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Environmental sustainability in agriculture: diet matters

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Abstract

There is no agreement that diet matters for environmental sustainability in the agriculture sector. Much current agriculture is unsustainable and worsening; the environmental impact of agriculture degrades natural capital (e.g. loss of topsoil, waste and pollution of water, nutrient loss, extinction of species). Cattle raising is one of the most damaging components of agriculture. Livestock now eat about half of global grain production. There is limited scope for improving food supply and what scope there is will further damage the environment. All means to improve nutrition, especially for the poor, will be needed as population increases. One such means is to improve diets of the rich by eating lower down the food chain. While most people in the world thrive on mainly grain-based diets, carnivory is high in OECD and is increasing in LDCs. In order to reduce food wastage and to improve health and food availability, a food conversion efficiency tax is proposed. The least efficient converters (pork, beef) would be highly taxed; more efficient converters (poultry, eggs, dairy) would be moderately taxed. Most efficient converters (ocean fish) would be taxed lowest. Grain for human food would not be taxed, while coarse grains might be modestly subsidized. Non-food agriculture also would be taxed: highest on tobacco and on starches destined for alcoholic beverages produced from land suitable for food production. © 1997 Elsevier Science B.V.

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1. Introduction

1.1. Environmental sustainability

This paper presents the case that diet matters for environmental sustainability. Environmental sustainability means improving our lifestyle in

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order to maintain natural capital. Keeping natural capital constant means maintaining the two source and sink environmental services unimpaired. Most environmental sustainability will be achieved to the extent the world achieves the transition to renewable energy, and to a stable human population. The most fundamental requirement of environmental sustainability is that capital should remain intact. This requirement must be applied to natural (soils, species, water) as well as to fabricated capital (Goodland, 1995). The paper is addressed to all concerned with accelerating the transition to sustainability in agriculture; its purpose is to sharpen one segment of the sustainability debate. Of all the important changes needed in order to approach environmental sustainability in agriculture, I chose diet for five main reasons.

First, there is no agreement that diet matters for agricultural sustainability, not even that it is a legitimate issue for agricultural policy nor for economic development. Current global trends are hastening in the wrong direction, away from the sustainable course. An increasing number of analysts report that we are moving towards the limits of global food production. Second, diet is a poverty and equity issue. Diet concerns mainly the poor and not the rich. The rich will always be able to buy what diets they want. However, even the rich suffer because their diets are unsustainable. Third, much agriculture is not sustainable, and there is little agreement on what sustainability is applied to the agriculture sector (FAO, 1995, 1996). Worldwide topsoil loss, salination, waterlogging, depleting aquifers, overgrazing, and agrochemical pollution exemplify lack of sustainability in the agriculture sector. Fourth, the environmental impact of the agriculture sector probably exceeds the impacts of all other sectors, even manufacturing and industry, in many countries. Agriculture has degraded more natural capital and caused more extinctions of species than any other sector. Agriculture uses more water than other sectors of the economy in many nations. Many agricultural practices pollute (e.g. feedlot runoff, abattoirs, effluent from oilpalm, rubber, coffee processing). The energy consumption of agriculture is substantial in industrial countries, considering diesel (tractors, pumps), energy contents of fertilizers and biocides, and transport infrastructure (Cleveland, 1995a,b). Expansion of food supply under any scenario makes the environmental impact of agriculture one of the most urgent and under-addressed predicaments of our times. Fifth, within agriculture, the case to demote cattle on the development, environmental, health and poverty alleviation agendas is strong and intensifying. Cattle caused or are related to the most environmental damage to the globe of any non-human species (e.g. overgrazing, soil erosion, desertification, tropical deforestation for ranches). Cattle biomass probably exceeds human biomass. Cattle numbers have increased 100% over the last 40 years; livestock now outnumber humans 3:1.

These five reasons combine into a compelling argument to promote environmental sustainability in the agriculture sector. Demand-side management, pollution control, loss reduction, and eating more simply will be essential. As a quarter million more people must be fed each day, sustainability must be approached as a matter of great urgency. The powerful ethical argument for promoting environmental sustainability by adjusting diet is left until later.

That diet has become a major opportunity to improve development is becoming recognized (e.g. Nobelist Kendall and Pimentel, 1994; Goodland et al., 1984; Brown and Kane, 1994; Brown et al., 1994; Brown, 1995; Cohen, 1995; Ehrlich et al., 1995; Brown et al., 1996). Even so, some people still find these proposals too controversial. Ignoring this opportunity to improve nutrition, reduce poverty, environmental impact and hunger by dietary improvements would be more controversial, uneconomic, and arguably immoral.

