How to feed people under a regime of Climate Change

The first thing that must be pointed out is that climate change is by far and away the most daunting problem that mankind has ever encountered. The Inter-Governmental Panel on Climate Change (IPCC) in its last assessment report has told us that we could expect a temperature change of up to 5.8 degrees within this century. However, the IPCC did not take into account a number of critical factors including the annihilation of our tropical forests and other vegetation. However, these contain six hundred billion tons of carbon almost as much as is contained in the atmosphere, much of which is likely to be released into it in the next decades by the increasingly uncontrolled activities of the giant logging companies. The Director General of the United Nations Environment Programme recently stated that only a miracle could save the world's remaining tropical forests.

Nor does the IPCC take into account the terrible damage perpetrated on the world's soils by modern industrial agriculture with its huge machines and arsenal of toxic chemicals. The world's soils contain one thousand six hundred billion tons of carbon, more than twice as much as is contained in the atmosphere. Much of this will be released in the coming decades unless there is a rapid switch to sustainable - largely organic - agricultural practices. On the other hand, the Hadley Centre of the British Meteorological Organisation has taken these and other such factors into account in its more recent models and has concluded that the world's average temperature will increase by up to 8.8 rather than 5.8 degrees this century.(1) Other climatologists who take into account often still largely neglected factors are even gloomier.(2)
If they are right, what then are the implications?

The IPCC tells us that we can expect a considerable increase in heatwaves, storms, floods, and of course, the spread of tropical diseases into temperate areas, which will not only affect human health but also that of our crops. It also tells us to expect a rise in sea levels of anything up to eighty eight centimetres this century which will affect (by seawater intrusion into the soils underlying croplands and by temporary and also permanent flooding) something like 30% of the world's agricultural lands. (3) Of course, if the Hadley Centre is right, the implications will be horrifying. Very worrying

too is the melting of the secondary Antarctic, the Arctic, and in particular, the Greenland ice-shields which is occurring far more quickly than was predicted by the IPCC. Among other things, this will reduce the salinity of the oceans which in turn must weaken if not divert, oceanic currents such as the Gulf Stream from their present course.(4) This process if it continues, would eventually lead to the freezing up of areas that at present have a temperate climate such as Northern Europe which could eventually resemble that of Labrador which is on the same latitude.

It is indeed ironic that global warming could lead to local or regional cooling. If this were not bad enough, we must realise that even if we stopped burning fossil fuels tomorrow, our planet would continue to heat up for at least a 150 years; the residence time of carbon dioxide the most important greenhouse gas in the atmosphere, while the oceans will continue to warm up for a thousand years at least. All we can do is take those measures - and very dramatic ones at that - that are required to slow down the warming process so that when our climate eventually stabilises, our planet remains partly, at least, habitable.

Unfortunately, climate change is proceeding faster than predicted. This has been made apparent among other things by the prolonged droughts in many parts of the world. Four years of drought in much of Africa have resulted in thirty to forty million people facing starvation. At the same time, drought in the main bread-baskets of the world: the American corn belt, the Canadian plains, and the Australian wheat belt will seriously reduce cereal exports which is not very encouraging for the vast masses of people in Africa and elsewhere who are today facing starvation. The climate in Europe has also been dreadful. Massive floods in Germany in 2002 are expected to cost at least 13 billion dollars. The terrible storms in northern Italy, with hail stones the size of tennis balls, destroyed crops in 2002 over a wide area. Drought in southern Europe as also drastically harvests.

I was personally driven through endless olive groves in the southern Italian province of Foggia and did not see a single olive on any of the trees. Worse still, southern Sicily is said to be drying up.

We must remember that all this is the result (partly at least) of no more than 0.7 degree increase in global temperatures. What will things be like when we have to grow our food in a world whose average temperature has increased by 2 or 3 degrees, let alone by 5 to 8 degrees as we are told we might have to later in this century?

Emissions of nitrous oxides and methane

All this must make it clear that climate change or rather its different manifestations mentioned above will be the most important constraints on our ability to feed ourselves in the coming decades. Clearly we cannot just sit and wait for things to get worse. Instead, we must do everything we can to assure the transformation of our food production system so that it helps us to combat Global warming and, at the same time, to feed ourselves, in what will almost certainly be far less favourable conditions.

The term ”transformation” is quite clearly appropriate as modern industrial agriculture by its very nature makes and must make a very large contribution to greenhouse gases. Consider that currently it is responsible for 25% of the world’s carbon dioxide emissions, 60% of methane gas emissions and 80% of nitrous oxide, all powerful greenhouse gases.(5)

Nitrous oxide is generated through the action of denitrifying bacteria in the soil when land is converted to agriculture. When tropical rainforests are converted into a pasture, nitrous oxide emissions increase by three times. All in all, land conversion is leading to the release of around half a million tonnes a year of nitrogen in the form of nitrous oxide.

