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Food Crises And Global Warming: Critical Realism And The Need To Re-Institutionalize Science

Hugh Lacey
Swarthmore College, hlacey1@swarthmore.edu

M. I. Lacey

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Critical realism and the need to re-institutionalize science

Hugh Lacey and Maria Inês Lacey

Activities in many and various domains of human life not only contribute causally to, but also experience harmful impact from, global warming, deriving from the build up of greenhouse gases in the atmosphere, and the climate changes that it is bringing about. Combating global warming, therefore, requires efforts in all these domains to eliminate its causes and to reverse its harmful impact. Agriculture is one of these domains (see p. 188).

Currently predominant agricultural practices are a major source of the build up of greenhouse gases in the atmosphere; and the harmful impact of global warming on agriculture and the food supply is significant. Many features of the food crisis of 2008, and the continued threat of food insecurity facing countless millions of poor people throughout the world, for example, are inseparable from global warming and the related climate changes. Combating the agricultural causes of global warming, then, should be accompanied by efforts to eliminate the threat of food insecurity. One proposal (perhaps the only serious one) currently being made for dealing permanently with the fundamental causes of food insecurity – a system of agricultural production that is based on working everywhere towards local 'food sovereignty' – if implemented on a large scale, would also bring about significant reductions in the emission of greenhouse gases (see p. 190). Global warming and the threat of continuing food insecurity can be combated together. Agricultural policies and practices that credibly promise to eliminate threats of recurring food crises – informed by the appropriate kind of scientific research – can be crucial components of the package of proposals needed to deal with global warming.

In the argument that follows, the links between agricultural practices, food crises and global warming are described and their fundamental causes located in the prevailing capitalist–market agricultural system. This is the basis for an explanatory critique of this system (see p. 188).[1] Then, the proposals to bring about food sovereignty are drawn upon in order to rebut efforts to dull the force of the explanatory critique, which are made by those who claim that there is no viable alternative system (see p. 190). Scientific research is needed to explore the credibility of the proposal that the practices aiming to bring about food sovereignty can provide a viable alternative. Conducting the relevant kind of research, however, requires space for the use of currently marginalized metho-

dologies and a role for broader democratic input into the priorities and character of scientific research. It requires that science be re-institutionalized (see p. 197).

Explaining the food crisis of 2008

The most severe worldwide food crisis in recent decades occurred during the first half of 2008, following the sudden rise of food prices to record-breaking levels. It was marked by increased hunger and starvation in impoverished sectors of the world as large numbers of people became unable to provide adequate food for themselves and their families and, in several countries, it provoked serious social unrest ('food riots').[2]

Why did this food crisis come about? Conventional wisdom, provided by the newspapers[3] (and mainstream science/food policy publications), attributes it to the conjoined impact of four factors:

(i) Sudden and large increases in the price of petroleum.
(ii) New policies encouraging the development of agrofuels.[4]
(iii) New demands coming from 'rapidly developing' countries such as China and India for food products, and especially for meats, and thus for the crops needed to feed livestock.
(iv) Crop failures due to persistent adverse weather conditions in countries that are large-scale food exporters.

Causal mechanisms

The causal mechanisms that connect these four factors to the food crisis are clear enough. The role of (i), increase in the price of petroleum, in contributing to higher food prices is accounted for by three main mechanisms that are related to the widespread use of petroleum and petroleum-derived products in the distribution and also the production of foodstuffs. First, most food products are marketed through the institutions and mechanisms of agribusiness and other large capitalist bodies, e.g. supermarkets, much of it transported long distances nationally and internationally so that transport costs (as well as profits for the various intermediaries between farm and supermarket) contribute significantly to food costs. Second, much farm production is mechanized, using machines that consume large quantities of gasoline or diesel fuel. Third, 'conventional' farming, and also farming based on growing transgenics (GMOs), is heavily dependent on the use of petrochemicals: fertilizers, herbicides, pesticides, and their use is exacerbated as a consequence of the widespread growing of monocultures.

Regarding the role of (ii), with the rising demand for agrofuels and international policies that foster their use, there arises competition to use farmlands, either to grow foodstuffs (and other traditional agricultural products, e.g. cotton, other fibers and tobacco), or to grow crops for agrofuels. Then, unless new farmlands become available, less land will remain available for growing food crops, resulting in smaller amounts of foodstuffs produced and, in the face of increased

demand for food, higher prices (Altieri, 2009; Holt-Giménez and Shattuck, 2009; Rosset, 2009a). The mechanisms of the role of (iii) are similar: raising livestock takes land away from plant food production, and also competes with human beings for consumption of plant products. And, in the case of (iv), weather-induced crop failures in major exporting countries lead to shortages of foodstuffs on the international market and thus increased demand for what is available; hence higher prices (Bradsher, 2008b).

These mechanisms relate the four factors *directly* to increases in the price of foodstuffs, and hence, *in view of the prevailing background conditions*, to the food crisis:

(a) Most people gain access to the food they need and want principally by means of buying it in markets that are responsive to international market fluctuations, and
(b) The *status quo* for a significant part of the world's population is one in which vulnerability to and even the immediate experience of hunger, starvation and malnutrition, and the threat of further food crises, are ever-present actualities.

Although with the onset of the financial crisis in the latter part of 2008, and the fall in price of petroleum, prices of food commodities have fallen and the severity of the food crisis has abated, *these two conditions remain in place*. For millions of poor people the condition of food insecurity and constant vulnerability to hunger and malnourishment was only exacerbated, not created, by the food crisis.[5]

In order to understand the 2008 food crisis, we need to answer, not only 'Why did *this* food crisis come about?' and 'Why did the four factors become salient at the same time?' but also 'Why do most people gain access to the food they need and want principally by means of buying it in markets that are responsive to international market fluctuations?' and 'Why do threats of further crises remain?' Factor (i) is no longer operative at the time of writing this chapter (August 2009) and, as stated above, the crisis has abated – and the relevance of (iv) varies with place and time. Nevertheless, while the two conditions (a) and (b) remain in place, the threat of further crises cannot be ignored, a threat that is not assuaged by the continuance of factors (ii) and (iii) and great uncertainties about (iv); and so the need remains urgent to create a system of food production and distribution that is not vulnerable to such crises.

