expansion, which in time would feed back into capitalist development.[10]

As other European powers emulated the English example, capital flows from the colonial plantation complexes found productive investment opportunities, given the newly emerging European proletariat. Cleared from the land, Europe's proletarians had little choice but to accept whatever wages they could find, on farms or in the fledgling manufactures. Even then, they resisted. Vagabonds were criminalised and soldiers deployed to clear the land and put down rural revolts.

Through this process, global circuits of capital emerged. Agricultural commodities such as sugar from the American plantations and tea and opium from Asia began to flow into

[9] Kerem Nisancioglu (2012), Before the deluge, the Ottoman origins of capitalism.

[10] Nisancioglu, op cit.

to producing cattle feed and biofuels. "The 2008 food crisis, which pushed around 100 million people into hunger, was not so much a result of a food shortage as (…) market volatility."[3]

Hence, even under the more extreme climate scenarios, the technical possibilities for feeding the world's population exceed the economic 'optimum', which reckons not in terms of needs but ability to pay. The editorial from a special feature on food for the journal *Nature* comments:

> Admittedly, climate change adds a large degree of uncertainty to projections of agricultural output, but that just underlines the importance of monitoring and research to refine those predictions. That aside, in the words of one official at the Food and Agriculture Organization (FAO) of the United Nations, the task of feeding the world's population in 2050 in itself seems "easily possible".[4]

However, the practicability of feeding everybody, and indeed of producing the food required to do so (a separate matter, still eminently possible), is premised on the idea 'all the options are on the table', including controversial practices such as transgenic crops (GMOs), 'modernisation' of land tenure (new enclosures), further integration of small farmers into financialised markets, and the use of synthetic fertilisers and insecticides. Practices such as these have become flashpoints in a polarisation between two visions of world food production, one of them multinational, biotech-led, the other a 'peasant' alternative promoted by social movements like La Via Campesina and intellectual-activists like Vandana Shiva.

[3] Nature eds (2010), How to feed a hungry world, Nature. 466, 531–532 (29 July 2010). Available at: http://dx.doi.org/10.1038/466531a

[4] Nature eds (2010), op cit.

> [2007], there have been several periods of rapid food and cereal price increases following climate extremes in key producing regions, indicating a sensitivity of current markets to climate extremes, among other factors. Several of these climate extremes were made more likely as the result of anthropogenic emissions.[1]

The report finds that while some regions, mainly northern high latitudes, could see increased agricultural yields, on balance the impact on yields is likely to be negative. In the near-term, out to 2050, the impacts are not catastrophic, with only 10% of projections showing yield losses of more than 25%, compared to the late 20th century levels. However, "after 2050, the risk of more severe impacts increases".

Business-as-usual global warming puts average global temperatures on course for 4-6℃ warming by 2100. The IPCC warn that "Global temperature increases of ~4℃ or more above late-20th-century levels, combined with increasing food demand, would pose large risks to food security globally and regionally (high confidence). Risks to food security are generally greater in low latitude areas." Parsing the IPCC's somewhat technocratic language from their previous reports into plain English, author Mark Lynas writes that "it's difficult to avoid the conclusion that mass starvation will be a permanent danger for much of the human race in a four-degree world."[2]

As the above references to food price rises and 'low latitude areas' suggest, these impacts are unevenly distributed. Mass hunger is mediated by market dynamics, and doesn't necessarily require an absolute scarcity of food (see our short article here). Indeed, already today hundreds of millions go hungry, while at the same time up to half of the world's food supply goes to waste and substantial areas of land are dedicated

[1] IPCC AR5 WGII p.488. Available at: https://ipcc-wg2.gov/AR5/

[2] Lynas (2008), Six Degrees, Harper Perennial, p.174.