Nitrous oxide is some 200 times more potent than carbon dioxide as a greenhouse gas, though fortunately atmospheric concentrations of nitrous oxide are currently over 1,000 times lower than that of carbon dioxide - 0.31ppmv compared with 365 ppmv. Nitrogenous fertilisers are another major source of nitrous oxide. Around 70 million tonnes a year of nitrogen are now applied to crops and are contributing as much as ten per cent of the total annual nitrous oxide emissions of 22 million tonnes. With fertiliser applications increasing substantially, especially in developing countries, nitrous oxide emissions from agriculture could double over the next 30 years. (6)

In the Netherlands, the site of the world's most intensive farming, as much as 580 kilograms per hectare of nitrogen in the form of nitrates or ammonium salts are applied every year as fertiliser and at least ten per cent of that nitrogen gets straight back into the atmosphere, either as ammonia or nitrous oxide. (7)

The growth of agriculture is also leading to increasing emissions of methane. In the last few decades, there has been a substantial increase in livestock numbers - cattle, in particular - much of which has been made possible by the conversion of tropical forests to pasture. Cattle emit large amounts of methane and the destruction of forests for cattle-raising is therefore leading to increased emissions of two of the most important greenhouse gases.

Worldwide, the emissions of methane emitted by livestock amount to some 70 million tonnes. With modern methods of production, cattle are increasingly fed on a high-protein diet - especially when fattened in feedlots. Such cattle emit considerably more methane gas than grass-fed cattle. Even the fertilisation of grasslands with nitrogen fertilisers can both decrease methane uptake and increase nitrous oxide production, which thereby increases atmospheric concentrations of both these gases. (8)

The expansion of rice paddies has also seriously increased methane emissions. Rain-fed rice produces far less methane than inundated rice fertilised with nitrogen fertiliser. Once again, the modernisation of agriculture increases methane gas emissions as well as nitrogen emissions.

Energy Intensity

The most energy-intensive components of modern industrial agriculture are the production of nitrogen fertiliser, farm machinery and pumped irrigation. They account for more than 90% of the total direct and indirect energy used in agriculture and they are all essential to it.

Emissions of carbon from the burning of fossil fuels for agricultural purposes in England and Germany were as much as 0.046 and 0.053 tonnes per hectare while they

are only 0.007 tonnes, i.e. roughly seven times lower, in non-mechanised agricultural systems.(9)

This ties in with the estimate made by Pretty and Ball (10) that to produce a ton of cereals or vegetables by means of modern agriculture requires 6 to 10 times more energy than it does by using sustainable agricultural methods.

It could be argued that a shift to renewable energy sources such as wind power, wave-power, solar power and fuel cells would avoid having to reduce energy consumption to protect our climate, however, this necessary substitution would take decades - some think about 50 years or so.

However a radical reduction in gas emissions is immediately necessary if we are to believe the Hadley Centre's contention that rising temperatures within thirty years will have become sufficient to begin transforming our main sinks, (our forests, oceans and soils) for carbon dioxide and methane gas into sources of these greenhouse gases. If this occurs, of course, we would be caught up in a "runaway" process, i.e. an unstoppable chain-reaction towards increasing temperatures and climatic instability.

What we must develop is of course an agricultural system that does not cause these terrible problems, and which on the contrary helps to revitalise and hence build-up our soil resources. Such an agricultural system would, surprisingly enough for those imbued with the ideology of progress, have much in common with those that were once practiced by our distant ancestors and which are still practiced by those communities in the remoter parts of the Third World, which have succeeded in staying, to some extent at least, outside the orbit of the industrial system. They may be "uneconomic" within the context of an aberrant and necessarily short-lived industrial society, but they are the only ones that are actually designed to feed local people and in a really sustainable manner. Significantly, the most respected authorities on sustainable agriculture, among them Jules Pretty and Miguel Altieri, and there are many others, increasingly use the term "sustainable agriculture" as synonymous with "traditional agriculture".

If traditional agriculture is the answer one might ask why are governments and international agencies so keen to prevent traditional peoples from practising it anymore

and to substitute modern industrial agriculture in its place. The answer is that traditional agriculture is not compatible with the developmental process that we are imposing on the people of the Third World, still less with the global economy, and less still with the immediate interests of the transnational corporations that control it all.

That this is so is clear from the following quotes from two World Bank reports. In the first, on the subject of the development of Papua New Guinea, the World Bank admits that "a characteristic of Papua New Guinea's subsistence agriculture is its relative richness". Indeed "over much of the country nature's bounty produces enough to eat with relatively little expenditure of effort". (10) Why then change it? The answer is clear, "Until enough subsistence farmers have their traditional lifestyles changed by the growth of new consumption wants, this labour constraint may make it difficult to introduce new crops" (11)- those required for large scale production for export of course.

