"A Fast and Cheap Way to Reduce Climate Disruption by 2017 While Preparing to Feed All in 2050"

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1. Climate Disruption

Recent climate science demands fundamental re-ordering of the world's priorities. The science shows overwhelmingly that we have left it too late to limit warming to 2 degrees Celsius. It will be very difficult to limit it to 4º C; there is not much time to accomplish that.[1] It is clearly too late to avoid lasting adverse impacts from global climate disruption. We are seeing them already. But it is not too late to take actions that will make significant and lasting risk reductions.

To achieve enough progress, a realistic price needs to be put on GHG emissions. Socially and politically we seem far from implementing what needs to be done. The Kyoto climate treaty was enacted in 1997. Little progress was made, so high hopes rode on the UN conference in Copenhagen in December 2009. While those hopes were dashed, we may have started to move in the right direction. For example, the US National Academy of Sciences came round earlier this year to recommending setting a price on carbon through a carbon tax.

Most key means to avert climate catastrophe are known and agreed upon: halt deforestation; switch from fossil fuels to renewables, efficiency and conservation; and phase out of large-scale livestock production. And when priorities are ranked, there is generally a consensus that reducing CO_2 emissions should be placed first.

However, CO_2 remains in the atmosphere for many decades. Therefore, as the time remaining to limit warming to 4º C is now so short, a prompt shift in priorities is now called for: The top priority is now to tackle the shortest-lived of the GHGs in order to reduce climate change in the short term.

Methane resides in the atmosphere for eight years, while soot (carbon black) remains less than one year, and nitrous oxide even less. Accounting for the residence time of each GHG, its climate forcing capacity, and the feasibility of reducing emissions (Table 1), methane reduction likely has the greatest potential benefits in terms of immediacy of results with no need for international treaties or economy wrenching changes – though such measures will be needed for the long term.[2]

In 2006, the FAO published a 388-page report entitled *Livestock's Long Shadow*, assessing for the first time in a major publication the greenhouse gas (GHG) emissions attributable to livestock's supply chain from forests cleared to supermarkets. According to FAO's report, the only way to increase global supplies of meat and dairy products is through more intensification and more deforestation.

That assessment by the FAO was echoed in a recent public statement by the Director-General of the International Livestock Research Institute, Dr. Carlos Ceres, who wrote that rich countries feed animals grains that "might instead have fed people." Nobody of such stature in the livestock sector has ever made such a statement before.

Livestock's Long Shadow estimates GHG emissions attributable to livestock worldwide. It shows that atmospheric carbon from the respiration of all organisms – along with oxidation and erosion of soil organic matter – already exceeds the capacity of photosynthesis to absorb such carbon.[3] This alone strongly suggests that there are already too many livestock in the world today.

Using our backgrounds in environmental assessment at the World Bank Group, Jeff Anhang and I prepared an article for *World Watch* – in which we consider whether any sources of GHG emissions might have been missed in *Livestock's Long Shadow*. The key ones that we found missing are in the land set aside for both livestock and for feed production, along

[1] The IPCC expects to explain the science behind the 2º C figure in 2010/2011. In 2009, the EU sought to reduce the 2º C goal by 0.5º C. Keeping below 2°C with 50% likelihood requires a 50% reduction in emissions below 2000 levels by 2050, barely feasible with known technologies.

[2] Cutting emissions of nitrous oxide would reap immediate benefits, but may entail lengthy struggles with the fertilizer industry. Reducing soot also would be immediately beneficial – but as it has millions of point sources, including fuelwood cooking fires, diesel, and transport pollution, its control is difficult and expensive. Yet the case for reducing soot is well portrayed by Wallach et al., as well as the difficulties and costs of persuading millions to use efficient stoves, etc.

[3] FAO, 2006, Table 3.2.

with several other significant sources. So our article suggests that livestock's shadow is not only long but colossal, responsible for at least 51% of human-caused GHG emissions.