Systemic roots of the causal mechanisms

The causal mechanisms linking factors (i)–(iv) to the 2008 food crisis and to the threat of further food crises have systemic roots, in the system of contemporary agricultural productive and distributive practices. These practices are capital-intensive, for the most part controlled by large agribusiness corporations, industrial, dependent on petrochemical inputs and on technoscientific innovations,

e.g. hybrid plants and transgenics, which tend to be implemented by way of planting monocultures. Furthermore, they are integrated into the international market system (regulated by such institutions as WTO and IMF), in which economic growth *per se* is considered to be essential to development, and the foremost aims are to generate profit, to consolidate and expand the control of agribusiness over as many dimensions of agricultural production and distribution as possible, and to satisfy in 'developing' countries consumerist desires and habits comparable to those taken for granted in the 'developed' countries.

Obviously, factors (i)–(iii) represent fluctuations within the international capitalist-market system; and (iv) is connected with another systemically based factor, viz. that agribusiness interests usually lead to the large-scale growing of monocultures. Adverse weather conditions are more likely to cause crop failures, and on a greater scale, when crops are grown in monocultures, especially varieties that require conditions (e.g. availability of a plentiful water supply, or perhaps a predictable temperature range) that are especially vulnerable to climate change (Pittock, 2005; Kaiser and Drennen, 1993). In addition, the severity of the crisis has been related by some observers to additional fluctuations within the system: increased speculation on food commodities aiming for short-term profit, deregulation of markets, and emphasis (backed by government subsidies) on growing crops for export (Rosset, 2009a).

The integration of the production and distribution of foodstuffs into this capitalist-market system ensures that food prices – and hence the availability of food for vulnerable people – will be responsive to market fluctuations and the interests of profit. Food will be considered a commodity like any other commodity (Altieri, 2009). Beneficiaries of this system promise that the proper functioning of the market would enable everyone to gain access to sufficient food. Nevertheless, that promise has never been fulfilled, despite the fact that currently food sufficient to feed everyone is produced and could be available to feed everyone alive today, if there were appropriate mechanisms of distribution.[6] The capitalist market does not provide such mechanisms, since its workings are subordinate to the interest of profit, and so food will not be made available on this market at prices that poor people can afford to pay, unless it is profitable to do so. Thus, the capitalist-market system cannot be counted on when unfavorable market conditions emerge. Consequently, access to food (food security) will not be considered a sovereign right of people. Then, the means of production and distribution of food that might enhance the possibility of food self-reliance will not be developed, and poor people will remain in a permanent state of vulnerability to hunger and starvation. Hence the threat of further crises! The system is the fundamental source of the persistence of the threat of worsened hunger and malnutrition (see p. 191).

Connections between the food crisis and global warming

The food crisis is inseparable from global warming and the climate change that it brings about.[7]

In the first place, global warming is among the causes of the food crisis. With respect to (iv): the adverse weather conditions experienced in many regions, especially the extremes of drought, high rainfall, increased numbers of hurricanes, etc., which lead to crop failures, are probably part of the climate changes caused by global warming (Pittock, 2005, p. 16; Battisti and Naylor, 2009), and they put pressure on the world's useable water supplies (Altieri, 2009; Pengue, 2009; Gommes, 1993).[8] In addition, it is anticipated that the increased temperatures will lead to the death of many forests from heat stress and that many crops will not yield well in their current locations (Pittock, 2005, pp. 45, 108–9, 119) and yields are likely to fall in 'developing' countries (Pittock, 2005, pp. 122, 270; Rosenzweig and Parry, 1993). With respect to (ii): although the new emphasis on agrofuels is part of the response to develop alternative energy resources stimulated by the rising price of petroleum, it also is seen as responding to global warming. Supposedly agrofuels are more 'ecologically friendly', less polluting in use and less generative of the greenhouse gases that are the principal cause of global warming.

Secondly, because of the mechanisms connected with the role of factor (i) (p. 184), the system of agricultural production contributes to the emission of greenhouse gases that generate and sustain global warming and, as factors (ii) and (iii) become more pronounced, is likely to do so on a larger scale.[9] On the one hand, increases in demand for agrofuels and for food products (especially meat) lead to destroying forests, typically by burning them, thereby both adding carbon dioxide to the atmosphere, and eliminating trees that absorb it. On the other hand, despite the claim that agrofuels are 'environmentally friendly', evidence has been put forward suggesting that, to the contrary, growing crops for agrofuels actually increases greenhouse gases in the atmosphere, in part because the process of converting crops (especially in the case of maize) into methanol requires the use of very large quantities of energy that (in many cases) is likely to be derived from fossil fuels (Fagione *et al.*, 2008; Rosenthal, 2008a; Scharlemann and Laurance, 2008; Searchinger *et al.*, 2008; NYT 2008c, 2009). In addition, there is evidence that suggests that growing these crops undermines environmental and social sustainability (Jacobson, 2009) and weakens food security (Altieri, 2009). Also, some of the new crops used for producing agrofuels are dangerously invasive species (Rosenthal, 2008c), and higher temperatures and increased carbon dioxide content of the atmosphere also foster the growth of certain weeds (Christopher, 2008), both of which lead to increased use of pesticides, thereby magnifying the effects of the mechanisms involved in the role of (i).