Europe, while slave-picked cotton would fuel Lancashire's rise to workshop of the world. Hence Marx writes that "the veiled slavery of the wage workers in Europe needed, for its pedestal, slavery pure and simple in the new world."[11] This connection between plantation slavery and the reproduction of free labour power is elaborated further by Silvia Federici:

> The plantation system was crucial for capitalist development not only because of the immense amount of surplus labour that was accumulated from it, but because it set a model of labour management, export-oriented production, economic integration, and international division of labour that have since become paradigmatic for capitalist class relations. (…) On one side, a global assembly line was created that cut the cost of the commodities necessary to produce labour-power in Europe (…) On the other side, the metropolitan wage became the vehicle by which the goods produced by enslaved workers went to the market, and the value of the products of enslaved-labour was realized.[12]

While political economists made arguments for the superior economics of free wage labour - after all, a capitalist is no longer responsible for the reproduction of his 'hands'[13] - it was revolt which proved a major driving force in the transition to free labour outside Europe. Slave revolts put abolition

[11] Karl Marx, Capital volume 1.

[12] Silvia Federici, Caliban and the witch, p.104.

[13] For example see Adam Smith in The Wealth of Nations: "From the experience of all ages and nations, I believe, that the work done by free men comes cheaper in the end than the work performed by slaves. Whatever work he does, beyond what is sufficient to purchase his own maintenance, can be squeezed out of him by violence only, and not by any interest of his own."

and emancipation on the agenda, most notably the Haitian revolution of 1791. Here, insurgent slaves scandalously took the universalist proclamations of the liberty emanating from the French Revolution two years prior to apply to all, including themselves.

The growth in support for abolitionism among sections of the ruling class is best understood as a response to such bloody insurrections, which lead to growing acceptance of the arguments of political economists. As such, the emancipation from slave to wage labour should only be considered tendential, with counter-tendencies always throwing up forms of unfree labour across the capitalist world, such as debt-bondage or prison labour. Indeed, following the American civil war of 1861-65: "the former slaves ended up working on the old plantations as sharecroppers, in reality debt peons, forced to work at extremely low wages to retain their plots."[14]

Conclusion

From the point of view of agricultural transformation, the European enclosures and the plantation complexes in the Atlantic, Americas, and Western Pacific formed two sides of the same historical process. This was a widespread shift from subsistence to commodity production, entailing the bloody separation of the rural population from the soil. Climate change, in the form of the Little Ice Age, had caused crop failures, chronic food crises, and famines around the world. The societal responses to these crises were mediated by the extant social relations, institutions, and the balance of class forces. As the circuits of European merchant and banking capital sought new profits in the colonies, enclosures and clearances created a landless proletariat in Europe.

[14] Tauger, op cit, p.89.

Contemporary agriculture: climate, capital, and cyborg ecology

Agriculture is probably the productive sector most vulnerable to climate change, for the obvious physical reasons. It is also the sector which is the basis for all others. UN bodies have focused on a 'food security' approach, incorporating many controversial practices such as transgenic (genetically modified) crops, high inputs of agrochemicals and water, and increased integration of farmers into commodity and financial markets. Against this model, agrarian social movements spearheaded by La Via Campesina have proposed a vision of 'food sovereignty', based on local production, distribution, and organic methods. While sympathetic to these social movements, we find the strict distinction between traditional and modern methods closes off important possibilities. We propose to rethink these questions of social relations, nourishment, technology, anti-capitalist struggle, and scientific and practical knowledges through the lens of *cyborg ecology*.

Climate change and food security

The Intergovernmental Panel on Climate Change's fifth assessment report ('AR5') in 2014 reported that:

> Negative impacts of climate trends have been more common than positive ones. (…) Since AR4

Increased yields in tropical, export-oriented agriculture have also contributed to systematic overproduction, and hence depressed prices on the world market. This in turn has squeezed smaller farmers into greater exploitation of family labour, or into bankruptcy and joining the urban proletariat… or suicide.[24]

This then is the agrarian context in which climate chaos looms. On the one hand, a vast concentration of capital that has given rise to modern agribusiness and an historic urbanisation of the world's population. On the other, there has been proliferation of rural social relations organised largely around the market; including family labour, gendered exploitation, sharecropping, small-scale capitalist farms, petty commodity production, and wage labour. Furthermore, the metabolic rift in the nitrogen cycle has been displaced onto the carbon cycle: world food production has become massively dependent on fossil fuels.