2. Food and Hunger

Agriculture faces a constellation of critical constraints, with looming scarcities of most inputs needed to produce high yields of food. Most of these scarcities can be traced to the Western diet and fossil-fuel based agricultural systems. Worldwide, there are now more than one billion hungry, yet more than one billion are overweight or obese. The world wastes enough food to feed three billion. Today's surge in global meat production – 70% from developing countries, achieved largely through deforestation – is responsible for far more waste than any other aspect of the food chain.

The recent meat boom is the result of people in countries such as China abandoning their efficient traditional diets, and adopting western diets richer in meat, poultry, eggs and dairy products. For example, meat consumption per capita in China has jumped to 59.5 kilograms per year, up more than fourfold from 13.7 kg in 1980. In Brazil, it has doubled to 80.8 kg. The world's per capita meat consumption has soared to 41.2 kg per year, up 37 per cent from 30 kg in 1980.[4] Demand has similarly soared for milk and eggs.

As currently framed, the climate/hunger challenge clearly is impossible if we are honest, as our choices are constrained by eight projections: (a) doubling in demand for food supplies by 2050, (b) halving of today's water use, (c) less per capita land availability, (d) the already high and increasing value of the carbon sequestering services of intact forest; (e) increasingly depleted soils, (f) scarcer fossil fuels, (g) more diseases and pests – and (h) all while needing to reduce atmospheric carbon. These challenges can be met only if livestock products are reduced and alternatives scaled up.

The 2008 global food crisis led to riots and bloodshed in many nations. Since then continued high food prices, droughts, the worldwide recession, and the Euro's weakening have reduced remittances from immigrant workers in developing countries. This combination of factors has swollen the ranks of the chronically hungry. With their numbers now over 1 billion, they make up about 15% of the world's population, up by nearly 80 million in just two years.

Population growth and rural-to-urban migration mean the numbers of hungry will continue to rise over the coming decades. Yet feeding the 8 or 10 billion of us in 2050 need not be insuperable. We already produce more than enough food. The main problem is that we feed most of it to livestock and vehicles, rather than directly to humans. Using the same land area as we use for food production today, we could produce 60% more food with plant-based agriculture. 30% of the earth's surface is allocated to feed and forage. Most grain today feeds livestock and fuels vehicles. Only 8% of global livestock is raised entirely grass-fed. The sad trade-off between humans and all other dissipative structures (livestock, automobiles, houses, and ultimately even trees) must be faced.

Measures raising crop yields on irrigated land tend also to raise the productivity of irrigation water.[5] Moving down the food chain reduces water use. In the United States, where the annual consumption of grain as food and feed averages 800 kilograms (four fifths of a ton) per person, a modest reduction in the consumption of meat, milk, and eggs could easily cut grain use per person by 100 kilograms. For 300 million Americans, such a reduction would cut grain use by 30 million tons and the need for irrigation water by 30 billion tons.

3. What Copenhagen Overlooked

If as we have assessed, livestock are responsible for at least 51% of anthropogenic GHG emissions, then mitigation measures no longer suffice; instead, broadly avoiding emissions attributable to livestock becomes critical. For example, improvements in the pasture-raising of livestock can somewhat increase carbon stores in soil. However, only about 8% of meat is produced from entirely pasture-raised livestock,[6] and there is little land available to increase this amount without further deforestation. Further, when livestock are pasture-raised, they emit as much as three times the amount of methane as do intensively-raised livestock. Moreover, the possibility for mitigation to increase soil carbon is available for only the

[4] With big variations, for example: US exceeds 342 g/day, Europe 220 g/day, SubSaharan Africa 36 g/day.

[5] Brown, 2010.

[6] FAO, 2006, p. 45.

first part of the lives of most pasture-raised livestock, as most are intensively-raised for the second part of their lives.

