Consumption patterns, ecosystem stress, and human development

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The consumption process

Consumption is essential for human development and is also the main driver of ecological stress. Since people need both consumption and a supportive ecosystem, it is necessary to identify and promote consumption patterns that make the greatest contribution to human development for the least stress on the ecosystem—or HHD/LES (High Human Development/Low Ecosystem Stress) consumption patterns.

In principal, policies to promote HHD/LES consumption patterns could be applied at any stage or combination of stages in the consumption process: during resource extraction, transport, manufacturing and construction, trade, and "final" consumption by the service sector, government and households (Figure 1). Consumption occurs throughout the process: resource extractors consume energy, plant and machinery; transporters consume energy, transportation equipment and infrastructure; manufacturers and builders consume energy and raw materials; and traders consume energy and equipment. Service organizations, governments and households are final consumers only in the sense that they consume final products (as well as energy). As recycling increases, they too are becoming intermediaries, returning materials to the manufacturing/construction stage. Accordingly, it is desirable to consider the process in its entirety.

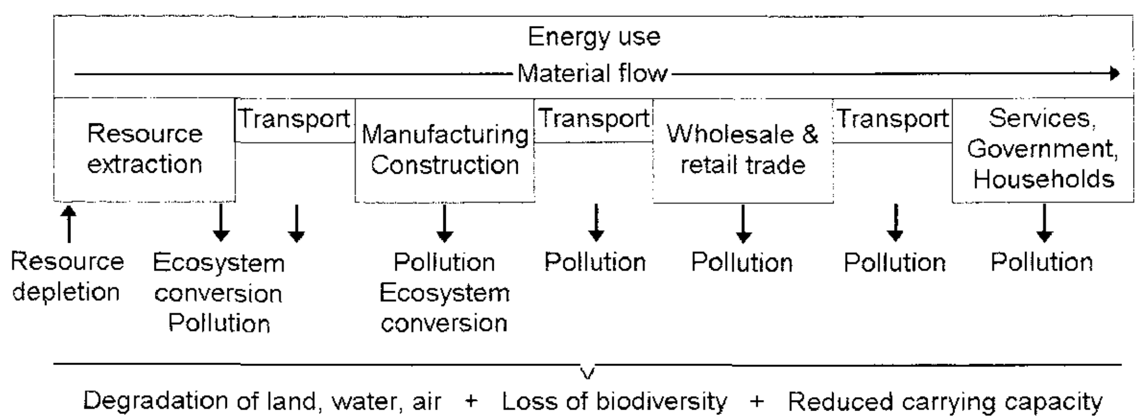

Figure 1. The consumption process and its effects on the ecosystem.

This paper reviews the relationship between consumption and ecosystem stress, first discussing ways of measuring ecosystem stress, and then examining four sets of consumption patterns and their relationship to ecosystem stress and human benefits: food, water, energy, and materials.

Measuring ecosystem stress

All consumption of goods and services entails the use of energy and materials. And any use of energy and materials causes some stress on the ecosystem. Stresses occur at every stage of the consumption process (Figure 1). Energy is used to drive the entire process and at each stage a proportion of material is returned to the ecosystem as waste and pollution.

Stress is unavoidable and all ecosystems can tolerate it some degree. Tolerance is a function of "carrying capacity"—the capacity of an ecosystem to support healthy organisms while maintaining its productivity, adaptability, and capability of renewal (IUCN-UNEP-WWF 1991). The carrying capacity of a particular ecosystem is finite, but people can use technology to increase their "share" of that capacity. This reduces the "share" of other species and so is usually at the cost of reducing biological diversity. In addition, a society can use trade to subsidize the capacity of its local ecosystem with that of another. Such subsidies can be increased and maintained for long periods until they impinge on the capacity of larger ecosystems to renew themselves and absorb wastes safely.