Since it exacerbates global warming and, in turn, global warming contributes causally to the persisting threat of food crises, the current agricultural system has effects that contribute to undermine its own sustainability and to reinforce its inability to ensure food security for the world's poor. Furthermore, it is plausible to project that efforts to maintain and extend the system will involve additional contributions to global warming. But that may not happen, for it should not be ruled out summarily that technoscientific innovations might make a great difference to what is possible within the system, perhaps even mitigating some of the harmful effects that have been discussed. The current trajectory of

technoscientific innovation in agriculture, however, increasingly dominated by agribusiness and exemplified by the widespread use of transgenics, is not promising in this respect, for it entrenches all the mechanisms that relate factor (i) to the food crisis (§1.1) (Lacey, 2005a, Part 2; Altieri, 2009; Rosset, 2009a) and thus to global warming.

An explanatory critique

The current agricultural system causally contributes simultaneously to exacerbate global warming and to maintain food insecurity for many people and nations – and shows no promise of major change in this regard (see p. 192). In line with the critical realist theme of 'explanatory critique',[10] therefore, a negative evaluation should be drawn of the agricultural system – unless alternative modes of agricultural production cannot produce enough to feed and nourish the world's population, or unless they would do comparable or even greater damage in the domain of global warming and its environmental accompaniments. Critical realism alerts us to consider seriously that there may be such alternatives and to engage in appropriate research for the sake of identifying them and investigating their prospects. The real, CR maintains, is not identifiable with the actual (or the dominant trajectories of actual structures and practices), but also includes the possible (including hitherto non-actualized possibilities). As part of explanatory critique, a positive evaluation (again, *ceteris paribus*) should be drawn of practices aiming to actualize alternative modes of agricultural production and distribution, which offer the credible promise of being sufficiently productive to feed everyone everywhere and without the adverse consequences of the prevailing system of production. The power of the critique of the agricultural system to motivate action for change will depend on a positive assessment of the potential of relevant alternative agricultural practices.

Alternative system of agricultural production

Organized social movements throughout the world are proposing an alternative system of agricultural production with the aim of ensuring food security for everyone, and they are engaged in implementing whatever aspects of it that their resources will permit. They do not propose a single alternative to 'conventional' and transgenic forms of agriculture, but rather a variegated array of farming practices – organic, subsistence, biodynamic, agroecological, ecologically sustainable, permaculture, the 'system of rice intensification' (Broad, 2008), and others adapted for use in urban settings (e.g. Royte, 2009) – and the deployment of appropriate combinations and variations of them. The system would be constituted by a multiplicity of complementary locally-specific combinations and variations, each adaptable to its social-ecological environment, that simultaneously are (a) highly productive of nutritious foodstuffs, environmentally sustainable and protective of biodiversity, (b) more in tune with and strengthening of communities of rural people and the variations of their aspirations with

place and culture, (c) able to play an integral role in producing the food necessary to feed the world's growing population, and (d) particularly well suited to ensure that rural populations in 'developing' countries are well fed and nourished, so that current patterns of hunger could be abolished.

It is not only social movements of the poor who are attempting to construct an alternative system.[11] Throughout the world today, among many different groups of people, the values of food security, sustainability, healthy foods and local productivity have taken on high ethical salience, and a great variety of efforts are under way to introduce practices that emphasize organic foods (thus rejecting the use of chemical pollutants), attempts to construct new relations between producers and consumers, new forms of marketing goods, questioning of eating habits that require foods the production of which undermines environmental sustainability, decentralized (and urban garden) production. All these efforts fall among the variegated array of practices that may be bringing the proposed new system into being. Although more research is needed before a definitive appraisal of its potential can be made, the prospects appear to be promising.

Such a system would not be vulnerable in the same way as the prevailing one either to market fluctuations or to weather-induced hazards, and it would provide the foundation for local self-reliance in food. It would permit *food sovereignty*, 'the right of peoples and sovereign states to democratically determine their own agricultural and food policies',[12] and it embodies the proposal that food sovereignty is the best means of ensuring *food security*, 'a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life' (IAASTD, 2008, executive summary, p. 8).

The conditions and governmental policies needed for the development and maintenance of such a system, and the central role of family and co-operative framing in it, have been elaborated in detail by the social movements – the international alliance of organizations of peasant and family farmers, farm workers, indigenous peoples, landless peasants, and rural women and youth (Rosset, 2009a) – that are part of *Via Campesina* (Via Campesina–Brazil, 2008; Rosset, 2009a). Agroecology is accorded a central role by *Via Campesina* among the various practices that would make up the alternative agricultural system. It is a form of farming that aims to develop and maintain agroecosystems that enable there to be a satisfactory balance of the four desiderata: productivity, sustainability (ecological integrity and preservation of biodiversity), social health, and strengthening of local people's agency (Altieri, 1995). 'Agroecology' also refers to a program of scientific research, whose aim is to investigate agroecosystems with respect to how they fare in the light of the four desiderata, with a view to discovering in all locales the conditions under which they may or may not be actualized in appropriate balance.[13]

The alternative agricultural system and reduction in greenhouse gas emissions

Furthermore, in this alternative system, with its local focus, transportation costs, and the use of petroleum that they imply, would be greatly reduced. Petrochemical inputs would be minimized because the careful design of agroecosystems – rich in biodiversity, that emphasizes growing mixed kinds and varieties of crops (with appropriate rotations), and running farms that produce a multiplicity of products – eliminates much of the need for (artificial, petroleum-derived) fertilizers, herbicides and pesticides. Moreover, it would involve producing food under conditions in which the enhancement of sustainability (respect for nature and maintaining ecosystems, preservation of biodiversity) and social health are more highly rated values that profit or economic growth; then the production of agrofuels (when undertaken) would not be at the expense of food production.

The alternative system, therefore, if it were developed, would find a ready place in the multiplicity of alternative practices that would have to be strengthened throughout numerous domains of human life and activity, if global warming is to be combated in a serious way. Already there is compelling evidence that agroecology, and other forms of farming listed on p. 195, successfully meet the food and nutrition needs of many small farming communities throughout the world, whose needs are not addressed by the prevailing system (for examples, see Altieri, 1995; Pimbert, 2009). Creating conditions and resources to enable these practices to expand should be a matter of urgency, both because of their demonstrated success in serving poor communities, and because only by doing so can evidence be obtained about the potential of the alternative system that would enable a definitive judgment to be made. Here the relevant research cannot be separated from engaging in the practices and recording their outcomes (Lacey, 2002, 2005a, Ch. 11).