We have let the world become so full that there is unfortunately already a trade-off between human numbers and diet. Kendall and Pimentel (1994) estimate that a world population of 7 billion could be supported at current levels of nutrition on a vegetarian diet, assuming ideal distribution and no grain for livestock, but without alleviating current hunger levels. Cohen (1995) writes that ca. 2500 kcal of food are needed for a vegetarian diet, but this figure soars to 9250 kcal if our diet is 30% from animals. This high figure (9250 kcal) means 3.7 times as many edible calories would have to be grown or grazed as are eaten.

Cohen (1995) assumes that 10 kcal of feed are needed for every kcal of energy consumed, then the amount of edible food energy that would have to be grown to supply everybody with 2500 kcal would be $0.7 \times 2{,}500$ (for the vegetable portion of the diet) $+ 0.3 \times 2{,}500 \times 10$ (for the animal portion) = 9250 kcal. If people eat some meat, only about 2.5 billion could be provided for; this excludes nearly two out of three people alive today. This is why it is so important for the world to remain low down the food chain, for those high to descend, and to discourage people from moving up.

2. The global food crisis

There has been no growth in the grain harvest during the first 5 years of the 1990s. Global grain reserves fell to an all-time low in 1995. At the end of 1995, grain carry over reserves dropped to 231 million tons, enough to feed the world for only 48 days. Previously, when reserves fell below 60 days, the price started to rise. In 1995 wheat and maize prices hit 15-year and 12-year highs respectively. The price of corn in China has doubled in the past 3 years; the price of barley has doubled in Europe over the last 2 years. Grain prices reached all time highs on the Chicago Stock Exchange in March 1996. Rice prices started to rise in 1987 and have maintained higher levels in the 1990s, with sharp upward volatility in 1993 and 1995 as carryover stocks fell to 20 year lows (Harris, 1996). Japan forecasts a doubling of world grain prices by 2010 (Brown, 1995).

All food aid categories fell significantly in 1995. Reduction in food aid, 25% less than in 1994 and far below the 1993 level, coincides with the increase in cereal prices, reduced availability of grain exports at concessional prices, and adverse conditions in food importing nations. Low income food-deficit countries will need to raise an additional $3 billion this year for their food imports. With 26 countries facing exceptional food shortages, there is potential for crisis (Diouf, 1996). Global cereal production must increase by at least 4% in 1996 if food needs are to be met without drawing down reserves even further. As corn becomes so scarce and expensive, there could be massive selling of US and other grain-fed livestock. The EU has started to tax grain exports to prevent a rise in prices at home. Brown et al. (1996) attributes these trends to a combination of three successive poor harvests and to increased carnivory.

Between 800 million (FAO, 1995) and one billion people lack sufficient calories and protein to function minimally. About 200 million children under five suffer from protein and energy deficiencies (Diouf, 1996). If adequate nutrients such as vitamins, iron and iodine are considered, the number of malnourished may exceed 2 billion. Half of these people live in South Asia; one-quarter live in sub-Saharan Africa, and about ten percent are in China. China is rich enough to buy grain; it is Africa that may suffer from future grain shortages. The world's population looks like jumping 50% to 8.3 billion by the year 2025. World food consumption will have to double by 2025 just to keep up with population increases, without reducing current hunger levels. The necessary tripling of food consumption over the next 50 years will need all conceivable help it can get; time is short. Such tripling has massive environmental implications which must be scrupulously assessed in advance.

3. Three ways to increase food

3.1. Extensification

There are only three choices to increase food production; none is encouraging. First is extensification, expansion of cultivated area. There is substantial farmland lying idle, especially where it has been taken out of cultivation by economic policy (e.g. parts of the EU), or because it is uneconomic, or it is fallowing.

There is much scope for raising developing country yields in the direction of OECD yields. Certainly, vastly more agricultural research is essential. Much of this information is taken from Kendall and Pimentel (1994); Pimentel (1994) and Pimentel and Giampetro (1994). Of course, there is much uncultivated land, particularly lands taken out of cultivation to keep farmers' prices high, as in the US and EC. But much of this land is marginal; that is why it was taken out of

production in the first place. It can support much wildlife. Unfortunately marginal lands will probably be brought back into cultivation. Their contribution to food production will be marginal and unsustainable due to erosion or whatever the constraints were. Erosion forces abandonment of about 10 million ha. Erosion exceeds topsoil regeneration rates by 16–300 times. About 0.7% of the world's total topsoil stock is lost annually. This means 30% of topsoil will be lost by 2050 unless erosion is slowed or halted.

Possibly 25% of current cropland should not be cropped (except under unusually tight management practices) as it is degrading fast. The only cropland not degrading rapidly is paddy-rice land. Soil erosion in Iowa is about 30 t/ha per year, while the sustainability level is 1 t/ha per year (Pimentel et al., 1995). During the last 40 years, nearly one-third of the world's arable land has been lost by erosion and continues to be lost at a rate of more than 10 million ha per year.