As shown in Figure 1, the main types ecosystem stress due to consumption are:

- Resource depletion, which has an immediate human impact, from higher costs to severe hardship. The collapse of fisheries, such as Atlantic cod, throws people out of work and denies many their only source of income other than social assistance. Reductions in fuelwood supplies add to the hours and distance that women have to seek fuel and carry it home. Exhaustion of accessible and easily extracted oil, gas and ore, increases the expense of producing energy and minerals.
- Ecosystem conversion and modification for agriculture, timber production, mineral extraction, and infrastructure. Impacts include reductions in carrying capacity (including loss of productive land) and declines in biodiversity (see below).
- Degradation of land, water and air, due partly to ecosystem modification but largely to pollution, as physical, chemical and biological materials are lost to the ecosystem at every stage of the process. Some consequences for human development are immediate, others are delayed. They include increased disease and death rates, alteration of atmosphere and climate, siltation of reservoirs, losses of soil, and reductions in the productivity and resilience of ecosystems.
- Declining biodiversity (reductions and extinctions of populations, species and ecological communities), a result of the above stresses. Extinctions of populations are early warnings of threats to species. The genetic stocks within crop varieties, livestock breeds and their wild relatives provide essential traits for increasing and improving agricultural production and the development of biotechnologies. The rising numbers of plant, animal and other species threatened with extinction represent an irreparable loss. Species have intrinsic worth. They also are the source of all biological wealth—supplying food, raw materials, medicines, recreational resources, and a store of other goods and services worth many

billions of dollars per year. Ecological communities maintain the ecological and evolutionary processes that sustain life. These in turn are necessary to help maintain the planet's chemical balance, moderate climate, renew soil, and conserve species diversity.

- Reduced carrying capacity. The consequences of reduced carrying capacity are that the Earth will support fewer people well, or more people less well, or a world of sharply increased disparities (a few people well, a great many poorly). It is likely also that the capriciousness of climatic and environmental events will increase: more frequent and severe storms, floods, and droughts.

No single consumption need—be it for food, water, housing, transport, clothing, or things—has a single environmental effect. Food consumption, for example, involves conversion of forests and other natural areas into ranchland and cropland, degradation of those lands by overstocking or excessive or inappropriate cultivation, contamination of water with pesticides and nutrients, pollution of air from burning pastures and crop residues (and kitchen air from cooking smoke), addition of carbon dioxide and methane to the atmosphere, and so on. These and other impacts of food consumption contribute to reductions in the diversity of ecological communities, species, and genetic variants—including losses of crop varieties and livestock breeds whose value to agriculture (as sources of disease resistance, productivity and other qualities) is increasing with advances in genetic engineering and biotechnology.

At the same time, other consumption needs contribute to these environmental effects. The task of disentangling the contributions to ecosystem stress of specific sectors and activities is onerous even with detailed information on energy and material flows. It is impossible without such information.

To obtain a clear picture of the main patterns of consumption and ecosystem stress, aggregate measures of both are needed. Attempts to obtain such measures have followed three main approaches: monetary, physical, and performance.

Monetary measures

The monetary approach converts natural resources and environmental services into monetary units, otherwise colloquially known as green accounting. Methods exemplifying the monetary approach include the System for Integrated Environmental and Economic Accounting (SEEA); the Index of Sustainable Economic Welfare (ISEW); and the World Bank's Genuine Saving and Wealth.

SEEAs are being developed in several countries (for example, Australia, Canada, Germany, Mexico, Netherlands, Sweden, UK, USA) as satellite accounts linked to the System of National Accounts (SNA). Environmental costs and benefits, expenditures for environmental protection and changes in natural resource assets are shown in flow accounts and balance sheets that are separate from the SNA but are concordant with it. The SNA covers income and assets that can be valued using market prices. The SEEA disaggregates the flow accounts to show those aspects that reflect the prevention, avoidance, treatment or repair of environmental damage. It treats natural assets in greater detail to show stocks and changes in wild species, ecosystems, soil, mineral reserves, water, and air. The SEEA uses market values where available, but in their absence employs near-market and non-market concepts such as replacement cost, maintenance cost, prevention and remediation costs, and contingent valuation (for example, willingness-to-pay). Satellite accounts include resource and pollutant flow accounts and environmental expenditure accounts. The SEEA can yield aggregate indicators of economic performance adjusted for ecosystem stress, such as the Eco-Domestic Product (EDP), which is Net Domestic Product (GDP less depreciation) minus depletion of natural resources and degradation of the environment (Hamilton & Lutz 1996; UN Statistical Division 1993).