Attempting to dull the force of the explanatory critique: 'There is no alternative system of agricultural production' – and rebuttal of the attempts

As stated above, the power of the explanatory critique of the agricultural system to motivate action for change will depend on the positive assessment of the potential of relevant alternative agricultural practices. But the critique, as it stands, does suffice to underline the urgency of conducting research (and providing the necessary resources and conditions for it) to test the potential of a promising alternative.

Beneficiaries of the current agricultural system often respond that no further research is needed, for *the matter is already settled*: outside the trajectory of the current capitalist–market system based on technoscientific innovation that contributes to economic growth, there really is no alternative system of agricultural production that can meet the food and nutrition needs of the world's growing population. Certainly, they say, there is no available scientific evidence

to support that claim – even if, in some cases, the alternatives meet the needs of small farming communities (or fill a special niche, e.g. for organic foods, not satisfied by the predominant system), this does not extrapolate to meeting the food needs of large urban populations.

It is important to be clear about what is at issue here. Food security for all, a system that will enable all to be fed and nourished, is the fundamental aim of those advocating the alternative. Although the prevailing system currently produces enough food to feed everyone, it does not have mechanisms to ensure that everyone is fed.[14] High productivity, by itself, is not sufficient to ensure food security. This is recognized by the alternative proposals, which aim to integrate productive and distributive mechanisms at the local level. The claim made against them is that they lack the productive capacity to meet the world's food needs as the population continues to grow, especially as it is more and more concentrated in large urban settings. It is true that *now* the alternative system does not have the productive capacity to feed the world's current population; after all it has not had the conditions to develop sufficiently for its potential to be assessed. The proponents of the prevailing system focus on productive capacity. They claim that only by strengthening current trajectories of agricultural innovation in this system (e.g. with the increased use of transgenics) can adequate food be produced to meet the expected demand for food in the future (Lacey, 2005a, Ch. 10). Is it a settled matter that there is compelling evidence that this is so?

Is the capitalist-market system the fundamental cause of persisting food insecurity?

One party maintains that the current system (and it's current trajectories) cannot bring about food security, the other that the alternative system lacks the needed productive capacity. The latter party, reflecting 'conventional wisdom', also challenges the diagnosis (p. 188) that the capitalist-market system, *as distinct from some of its historically contingent features*, is one of the fundamental causes of vulnerability to food crises and of global warming. If there really are no viable possibilities outside of this system (discussed in Lacey, 2002, 2005, Ch. 11), then the system cannot be the fundamental cause of food insecurity. For the proponents of the system, factors (i)–(iv) – together with the condition (b): 'The *status quo* for a significant part of the world's population is one in which vulnerability to and even the immediate experience of hunger, starvation and malnutrition, and the threat of further food crises, are ever-present actualities' (p. 185) [15] – suffice to explain the 2008 crisis. Moreover, they may explain its severity and the persistence of (b) by a further factor:

(v) Protectionist policies enacted by many countries inhibit competitiveness, with the effect that food production is kept below what it could be and large quantities of food are withheld from the international market, and so they artificially generate further scarcity.

Among the proponents, there is some variation of opinion about the significance of the causal contribution of the various factors. For some, (ii) is the most serious factor: a time of rising costs of production and distribution of foodstuffs is not the time to put further pressure on food costs by taking away agricultural land for the sake of marketing non-food products (NYT, 2008a–d). Others tend to say that, given market mechanisms and the success of development programs in China and India, higher food prices are now here to stay – but they have been distorted upwards by misfortune (iv) and misguided policies (v). The 'solution' for them is a new equilibrium to be worked out in the play of the free market – so, to avoid starvation for large numbers among their populations, impoverished countries will have to find new ways to enter more effectively into the free market so that people will have the money to buy food at the higher prices, and restrictions (e.g. to preserve forests and other matters connected with reducing global warming) will have to be set aside.

Until now, however, condition (b) has persisted within the capitalist-market system, and given condition (a), that most people must buy the food they consume at prices subject to market fluctuations (p. 185), it is difficult to see how such a new (yet to be established) equilibrium would solve the problem. The only alternative to (a) seems to be the provision of much greater aid to impoverished people and nations. Perhaps aid aimed to strengthen local productive capacity (as distinct from just food aid) would make a difference to market conditions. Historically, aid has prevented catastrophe at some times of great calamity. But it has not provided long-term redress to the vulnerability of many people to hunger. It cannot be expected to so, for food aid – in addition to the fact that it can easily generate dependence and reinforce the corruption of the powerful in poor nations – cannot provide a permanent solution, since it is subject to the whims and changing interests of the rich countries.

Despite the persistence of (b) coexisting with ample production of food, the proponents of the prevailing system continue to focus on productive capacity without addressing how the mechanism of production may affect food security issues. When they affirm that there is no agricultural alternative, they are confident that the productivity of their system will increase, because it utilizes ongoing technoscientific innovation in farming. Furthermore, they maintain, these innovations pose no significant risks (when properly regulated) to health and the environment, and they even promise to reverse some of the environmental damage caused by current 'conventional' methods of farming that derive from excessive dependence on petrochemicals. Hence, e.g. the use of transgenics, an exemplary technoscientific innovation, has spread throughout the world and become important in the agricultural policies of many countries, *accompanied by the legitimating claims of 'no alternatives' and 'no serious risks'*. Reflection on the case of transgenics raises general issues pertinent to the kind of research needed to inform practices designed to redress the problems of global warming and to produce a more sustainable and less vulnerable world.