Already we hear the dismal forecasts of that most hardy of perennial species - the Malthusian. It is in this context that biofuel production is being promoted as a 'green' alternative to fossil fuels - while taking land out of food production. Meanwhile, agribusiness promotes proprietary biotechnology as the solution to hunger and climate-threatened yields, while financialisation leads to greater food price volatility. Will unmitigated climate change (finally) prove the Malthusian prophecies of carrying capacity overshoot correct? These are the questions we'll take up in the next installment.

[24] BBC, Indian farmers and suicide: How big is the problem?

As the European empires expanded, they encountered empires facing crises of their own. This facilitated the conquests, which were invariably followed by massive depopulation through disease and intentional mass slaughter. Colonial genocide provided returns on capital which flowed back to Europe, finding profitable investment in the employment of the new proletariat. Thus the colonialism of the late feudal period and the transformations of early modern agriculture formed a feedback loop which gave rise to a new capitalist mode of production.

Henceforth agricultural production became increasingly *commodity* production, as subsistence producers were expropriated, exterminated, or pushed to the margins. While the story of capitalist agriculture certainly does not end here, the basic contours of the contemporary world agricultural system were all in place by the end of the Little Ice Age.

The political economy of hunger

So far in our series on the relationship between climate, class society, and food, we've focused on historical investigation. This has lead us to look at the emergence of agriculture after the end of the last ice age around 10,000 years ago, and the early modern origins of capitalist agriculture during the little ice age of 1550-1850.

We intend to continue these historical investigations up to the present day, to enable some informed speculation about the future of food production in the context of global warming and climate chaos. However, first we want to ask a more basic question. Why do people go hungry?

Common sense: absolute scarcity?

The intuitive answer to this question is that there must be a lack of food. This explanation comes in two flavours. Chronic hunger is typically explained by the Malthusian argument that population growth perennially outstrips food production. Acute hunger, such as famines, is typically explained in terms of Food Availability Decline, such as crop failures due to drought.

Malthus' argument, which underpins Garrett Hardin's reactionary ecology, is a simple one. Malthus (1776-1834) claimed that that population grows 'geometrically' (exponentially), whereas food production grows 'arithmetically' (linearly). Therefore the population will always grow faster

> This association between food production and anti-Communism was quite conscious. Though it may seem a bit unsophisticated today [i.e. 1972], when anti-Communism is called humanitarian intervention in the academic community, during the 1950s the relation was discussed quite openly. "The major problem in the struggle to keep South and Southeast Asia free of Communist domination," wrote Fulbright scholar John King in Foreign Affairs in 1953, "is the standard of living of their peoples (….) The struggle of the 'East' versus the 'West' in Asia is, in part, a race for production, and rice is the symbol and substance of it."[22]

The performance of the Green Revolution was mixed, but is generally held to have significantly boosted world food production. In addition to fertiliser and pesticide inputs, which had to be purchased on the market from agrochemical firms, the HYVs also required substantial irrigation to produce higher yields. The combined effect of this was thus to raise the threshold of capitalization for farms. Productivity gains increased the agricultural surplus population, and hence the rate of migration to the cities. "The Green Revolution is basically an extension of capitalist agriculture to the tropics", writes Harry Cleaver.

> …if increased food production has been the principal thrust of the new strategy it has not been the only one. Closely tied to the effort to increase output has been the transformation of agrarian social and economic relations by integrating once isolated areas or farmers into the capitalist market system.[23]

[22] Harry Cleaver, The contradictions of the Green Revolution.
[23] Harry Cleaver, *op cit.*

> What Fritz Haber could not foresee, however, was the cascade of environmental changes, including the increase in water and air pollution, the perturbation of greenhouse-gas levels and the loss of biodiversity that was to result from the colossal increase in ammonia production and use that was to ensue.[20]

The Haber process is now responsible for fertilising the food which feeds almost half of the world's population. The problem is, from a climate change point of view, that the high temperatures and pressures required by the process are very energy intensive, and additionally, natural gas (CH4) is required as a source of hydrogen (H2).[21]

Thus insofar as fossil fuels are the energy source, the process contributes to greenhouse gas emissions twice, since the method of 'steam reforming' to produce H2 gas from CH4 produces CO2 as a byproduct. It contributes three times if the emissions from transporting manufactured fertiliser back to agricultural regions are included. The purpose of this brief chemistry lesson is to highlight that *the metabolic rift in the nitrogen cycle is not resolved but displaced onto the carbon cycle.*