The rate of land abandonment or degradation increases and may exceed the rate of cultivation of new land (Kendall and Pimentel, 1994; Pimentel, 1994). As most accessible and fertile soil already has been cultivated, practically all of what is not yet cultivated is less or unsuitable for agriculture as it will be lower in quality and more degradation prone. There may be up to 500 million ha of potentially arable land; but its productivity will be well below today's average. Much biodiversity will be lost by such conversion to agriculture, if conventional management practices are used. It is not by accident that the remaining wildlands, especially tropical forests, are not cultivated. There are compelling environmental reasons why they were left until now in their natural state. These reasons differ from place to place: biodiversity values, habitat, erosion proneness, oligotrophy, inaccessibility, aridity.

Abandonment of highly eroded or otherwise damaged land, and the conversion of cropland to non-farm uses are accelerating, thus further reducing the potential to increase cropped area. Some degraded lands can be fallowed thus providing time for rehabilitation. However, there is not a lot of such land to be rehabilitated. Rehabilitation usually takes at least several decades, and when rehabilitated to cropland such sites remain fragile. Thus there is little scope for expansion of agricultural area as a whole, although there is much regional variation. For environmental sustainability, most if not practically all, expansion of cultivated area would probably impose greater environmental costs than food benefits.

3.2. Intensification

The second choice to increase food production is intensifying existing cultivated area. Here the outlook is not quite as bleak as for extensification. There is little optimism in agricultural research centers. IRRI's prototype rice variety, announced in 1994, may boost yields by 10% under field conditions in about five years time. But even this will need more fertilizer and water. Apart from this, no major breakthroughs seem to be in the offing. IRRIs own rice yields have plateaued or are falling, even under the world's most careful scientific management. Japan's rice yields have ceased rising despite unlimited money and the best management available.

The prospects are not bright for a repeat of technological fixes that reaped major gains in the Green Revolution's high-response hybrids. Much of the Green Revolution's productivity increases came from increasing energy intensiveness, by 100-fold in some cases (Kendall and Pimentel, 1994; Cleveland, 1995a,b). Fossil energy has now become too expensive for that to be repeated. Part of the Green Revolution's success stemmed from using vastly more water. As water has now become the limiting factor in most agriculture, that is less of an option for the future. Engineering nitrogen-fixation capability into grains seems little closer than it did two decades ago, despite much research.

Biotechnology (e.g. brewing, wine) is thousands of years old; antibiotics and vitamins have been manufactured by fermentation for half a century. Genetic engineering began in the 1970s, so is about two decades old. The groundwork has been laid, especially now that recombinant DNA is becoming reliable in vitro, so transgenic plants are widely available. The promise of enhancing crop plants to withstand bacterial, fungal, viral and insect attacks, as well as environmental stress,

could exceed the benefits of the Green Revolution. Although genetic engineering is so promising, it has not yet produced much of substance for world food supplies. Some biotechnology may in the future help the poor, but is it likely to do so as well as research that starts with the needs of the poor as the point of departure? (Kloppenburg and Burrows, 1996). Genetic engineering is expensive; it has consumed of the order of a billion dollars.

The rate at which new crop varieties are introduced is declining. The rise in grain yields per ha during the late 1980s and early 1990s has slowed dramatically. From 1990 through 1993 worldwide grain yield per ha declined.

Overgrazing is increasing on every continent. Rangeland beef and mutton production seems unlikely to increase much, leading to a steady decline in per capita supply. The cumulative effects of soil erosion has reduced the potential of perhaps one-third of the world's remaining cropland.

Most major ocean and freshwater fisheries are in decline. Unsustainable catch sizes have exceeded regeneration rates for so long that the fish resource itself is damaged. Pollution and destruction of estuaries, mangroves, wetlands and other fish habitat intensify these trends. Seafood per person probably peaked in 1989. Formerly eaten mainly by the poor, prices are now so high that only the rich can afford to eat much seafood, and this situation looks likely to worsen in the future. Fish and other aquatic protein provide less than 1% of the world's food today. Measured as protein it is less than 5%. While this makes a big difference to many of the world's poor, it is less significant for global food supplies. From now on fish consumption seems likely to decline from 19 kg/person to about half that in the next couple of decades. Fish used to be cheap because they concentrated their dilute, but very widely spread, food source, plankton, which in turn feeds on sunlight and water.