Alternatives and risks – and scientific research

Questions of alternatives and risks are, of course, matters for scientific investigation (Lacey, 2005a, Part 2). As pointed out above (§3.1), more research is needed before the definitive appraisal of the potential of the 'food sovereignty' alternative system aiming to satisfy the food and nutrition needs of everyone can be ascertained. So too more research is needed on the potential of the methods based on technoscientific innovations to be sufficiently productive, at the same time sustainable and free from serious risks, and whether the means of distribution accompanying the productive innovations are adequate to ensure that everyone everywhere can be properly fed. What is the appropriate research to engage in for the sake of reaching sound judgments on these matters, and what methodologies need to be deployed?

Sound agricultural policy should be informed by scientific research that attempts to provide empirically well-grounded answers to the following question about '*the range of agricultural alternatives*': what agricultural methods – 'conventional', transgenic *and* the variegated array of methods listed on pp. 188–9 – and in what combinations and with what locally specific variations, *could* be *sustainable*, relatively free from risks (including those connected with greenhouse gas emissions), and *sufficiently productive*, when accompanied by viable distribution methods, *to meet the food and nutrition needs of the whole world's population* in the foreseeable future?

Methodological considerations

Unless appropriate research is conducted responding to the range-of-alternatives question, the matter of whether or not there is a viable alternative system cannot be considered scientifically settled. What methodologies need to be adopted in order to engage in such appropriate research? Here it is important to keep in mind that seeds used in farming are simultaneously many kinds of things:[16] (a) Biological entities: under appropriate conditions they will grow into mature plants from which (e.g.) grain will be harvested. (b) Constituents of various ecological systems. (c) Entities that have themselves been developed and produced in the course of human practices. (d) Objects of human knowledge and empirical investigation. All these need to be taken into account when investigating risks and the potential of alternatives. In addition, in accordance with another theme of critical realism – that ontology is prior to methodology, that methodology must be appropriate to the kind of object being investigated – deliberations about methodological issues need to enter into the argument.

Decontextualized/reductionist – D/R – methodologies

Sufficiently far-reaching methodological deliberations usually do not take place in mainstream science, however. In it, science tends to be identified with technoscience, research conducted with the horizon of technoscientific innovation in

view, and often conducted specifically for the sake of generating such innovation.[17] The methodologies of technoscience deploy a mode of understanding that focuses on underlying molecular structures of phenomena, their physicochemical mechanisms (interactions and processes), mathematical laws and quantifiable properties, and that (consequently) enables discovery of the possibilities for exercising technological control – and, in so doing, they *decontextualize* the phenomena by ignoring their ecological, human and social contexts, and any possibilities that they may gain from being in these contexts and from their relationship to human experience and values, and (in the case of biological and human phenomena) *reduce* them to underlying physicochemical mechanisms.[18]

No phenomena can be *fully* understood without some use of decontextualized/reductionist methodologies (*D/R methodologies*). But, if only they are used, *some phenomena* cannot be adequately understood – including:

- Risks: especially long-term ecological and social risks of technoscientific innovation (Lacey, 2005a, Ch. 9) – and not just risks, but harm already caused by technoscientific innovation under the socio-economic conditions of their implementation, such as that manifested in global warming.
- The causal networks in which problems facing the poor (such as vulnerability to food crises) are located (Lacey, 2005a, Ch. 8).
- Alternative practices (e.g. agroecology) that are not primarily based on using technoscientific innovations as, e.g. practices involving the use of transgenics are (Lacey, 2005a, Ch. 10).
- Phenomena that cannot be reduced to their underlying physicochemical mechanisms: e.g. biological organisms and their developmental stages, ecological systems, human intentional action, and social structures.

To investigate *these four kinds of phenomena*, methodologies that do not decontextualize or reduce, and that are marginalized in mainstream science, must be used.

Risks

Concerning risks, it is not sufficient to consider only *direct risks* to human health and the environment connected with chemical, biochemical and physical mechanisms, that can be quantified and their probabilities estimated (and which can, to a significant extent, be well investigated using only D/R methodologies). *Indirect risks* also need to be considered, i.e., risks that arise because of socio-economic mechanisms, e.g. *in the case of the widespread use of transgenics*, long-term environmental risks that arise because most transgenics are not only biological objects, open to genomic and molecular biological investigation for example, but also commodities, entangled in issues of intellectual property rights; or risks to social arrangements that arise from the actual context of their use, including risks of undermining alternative forms of farming, and (hence) risks occasioned because extensively using transgenics serves to bring the world's food supply

increasingly under the control of a few corporations and so more vulnerable to market contingencies.

Indirect risks, since they cannot be separated from ecological and social context, cannot be investigated adequately only using D/R methodologies. The methodologies appropriate for generating technoscientific innovations are not by themselves adequate for investigating the risks that may be occasioned by the social implementation of the innovations. In mainstream science, given its tendency to identify science with investigation conducted with D/R methodologies, this tends to mean that indirect risks are investigated only when paying attention to them cannot be avoided, and then only in fragmentary, haphazard, sporadic, *ad hoc*, *post hoc*, easily manipulated, opportunistic ways. Mainstream science, for the most part, investigates phenomena only insofar as they can be investigated under D/R methodologies; it effectively subordinates ontology to methodology, since it cannot identify the possibilities open to phenomena that cannot be grasped under these methodologies and (by not raising the question of how to investigate them) effectively takes for granted that they do not exist.

Alternatives

Just as the mainstream marginalizes relevant research on indirect risks by declaring it (since not conducted utilizing D/R methodologies) to be 'not really scientific', so it also questions the scientific credentials of the research that is needed to inform the alternative forms of farming listed above (pp. 188–9) – and, therefore, needed so to be able to reach an empirically-informed judgment about the range-of-alternatives question.

Consider agroecology.[19] In agroecological investigation, the seed is considered as component of an agroecosystem that is investigated in terms of how well it fares in light of the desiderata: productivity, sustainability (ecological integrity and preservation of biodiversity), social health, and strengthening of local's peoples agency (Altieri, 1995), with a view to discovering the conditions under which they may or may not be actualized in appropriate balance. Context is essential; the role and potential of the seed in an agroecosystem cannot be reduced to what can be grasped from attending only to its underlying (genomic and molecular) structures and mechanisms and their physicochemical interactions with other (decontextualized) components of the agroecosystem. The results of molecular biology may inform agroecology in many ways, but molecular biology simply lacks the conceptual resources to deal adequately with the agroecosystem.