Our *World Watch* article first recognizes the importance of broadly avoiding emissions attributable to livestock. Then it develops a case for achieving almost as much GHG reduction by 2017 as was expected to be agreed on in Copenhagen – simply by replacing 25% of today's livestock products with better alternatives. According to Chris Mentzel, the CEO of a solar power company, our article shows that a 1% reduction in worldwide meat intake would have the same benefit as US$3 trillion in solar energy investments.[7]

Coverage of our article by media outlets and on the internet has been voluminous. But some of this seems due to unfortunate coincidence. That is, at the time our article was published, reports began to emerge from one country after another regarding harm to crops and livestock as a result of climate disruption. In November 2009 alone, livestock in India, Argentina, and the Philippines were among those reportedly harmed significantly by climatic events. Livestock dying from drought in Kenya have been proposed as possibly the first source ever of violent climate conflict.[8]

These recent reports are unsurprising, as it had been predicted that the most harm to crops and livestock would occur in countries where people can least afford it. More broadly, it has been forecast that 75 to 80% of harm caused by increased atmospheric carbon will occur in developing countries, although they contribute only about one-third of GHG emissions.

Nevertheless, weak conclusions are often reached when livestock products are assessed through a national or even regional lens. Livestock products and feed are global commodities, so they get flown, shipped and trucked all over the world; and climate change is transboundary. So policymakers must look beyond their own borders in considering the impacts of livestock on climate. In this way it becomes understandable – and even necessary – to imagine a world where not all land today dedicated to livestock and feed would remain so.

While generally overlooked, there is vast carbon absorption foregone today in land set aside for grazing livestock and growing feed. Yet any amount of foregone carbon absorption has exactly the same effect as an increase in emissions of the same magnitude. Moreover, carbon absorption available from land used for livestock and feed production is the only feasible way to absorb a significant amount of today's atmospheric carbon in the near term.[9]

Considering the land used for livestock and feed that could regenerate forest, along with the high levels of relatively short-lived methane attributable to livestock, reducing livestock numbers would be the quickest way to reverse climate change. Yet renewable energy has been the most-discussed option for reversing climate change.

Certainly, the switch to renewables must be pursued to keep emissions down over the long term. However, following the failure of the December 2009 climate conference in Copenhagen, there is no clear path for quick worldwide large-scale increases in renewable energy and energy efficiency. So consumers will have to wait many years for sufficient renewable energy infrastructure across the world to reduce emissions significantly. In the meantime, better alternatives to livestock products can be scaled up and have large and quick positive effects on climate, at minimal cost, through joint action by government, industry, and citizens/consumers.

The ability of individuals to make a significant difference in climate change through a single, relatively simple change in their food choices is distinguished from choices in energy – where the same effect entails pushing consumers to make dozens of changes in behavior. Necessary as those changes will be over time, they will require decades and cost trillions of dollars by governments and industry, before the required consumer action can be fully achieved.

Following the 2009 publication of "Livestock and Climate Change" by Jeff Anhang and me, the FAO graciously invited us to participate in two fora. The first was an FAO expert consultation in Rome, Italy in December 2009 on greenhouse gas emissions and mitigation potentials in the agriculture, forestry and fisheries sectors. The second was the FAO-organized session at the Global Forum for Food and Agriculture during International Green Week in Berlin, Germany in January 2010. For those fora we prepared presentations with many details that interested people may want to read.[10]

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7 Mentzel, 2010.

8 Guardian, 2009.

9 Shulze et al. 2009.

10 See http://awellfedworld.org/sites/awellfedworld.org/files/pdf/GoodlandFoodIndustryBerlinJan2010.pdf and

More recently, however, the FAO has publicly disclosed plans to assess GHGs by region and livestock type. However, these plans seem to overlook many reasons why it makes sense to assess GHGs for livestock on a sectoral basis, as the FAO itself did in its 2006 "Livestock's Long Shadow."

Some of the reasons flow from analysis by Dr. Alan Calverd, a British physicist. According to Calverd, the specific metabolic rate of large mammals and flightless birds is broadly consistent, with each animal dissipating about 2 Watts/kg to stay alive, regardless of species. To reflect the 2W/kg dissipated by livestock regardless of species, a more or less constant amount of CO_2/kg is emitted from the breath of each type of livestock, regardless of species.