Aquaculture, the farming of aquatic resources low down the food chain (fish, mollusks, crustaceans, and aquatic plants such as seaweeds), could substitute for some natural seafood or river fish. Aquaculture has two extremes. Low productivity and low impact aquaculture depends on autotrophs (green plants, plankton, algae) for nutrients to feed whatever the crop is. High productivity and high impact aquaculture depend on inputs of feed (sewage, agricultural residues, by-catch fish meal). This is more productive from the same area, but expensive in terms of environmental impact for the feed, diesel, pumps, transport etc. Fish farming is more productive than producing beef. Fish need only 2 kg of feed per kg of liveweight gain, compared with 7 kg for beef. Aquaculture, a $30 billion industry worldwide, is valuable in producing protein and recycling waste. Clean water is often the main constraint for expansion of aquaculture. The main source of aquaculture feed is the by-catch of ocean fisheries. That source has been unsustainably harvested and is declining. About 25% of shrimps are farmed, and many come from converted mangroves which raises the impact to that of cattle raising.

Productive aquaculture depends on manufactured inputs (grain, starches, fishmeal and diesel), hence lower efficiencies, rather than dependence on autotrophs (green plants) as do 'natural' aquatic resources and traditional (low input) aquaculture. Even so, aquaculture can be more productive and at much less environmental impact than its competitor, livestock if grain inputs only are counted. If fossil energy and water costs are included, aquaculture is not competitive.

Similarly with irrigation: there is restricted scope for expansion of irrigated area, although there is much scope for improving current irrigation efficiencies, retarding salination, and improving land tenure. Water is the main limiting factor for world agricultural production (Kendall and Pimentel, 1994). A huge 40% of water abstracted for irrigation never reaches farmers fields. But the fact is that irrigated area per capita has begun to decline; irrigation is falling behind in the quest for increased food production. The trend in irrigated area per capita has been negative since 1978 (Postel, 1992, 1994). Aquifer abstractions in major food-production areas exceed replenishment rates, so levels are falling. Aquifers are falling as much as 1–5 m annually in major croplands of China and India. Irrigation water thus becomes more expensive and is diverted from agriculture to cities: the world's cities are growing at one million people each week.

There is decreasing scope for additional fertilizers; world fertilizer production and per capita use peaked around 1989 and seems to be mainly in decline since then. Diminishing returns have begun to bite (Brown, 1995). Research and development on intensification demands high priority, as there is still substantial cultivation not yet using fertilizer. Most fertilizer (60%) is used on grain; adding oilseeds and cattle fodder ups this to 75%. The remaining fourth is applied to legumes, vegetables, fruits, tubers, sugarcane, cotton and other fibers (Brown et al., 1996). As irrigation efficiencies improve, the margin for error shrinks. Climate instability increasingly risks yields; losers are likely to vastly outweigh winners.

3.3. Decrease grain-fed meat

The third choice is to feed grain and vegetables to people rather than to livestock. This could increase consumption without any increase in production. Many more people could be well fed on grain-based diets, become healthier, and at much lower environmental and social costs than on meat-based diets. Formerly, practically all meat came from grazing; most meat now comes from grain-fed animals. When farm animals were fed largely on surpluses and farm wastes, they acted as valuable buffers, evening out fluctuations in food supply, being used for traction and providing manure. That idyllic era is over. Animals are increasingly the main consumers of grain formerly eaten directly by humans.

Most nations were basically self-sufficient in food until the early 1960s; now only a few are (Kendall and Pimentel, 1994). Until recently, FSU, Taiwan and China were substantial exporters of grain; now all import heavily. FSU and China are the first and second largest grain importers. Mexico recently became a net corn importer in 1996, two years after the implementation of NAFTA. Mexico seeks to borrow finance to pay for importing six million tons of corn to meet demand at a time when there is little to be had on the world market. Mexican consumption per person of maize, beans and wheat dropped an average of 35% over the past decade; this has led to increasing social unrest, starvation and grain train robberies. Bangladesh became a big rice importer in 1995 after years of self-sufficiency. Now only Canada and the US are major grain exporters. FAO predicts global rice stocks will fall for the fourth successive year (Yap, 1996).

Only 17% of China's grain went to livestock in 1985; by 1994 this figure had risen to 23%. This compares with the 68% of grain fed to livestock in the US. As animals' conversion efficiencies of grain to meat are so low, trends to carnivory exacerbate food supplies. This is rarely raised in sustainability debates, and even more rarely, or not at all in development policy setting.

The prospects for increasing the supply of food by expansion of cultivated area are not promising. The prospects for intensification are somewhat more promising, and merit great attention. However we must also look at the demand side. Of course, there is much recognized scope for reducing losses, but one under-recognized area for major gains is eating lower down the food chain. Vast amounts of food are wasted by inefficiently converting grains into meat. Eating lower down the food chain would improve health and food supply.

4. Eating more sustainably

Affluent people in OECD countries consume about 800 kg of grain indirectly (Durning and Brough, 1991), much of it inefficiently converted into animal flesh, with the balance as milk, cheese, eggs, ice cream, and yogurt. Such diets are high in fats and protein, low in starch. In contrast, in low-consuming countries, annual consumption of grains averages 200 kg per person, practically all of it directly, with high efficiencies in conversion. Such diets are rich in starch, low in fats and protein; most protein coming from beans and grain. The grain consumption ratio between rich and poor countries is about four to one (Brown and Kane, 1994).