The growing reliance on synthetic fertilisers was accelerated from the 1940s with the development of 'High Yielding Varieties' (HYVs) of maize, wheat, and rice, specially bred for use as a 'package' with both fertilisers and pesticides. While it is often presented as a humanitarian gesture which purportedly saved a billion people from starvation, what became known as the 'Green Revolution' did not exist outside political economy, and especially Cold War geopolitics. Harry Cleaver writes:

[20] How a century of ammonia synthesis changed the world, Nature Geoscience.

[21] We say from a climate change point of view, as there are also other ecological considerations, such as pollution from fertilizer run-off creating 'dead zones' in waterways.

than the food supply, and chronic hunger will be ever-present. Malthus was motivated by politics, particularly opposition to the English Poor Laws. He also just made it up. Geographer Danny Dorling writes:

> He was not just wrong because he lacked imagination; he also cheated. It is now known that the even made up the correlation he used to try to suggest causation.[1]

However, Malthus' argument continues to be cited as if it's self-evident in both everyday conversations and scholarly works (though the experts have no excuse).[2] "If it had not been Malthus", Dorling continues, "it would have been some other fool". A similar assumption of absolute scarcity informs the Food Availability Decline (FAD) approach, which was debunked by economist Amartya Sen in his hugely influential 1981 essay on poverty and famines.

Sen took several major famines as his case studies, and found the FAD approach was unable to explain why people went hungry, but also who went hungry. The Bengal Famine of 1943 claimed 1.5 million lives. Yet food production was only marginally below the previous year, and in fact higher than other years which had not seen famine. The Ethiopian famines of 1972-74 also saw only single-digit declines in food production, too small to account for the 50-200,000 deaths. In the 1974 Bangladesh famine, food availability actually hit a four-year per capita high. In the Sahelian famine which peaked in 1973, drought did lead to significant declines in food

[1] Danny Dorling, Population 10 Billion, p.111.

[2] For instance, David Cleveland, professor of environmental studies at UC Santa Barbara, states bluntly that "over the longer term *Malthus was right*. His fundamental observation seems incontrovertible" (original emphasis). This quote comes from his otherwise somewhat critical book 'Balancing on a planet: the future of food and agriculture' (p.26).

availability, but Sen argued this fact alone could not explain who went hungry and where.

Sen's entitlement approach

Amartya Sen developed a new theory to explain famines in terms of 'entitlements'. In a monetary economy, money entitles the owner to commodities of equal price. A rise in food prices, a decline in income, or an exhaustion of savings could all lead to an 'entitlement failure' and hunger, that is, insufficient money to buy sufficient food. But the reason Sen talks in terms of entitlement rather than money is that not all food entitlements are monetary. Sharecroppers or peasant farmers may be entitled to consume (a portion of) their own production without market mediation. Pastoral nomads may similarly possess food entitlements outside of the monetary economy, as may recipients of food stamps or similar welfare measures.

> It is sometimes said that starvation may be caused not by food shortage but by the shortage of income and purchasing power. This can be seen as a rudimentary way of trying to catch the essence of the entitlement approach, since income does give one entitlement to food in a market economy. While income may not always provide command [food] in a fully planned economy, or in a 'shortage economy', in which a different system of entitlement might hold, the income-centred view will be relevant in most circumstances in which famines have occurred.[3]

It is important to note that Sen does not deny that decline in available food can be a factor in increasing hunger. He only

[3] Amartya Sen, Poverty and Famines, p.155. Original emphasis.

a result of producing greater yield demands on the soil, and in part a result of the spatial break in the nutrient cycle as human waste accumulated as a public health hazard in the cities as opposed to being metabolised by detritivores in the soil. In places, this problem was countered by the use of 'night soil' (human excrement, gathered by night to spread on the fields).This maintained fertility, but was also a vector for infectious diseases.