Research in agroecology is essentially inter- and multidisciplinary, drawing not only on the mainstream biological sciences, but also on (at least) ecology, sociology, economics, and political science. More, it draws upon indigenous and local knowledge and traditional practices, with which it often manifests continuity. It needs to utilize the farming, observational skills and knowledge of the farmers themselves, who characteristically have a more complete knowledge of the ecosystems that they work in than formally trained scientists do, and also of their histories and of the practices that can be sustained and that maintain

biodiversity. Moreover, since they are the ones whose values and cultures are to be strengthened by agroecological practices, agroecological research cannot be conducted without their committed participation. In agroecological research, there is not a clear line between the researcher and the farming practitioner, and between formally trained scientists and the bearers of traditional knowledge. This adds credibility to the scientific credentials of agroecological research. This claim may appear odd, but only where science tends to be reduced to technoscience, and its methodologies to those that explore the underlying mechanisms and laws of phenomena in dissociation from their place in agroecosystems.

Science

Science should be thought of as systematic empirical inquiry, responsive to the ideal of objectivity (Lacey, 2005a, Chs 1, 2) – while recognizing inevitable uncertainties in investigations on, e.g. risks and alternatives (Lacey, 2005b) – conducted using whatever methodologies are appropriate for gaining understanding of the objects being investigated. Then, technoscience and, more generally, research conducted under D/R methodologies, is just one, albeit an important and indispensable approach to science.

Then, indigenous knowledge – and also knowledge gained from, e.g. agroecological, feminist, deep ecological and other perspectives – need not stand opposed to scientific knowledge, and only investigation on a case-by-case basis can establish whether or not its epistemic credentials (and also those that use only D/R methodologies) are deficient for dealing with particular objects of investigation. Traditional knowledge practices, provided that they are subject to empirical constraint (not necessarily constraint from data obtained in the laboratory, but also from 'the test of practice', the exercise of practical 'know how', and 'the test of time'),[20] may reasonably be incorporated under the category of 'science' – noting that, when science is thought of as including a pluralism of methodologies (not only D/R ones, but also those that do not dissociate from context), there is no threat of reducing traditional knowledge-gaining practices to those that exclusively utilize the D/R approach[21] and, in a patronizing way, granting them the status of 'science', provided that they meet the strictures of research conducted within this approach.

Methodological pluralism

Unless science is thought of in this expanded way, permitting methodological pluralism, the range-of-alternatives question cannot adequately be addressed scientifically, for D/R methodologies can deal adequately neither with risks nor alternatives. Then, any claim, made without utilizing the appropriate pluralism of methodologies, that there are no alternative forms of agricultural production (and no serious risks) (see §4), would be simply dogmatic – reflecting either the empirically uninvestigated hypothesis that all phenomena can be grasped with the categories available when decontextualized methodologies are used, or the equally

empirically uninvestigated hypothesis that the resources of the D/R approaches (and consequent technoscientific innovations) are able to inform all viable practices.

The range-of-alternatives question remains central. Sound food policies need to be informed by empirical research pertaining to it. Moreover, given the causal links of current predominant agricultural practices with global warming, as well as their systemic links with the vulnerability of poor people to further food crises, there is urgency about investigating the productive potential of the alternative system. And the relevant research needs to be multi- and interdisciplinary, making use of an appropriate plurality of methodologies, and integrated with developments of knowledge that informs traditional and indigenous practices. But currently institutionalized science practically identifies scientific research with that conducted under D/R methodologies and, within it, research priorities are chosen in the light of the strictures of these methodologies and the interest in technoscientific innovation that would contribute to economic growth within the prevailing capitalist–market system. Thus, currently institutionalized science is unable to inform policy makers reliably on relevant matters of risks and alternatives. It tends to dismiss proposals, like those made for the priority of food sovereignty, not on the basis of the results of relevant research framed by the range-of-alternatives question; rather, since they are not amenable to being investigated using only its favored methodologies, they do not even become candidates considered for investigation.[22] Hence, if the proponents of food sovereignty are right, currently institutionalized science – by prioritizing research that might lead to technoscientific innovation, rather than that framed by the range-of-alternatives question – contributes to maintain the state of food insecurity for many poor people.

It also emphasizes looking to find technoscientific innovations that might contribute to alleviating the problem of global warming, rather than exploring that potential of alternatives like agroecology, which lie outside of the trajectory of the capitalist–market system and are not based on technoscientific innovation, and which depend on changes in relations of human beings with nature and with one another (without excluding an essential role for technoscientific innovation).

Re-institutionalized science

In order that the range–of–alternatives question may be addressed, therefore, science needs to be re-institutionalized. The re-institutionalized science would have broad democratic participation and oversight, in order to redirect the uses of scientific knowledge and the priorities of research, to make use of important methodologies that are currently marginalized, and to create space where researchers can *begin with* the aspirations, assessments of needs, and practices of the social movements (like *Via Campesina*), and involve their participation in an integral way. Then, the forms that science takes, and the kinds of questions it addresses, could be determined in collaboration with the social movements and reflect their values and experiences. The proposal is not intended to deny space

for research aiming for technoscientific innovation, but to create institutional forms in which there can be democratic deliberation – involving the participation of representatives of all who experience the impact of technoscientific innovation, and who have proposals for dealing with the world's serious problems – about appropriate priorities for research and allocations of resources.[23] Above all, it is to enable resources to become available for research that could test the potential of alternatives and inform their conduct; and it would insist that the range–of–alternatives question be thoroughly investigated, concerning risks (including causal connection to global warming) and alternatives, before technoscientific innovations be socially introduced.