Feedlot cattle consume 7 kg of grain to produce a single kg of liveweight. Pork takes nearly 4 kg of grain per kg of liveweight. Poultry and fish are more efficient converters, needing about 2 kg of grain for each kg of liveweight produced. Cheese

and egg production are in between, consuming 3 and 2.6 kg of grain per kg of product respectively (Brown and Kane, 1994). Where animals are restricted to recycling products (household scraps, peelings, agricultural residues) that would otherwise be wasted or would pollute, they must be ranked as efficient converters.

FAO (1995) calculates that almost 50% of global grains are fed to livestock. The two countries converting the most grain into meat are the United States and China, 160 and 100 million tons respectively (Brown, 1995). Developing countries' elites are eating increasingly high up the food chain. Such dietary shifts have long been regarded as an indicator of development; this view must change if sustainability is to be approached. Developing countries' animal consumption between 1960 and 1990 soared 48% for large ruminants, 53% for small ruminants, 200% for hogs and 280% for poultry. Little of this reaches the poor. FAO (1995) calculate that increased grain importation in developing countries is to feed 'animals that are consumed by the minority higher-income sectors of society.' The question becomes, would the world's more affluent be willing to simplify their diets for whatever reason, health, ethics, equity, environment, economics, religion? Would the grain thus freed-up be distributed to prevent famine and hunger where and when needed?

Not only are mammals inefficient converters, their production is environmentally costly in terms of water used and greenhouse gas (GHG) generated. The production of one pound of beef consumes over 2700 gallons of water, whereas one pound of grain production consumes less than 200 gallons, and vegetables about half that.

FAO (1995) points out that methane from cattle contributes 2.5% of global greenhouse gas production. Cattle contribute about 60 million t of GHG per year, slightly less than rice paddies (70) but more than burning vegetation (55), gas drilling (45), termites (40) and landfills (40).

Food prospects relate closely to poverty and equity. The poor commonly allocate 70% or more of their incomes to food; the rich allocate less than 20%. A few good harvests could conceivably restore food stocks, but as climatic instability is increasing, a row of good harvests is becoming less likely. Climate instability is primarily caused by burning fossil fuel. This highlights the need for a rapid transition to renewable energy to reduce GHG emissions. Climatic instability will vastly reduce the likelihood of successive bumper harvests in the future.

The other climate risk for agriculture is the seasonal perforation of the ozone shield. The 1995-1996 winter ozone hole over the Northern hemisphere was unpredictedly the largest on record. This is likely to increase risks to the world's largest wheat areas as well as to the plankton-fish food chain. Climate instability in 1996 is constraining yields in China, US, Canada and parts of Europe. Agricultural development and food policy workers need to support their colleagues to promote climate stability, and the transition to renewable energy. Sustainability in food supply will be impossible unless the demand side also is stabilized. This means stable human numbers eating more efficiently on the food chain (Fig. 1 and Fig. 2).

One acre of cereals can produce twice to ten times as much protein as an acre devoted to beef production. One acre of legumes can produce ten to twenty times more protein than an acre in beef production. The UN World Food Council calculates that '10-15% of cereals now fed to livestock is enough to raise the world calorie supply to adequate levels' (Goodland et al., 1984). In summary, raising livestock is more destructive in depleting topsoil, groundwater and energy resources than all other human activities combined, as well as causing enormous environmental damage, such as clearing of forests, destruction of wildlife habitat, and pollution of rivers and lakes.

4.1. Grain-based diet

Grain-based diet is a matter of degree. Human societies differ in what diet they find comfortable. There is a continuum from eschewing red meat, then 'white' meat (poultry), then mammals or all terrestrial animals (Fig. 2). Some people draw the line between eating warm-blooded animals and cold-blooded animals. This means some people eat fish, but not rabbits or chickens. The next stage on the continuum is to eat only inverte-

Country	Grain Use	Consumption						
		Beef	Pork	Poultry	Mutton	Milk	Cheese	Eggs
U.S.	800	42	28	44	1	271	12	16
Italy	400	16	20	19	1	182	12	12
China	300	1	21	3	1	4	--	7
India	200	--	0.4	0.4	0.2	31	--	13

Fig. 1. Annual per capita grain use and consumption of livestock products in selected countries [1990, kg rounded to the nearest 100 kg] from: Brown and Kane, 1994.

brates, shrimp or shell-fish for example. Ovo-lacto-vegetarians eat animal products (eggs, milk, cheese) but not the animal itself. Vegans eat no animal products of any kind knowingly (although most food contains insect parts). Ethicists try to interpret peoples' behavior, but people often are neither strictly logical nor consistent in their diets. Nor need they be. Flexibility and opportunism in diet are valuable, especially for the poor.