In industrialising England, the crisis of soil fertility was met by the massive import of guano, as the colonies were plundered to sustain the agricultural production of the core (the potato blight which depopulated Ireland is now thought to have been imported with potatoes alongside Peruvian guano).[17] Guano remained a vital agricultural input until the early 20th century, until the invention of the Haber-Bosch process, a method for fixing abundant atmospheric nitrogen into bioavailable forms by means of ammonia synthesis.

> While in 1900 the world consumption of the three principal mineral fertilisers, nitrogen (N), phosphoric acid (P2O5), and potassium (K2O) did not reach 4 million tons of fertilizer units, in 1950 it was a little over 17 million tons, and, at the end of the 1980s, it reached 130 million tons.[18]

According to FAO data, this figure had reached 160 million tons by 2008, although the rate of growth has slowed since the late 1980s.[19]

[17] Source. However, the responsibility for the famine was not principally biological but political-economic; the British colonial authorities' free trade policies ensured "huge quantities of food were exported from Ireland to England throughout the period when the people of Ireland were dying of starvation." - Amartya Sen, Poverty and famines, Oxford University Press, p.161.

[18] Mazoyer & Roudart, p.385.

[19] FAO

ate alongside the more familiar capital-labour wage relation. It is also often the case that individuals move between seasonal sharecropping and wage labour or work in several different modes at the same time. The category of 'peasant', while useful in drawing attention to persistent agrarian social relations other than simple wage labour, can also obscure these complexities.

The metabolic rift and the Green Revolution

> ...all progress in capitalistic agriculture is a progress in the art, not only of robbing the labourer, but of robbing the soil[16]

While Karl Marx is mostly known as a theorist of industrial capitalism, he was also interested in the effects of the capitalist mode of production on agriculture and the soil. Marx's work on this topic is scattered across some comments in Capital, his earlier philosophical manuscripts, and his notes on the work of his contemporary, the agricultural chemist Justus von Liebig. This 'ecological Marx' has been reconstructed most notably by John Bellamy Foster and his collaborators, centering on the notion of the *metabolic rift*.

In biology, metabolism is the set of life-sustaining transformations of matter and energy flows. A metabolic rift therefore, is a rupture in such flows. The prime example of such a rift, and the one which preoccupied Marx, is the depletion of soil fertility under the pressure of competitive commodity production.

Traditionally, soil fertility was maintained by practices such as crop rotation, fallowing, and use of livestock. But as agrarian capitalism drove both productivity and urbanisation, the result was a steady depletion of soil nutrients. This was in part

[16] Karl Marx, Capital Volume 1.

claims that this is mediated by entitlements, that is, social relations. Indeed, Sen claims that "food being *exported* from famine-stricken areas may be a 'natural' characteristic of the market which respects entitlement rather than needs"[4]. Hence geographer Mike Davis, based on his own studies of Victorian-era famines, concludes that "the great hungers have always been redistributive class struggles."[5]

The absolute scarcity approach employs fallacious reasoning: because an absolute scarcity of food implies hunger, absolute scarcity is wrongly inferred from the existence of hunger. This reasoning itself betrays a naive assumption: that food is produced for use. However, with the near-global spread of enclosures and colonisation, a large and growing proportion of agricultural production is commodity production - production for the market. Commodity production is not motivated by the use to which commodities are put, but the prices they can fetch. If biodiesel or beef fetches a sufficiently high price, agricultural land is switched to feeding cars or cows while millions of human beings go hungry. Hence to quote the opening lines of Sen's essay:

> Starvation is the characteristic of some people not **having** enough food to eat. It is not the characteristic of there not **being** enough food to eat.[6]

The political economy of hunger

The fact there's enough food to feed everyone has slowly been acknowledged amongst the ruling institutions. For instance the UN's Food and Agriculture Organisation (FAO) states clearly that:

[4] Amartya Sen, Poverty and Famines, p.162
[5] Mike Davis, Late Victorian Holocausts, p.20.
[6] Amartya Sen, Poverty and Famines, p.1.