Concluding remarks

The current predominant system of agricultural production causally contributes significantly, not only to the vulnerability of many poor people and nations to food crises, but also to the quantity of greenhouse gases present in the atmosphere and thus to global warming and the climate changes that accompany it. Hence, the explanatory critique, that this system should be negatively valued. In general, however, the power of an explanatory critique to motivate action for change, depends on identifying proposed courses of action for eliminating the object criticized (in this case, for transforming the system of agricultural production) that are positively valued. Concerning issues connected with global warming, the motivation for change has been difficult to generate; even though the authoritative reports put out by IPCC (International Panel on Climate Change) offer compelling models of anticipated dire climate change, they have not instigated much governmental action to deal with its causes. After noting this fact, Revkin (2009) quotes a leading climate scientist: 'For IPCC, this means providing guidance that will minimize climate impacts and maximize investments in a prosperous and sustainable future'.

To motivate change, no matter how dire the outlook of continuing the current trajectory, a positively attractive course of action needs to be at hand. Hence, the extended discussion of the possibility of an alternative system of agricultural production, the forms it might take, and the agents who would develop it. If global warming is to be contained, the 'investments' will have to be in many areas. Agriculture is one of them and, connected with it, the practices aiming for food sovereignty should be leading contenders for investment, and also the forms of scientific investigation that can be expected to inform these practices. Certainly, it should not be presumed, prior to appropriate scientific investigation, that only forms of scientific research that can inform technoscientific innovation are relevant. Hence, the need to re-institutionalize science, so that proposals, e.g. concerning the importance of food sovereignty, that simultaneously promise to address the vulnerability of poor people to food crises and to contribute to redressing global warming, can be investigated fully and (as appropriate) implemented.

Notes

1 Explanatory critique is a central theme of critical realism (see Note 10). In making the argument, other themes of CR are also drawn upon, *viz.*, that the real is not identifiable with the actual but includes also the possible, and that methodology should be subordinate to ontology and appropriate to the kind of object being investigated.

2 FAO (2009b); Rosset (2009a) For newspaper reports see, e.g., Bradsher (2008a) and Lacey, M. (2008). Lacey reports food riots in Guinea, Mauritania, Mexico, Morocco, Senegal, Uzbekistan and Yemen; Rosset (2009b) in Bangladesh, Brazil, Burkina Faso, Cameroon, Côte d'Ivoire, Egypt, India, Indonesia, Mozambique, Pakistan, Myanmar, Panama, the Philippines, Russia, Senegal, and Somalia.

3 See, e.g., Krugman (2008). USAID (2008). Re. (ii): see Martin (2008); re. (iv): Bradsher (2008b).

4 'Agrofuels' – fuels produced from agricultural products, often called 'biofuels'.

5 'International food prices have come down from their 2008 peaks, but are higher than they were in 2006 and likely to remain volatile. In many developing countries, the cost of staple foods remains stubbornly high. The financial crisis is straining the ability of the poor to cope. Easing the burden of high food prices at the outset was critical – but more needs to be done. Efforts now need to focus on building farmers' resilience to future shocks and improving food security over the long term' (FAO, 2009a).

The financial crisis led to the fall in prices of food commodities. But, in other ways (e.g. through increasing unemployment) it created additional difficulties for poor people to buy food.

'The double whammy of high food prices and the economic meltdown has pushed more than 100 million people into poverty and hunger. Although international prices have come down from their record highs in 2008, they have yet to drop to their levels before the food crisis, and the risk of volatility continues. Average food prices in May 2009 were about 24 percent higher than they were in 2006. And, in many developing countries, the cost of basic food staples is stubbornly high. Unemployment and reduced wages, remittances and government services – by-products of the economic slump – threaten to add to the woes of the world's poorest people, who already spend between 60 and 80 percent of their income on food' (FAO, 2009a).

6 This claim has been widely documented; see, e.g., Boucher (1999), and it is not contested in the discussions of the 2008 food crisis.

7 The following websites provide up to date references to the literature on this topic: Science and Development Network, http://www.scidev.net and Food First, http://www.foodfirst.org.

8 'Water sources will become more variable, droughts and floods will stress agricultural systems, some coastal food-producing areas will be inundated by the seas, and food production will fall in some places in the interior. Developing economies and the poorest of the poor likely will be hardest hit' (Nelson, 2009).

'Water scarcity and the timing of water availability will increasingly constrain production. Climate change will require a new look at water storage to cope with the impacts of more and extreme precipitation, higher intra- and inter-seasonal variations, and increased rates of evapotranspiration in all types of ecosystems. Extreme climate events (floods and droughts) are increasing and expected to increase in frequency and severity and there are likely to be significant consequences in all regions for food and forestry production and food insecurity. There is a serious potential for future conflicts over habitable land and natural resources such as freshwater. Climate change is affecting the distribution of plants, invasive species, pests and disease vectors of many human, animal and the geographic range and incidence of many plant diseases is likely to increase' (IASSTD, 2008, executive summary, p. 15).

9 'Today, agriculture contributes about 14% of annual greenhouse gas emissions, and land use change including forest loss contributes another 19%. The relative

contributions differ dramatically by region. The developing world accounts for about 50% of agricultural missions and 80% of land use change and forestry emissions' (Nelson 2009). 'Agriculture presently contributes about 21–25%, 60%, and 65–80% of total anthropogenic emissions of carbon dioxide, methane and nitrous oxide, respectively . . . Agriculture is also thought to be responsible for over 90% of the ammonia, 50% of the carbon monoxide . . . released into the atmosphere as a result of human activities' (Duxbury and Mosier, 1993, p. 232).

10 The idea of explanatory critique – that a negative evaluation should be drawn (*ceteris paribus*) of the causes of the social acceptance of false beliefs and (*as in this case*) of negatively valued phenomena, and a positive evaluation (also *ceteris paribus*) of courses of action rationally chosen for the sake of removing the causes – has been thoroughly developed in several writings by Roy Bhaskar, most fully in Bhaskar (1986), Ch. 2, Sects. 6, 7. For an overview, analysis, and a lot of references, see Lacey (2007).