Even in the World Bank's iniquitous Berg report, it is acknowledged "that smallholders are outstanding managers of their own resources - their land and capital, fertiliser and water". (12) But in the same report it is also acknowledged that the dominance of this type of agriculture or 'subsistence production' "presented obstacles to agricultural development. The farmers had to be induced to produce for the market, adopt new crops and undertake new risks". (13)

Whether we like it or not, modern industrial agriculture is on the way out. It is proving ever less effective. For instance we are now encountering diminishing returns on fertilisers. The Food and Agricultural Organisation of the United Nations (FAO) admitted in 1997 that wheat yields in both Mexico and the USA had shown no increase in 13 years. In 1999, Global wheat production actually fell for the second consecutive year to about 589 million tons, down 2% from 1998. Fertilisers are too expensive and as McKenney puts it "the biological health of soils has been driven into such an impoverished state in the interests of quick, easy fertility, that productivity is now comprised, and fertilisers are less and less effective". (14)

Pesticides too are ever less effective. Weeds, fungi, insects and other potential pests are amazingly adaptable. 500 species of insects have already developed genetic

resistance to pesticides as have 150 plant diseases, 133 kinds of weeds and 70 species of fungus. The reaction today is to apply evermore powerful and more expensive poisons, which in the US cost 8 billion dollars a year not counting the cost of spreading them on the land. (15) The farmers are loosing the battle, the pests are surviving the chemical onslaught but farmers are not. More and more of them are leaving the land, and the situation will get much worse.

Today we are witnessing the forced introduction of genetically modified crops by international agencies in collusion with national governments, as the result of the massive lobbying being carried out by an increasingly powerful biotechnology industry. Genetically modified crops, quite contrary to what we are told, do not increase yields. Also they require more inputs including more herbicides, whose use they are supposed to reduce significantly, as well as irrigation water. Also the science on which they are based is seriously flawed. No one knows for sure what will be the unexpected consequences of introducing, by a very rudimentary technique, a specific gene into the genome of a very different creature. Surprises are in store and some could cause serious problems of all sorts. (16)

Another reason why industrial agriculture has had it's day, even without climate change, is that it is far too vulnerable to increases in the price of oil, more so, to shortages in the availability of this fuel.

If three million people starved to death in North Korea in the last few years, it was partly because, as a result of the collapse of the Russian market which absorbed most of its exports, it could no longer afford to import the vast amount of oil on which its highly mechanised, Soviet inspired, agricultural system had become so totally dependent. Its "farmers" had simply forgotten how to wield a hoe or push a wheelbarrow.

The UK could have been in a similar plight if the transport strike of 2000 had lasted a few more weeks. In an industrial society, oil is required to transport essential food imports, to build and operate tractors, to produce and use fertilisers and pesticides and process, package and transport food to the supermarkets - a more vulnerable situation is difficult to imagine at the best of times - but it is suicidal today.

It is not just temporary oil shortages associated with temporary jumps in the price of oil that we are destined to face but the steady decline in the availability of this commodity. As this occurs oil is due to become increasingly expensive until it will be affordable only a minority of corporations - US ones, in all probability, as the US oil industry is positioning itself to take over and use for its own purposes the fast declining supplies. The truth is that worldwide oil production will peak within the next four to ten years. Oil discoveries have been very disappointing and much of the oil we are using today was discovered some forty years or so ago. The Caspian Sea area which many people in the oil business expected to contain as much as 200 billion barrels of oil, according to Colin Campbell, (17) one of the world's leading authorities on the oil industry, is more likely to contain some 25 billion barrels and no more than 40 or 50 billion. This is not all that significant in a world that uses 20 billion barrels a year, and whose consumption goes on increasing at an alarming rate.

Though the US has tried desperately to reduce its dependence on the Middle East that it has succeeded in doing to a certain extent, alternative sources of oil are drying up more quickly than expected. Iran for instance is unlikely to produce more oil than it requires for its own use in more than ten or fifteen years - indeed in the next twenty years the US will have become more dependent on the Middle East than it is today as oil production of countries like Angola, Nigeria, Venezuela, and Mexico also begin to fall. This explains of course, why the US oil industry which is now in effect, the government of the USA, is so fanatically determined to conquer Iraq which has 11% of world known reserves of which only a fraction are exploited, and whose oil is the cheapest in the world. The economic consequences of the coming world oil crisis cannot be over-estimated.