For CO_2 from the breath of each human on earth to be absorbed by trees rather than stay in the atmosphere, 7 mature trees need to remain standing. As for each human to maintain a Western diet there must be slightly more livestock mass than human mass alive at any given time, more than 7 mature trees are needed to absorb the CO_2 from the breath of livestock for each human eating a Western diet, regardless of the species of livestock consumed (or more than 45 billion trees worldwide).

Accordingly, either CO_2 from the breath of livestock should be counted – or absorption by trees of that same amount of CO_2 should be counted, as carbon absorption by trees is foregone for any other purpose if it is set aside for absorbing CO_2 from the breath of livestock.

Transportation fuels accounted for about 6 billion tons of CO_2 in 2009. In comparison, CO_2 from the breath of livestock raised in 2009 accounted for about 10 billion tons of CO_2. Not only are the approximately 10 billion tons of CO_2 from the breath of livestock in 2009 invariable regardless of animal type, but there are also billions more tons of GHGs that are more or less invariable from these aspects of livestock production:

1. GHGs from transporting each kg of livestock product
2. GHGs from solid and liquid waste from livestock and their products
3. GHGs attributable to livestock byproducts such as leather and feathers
4. GHGs from the substantially higher amount of refrigerating, cooking, and packaging of meat *versus* analogs
5. GHGs attributable to carbon-intensive medical treatment of millions of cases worldwide each year of zoonotic illnesses (such as swine flu) and chronic degenerative illnesses (such as coronary heart disease, cancers, diabetes, and hypertension leading to strokes) linked to the consumption livestock products – but not to analogs.

The point here is that close to half the GHGs attributable to the life cycle and supply chain of livestock products are more or less invariable, regardless of the type of livestock produced.

Therefore, while significantly more GHGs are attributable to beef than to other meats because of cattle's grazing, feed, enteric fermentation, and manure management, that significance is much smaller than commonly thought – and no particular meat product is likely to have a GHG footprint more than 25% lower than any other. Therefore, eating chicken instead of beef (for example) would not result in any appreciable slowing of climate change. Conversely, the GHG footprint of an analog such as a soy-burger product or whole legume may be as much as 90% lower than the livestock product that it can replace.

4. Methane, the fastest and cheapest fix for global warming

Methane makes up a small (1.77 parts per million) portion of the atmosphere compared to carbon dioxide (380 ppm), but is a significant component of the greenhouse effect. Methane molecules absorb 20-30 times more infrared energy than carbon dioxide molecules in their respective lifetimes in the atmosphere, and their overall contribution to the greenhouse effect is estimated at 18 per cent compared to 63 per cent for CO_2. Apart from this potency, methane has a short lifespan in the atmosphere of eight years (compared to 100 years for CO_2) before it degrades to carbon dioxide. The world is

awellfedworld.org/sites/awellfedworld.org/files/pdf/FAOConsult12-09.pdf

wasting precious time by not acting on methane.[11]

That many methane emissions are not anthropogenic is problematic (Table 2). The main natural sources at the moment are wetlands, accounting for 30 per cent of all methane emissions and caused by bacteria breaking down organic matter in the absence of oxygen. This process will produce more methane if air temperatures rise.

As soon as wetlands dry out, they become susceptible to fire that results in large amounts of CO_2 and CH_4 being released to the atmosphere. That is part of the reason why Indonesia agreed in May 2010 not to convert its extensive peat forests into oil palm plantations, supported by Norway with US$1 billion.[12]

Vast methane reservoirs are locked up in the Arctic tundra's permafrost in the highly compressed form of methane hydrates, molecules in which water and methane are bonded under high pressure or low temperature. At present these reservoirs are frozen. Scientists fear that small increases in temperature could melt the permafrost, thus releasing vast amounts of methane.

Modest efforts are being made to reduce emissions from human sources. In the UK, waste management is being tightened to reduce emissions from landfills, and research is underway to alter the diets of livestock to reduce agriculture's contribution. In wet rice cultivation, emissions can be cut through hydrological management (reducing the water levels in flooded paddies half way through the growing season before re-flooding again). Gas emitted by mining can be captured. Russia significantly cut methane levels in the 1990s by fixing leaks and improving its gas pipeline infrastructure.