The Index of Sustainable Economic Welfare (ISEW) is an attempt at a better measure of welfare than GNP/GDP. ISEWs have been calculated for Australia, Denmark, Germany, Netherlands, UK, and the USA where it is termed the Genuine Progress Indicator (GPI) (Daly & Cobb 1989, 1994; Dieren 1995). The GPI consists of personal consumption expenditures (taken from the SNA) weighted for income distribution, plus the value of household work, parenting, and volunteer work, plus services of consumer durables and highways and streets, plus net capital investment, plus or minus net foreign lending or borrowing, minus social costs (crime, family breakdown, loss of leisure time, underemployment, commuting, automobile accidents), minus environmental costs. Note that consumption is treated as the core contributor to welfare. The environmental costs are household pollution abatement (expenditures on equipment such as air and water filters), water pollution (costs of reduced water quality and siltation), air pollution, noise pollution, radioactive waste management and greenhouse gases, ozone depletion, loss of wetlands, loss of farmland, soil degradation, loss of forests, and depletion of nonrenewable energy resources. The costs are derived from two estimates: a physical estimate (such as the rate of siltation or the area of farmland lost to urbanization) and an estimate of the monetary value of that physical change(Cobb, Halstead & Rowe 1995). Either the physical or the monetary estimate applies to one or a few years, and even more adventurous judgments on performance are made for the rest of the 45-year series.

Genuine Saving is net saving less the value of resource depletion and environmental damage (Hamilton & Lutz 1996; World Bank 1997a). The starting point is the SNA's gross domestic investment less net foreign borrowing including net official transfers (gross saving) less depreciation of produced assets (net saving). Then values for resource depletion and pollution damage are subtracted from net saving. Depletion of fossil fuels and other minerals is estimated as the difference between the value of production at world prices and total costs of production (including depreciation of fixed assets and return on capital). Forest resources are included on the basis of the difference between the rental value of roundwood harvest and the corresponding value of the net increment in forests and plantations. Pollution damage to produced assets and the effects of pollution on output (e.g., damage to crops) are assumed to be captured already by the national accounts. Genuine Saving's contribution is to include pollution's effects on welfare, valued as willingness to pay to avoid excess mortality and the pain and suffering from pollution-linked illness and disability (World Bank 1997a).

The World Bank's concept of wealth adds natural resources, healthy ecosystems, and human resources (healthy and educated people), to the conventional accounting concept of produced assets. Thus values are placed on stocks of fossil fuels and other minerals, timber, nontimber benefits of forests, cropland, pasture land, and protected areas (World Bank 1997a).

These methods make a substantial contribution to informed decision making by providing an environmental dimension to the SNA. However, they show the inherent limitations of using money as a measure of the condition of the ecosystem and people-ecosystem interactions. Issues that are not easily or appropriately converted to a monetary value are either left out or distorted. In the GPI, air pollution does not include impacts on health and mortality. In Genuine Saving's valuation of forests, non-wood products and services such as carbon storage and watershed protection are excluded. In the World Bank's wealth estimates, the ecological and life-support functions of natural systems are described as "critically important" but nonetheless are omitted because of the difficulty of putting a money value on them (World Bank 1997a). Sometimes the distortions are large—as in the valuation of protected areas as the opportunity cost of not using them as pasture—and the discipline of economics is used in a highly relaxed way, as in the valuation of "excess" clearance of tropical forests as willingness the pay for their preservation (World Bank 1997a).

Monetary measures of resource depletion rely on future values of extraction and resource prices that are inherently uncertain (Aaheim & Nyborg 1993, cited in Hamilton & Lutz 1996). All the methods use reserve life as the basis for valuing depletion of fossil fuels and other minerals. Yet stocks of ore or oil or gas change with exploration effort, which changes with the price of the mineral. As the richer more accessible deposits are depleted the poorer and less accessible deposits become economic. Thus mineral reserves are a measure of inventory, and the market value of a mineral reflects the relationship between inventory and demand—not the mineral's actual scarcity. In some accounts, reserve discoveries are treated as additions to the stock of wealth, with the effect that these inventory changes can outweigh real depletion and degradation of soils and forests (as in natural resource accounts prepared for Indonesia [Repetto *et al.* 1989]). Since the current price does not track depletion of fossil fuels, the GPI uses replacement cost instead—the cost of producing the same amount of energy from renewable sources. However, calculating this cost involves a great deal of speculation about the effect on, for example, grain prices if corn became a major source of fuel as well as of food and feed—to say nothing of environmental impacts such as erosion (Cobb, Halstead & Rowe 1995).

A troublesome aspect is that the money values mask the physical data on which they are based. The estimates, assumptions and judgments embedded in the physical data are overlain by another set of estimates, assumptions and judgments. A more fundamental problem lies in measuring the condition of the ecosystem only as an adjustment of a measure of human wealth. The paradox is revealed in the observation that "Even though natural capital is normally third in importance as a source of wealth behind human resources and produced assets, it does form the ecological basis for life and is a fundamental building block of national wealth" (World Bank 1997a). If something is irreplaceable and essential for us, we need to know its condition and the stresses we are placing on it independently of some measure of our own condition. As value added rises, the importance of resources and the environment appear to diminish, even though their contribution to human wellbeing does not change. The situation is analogous to the relationship between the daily food energy people *must* consume to exist and the energy they *may* consume in the course of their existence: the 2200 calories or so are utterly dwarfed by the 340 gigajoules consumed by (say) the average North American.