Protecting the Soil

Industrial agriculture's main contribution to carbon dioxide emissions is via the loss of soil carbon to the atmosphere.(18) This is caused by intensive industrial agriculture in particular by such practices as :

- deforestation and the drainage of peat lands and wetlands
  in order to make available ever more land for agriculture and livestock rearing,
- deep ploughing which exposes the soil to the elements, and

when practised on steep slopes, causes serious soil erosion,

- the use of heavy machinery that compacts the soil reducing or eliminating open pore space for providing channels for air, water, plant roots and soil micro-organisms,
- the use of fertilisers as a substitute for natural fertilisers which destroys soil structure killing and hence soil organisms,
- the use of pesticides, some of which as Rachel Carson (19) showed way back in 1962, do exactly the same thing,
- overgrazing that has led everywhere to soil degradation and desertification,
- in general intensive large scale monoculture of wheat and maize etc. year after year which eventually turns the soil into a lifeless dust-like substrate for crops that can only mature if dosed with increasing amounts of artificial fertilisers and other inputs.

The most obvious method of preventing soil-loss and indeed of increasing the organic matter in the soil, is by the use of manures, compost, mulches and cover crops such as forest bark, straw or other organic materials which can be fed back into the soil. These serve to protect the soil from erosion, desiccation, excessive heat and to promote, in this way, the decomposition and mineralisation of organic matter. (20)

It also has other advantages such as reducing soil-born diseases and in addition it also increases productivity. As Jules Pretty notes, in the Niger Republic mulching with twigs and branches permits cultivation on hitherto abandoned soils, (21) "producing some 450kg of cereals per hectare. In the hot Savannah area of northern Ghana, straw mulches combined with livestock manures, produce double the maize and sorghum yields than does the equivalent amount of nitrogen added as inorganic fertiliser".(22) Pretty cites other impressive examples of this sort, in Guatemala, the State of Santa Katarina, Brazil and elsewhere.

It is important that the soil should be left uncovered for as short a time as possible. An undercrop, preferably leguminous such as lucerne, can be sown along with a crop of cereals so that when the latter is harvested the land remains under cover, and at the same time, enriched.

Conservation tillage, better still zero tillage appears ideal as it entirely avoids ploughing. However to get rid of the weeds requires a lot of herbicides which are undesirable on many counts. What is clearly needed is zero tillage without the use of herbicides. If the area involved is small, mulches could presumably be used to smother the weeds. A little ingenuity would, I am sure, enable us to find alternative methods for killing weeds. Significantly, "Waipuna" a New Zealand Company suppresses weeds on roadsides by spraying them with hot water. The heat is retained with the use of an organic mousse partly made from coconut milk. It is apparently very effective.

The FAO, in a report already referred to, tells us that the absorption of carbon by the soil is maximised under a system of agroforestry. It can be as high as from 2 to 9 tonnes annually. (23) Apparently, if agroforestry were practised worldwide, agriculture could absorb in a ten year period some 2010 1.3Pg of atmospheric carbon annually. (24) The IPCC, in its Third Assessment Report (2000), (24) also concludes that agroforestry yields the best results not only by increasing soil organic matter but also above-ground, woody biomass.

The USDA National Agroforestry Centre (2000) agrees that carbon sequestration under agroforestry is particularly high. They favour short-rotation coppicing that, if the wood is burnt instead of a fossil fuel, provides a double benefit through carbon sequestration and energy substitution. The Agroforestry Centre suggests that, with coppicing, soil carbon can be increased by 6.6 tonnes C/ha/yr over a 15-year rotation and wood by 12.22 tonnes C/ha/yr over the rotation. (25)

Combining agriculture with forestry is a solution multiplier: - Thus wind velocity is reduced. In summer, the temperature under trees is much lower than in open areas and also warmer in winter. Just planting individual trees in the fields provides the necessary shade for plants and for livestock. The humidity under trees is also greater than on open sites because of the reduced evaporation and increased water-retention made possible by the improved soil structure. The litter provided by the trees makes excellent fertiliser especially when composted. Forested areas also play an enormous role in preventing floods as the rainfall stored under the forest floor, rendered porous by the tree roots, is released slowly to open spaces and to rivers rather than all at once from otherwise hard deforested land. (26)

Forested areas are also a source of food and forage as well as vegetable dyes, medicinal herbs and wood for posts, to prop up vines for instance, and for fencing. Tree crops are also a valuable supplement or substitute for annual crops. The sweet chestnut has a very high food value, for instance, and was grown extensively in high altitudes in southern Europe for making flour for pasta and bread. In the tropics, perennial tree crops such as breadfruit, plantain, jackfruit etc. are still important and are made the most of in Javanese and Singhalese forest gardens.

All in all, the agricultural methods required to protect our invaluable soil resources, which is essential for coping with climate change, provide many additional benefits. They give rise to a higher biodiversity of soil micro-organisms and micro-fauna. They are much more energy efficient because of their far lower dependence on energy-intensive inputs. By adding so much biomass to the soil, they increase productivity as well as reduce costs, thereby rendering a farm less vulnerable to discontinuities. Last but not least, they provide very much healthier food.