4.1.1. Diet and the Food Chain

Where individuals are comfortable on this continuum is for each individual to decide; that is not the main issue here. The issue is that richer people tend to eat higher on the food chain than poor people do. The taxes and other incentives proposed below seek to ensure that people eating high up the food chain pay the full environmental and social costs of their diets. When people get richer, they tend to move up the food chain and eat more meat. This partly explains why the world is hurtling away from sustainability. For sustainability, these tendencies need to be reversed. For sustainability, and to help avoid hunger or worse in poorer societies, we have to descend the food chain, eat less meat, and move towards a grain-based diet. The most needed transition is towards eating mainly autotrophs (green plants) and saprophytes, and less heterotroph products, especially homoiotherms. This would buy valuable time to implement other prudential measures on the transition to a sustainable society and would postpone the onset of worse environmental damage.

↑WORST
Highest Tax
Most Impact/Most Sentient/Least Efficient/Least Healthy

1. Mammals: Swine/Cattle/Goats/Sheep
Rodents/Lagomorphs/Camelids/Deer
Eggs/Cheese/Milk/Butter/Leather/Fur (Wool)

2. Birds: Chickens/Geese/Ducks/Pigeons/Turkeys

Homoiotherms (Warm-blooded)

.....

Poikilotherms (Cold-blooded)

3. Cold-blooded vertebrates: Fish /Lizards/Amphibians

4. Invertebrates: Crustaceans/Insects/(Silk/ Honey/Propolis)/Annelids/Mollusks

HETEROTROPHS CARNIVORY

.....

VEGAN

5. Saprophytes: Fungi/Yeasts/Other Microbes

6. Autotrophs: Legumes/Grains/Vegetables/Starch Crops/Fruits/Nuts/Algae

↓BEST
Zero Tax
Least Impact/Least Sentient/Most Efficient/Healthiest

Fig. 2. Environmental and bioethical food chain ranking.

Eating lower on the food chain reduces the environmental damage and suffering caused by overconsumption and excessive population. This is a lifestyle change that most individuals can adopt if they want to consume less of the earth's carrying capacity. Both our health and that of the planet would improve. Hunger, starvation and malnutrition could be alleviated by such trends. Like voluntary population control, better diets are preferable to starvation, disease and deteriorating environments.

If humanity moves down the food chain, the saved carrying capacity should be used to alleviate hunger of the poor as the first priority, although further redistribution will also be necessary.

5. Food policy

This paper specifically does not advocate that everyone should adopt grain-based diets immedi-

ately. Humans are omnivores, not obligate carnivores. Humans do not need to eat flesh to stay healthy, according to the Nobel biochemist laureate Konrad Bloch (1994), not even infants. Clearly everyone needs to balance their diet, including vegetarians. The amount of protein (plant or animal) that humans need for health is small although not precisely known; 0.8 g/day is on the high side for a healthy adult; adults consuming 0.5 g/day are fine, but this is too low for an average. Young children, the poor and unhealthy need more.

The changes needed are gradual and relatively modest; nothing draconian. Most importantly, rich people now eating high on the food chain would improve their health by continuing to move down it. Encouragingly, this powerful trend has started.

For example, annual US beef consumption peaked in 1976 at 95 lb/person; in the 1990s it has stagnated around 66 lb. US beef consumption grew at only 1% between 1990 and 1995. European and especially UK beef consumption never reached those levels, but is falling faster than in the US. EU consumption of beef and veal fell 6% between 1990 and 1995.

The countervailing trend is for people to eat more meat as they become richer. China's pork consumption, for example, jumped 14% in 1995 alone (Brown et al., 1996). IFPRI (1995) predicts meat demand in developing countries will increase by a staggering 160% by 2020. Current incentives to move higher on the food chain need to be removed in order to promote sustainability and to reduce hunger. If people of increasing wealth, now low on the food chain, could be encouraged to stay where they are, rather than climbing up, that would greatly help. The poor, already low on the food chain, should be encouraged to stay there by improving their food security, and enriching the variety of diet such as by increasing fruits, vegetables and nuts. Both educational campaigns and incentives (e.g. school feeding programs, programs and education improving maternal and child nutrition, ration shops selling coarse grain, possibly subsidized, campaigns disseminating the major and inescapable health risks associated with eating high on the food chain) will be needed to foster such lifestyle changes. Removal of subsidies for livestock, both direct and indirect, should be the first step.