But, as with carbon emissions, we appear to have reached a point where further reductions in human sources of methane require harder choices. Calculation of the 'methane footprint' as a part of the environmental assessment of all projects is needed to achieve a 'low-methane economy' as soon as possible. Breeding rice varieties that produce less or no methane looks promising. But easiest and most promising is reducing livestock production.[13]

5. Conclusions: Next Steps for All

With no new climate treaty forthcoming, and with most national governments preoccupied with short-term economic challenges, the short-term perceived self-interest of constituents may prevent their legislators from effecting changes in agriculture needed to reverse climate change and ensure food security. With that in mind, following are specific recommendations for government bodies, industry and consumers.

A. Government

Hitherto, governments have sought food security in two main ways. The first way to reach food security has been through boosting productivity on existing agricultural lands in a "green revolution," using inputs such as fertilizers and biocides. Indeed, there is still significant scope to boost productivity by improved agricultural practices. The second way toward food security involves converting more forest to agriculture. However, this undermines the world's priority of reducing carbon by sequestration. In addition, much carbon is released by conversion of forest to food production by burning the cut forest and its subsequent rotting.[14]

There is a third way that most governments have ignored, namely promoting an increase in the nutritional value of production from agricultural land. This means feeding more people from existing arable lands, while improving human diets. It means phasing down the least efficient land uses (industrial livestock and feed) and focusing instead on more direct and efficient human nutrition (soy, grains, vegetables). About 70% of meat is produced in developing countries. A 25% reduction in this least efficient human food would not only achieve the promise of Copenhagen in terms of GHG reduction, but would also help governments to achieve their objectives in food security.

To grow better alternatives to meat and dairy products, less than half the acreage is required as that which is needed to

[11] Methane Network and Jardine, C., 2005.

[12] See www.norway.or.id/.

[13] Arts, Noelle et al., 2010.

[14] According to Nepsted et al. (2004), a full 50% of the Amazon forest is drying out at or beyond the fire risk level.

produce meat and dairy products themselves. It would not only improve the nutritional efficiency of land[15] but also reduce the high wastage in meat and dairy production.[16]

There is consensus among agricultural experts that raising food productivity is essential, possibly by means of another green revolution. Basically, there are only five options to double food production by 2050: (1) Raise agricultural yields; (2) increase production limits; (3) reduce waste; (4) expand agriculture into forest; and (5) improve diets. Only the latter can suffice on its own.

B. Industry

As with all other emissions in the world, the emissions attributable to livestock should be considered as impacts managed or owned by the industry or sector that emits them. But the livestock sector sits within the larger food industry – which in total produces much smaller volumes of livestock products than the volumes it produces of grains, legumes, fruits, and vegetables, all of which are exposed to the impacts of emissions attributable to livestock. Moreover, this exposure is probably greater than the exposure of any other industry to the very same emissions. Therefore, there is a compelling commercial motivation for the food industry to manage the impacts of these emissions, as soon as they are understood.

Interest in managing the risk of livestock should rise even higher when the food industry realizes that there are pragmatic business opportunities that would balance the impacts – namely, to produce better alternatives to livestock products. Nobody else owns or can manage the existing impacts and available opportunities as directly as can the food industry. So ideally, the impacts and opportunities will be first understood and then managed directly by the food industry.

In fact, all large companies in the food industry already employ their own environmental specialists. However, those specialists have apparently so far overlooked the impacts and opportunities identified in *Livestock's Long Shadow*, *World Watch*, and elsewhere. This is a significant gap, considering that individual food companies and the food industry may be first in line among all industries to suffer from climate change -- but also first in line to benefit if they take the lead in pursuing opportunities for alternatives to livestock products.

Livestock production is becoming an obsolescent, sunset industry. Climate and other environmental imperatives, as well as costs, all militate against this industry. On the other hand, meat and dairy analogs are likely to improve profit margins. They will sell well because of their quality, including ease and speed of preparation and delivery, and good taste. Preferences change readily if price, taste and other benefits are realized. Where vendors promote analogs, palates follow.