Irrigation

Another essential change to our present agricultural system involves the phasing out of modern perennial irrigation methods. Modern irrigation is one of the most energy intensive components of industrial agriculture. Pimentel considers that when it is based on the use of water extracted from a depth of more than 30 metres, pumped irrigation requires more than three times more fossil fuel energy for corn production than does the rain-fed cultivation of the same amount of corn. (27) In addition, rice cultivation which feeds a vast proportion of the people of the tropical world gives rise as already mentioned, to very much more methane gas when rice fields are flooded and treated with artificial fertiliser rather than rain-fed and grown organically. The reason is that flooding cuts off the oxygen supply to the soil, causing the organic matter it contains to decompose into methane gas. (28)

Admittedly modern perennial irrigation is highly productive and makes three crops a year quite feasible. Indeed, about 11% of the world's crop land (250 million

hectares in 1994) are under perennial irrigation and supply as much as 40% of the world's food.(29)

Our dependence on perennially irrigated land is largely due to the cultivation of crop varieties such as the hybrids of the Green Revolution and now the genetically modified varieties which require very much more irrigation water, just as they do more fertiliser and pesticides. This is not the case with traditional varieties some of which are also highly productive and to which, in some areas of India, farmers are beginning to return to. It is also due to the accent today on highly water-intensive export crops such as sugar cane, eucalyptus and worse still "beef". As Reisner notes, to produce a pound of corn (maize) requires some 100 or 200 gallons of water. But to produce a pound of beef requires up to 8500 gallons i.e. 20 to 80 times more water. (30)

In any case, modern irrigated agriculture could not be less sustainable. The amount of water used for irrigation is doubling every 20 years and at present consumes nearly 70% of all the water used world-wide, something that cannot go on for much longer, with or without climate change. Almost without exception modern irrigation especially in tropical areas leads to waterlogging and salinisation. As this occurs so the land is taken out of production - more of it, so it appears, than is actually brought under irrigation every year.

In the USA alone, 50-60 million acres, 10% of all cultivated land has already been degraded by salinisation and many thousands of acres have been removed from cultivation. The depletion of groundwater resources has been just as dramatic. The massive Ogallala aquifer, which was at one time regarded as practically inexhaustible, is been depleted at the rate of 12 billion cubic metres per year. Over the years it has lost 325 billion cubic metres of water, the annual depletion of aquifers worldwide amounting to at least 163.6 billion cubic metres. (31) Land taken out of irrigated agricultural simple becomes second rate grazing land, that can support a mere fraction of the previous human population in the area.

If modern irrigated agriculture has had it's day it is also because more than a billion people world-wide are now suffering from water shortages, and it is expected that the number will increase dramatically in the coming decades especially with global-

warming. We must remember that much of the water that flows in many of the world's main rivers is derived from melting glaciers in the mountains where the sources of the rivers lie. However, glaciers world-wide are in full retreat as a result of global warming, which means that the flow of many rivers will be seriously reduced - in some cases, according to Cynthia Rosensweig, by as much as 25%.

Also, as Bunyard notes, (32) the amount of water required for irrigation as surface temperatures rise, must increase, partly because of the increased evaporation from the soil, the reservoirs and the irrigation channels but also because of increased evapotranspiration from the vegetation and in particular the forests. The reaction of governments and of the World Trade Organisation is as usual, to transform the problem into a business opportunity. Under the General Agreement on Trade in Services, water is being privatised and wherever this happens, of course, the price of water doubles or trebles and in the state of Orissa, according to Vandana Shiva, (33) has increased tenfold and is now way beyond the means of the small farmers.

The only answer is to abandon the cultivation of water intensive crops and the rearing of livestock for export. Instead we must return to the traditional varieties of subsistence crops most of which are rain-fed, and to traditional methods of irrigation which are seasonal as opposed to perennial and do not give rise to salinisation, water-logging or the other terrible problems caused by modern irrigation systems. (34)

Significantly, farmers in the Malwa Plateau in the State of Madhya Pradesh in Central India are returning to unirrigated wheat varieties which they had abandoned under government and corporate pressure some 30 years ago. Some of them grow a short season leguminous crop or an early ripening variety of cereal which is given a full dose of farm manure before the monsoons and is thoroughly ploughed in. No drainage is required so that as much as possible of the rainfall is absorbed as soil moisture. Neither of these crops interferes with the traditional wheat, the variety grown being very deep rooting as it searches for moisture and nutrients, and this insulates it from competition from the largely leguminous weeds. When the monsoon waters withdraw, the field is tilled and the wheat sown, the winter dew assuring that it reaches maturity in late February. At the same time there are great savings on inputs for the Green Revolution HYVs require that the weeds be removed since, with their short roots, they

are unable to utilise the moisture that lies deeper down in the ground. There are further benefits in terms of soil quality improvement of course, the reduced demand for water. (35)