The direct and indirect subsidies currently enjoyed by the livestock sector should be economically analyzed. Such subsidies include: full social and environmental costs of topsoil loss, erosion, siltation, biodiversity loss, and deforestation due to cattle; water prices (removal of water subsidies, it is said, would increase the cost of one pound of protein from steak to $89); sewage disposal from feedlots; medical costs associated with diets rich in animal products, loss of work, taxes, etc. due to animal-rich diets; antibiotic resistant infections induced from routine antibiotic feeding to cattle; transport costs; internalization of GHG costs in transport, diesel, fertilizers used for cattle feed production.

In summary, of the three diet-classes of people, first, most people of the world (those already at the efficient, low impact end of the food chain) would remain as they are. Second, affluent people now consuming much meat would consume more efficiently lower down the food chain. Third, people starting to move up the food chain (e.g. China, India) would be encouraged to stay where they are.

Incentives are needed to promote grain-based diets by applying good economics and good environmental management to food and agriculture. In particular, conversion efficiency and 'polluter pays' principles should be used in setting full-price which internalizes environmental and social costs. Cattle feed-lots and slaughter houses consume much water and generate much highly polluting waste. These costs also need to be internalized. Just as society taxes fuel inefficiency in cars, so with conversion efficiency in food. Highest taxes would fall on the least efficient converters, namely hogs and cattle.

In this conceptual paper, the precise methodological nature of the incentives is left to economists. Removal of livestock subsidies, education campaigns, reallocation of research and development investments away from cattle and towards grains, starches, fruits and legumes should be the start. Presumably the meat inputs (water, diesel and grain) could be taxed. Beef sales are the US' largest revenue source in the whole agriculture sector. Only four meatpackers in the US hold 82% of the market, so that might be a low cost place to tax. Incentive methodology could address taxing feedlots, ranchers or slaugh-

ter houses. The US' 104 million-strong cattle herd is the largest single user of grain, mainly in the form of winter feed cakes or pellets. Possibly that can be taxed. In some counties, livestock account for half of the taxes. Presumably this could be raised. Or a landuse intensity tax would foster intensification and demote extensification, such as ranching. Presumably one could carry the argument further, if the food/population outlook worsens, and tax crops based on how inefficiently they use water and fertilizer. Taxing grain as an input for cattle would be difficult to discriminate from human food use. If taxing grain becomes necessary in the future in order to foster only its most efficient uses, such a regressive tax should be balanced into neutrality by reducing income taxes commensurately. Higher priced grain would then automatically go to the more efficient users, namely feeding people.

Slightly lower taxes would be assessed on sheep as they graze natural grassland more than do cattle. Taxes would be lower on free range poultry recycling household wastes than on cattle; even lower on rodents and lagomorphs which eat wastes or are not fed. Small scale cattle feed-lots on farms facilitate recycling manure and help in grain production.

If such sustainability and poverty-alleviating measures become widely adopted, mammalian flesh consumption would decline and would consist mainly of males not needed for draught and females when they have finished producing milk. Hogs and poultry would be kept mainly to recycle wastes; their meat would be an occasional by-product. Ruminants would be restricted to natural range unusable for more intensive production. Aquaculture fish would become more widespread than today.

Higher taxes would be levied on animals overharvested from the wild such as whales and most major fishery species. Human society so far seems incapable or unwilling to harvest sustainably any product from the wild. All harvests from the wild are in decline: great whales, cod, tuna, herring, mackerel, tropical timber, most natural tropical and temperate forests, even natural rangelands harvested by cattle. Taxes (fines) are already legislated for killing rare or endangered species in many countries. As their enforcement is weak or absent, that needs to be reinforced.

No taxes would be paid on grains (rice, maize, wheat, buckwheat), starches (potatoes, cassava), and legumes (soy, pulses, beans, peas, peanuts). Modest subsidies on coarse grains (millet, pearl millet, sorghum) would alleviate hunger and are unlikely to be abused as the rich won't eat them. West African elites have abandoned indigenous grains (millet, sorghum), and have substantially converted to imported wheat and rice. Fortification of cereal flour with vitamin B complex, iron and calcium, and adding iron to salt are highly cost effective, especially where diets are too high in roots and tubers. Encouragement for domestic or village-scale beneficiation, such as of peanuts to peanut butter and cashew fruits to roasted nuts, often doubles or triples the profit to the grower. Pet food also needs to be taxed commensurate with the environmental costs of its production. Adoption of such policies will not solve world hunger overnight, but it will certainly help.

6. Non-food agriculture

Land allocated to production of products other than food will increasingly be decreased to the extent possible. The tradeoffs between cotton and synthetic fibers need to be environmentally assessed. Land allocated to tobacco production should be taxed higher than for grain-fed beef production. Land allocated to potable alcohol production also would be taxed.