Scaling up analogs will insulate food corporations from rising oil prices. The 'peak oil' phenomenon makes it likely that industry will be forced to produce less meat and dairy products. Food industry leaders such as Cargill[17] and Whole Foods seem to be moving in this direction. Any significant innovation in this area by food industry leaders will tend to lower the costs both of climate disruption and climate adaptation.

C. Individuals

Many experts have recently targeted the public with messages about livestock and climate change. For example:

- Dr. Andy Thorpe, University of Portsmouth, calculated that 200 cows emit methane each year equivalent to the emissions from a family car driven 111,850 miles.

- Nobelist Dr. Rajendra Pachauri, Chair of the Intergovernmental Panel on Climate Change, has stated: "A major shift toward plant-based diets is imperative if we are to have even a chance of preventing catastrophe

[15] Improving human diet efficiency by increasing the plant-based ratios of the human diet is quite different from boosting livestock and dairy 'feed conversion efficiency,' which means phasing down pasture-feeding, while ramping up feedlots, stall feeding and factory-farms for meat, egg and dairy production. On the contrary, efficiency should above all mean reducing the feed and grains allocated to livestock.

[16] Tristram, 2009.

[17] Cargill, the largest privately held company in the US (six times the size of McDonald's), recently launched a 100% non-dairy cheese analog called 'Lygomme' for pizza and other prepared food applications. According to Cargill, it "replicates the functionality of dairy protein and replaces it fully at an outstanding cost advantage for the manufacturer"; and "its appearance, taste and texture perfectly match those of processed cheese."

according to top climate leaders… In terms of immediacy of action… reducing meat consumption clearly is the most attractive opportunity."

- Sir Paul McCartney is promulgating a worldwide Meat Free Monday campaign for the general public, and spoke in December 2009 to the European Parliament on this topic, along with Dr. Rajendra Pachauri.

- Former U.S. Vice President Al Gore has written that "refusing meat" is the "single most effective thing you can do to reduce your carbon footprint."[18] He now often speaks publicly along these lines.

- Baron Stern of Brentford, former World Bank Chief Economist, and lead author of the UK government's Stern Review on the Economics of Climate Change (2006), has publicly stated: "Meat is a wasteful use of water and creates a lot of greenhouse gases. It puts enormous pressure on the world's resources. A vegetarian diet is better."

Such statements are not entirely new. Albert Einstein wrote many years ago that "nothing will benefit humanity and increase the chances of survival of life on earth as much as the evolution towards a vegetarian diet."

After media exaggerated a claim by Dr. Frank Mitloehner in a speech in March 2010, asserting that the climate impact of livestock had been overestimated, numerous independent analyses followed up to show that his claim is false.[19]

The many recent efforts by public figures and media outlets to raise awareness among individuals are commendable. However, even more powerful momentum to reverse climate change by replacing meat and dairy products with better alternatives can be developed through collaborative efforts by governments, industry, and the general public.

Reducing large-scale livestock production would be a "Trifecta" win/win/win. It would reverse climate disruption quickly; it would solve the hunger/starvation challenge while boosting human health; and it would solve the global water crisis.[20] While it may not be a panacea for the future of humanity on earth, reducing livestock production comes far closer than any other option.

Annex 1: Tables

Table 1 - Global Warming Potentials of Six Anthropogenic Greenhouse Gases From: IPCC, 2001

Gas	Global Warming Potential (100 years)	Lifetime in the atmosphere (years)
CO_2	1	5-200
CH_4	23	8-12
N_2O	296	114
HFCs	12 - 12,000	0.3 - 260
PFCs	5,700 - 11,900	2,600-50,000
SF_6	22,200	3,200

Table 2 - Sources of Global Methane Emissions

Natural (40%)	Anthropogenic (60%)
Wetlands	Livestock (50-100 Mt/yr)
Termite activity	Wet Rice cultivation
Oceans	Waste practices
	Coal mining

[18] Gore, 2009.