Traditional irrigation has been practised throughout the Indian Subcontinent, Sri Lanka, Java and elsewhere for hundreds of years. It is based on water harvesting and is managed by local communities in a highly democratic and equitable manner and needless to say, in a totally sustainable one. Anil Agarwal and Sunita Narain tell us that during the drought of 1987 in India, distant villages close to the Pakistan border, which had not yet "benefited" from government water schemes, still provided water for people to drink for the simple reason that their traditional water harvesting systems had remained intact. In the "developed villages", on the other hand, people went thirsty, wells had either no water or no electricity for powering the pumps and the villages were forced to depend on occasional government tankers. Agarwal and Narain also tell us how Jodpur, the famous desert city, once had an astounding water-harvesting system with nearly 200 water sources - about 50 tanks, 50 step wells and 70 wells. In their houses, people used to collect the rainwater from rooftops via water collection devices called "tanks". (36)

In addition, the surrounding catchment areas were once covered with thick forest abounding in wild animals. Today of course, the forest has gone and the tanks - beautiful structures as they were - are largely used as refuse dumps. When modernisation brought people a piped water supply, Agarwal and Narain note "they came to neglect their traditional systems and to depend on the government"(37) - yet another policy that must be reversed.

The tanks must now clearly be restored and indeed extended as a matter of urgency. At the same time communities must organise themselves in order to learn how to operate and manage them as they once did. There is no alternative.

Local Food

What must be the structure of the agricultural system that satisfies our requirements? The first, quite clearly, is that it must be highly localised. Food instead

of being produced for export, as farmers are forced to do by the IMF and now by the World Trade Organisation, must be produced primarily for local consumption. One reason is that transport in general accounts for one eighth of world oil consumption. (38) and the transport of food products accounts for a considerable slice of this. Consider that the import of food products and animal feeds into the UK by sea, air and road, accounts for over 83 billion ton kilometres and this requires 1.6 billion litres of fuel which would normally lead to annual emissions of 4.1 million tonnes of carbon-dioxide. (39)

Air transport is the most energy-intensive form of transport. To give an idea, 127 calories of energy (aviation fuel) are needed to transport 1 calorie of lettuce across the Atlantic.(40) Unfortunately more and more food is being transported by air rather than by ship, indeed since 1980 imports by air- freight of fruit and vegetables into the UK have increased by nearly 4 times. The Royal Commission on Environmental Pollution has estimated that, on current trends, the contribution of air transport to man-made global warming is expected to increase by no less than 5 times between 1992 - 2050. (41) Scandalous as this may seem, the UK Government actually promotes this trend by exempting airlines of both the fuel tax and value added tax. As a result airlines pay up to 4 times less per litre for fuel than does anyone else. (42)

The only answer is the localisation of food production and distribution. According to a study carried out in 2001 greenhouse gas emissions associated with the transport of food from the local farm to a farmer's market are 650 times lower than the average sold in supermarkets. In addition, to produce food locally, as the Report notes, "would be a major driver in rural regeneration as farm incomes would increase substantially". There would also be very much more co-operation among local people and communities would be revitalised. (43)

The localisation of food is necessary even without climate change for it is only by producing food locally that the poor, particularly in the Third World, can have access to it. Indeed, one of the main causes of malnutrition and hunger in poor countries is the shortage of land for producing food for local consumption. Anything between 50 and 80% of the agricultural land of Third World countries is geared to the export trade. Local people are reduced to growing their own food on rocky outcrops or steep slopes

that soon erode and become infertile. Urban Jonsson, the UNICEF country representative in Tanzania tells us that, "when the World economy and Tanzania's State economy are doing well, the villagers sell much of their maize and other staple foods. But when the State economy is in a bad way.....prices for food drop and give the farmer less incentive to sell. Thus "the villagers do the only thing possible - they keep the food and eat it themselves". They also use land which they previously used for cash crops to grow food for their own consumption. In other words, it is only when they cannot export their food that they can eat properly. (44)

Relative Self Sufficiency

To produce food locally means, in effect, increasing self-sufficiency at a village, regional and state level. It also means storing food at all these levels in order to face possible food emergencies, which, scandalously enough, is illegal today as the WTO considers that the money required is better spent on paying back debts to Western banks. Of course, the way International Agencies define "self-sufficiency" has nothing to do with the way the term is normally used for a country that produces no food at all can still be regarded as "self-sufficient" so long as it can pay for its imports. What we call food self-sufficiency they call "food autarky" and for them this is the greatest crime any country can possibly commit, for if it were adopted world-wide there would be no international trade, no global economy and no transnational corporations, while the economy of countries made dependent on world-trade would have to be drastically transformed. That is perhaps the most important reason why the shift to something approaching food autarky or rather self-sufficiency, in the real sense of the term, is essential - though not in the extreme sense of the term as some trade will always be beneficial but it is largely surpluses that must be traded.