Alcoholic beverages divert much grain; they also should be taxed on conversion efficiency: slightly lower on beer, higher on grain alcohols (gin, whisky) and starch alcohols (vodka). Grapes grown on rocky hillsides and not displacing food crops would be exempt. So some wine, brandy and chacha (grape vodka) might escape. Molasses, a by-product of cane-sugar production, often is released into rivers where it is highly polluting. Therefore, potable spirits distilled from molasses (Cachaça, rum) which otherwise would be a pollutant also might be exempt. As some fermented starch products (e.g. cassiri, gari) contain more nutrients, vitamins and amino acids

than the original starch, they can be more nutritive than the unfermented stage. *Lactococcus lactis* produces lactic acid and antibacterials when fermenting rice cakes. These products conserve the rice and prevent much diarrhea in recently weaned infants. In addition, many fermented products last longer than when unfermented so can act as buffer or carryover stocks in times of glut.

This conversion-efficiency sliding-scale tax should be refined by adding the 'polluter pays' principle. Polluting cattle feedlots and meatpackers would be taxed highest; domestically-fed rodents and lagomorphs the least. If biodiversity and habitat destruction are included in environmental damage, then cattle raised from pastures created from rainforest would be taxed highest. Natural range cattle (e.g. Maasai pastoralists in Kenya; US buffalo) would incur a lower tax.

Unilever and WWF award stamps of approval for sustainable fish products. The Forest Stewardship Council and WWF awards logos to sustainable timber products. These empower consumers to promote sustainability by their purchasing behavior. Such consumer sovereignty is now needed to encourage food conversion efficiency, improve health, and to reduce environmental impact.

Governmental and public research and development investments should be restricted to the zero tax foods. Least-efficient converters, livestock, should not be supported by public funds. Livestock and dairy should be left up to consumers and the private sector. Livestock on natural rangeland unusable for cultivation should be supported by landowners. Practically all such research and development should be focused on grains, especially coarse grains, starches, legumes, and vegetable oils. There are useful returns to research and development on fruits, nuts, seasonings, micronutrients and vitamins.

As the environmental impact of obtaining cooking fuel can approach the impact of food harvesting, substantial attention should be given to the environmental sustainability of cooking methods and its fuels. Such measures as use of solar cookers, fuelwood hedges, efficient stoves and pressure cookers would decrease the environmental impact of gathering fuelwood and burning agricultural residues. Recycling wastes merits higher attention too. Mulch, manure, agricultural residues, nightsoil and carcasses are concentrated forms of nutrients. Their recycling decreases the need for fertilizer.

7. The health argument

The fact is that if energy needs are obtained from grain-based diets, then protein requirements will be met. Cereals supply 50% of dietary protein and calories globally, and up to 70% in developing nations (Harris, 1996). As most poor people worldwide are forced to eat grain-based diets and little else, and survive, there should be no argument that eating lower on the food chain risks health. Now even orthodox western health authorities cannot muster arguments strong enough to satisfy meat lobbies. Italians eat less than half the amount of beef and poultry that Americans eat (Fig. 1), yet enjoy a higher life expectancy. Part of this is related to diet.

Problems arise when energy requirements are not met by grain-based diets, but from low-protein staples such as roots, tubers, bananas and sweet potatoes. That highlights the importance of legumes and proteinaceous seeds (sunflower, sesame), particularly for vulnerable groups, such as infants. Many studies of vulnerable groups (pregnant women, infants, macrobiotics, athletes, oldsters, wounded, Trappists) reconfirm the adequacy of eating low on the food chain (citations available from the author).

The other side of the argument is increasingly clear. Western carnivory kills or maims increasing numbers of people. The stroke, heart disease, cancer, obesity, hypertension, diabetes and foodborne illness links to high meat diets are now inescapable. The message is clear, eating high on the food chain severely damages one's health. Heart disease in the US alone cost $66 billion in 1996 according to the American Heart Association. Much of this can be attributed to high meat diets. Cardiovascular disease need not be a consequence of living, if one avoids carnivory. A low-fat grain-based diet has now become the main therapy for the 1.25 million annual preventable

US heart attacks. Heart disease can be reversed partly by moving low on the food chain.

8. Conclusion

Diet is one of the measures needed to approach environmental sustainability in the agricultural sector. Improving diets by eating low on the food chain, eating much less or no meat and more grains, would vastly improve food production efficiency, decrease environmental impact, and reduce waste. Improving diet also improves health. Vegan infants and children are better off than their carnivorous colleagues. These are compelling arguments to eat low down the food chain.

The only reasons to eat high up the food chain are weaker, namely fashion, taught taste and status. As lifestyle changes are difficult, they are here left up to individual preferences. However, subsidies and other public funds promoting inefficient and high impact food such as grain-fed mammalian flesh should be halted and redirected to efficient and lower impact foods such as grains and pulses. High taxes on inefficient food and no taxes on efficient food, combined with full cost pricing to internalize externalities would alleviate the global food crisis, and promote sustainability.

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