[19] For example: www.theatlantic.com/food/archive/2010/04/the-myth-of-green-beef/38810/ and: www.cjr.org/the_observatory /meat_vs _miles.php

[20] 1 lb of beef needs 2000 gallons of water. 1 lb of soy needs 200 gallons of water. Corn needs 100 gallons. A vegetarian uses 300 gallons/week, whereas a carnivore uses 2000g.

Natural gas pipelines
Biomass (e.g. forest) burning

Table 3 - Rough Ranking of the Cost Effectiveness of Different Ways to Reduce Climate Risks After: Thomas Wire

- Family planning
- Reducing livestock production & deforestation for industrial ranches
- Reducing waste: improved efficiencies and conservation
- Improved wet rice technology
- Phasing down coal
- Phasing down oil
- Ramping up renewable energy: wind and solar
- Phasing down natural gas

Annex 2: The Declining Role of Fish

One billion people, mostly from poorer countries, rely on fish as their main protein source. About 35 million fisherfolk use 20 million boats. About 170 million jobs depend directly or indirectly on the fish sector. At least 30 percent of fish stocks have already collapsed, meaning they yield less than 10 percent of their former potential, while virtually all fisheries risk running out of commercially viable catches by 2050. Only a quarter of fish stocks – mostly the cheaper, less desirable species – are now considered to be thriving. The most severe driver of this predicament is the perverse US$27 billion government subsidies encouraging bigger fishing fleets to chase ever fewer fish, with little attempt made to allow fish populations to recover. The value of the catch is less than US$85 billion. The world faces the possibility of essentially fishless oceans by 2050, unless fishing fleets are drastically cut and stocks allowed to recover. This disaster can be avoided if subsidies to fishing fleets are slashed and fish are given protected zones. Ultimately, this might lead to sustainable fishery industries. As pond fish (e.g., Tilapia, Catfish) consume up to 50% of ocean catch (bycatch), they do not seem promising in climate risk reduction nor in hunger alleviation.

Annex 3: Humans' needs for quality protein

This paper focuses on improving the efficiency of human diets in order to prevent climate disasters and in order to prevent starvation in the years to come. Even so, when people hear calls for 25% less industrial cattle ranching, or even for "Meat-Free Mondays", the most frequent questions usually center on protein. Therefore, although this brief annex diverges from the topics of climate change and hunger, and is only distantly related to environment or ethics, it is designed to reassure people that they need not worry at all about their protein intake.

Most people in the world eat little or no meat because traditional plant-based diets are much lower in cost. In most countries it is impossible to become protein deficient if one ingests a 'normal' range of foods in a c.2000 calorie diet. For example, the Irish survived and even thrived only on potatoes for decades. Protein deficiency can occur in those eating only cassava, but this is restricted mainly to extremely poor societies in West Africa. The US Government recommended daily allowance (RDA) is 0.8 g of protein per kg of body weight per day, or 40-70 g per 'average' weight person.[21] The American Dietetic Association has concluded that 'well-planned vegan diets are appropriate for all stages of the life cycle, including during pregnancy, lactation, infancy, childhood and adolescence.'[22]

The 'best' protein has several attributes. First, the protein must come with little or no harmful substances, such as transfats,[23] saturated fats, hormones, antibiotics, nitrites, nitrosamines, sodium preservatives (e.g., bacon) and cholesterol. Second, the protein should be associated with healthful substances, especially fiber. Third, the daily mix of proteins ingested should contain all the essential amino acids. On these criteria, plant protein comes out as the best protein source. Animal muscle is high in protein but cannot be eaten without also ingesting much saturated fats, hormones, antibiotics etc, and no fiber. Thus 'quality' protein is plant based.

If cost and availability are taken into account, then grains are one of the best quality protein sources. Whole grain or pumpernickel breads, oatmeal, whole grain pasta, and brown rice, for example, are excellent sources of calories, minerals, vitamins and fiber while contributing about 10 g of protein per serving. The traditional grain-based diet is the most efficient, lowest cost, healthiest and environmentally preferred in the world.[24] For those preferring meat analogs, there is a wide ranch or soy-burgers, -milk, -icecream and –cheese, as well as seitan (wheat gluten) equivalents.