> There is sufficient capacity in the world to produce enough food to feed everyone adequately; nevertheless, in spite of progress made over the last two decades, 805 million people still suffer from chronic hunger.[7]

However, Sen's stress on the mode of production, forms of property, and class relations has been replaced by a technocratic approach to this "challenge" which sees it simply as a matter of policy. 'Food availability' is still the first term on the FAO's list of dimensions of hunger. And while between a third and a half of world food production is currently wasted, the World Bank, like Malthus, invokes a growing population to emphasise raising agricultural productivity. There's nothing wrong in principle with increasing agricultural productivity, indeed, more output for less inputs seems like a good idea, but this can often be a euphemism for land-grabs.[8]

These new enclosures dispossess and proletarianise the rural population, making them dependent on the market for food. In other words, while Sen's insights are formally acknowledged, the policy emphasis quickly regresses to the familiar capitalist one of increasing output, increasing productivity, and the development of markets in farm-related financial services, fertilisers, and machinery. Hunger is treated *as if* it were principally a problem of food availability, even though this is acknowledged not to be the case. To understand why this is, we need to turn to the economic historian Karl Polanyi.

Polanyi was interested in 'the great transformation': the rise of the market society, capitalism. Like Karl Marx before him, Polanyi identified the separation of the population from the

[7] http://www.fao.org/about/what-we-do/so1/en/

[8] See Stefano Liberti, Land grabbing: journeys in the new colonialism. Silvia Federici and Glen Coulthard are among those who have theorised primitive accumulation as an ongoing process, and not a completed historical episode.

> …there is no single "class" of "peasants" or "family farmers" but rather differentiated classes of small-scale capitalist farmers, relatively successful petty commodity producers and wage labour.[13]

Alongside the persistence of unpaid family labour and reliance on second jobs, the agrarian workforce is further differentiated through various relations. These include sharecropping, where workers are allowed to use land in return for pledging a portion of the product to the landlord. While this may appear similar to a feudal peasant-lord relationship, sharecroppers are usually producing commodities for the market and their landlords typically operate as capitalists, and there are no obligations of military service such as those which characterised European and Japanese feudalism. This does not preclude an element of subsistence production, i.e. production for the workers' consumption among sharecroppers, but it would be a mistake to view such arrangements as a throwback, rather than a mode of labour exploitation thoroughly integrated into modern agricultural markets.

Agrarian relations are also often strongly gendered. The nonprofit GRAIN contends that "women are the main food producers on the planet, although their contribution remains ignored, marginalised, and discriminated against."[14] For example, Henry Bernstein cites a rural Tanzanian activist on the sharecropper wives who work the land, only for their husband to receive payment, allowing him to live in the city, returning only to implore his wives to produce more once the money runs out.[15]

The activist refers to this arrangement as 'slavery', but however it's classified, such relations of micro-exploitation prolifer-

[13] Bernstein, p.4.

[14] GRAIN, Hungry for land: small farmers feed the world with less than a quarter of all farmland.

[15] Bernstein p.5.

> enterprises is therefore much higher than that for family farms.[11]

Thus, 'family farms', even when the means of production are worked by those who own them, are able to survive, but only through the exploitation of unpaid labour, and even then, often only because the reproduction of the farming family is subsidised by off-farm incomes. For example, in the US:

> According to USDA data from 2012, intermediate-size farms like mine, which gross more than $10,000 but less than $250,000, obtain only 10 percent of their household income from the farm, and 90 percent from an off-farm source. Smaller farms actually lost money farming and earned 109 percent of their household income from off-farm sources. Only the largest farms, which represent just 10 percent of farming households in the country and most of which received large government subsidies, earned the majority of their income from farm sources. So, 90 percent of farmers in this country rely on an outside job, or a spouse's outside job, or some independent form of wealth, for their primary income.[12]

This could perhaps be compared to industries such as trucking or taxi cabs, where the means of production are often owned by formally self-employed workers, who nonetheless occupy a subordinate position in the value-chain, with the greatest profits captured downstream by properly capitalist intermediaries. This does not of course preclude some family-owned farms successfully accumulating capital and employing non-family wage labour. Here we see the analytic inadequacy of the 'family' concept for assessing agrarian class relations.

[11] Mazoyer & Roudart, p.435.

[12] See: What nobody told me about small farming: I can't make a living

land as the key factor in the transformation of markets from a relatively fringe phenomenon for most people to the central institutions governing social reproduction.