Physical measures

All monetary measures of resource depletion and environmental degradation rely on physical measures. Aggregate physical measures can be produced using equivalent effects, weight, energy, or area as common units.

When equivalent effects are used as the common unit, pollutants that have similar effects are combined according to their potential for that effect. Greenhouse gases are combined on the basis of their global warming potential, ozone depleting substances are combined according to their ozone depletion potential, and other pollutants are combined according to their potentials for acidification or eutrophication, or their toxicity (for example, Adriaanse 1993).

The materials used by an economy can be combined according to their weight, allowing calculation of the total material flow through the economy (for example, Adriaanse *et al* 1997). Similarly, both energy and material flows through the economy, and changes in ecosystems, can be expressed in terms of the amount of solar energy they embody. Material flow is discussed in detail in a separate section below.

The Ecological Footprint quantifies the biologically productive areas necessary to provide a society's resource supplies and absorb its wastes. It converts uses of energy and renewable resources into the area of productive land and sea required to supply the resources and absorb carbon dioxide from fossil fuels: this a society's "ecological footprint" (Wackernagel & Rees 1996). In a report on the ecological footprint of 47 nations (Wackernagel *et al.* 1997), the productive area is defined as "fossil energy land" (land required for carbon dioxide absorption), arable land, pasture, forest, built-up areas, and the most productive part of the sea. The report estimates the size of these areas world-wide and hence the average area available for each person in the world. It then subtracts 12% for protected areas, leaving (in 1993) 1.8 hectares per capita of "available ecological capacity", or biologically productive area available for human use. A country's resource consumption is translated into land and water areas on the basis of estimates of world average yields of a basket of resources. Energy consumption is calculated as the country's energy requirement plus the energy embodied in imports minus the energy embodied in exports. The land and water area is converted to a per capita requirement adjusted for the difference between the productivity of the ecosystems of the country concerned and world average productivity. This is the ecological footprint. The difference between the ecological footprint and available ecological capacity is the ecological surplus or deficit (Table 1).

Physical units usually have a very limited scope. Thus equivalent effects combine indicators of land, air and water degradation. Weight combines indicators of material use. Weight and equivalent effects could be used together to show the impacts of material flows. Energy combines indicators of material and energy use and can be used somewhat more widely to model ecosystem functions and human-ecosystem interactions. However, the measures often call for many assumptions and judgments, and if they are extended beyond their core scope, they produce distortions similar to those in monetary evaluation. The ambitious use of area in the Ecological Footprint vividly reveals disparities in ecological demand among countries. However, it has difficulties reflecting the impacts of pollution (only carbon dioxide is accounted for) and changes in biodiversity.

COUNTRY	AVAILABLE ECOLOGICAL CAPACITY ha/capita	ECOLOGICAL FOOTPRINT ha/capita	ECOLOGICAL SURPLUS/ DEFICIT ha/capita
WORLD	1.8	2.3	-0.5
Australia	16.6	8.2	8.4
Bangladesh	0.1	0.6	–0.5
Belgium	1.1	5.3	–4.2
Canada	11.0	7.2	3.8
Chile	9.2	3.6	5.6
China	0.9	0.9	0.0
Denmark	10.0	5.5	4.5
Egypt	0.2	1.1	–0.9
Ethiopia	0.5	1.0	–0.5
Germany	1.8	4.9	–3.1
Iceland	96.3	11.4	84.9
India	0.3	0.8	–0.5
Italy	1.2	4.7	–3.5
Japan	2.1	7.0	–4.9
Korea, R	0.4	4.9	–4.5
New Zealand	53.9	9.7	44.2
Norway	16.7	6.2	10.5
Pakistan	0.5	0.8	–0.3
Singapore	0.0	5.8	–5.8
USA	6.8	8.6	–1.8

Table 1. Available ecological capacity, ecological footprint, and ecological surplus/deficit of a sample of countries, selected to represent the extremes of performance [1993] (Wackernagel *et al.* 1997).