Soymilk contains about the same amount of protein as cows milk (8 g/cup) but without the saturated fats, hormones, and antibiotics. In addition, many if not most people in the world are lactose intolerant, hence are sickened if they take cows' milk. Human milk is perfect for human babies, and its composition adjusts depending on the needs of the baby. But after weaning, cows' milk is not ideal for children, and even less so for adults.[25]

[21] The USG notes that children, pregnant and lactating women, the elderly, and those with disease need slightly more protein.

[22] American Dietetic Association, 2003.

[23] Transfats occur naturally in most meat and dairy products, but not at all in plant-based diets. Transfats have been dangerously prevalent in processed foods containing partially hydrolyzed unsaturated fats, shortenings and margarines, but are being banned or phased out in many countries.

[24] Campbell and Campbell, 2005.

[25] Goodland, 2002.

It is very expensive to render milk healthy. If one removes all the fat, and removes lactose for all the lactose intolerant people, the resulting product still probably contains growth hormones and antibiotic residues; similarly with ruminant cheeses. It is very difficult to find a cheese rich in protein while low in saturated fats, cholesterol and salt.

Most beans and peas contain 7-10 g protein per half cup cooked. Chick peas (garbanzos), tofu, tempeh, soy flour, textured soy protein, and soybeans themselves contain about twice the amount of protein as other pulses. Soy contains more protein than beef and more calcium than cow's milk. Most nuts, seeds and pulses are rich in fiber; most are very low in unhealthy fats. Leafy greens, such as spinach and broccoli, and seaweeds (e.g., dulse, laver bread, kim, nori) are tops in protein with no harmful associated substances, but with many beneficial non-protein contents, such as zinc, calcium, magnesium. The Laminaria kelps are marine algae or seaweeds, (e.g., Wakame, Dashima, Miyok, Kombu) in a normal 1-2 tablespoon serving contain roughly 3.75-7.5 kcals and provide 15-30 mgs of Omega-3's. Kelps also have high levels of minerals, such as calcium, iodine, thiamine and niacin. Lactating mothers in Korea and Japan take kelp soup for their very high calcium contents, far higher than cow's milk. Many nuts and seeds contain 6-9 g protein per quarter cup.

Some people worry that a vegan diet may be too low in some specific substances essential to good health. In general, WHO and others have found that fortification of staples and the addition of supplements is very cost effective in most cases. Even some of the poor are advised to ingest one low-cost multivitamin daily.

Lysine: Inadequate in some vegan diets. To ensure sufficiency, a plant-based diet should include a wide variety of plant foods, especially legumes such as chickpeas (hummus, channa) and soybeans, which are good sources of lysine.

Iodine: Now widely available at very low cost in fortified salt.

Iron: Low in many diets, it is nowadays easily and cheaply available in fortified salt, flour and other foods.

Zinc: The first case of zinc deficiency was reported only in 1961. But as soils in developing countries are being depleted and becoming more acidic, zinc deficiency could become more of a problem. Fortification of cereals and tortilla flour is the most cost-effective according to WHO and the World Bank. Wheat germ, yeast, whole grains, pulses and algae are good natural sources.

Vitamin A: Carrots, broccoli and leafy greens are good sources of beta-carotene and retinol.

Vitamin B 12: Human requirement for vitamin B12 is very small, about 1.5 µg/day – yet is essential. Neither plants nor animals make vitamin B12; only micro-organisms (e.g., bacteria, yeasts) produce it. Root crops (unpeeled potatoes, yams, sweet potatoes) used to be sources of B12 from the naturally fertile soils in which they were grown. But industrial agriculture has depleted soils into an almost sterile growing medium with chemicals and biocides, so that source of B12 has declined. Despite their yeast content, many beers don't seem to be rich sources of B12. However, it is widely available as a supplement at low cost. Adding a spoonful of B12 yeast to one's daily soup or stew fully meets requirements. Most soymilk and cereals are fortified with B12.

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