> The first stage was the commercialisation of the soil, mobilising the feudal revenue of the land. The second was the forcing up of the production of food and organic raw materials to serve the needs of a rapidly growing industrial population on a national scale. The third was the extension of such a system of surplus production to overseas and colonial territories. With this last step land and its produce were finally fitted into the scheme of a self-regulating world market.[9]

Polanyi gets the chronology slightly wrong - colonial production preceded and helped finance the industrial revolution. James Watt's engine was funded by profits from the West Indies slave plantations.[10] But more importantly for the matter at hand, Polanyi goes on to stress the necessity of hunger for a functioning labour market:

> The critical stage was reached with the establishment of a labour market in England, in which workers were put under the threat of starvation if they failed to comply with the rules of wage labour. As soon as this drastic step was taken, the mechanism of the self-regulating market sprang into gear.[11]

Hunger is not, therefore, an incidental problem in capitalism but *a condition of its possibility*. This process of proletarian-

[9] Karl Polanyi, The Great Transformation, p.188.

[10] Eric Williams, Capitalism and Slavery, p.102.

[11] Karl Polanyi, The Great Transformation, p.225.

isation created the category of the unemployed, which superseded that of the pauper. Polanyi continues to argue that unless the unemployed were "in danger of famishing with only the abhorred workhouse for an alternative, the wage system would break down."[12] For this reason, Polanyi thought that the post-WWII welfare state and the Keynesian policy of full employment had, in minimising the threat of hunger, superseded the market society. But social democracy turned out to be an unstable compromise between capitalism and something else. Workers revolted, and following the crisis of the 1970s the capitalists responded with a renewed round of economic liberalism.

The return of rickets, food banks and the workhouse (in the guise of workfare) can therefore be seen as a return to capitalist normality.[13] Capitalism needs to maintain this artificial scarcity of food to underwrite the labour market. Climate change is likely to damage crop yields and reduce available agricultural land through desertification, salination of coastal aquifers and flooding from sea level rises and changing precipitation patterns.[14] But food availability is always mediated by social relations. As Rolando Garcia puts it, "climatic facts are not facts in themselves; they assume importance only in relation to the restructuring of the environment within different systems of production."[15]

Discussions of world hunger almost invariably assume that food production is and will continue to be commodity production, whilst simultaneously assuming that food is produced for use. But whatever climate change has to throw at us, there is always a gap between what is possible and what is possi-

[12] Karl Polanyi, The Great Transformation, p.232.

[13] On rickets, see: http://www.theguardian.com/society/2014/aug/30/child-poverty-link-malnutrition-rickets

[14] We will discuss the future of food under various climate change scenarios in future articles, once we've brought our historical look at capitalism and agriculture up to the present day.

[15] Quoted in Mike Davis, Late Victorian Holocausts, p.19.

and Roudart suggest that prime vineyards can support viable farms of a much larger extent than on less fecund land.[8] Another is the availability of unpaid labour in 'family' or 'peasant' contexts: "it quite often remains true that the strong competitiveness of peasant farms is based on underpaid family work."[9]

Perhaps most significant factor is the relatively low point at which economies of scale in terms of farm area turn into diseconomies. It is clear that a worker with the latest agricultural machinery can work a larger area than one with only hand tools or animal power. But combining ever-more workers on the model of the factory does not yield ever-greater economies.

The diseconomies of scale include transportation costs, waste from standardising across different micro-ecologies, and the overhead costs of managerial and administrative labour. Mazoyer and Roudart argue that this means that "beyond several workers, there is no longer any economy of fixed capital in practice (…) in agriculture significant economies of scale are only attainable up to a modest threshold, corresponding to an autonomous work team of several persons."[10] These factors together mean that:

> …for a capitalist entrepreneur to maintain a business, he must not only pay market prices for the wage laborers and the lands that are farmed but also must extract from the capital invested in agriculture a profit rate higher than or equal to the profit rate attainable in the rest of the economy. Now, that is not necessarily the case for a family farmer (…) The threshold of renewal for capitalist

[8] Mazoyer & Roudart p.418.