Small Farms

Farms that cater for the local area and are largely self-sufficient must necessarily be small. Big farms to survive must cater for the world market as they increasingly do, or they would not survive. What is more, to maximise efficiency they must use heavy machinery, fertiliser, pesticides and irrigation water, eliminate hedgerows and tree cover

and grow a single cash crop over vast stretches of land year after year - exactly what we need to avoid - even without climate change. We also need small farms because they are very much more productive than big ones. Even the Food and Agricultural Organisation of the United Nations (FAO), which has spearheaded the shift towards industrial agriculture worldwide, (45) now admits this. Thus an FAO report makes clear that the farms with the highest productivity in Syria, for instance, were found to be about 0.5 hectares, in Mexico 3 hectares, in Peru 6 hectares, in India less than 1 hectare and in Nepal a little less than 2. In each case output was found to fall as soon as the size of the farm increased beyond these levels. (46)

The most productive form of food production is undoubtedly horticulture. In the UK, according to Kenneth Mellanby, (47) an English vegetable garden can produce as much as 8 tonnes an acre. Significantly, during the war, 40% of Britain's food and vegetables were derived from just over 300,000 acres of vegetable gardens and allotments. Unfortunately most of these allotments were situated close to urban centres and have since been "developed". Clearly they must urgently be replaced.

One reason why productivity is so high in a small farm or garden is that, the most important input, as Dr Schumacher always put it, is TLC - "tender loving care", and this, small farmers, who totally depend on their land for their livelihood, are more likely to bestow on it than large-scale commercial farmers who are only in it for the money. With climate change, of course, ever more TLC will be required.

Diversity of Crops and Varieties of Crops

A localised, largely self-sufficient farming system largely made up of small farms necessarily cultivates a wide variety of different crops and even different varieties of these crops as traditional farmers have always done. In addition, some farmers, as Peter Rossett notes, often intercrop, using the empty space between rows which would otherwise produce weeds and combine or rotate crops and livestock. (48). Jose Lutzenberger, who was once Minister of the Environment in Brazil, (49) tells us that the Italian and German peasantry that established itself in South Brazil cultivated sweet potatoes, Irish potatoes, sugar cane, cereals, vegetables, grapes, all kinds of fruit, and also silage for their cattle, as well as rearing chickens, pigs and cows. The total

production of each small farm amounted to at least 15 tonnes of food per hectare, incomparably more than is produced on a modern soya-bean monoculture in the same area, all of which use the usual chemical inputs. What is more, there is a strong synergic relationship between the different crops cultivated by these traditional farmers.

Thus in a well-planned inter-cropping system early established plants tend to reduce soil temperature and produce the appropriate microclimate for other plants. Plants also complement each other in terms of nutrient cycling, thus deep-rooted plants can act as "nutrient pumps" bringing up minerals from deep down in the sub-soil. Minerals released by the decomposition of annuals are taken up by perennials. The high nutrient demands of some plants are compensated for by the addition of organic matter to the soil by others. Thus cereals benefit by being grown in conjunction with legumes, which have deeper roots, permitting a better use of nutrients and soil moisture as well as possessing root nodules, which host bacteria specialised in fixing nitrogen. Crop diversity thereby plays a significant role in the metabolism of a traditional agricultural ecosystem and thereby contributes to its productivity. However, if traditional small farmers plant such a wide diversity of crops, it is not primarily to maximise yields, but to reduce vulnerability to discontinuities such as droughts, floods and plant epidemics.

As James Scott, who was an authority on peasant agriculture writes, "the local tradition of seed varieties, planting techniques and timing was designed over centuries of trial and error to produce the most stable and reliable yield possible under the circumstances".....Typically, the peasant seeks to avoid the failure "that will ruin him rather than attempting a big but risky killing", (50) and this he largely achieves by cultivating a carefully chosen diversity of crops and crop varieties, whose exact composition he is well capable of adapting whenever necessary to changing environmental requirements. (51) As with climate change, nobody knows in advance which crops or crop varieties are capable of surviving the predictable heat waves, floods, droughts and invasions of exotic pests, it has never been more important for farmers to cultivate a well chosen diversity of traditional crops.

Needless to say, a deindustrialised world in which people live in small towns and villages, and produce locally much of their own food and artefacts, would be largely unaffected by the oil shortage that faced us today. It would also be an incomparably

healthier, sounder and more sustainable world and there would be far less poverty, far less hunger and far less wars, as the majority that have been fought in the last fifty years are above all wars to obtain access to markets and resources that only a globalised industrial society requires. Nor of course would its economic activities transform the chemical composition of the atmosphere's body to climatic destabilisation.

Appendix

Eliminating artificial fertiliser : a solution multiplier

Every measure that serves to bring our agricultural methods closer to the natural ones used by traditional farmers is a solution multiplier. It might be worth considering the host of problems created by the use of artificial fertiliser. By replacing them with natural fertiliser as suggested above we would be solving a corresponding number of serious problems - quite apart from drastically reducing the contribution of agricultural activities to the destabilisation of world climate.