11 The goal, food security for all and the minimization of threats of further food crises, is shared by many international (humanitarian, aid and agricultural) agencies, which reject the reliability of the capitalist market for meeting this goal, and point to the need to enhance and protect local food productive capacity in all countries. Some agencies endorse proposals close to those of the social movements (e.g. IAASRD); for others the goal of obtaining food security is not to be at the expense of strengthening modified mechanisms of the international market.

12 Cf., food sovereignty 'as people's right to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agricultural systems. . .. It requires an immediate moratorium and eventual rollback of agrofuels . . . It relies on agroecological approaches to production and protects the farmer's right to seed, land, water, and fair markets. Food sovereignty requires the democratization of our food systems – their spaces and places – in favor of the poor' (Holt-Giménez and Shattuck, 2009).

Rosset (2009a) summarizes 'Food sovereignty policies to address the global food price crisis' as involving the following demands:

- Protect domestic food markets against both dumping (artificially low prices) and artificially high prices driven by speculation and volatility in global markets.
- Return to improved versions of supply management policies at the national level and improved international commodity agreements at a global level.
- Recovery of the productive capacity of peasant and family farm sectors, via floor prices, improved marketing boards, public-sector budgets, and genuine agrarian reform.
- Rebuild improved versions of public sector and/or farmer-owned inventories, elimination of transnationals and the domestic private sector as the principal owners of national food stocks.
- Controls against hoarding, speculating, and forced export of needed foodstuffs.
- An immediate moratorium on agrofuels.
- The technological transformation of farming systems, based on agroecology, to break the link between food and petroleum prices, and to conserve and restore the productive capacity of farmlands.

13 See Lacey (2005a), Part 2, for discussion of the evidence for and extensive documentation of the productive potential of agroecology as an agricultural practice, and a defense of the sound scientific credentials of agroecological research.

14 Condition (b) is considered a historically contingent feature of the system – or, if food security cannot be ensured within the system and so cannot be ensured at all, then (b) would represent just the tragic fact that scarcity is part of the human condition. Of course, those who experience food insecurity have every motive to demand that the

potential of all alternatives be investigated urgently and with provision of adequate resources, that practices that demonstrably meet their needs be expanded, and not be stopped short by easy projections from the current state of affairs or the interests of the beneficiaries of the prevailing system. It is also important to keep in mind that highly motivated organized action to bring about an alternative can be a crucial causal factor in realizing an alternative; the potential of alternatives cannot properly be appraised independently of this factor and so it cannot be 'read off' from current predominant trajectories (Lacey, 2002, 2005a, Ch. 11).

15 Seeds are examples of 'laminated systems' (Bhaskar and Danermark, 2006).

16 The nature of technoscience and its characteristic methodological features are discussed in more detail in Lacey (2008b). A fuller account is not needed here, for what matters, so far as the present argument is concerned, is only that research in technoscience involves the use of D/R methodologies. Note the characterization of 'science' below (§4.4), which does not limit 'scientific' research to that conducted under D/R methodologies, and which recognizes the scientific status of the methodologies used, for example, in agroecology (Lacey, 2005a, Part 1).

17 These methodologies, the reasons for their being virtually exclusively deployed in modern science, and the possibility of a pluralism of methodologies (not all of which are reducible to those of the decontextualized approach) under which objective scientific knowledge may be gained, are discussed fully in Lacey (1999, Chs 6–10; 2005a, Part 1).

18 For further details, see Lacey (2005a), Chs 5, 10.

19 Remember that traditional knowledge informed the selection practices that bequeathed us the seeds that are indispensable for growing all crops today, and without which transgenics would be impossible.

20 There is a growing literature showing the richness, variability, versatility, sensitivity to sustainability issues, and empirical soundness (that is not undermined by being reflective of the interests and values of particular cultural groups) of much traditional and indigenous knowledge (e.g. Pimbert, 2009; Santos, 2007). As 'science' is being used here, it can incorporate all these forms of knowledge, while retaining their specific features and not forcing them into a shape that supposedly fits all scientific research; and they become indispensable resources for addressing – scientifically – the range-of-alternatives question. The authors cited here prefer to talk of these forms of knowledge, not as 'scientific', but as 'other knowledges' ('decolonialized knowledges'), terminology that they intend to have relativist connotations. Whether or not these other forms of knowledge are to be called 'scientific' is not very important; the important things are their sound empirical credentials, and that having these credentials does not depend on using D/R methodologies. The connoted relativism is unnecessary (and unfounded). What is present here is not knowledge relative to particular cultures, but approaches to investigation that are properly reflective of the character or aspects of the object being investigated – aspects that may be considered important because culturally specific values are held. This does not make the knowledge, as distinct from its significance, relative to these cultural values.

21 That D/R methodologies are used almost exclusively in modern science is linked either with commitment to materialist metaphysics, that all possibilities can be grasped with the categories deployed in (current or still to be developed) D/R methodologies (Lacey 2009), or by making certain assumption about technological progress, e.g. that all the great problems of the world, including dealing with harm caused by technoscientific innovations themselves, can be resolved by technoscientific innovation, and typically only in that way (Lacey 2005a, Ch. 1). Either way, assumptions are involved that could not be confirmed by research exclusively conducted using D/R methodologies. However, they are deep in the 'common sense' of modern science, and so taken for granted, as well as being powerfully reinforced by current forms of funding for research that emphasize that research should lead to contributions to economic growth, that

their empirical status is seldom thought about. This makes it difficult for the sound claims of alternatives to gain a hearing within mainstream science.

22 One might put it: the claim is, in the name of human rights, for a niche for research that does not reflect market relations.

23 This is a general claim. How it would be worked out in areas, other than agriculture, is beyond the scope of this chapter (see Lacey, 2008a).

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