[9] Mazoyer & Roudart, p.420.

[10] Mazoyer & Roudart, p.421.

> their 'entry costs' in economists' terms - and to reproduce them.[6]

It is this notion of capitalization which - perhaps unsurprisingly - helps make the most sense of capitalist agriculture. Geographically 'small' farms can be highly capitalized. Mazoyer and Roudart identify a 'threshold of capitalization' or a 'threshold of renewal', which represents the level of reinvestment (and hence, minimum level of gross profit) required to maintain the viability of the farm.

> The gains in productivity achieved by developing farms have lead to a secular tendency of lower agricultural prices, in real terms, and lower incomes for farms that have not adequately invested and developed.[7]

This process corresponds to a secular trend towards greater capitalization in agriculture to maintain viability. However, not all farms operate at the same threshold of capitalization, and this accounts for the fact that the tendency towards greater substitution of mechanical and chemical inputs for labour does not simply create an ever-smaller number of larger capitalist farms worked by landless wage labourers. This does happen, but alongside this process a range of more differentiated and complex relations to capital proliferate.

The persistence of 'peasant' agriculture, 'family farms', and practices such as sharecropping thus cannot be understood simply as relics from a pre-capitalist world, but as differentiated moments in the developing reproduction of capitalist agriculture. The differences in thresholds of capitalization reflect several factors. One is the differential rent arising from differences in the productivity of land. For example, Mazoyer

[6] Bernstein p.93.

[7] Mazoyer & Roudart p.378.

ble *in capitalism*. All other things held equal, declining crop yields and loss of arable land can be expected to increase world hunger. But all other things need not be held equal. The social relations through which biophysical forces are organised are not themselves laws of nature: they are subject to change. This is the revolutionary possibility that Malthusian mythology serves to obscure.

Capitalist agriculture: class formation and the metabolic rift

Centralisation, urbanisation, and class formation

> Everywhere the farmers were howling, and the London Economist, with reference to these starvation-wages, prattled quite seriously of "a general and substantial advance." What did the farmers do now? (…) They introduced more machinery, and in a moment the labourers were redundant again in a proportion satisfactory even to the farmers. There was now "more capital" laid out in agriculture than before, and in a more productive form. With this the demand for labour fell, not only relatively, but absolutely.[1]

Ever since enclosures and colonialism began turning farming into capitalist agriculture around the world, agricultural capital has become increasingly centralised. Investment in labour-saving machinery reduced the demand for agricultural labour, driving an exodus from the countryside to the towns.

The productivity gap between the most and least productive farms exploded in the 20th century, from a ratio of 10:1 to 1000:1.[2] Today in the post-industrial states, agriculture typically employs less than 5% of the labour force. 54% of the world's population is urban, a figure expected to rise to 66% by 2050.[3]

But while there has been a secular trend towards the substitution of machinery (and subsequently, chemical inputs) for labour, the process of capitalist development has not been a straightforwardly homogenising one. Indeed 'small', 'family' and 'peasant' farms continue to make up a significant proportion of world farming by both land area and production volumes. In terms of land area, estimates for such small farms range from 25-70% of the world's agricultural land, producing up to 80% of the world's food.[4]

This wide discrepancy in estimates hints at the imprecision of terms like 'small', 'family' and 'peasant'. For instance, Henry Bernstein points out that "the notion of the 'family farm' is often used to refer variously to family-*owned*, family-*managed* or family-*worked* farms, which can be misleading."[5] Similar ambiguities pertain to the use of the term 'peasant', which sometimes means anyone who works the land for their own subsistence, sometimes refers to various sharecropping arrangements, and sometimes refers to the specific extra-economic obligations of serfdom. Land area can also be a misleading measure of farm size:

> In modern capitalism, a more relevant scale is farm capitalization: the amounts of capital required to establish different types of farming -

[1] Karl Marx, Capital Volume 1

[2] Ratios in terms of weight yields per worker. Marcel Mazoyer & Laurence Roudart (2006), A history of world agriculture, Routledge, p.441.

[3] UN figures.

[4] See Table 1 here.

[5] Henry Bernstein (2010), Class dynamics of agrarian change, Kumarian Press, p.93.