Let us look at some of these problems:

1. Artificial fertiliser can reduce the capacity of the soil to absorb carbon dioxide by disrupting soil ecosystems and according to P.A.Steudler this also applies to the absorption of methane gases.(52)

2. Artificial Fertilisers wash away into our rivers and estuaries where they stimulate the often massive growth of algae, which, when they die, consume the oxygen in the water, suffocating fish and other river or sea-life (i.e. eutrophication).(53)

3. The algae often form huge algae masses which emit dimethyl-sulphide, a chemical, which oxidises in the air to form sulphur-dioxide, the principal source of acid rain.(54)

4. Fertilisers are the largest source of pollution of our ground water and hence of our drinking water, the latter being a major problem throughout the world.

5. Fertilisers applied to the soil increase nitrate levels in vegetables and plants, which when too high, can cause health problems.(55)

6. Nitrates are transformed by bacteria into nitrites which bind to haemoglobin and reduce the ability of blood to transport oxygen, often giving rise to methaemoglobinaemia, a blood disorder of young children.(56)

7. Nitrates when combining with amines in the gut can be further transformed into highly carcinogenic nitrosamines.(57)

8. Available studies reveal that food produced with artificial fertiliser is inferior on a number of costs. In addition to reducing exposure to potentially harmful pesticide residues, nitrates, GMOs and artificial additives used in food processing, organic food and food produced without fertilisers has a higher Vitamin C content, and some studies show that it also has a higher mineral content. Organic crops also contain an increased range and volume of secondary plant metabolites or phytonutrients which increase the capacity of plants to withstand external challenges from pests and diseases. What is more, feeding trials have shown significant improvements in the growth, reproductive health and recovery from illness of animals fed organic feed. (58)

9. Studies at the Obervil Institute in Switzerland have shown that wine grape yields can be increased by maximising nitrogen applications but only at the cost of reducing their sugar content, which prevents them from ripening properly. Studies at the Biodynamic Research Station in Sweden found that the same was true of potatoes whose yield could be increased by 15% if enough fertiliser was applied but which drastically increased post harvest losses during storage.

   In Sri Lanka a traditional farmer (Mudiyense Tennakoon) told me that Sri Lankan farmers used to have no difficulty in keeping traditional strains of rice for 3-4 years, however the hybrid varieties using artificial fertiliser get mouldy in 3 months. (59)

   The reason seems to be that higher nitrate applications create a problem for the plant by increasing the osmotic pressure on the affected cells and to deal with this, the plant must take up more water. Thus, not surpassingly, the yield of a compost grown plant was found to be 24% lower, but its dry matter, was 23%

higher. In other words the fertiliser did not increase the dry weight but simply added more water to the crop. As a result of course, the use of artificial fertiliser leaves the crops very much more vulnerable to fungal infestations correspondingly increasing post harvest losses. To avoid this, a higher use of poisonous pesticides is regularly made during storage.

10. Such studies suggest that the much-vaunted benefits provided by the use of artificial fertilisers are largely illusory. This is not altogether surprising as artificial fertilisers were not developed in the first place for the purpose of providing people with cheap, plentiful and healthy food. They were originally designed as explosives (TNT), and the IRA in Northern Ireland has consistently used fertiliser bombs.

11. The Green Revolution imposed by America on the Third World was above all part of a campaign to sell more fertiliser and keep the armaments industry afloat after World War II in spite of a falling demand for their lethal wares. The Green Revolution's high yielding varieties (HYVs) should in fact be referred to as "high response varieties" (HRVs) i.e. varieties designed to be highly responsive to fertilisers. Significantly, many traditional varieties can provide equally high yields without the use of fertilisers.

    Similarly, the "Gene" revolution is above all a means of selling more herbicides. Some 60% of genetically modified varieties marketed so far have been designed for resistant to herbicides such as Monsanto's best-selling Round-Up, rather than to the diseases themselves, drastically increasing the markets for these poisonous substances that can now be used on crops (soya, beet, etc.) which would not previously have tolerated them. It can be argued of course that the overriding goal of the Biotech companies is to control the world's entire food production process. How better to do this than by controlling the seeds on whose nature that of the whole process must clearly depend.

12. Fertilisers are not just used on their own but as part of a package deal that includes hybrid seeds, increasing genetically and modified patented seeds,

pesticides, heavy machinery, and water derived from modern perennial irrigation systems all of which create serious problems of their own.

13. In any case, as already noted diminishing returns on fertiliser are now being experienced just about everywhere and it means that they are ever less effective and less economic. With the coming world water and oil shortage already referred to, the use of fertilisers like that of all the off-farm inputs to modern agriculture can only become ever less attractive and their use must seriously decline.

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