Performance measures

A performance scale combines indicators according to how well a society or organization performs on each indicator. Indicators are plotted on a performance scale in relation to one or both ends of the scale. In some performance scales, the end points are decided on the basis of *experienced performance* (and sometimes also expected performance). An example is the Human Development Index (HDI), in which the minimum levels represent the lowest observed values over the past 30 years, and the maximum levels represent the highest expected values in the next 30 years. In other performance scales, the end points are decided on the basis of *desired performance*. An example is the Dutch Environmental Pressure Index (EPI). Aggregate measures of ecosystem stress that use a performance scale include the EPI and the Ecosystem Wellbeing/Stress Index (EW/SI).

The EPI aggregates Dutch environmental policy performance indicators covering seven issues, which are combined on the basis of the gap between current performance and a sustainability or "no-major-effect" level (Table 2). The measurement for each issue (expressed as global warming equivalents, acidification equivalents, etc.) is multiplied by the distance from the sustainability level (expressed as a percentage of that level) to give a score for each issue (expressed as environmental pressure equivalents). The scores are added to give a total index of environmental pressure. The scale goes from 0 (sustainability levels achieved for all issues) to more than 8,000 (the combined distance from sustainability in 1985) (Adriaanse 1993).

ISSUE	SUSTAINABILITY LEVEL
Greenhouse gases	Pre-industrial levels (background rates)
Ozone depleting substances	Zero (background rates)
Acidification	Level at which little damage occurs to vegetation on sensitive sites
Eutrophication	Soil: equilibrium fertilization (balance between nutrient addition and removal) Water: zero (nutrient carrying capacity already reached or exceeded)
Toxic substances	Maximum acceptable risk (national standard)
Solid waste disposal	As low as possible
Nuisance from noise and odour	As low as possible

Table 2. Sustainability or "no-major-effect" levels of indicators in the Environmental Pressure Index.

The Ecosystem Wellbeing/Stress Index (EW/SI) is one axis of a biaxial performance scale, the Barometer of Sustainability, the other axis producing a Human Wellbeing Index (HWI). The EW/SI and HWI can be related and compared, and an additional aggregate measure produced: human wellbeing per unit of ecosystem stress. The Barometer scale has five bands, allowing users to define not just the end points of the scale but intermediate points as well, for greater flexibility and control. Performance criteria are defined on the basis of objectives, international or national standards and targets, background rates, or combinations of these (Prescott-Allen 1997). In *The Wellbeing of Nations*, the EW/SI has been constructed for 170 countries, combining indicators of land conversion and modification, land degradation, forest change, river conversion and modification, water quality, water withdrawals and supply, stress on the atmosphere, protected areas, threatened species, threatened livestock breeds, energy use, timber harvesting, and fisheries (Prescott-Allen. In press).

Performance scales allow use of whatever yardstick is most appropriate to the issue concerned. Income and value added are measured in money; but health is measured in disease and death rates, species diversity in percentages of threatened species, land degradation as erosion rates, and so on. This is especially useful in devising aggregate measures of environmental stress, because the physical units in which stress is measured can be kept intact, so keeping distortion to a minimum. Judgment is required in defining end and intermediate points on the scale, but the judgments are no greater than those called for when converting ecosystem value to money.

Food

A desirable pattern of food consumption is one in which everyone has enough food (low food insufficiency), virtually all of the food supply is produced domestically (high self-reliance), and ecosystem stress is low.

A good indicator of food insufficiency is the percentage of the population that is undernourished, defined as food consumption below the minimum energy requirement. Where this indicator is not available, a substitute is the percentage of babies with low birth weight (under 2500 grams). Poor nutrition is often a major factor in low birth weight, although other factors such as malaria may be significant. The percentage of the population that is undernourished ranges from 1% in South Korea to 73% in Afghanistan (FAO 1996b). In countries for which undernutrition data are not available, the percentage of babies with low birth weight ranges from 2% in Tonga to 20% in Guinea-Bissau and the Solomon Islands (WHO 1997).

High self-reliance is important for several reasons. First, it increases the security of the food supply and a society's control over the quality and safety of food and the manner in which it is produced. Second, shorter transportation distances reduce the chance of environmental damage due to transport (except in some large countries, such as the USA, where the distances are great). The UK-based SAFE Alliance has developed the concept of *Foodmiles*, the distance travelled by agricultural products from producer to consumer. UK food imports by air more than doubled during the 1980s, leading to greater energy consumption and air pollution (OECD 1997). A third reason is that countries that produce the bulk of their own food will incur the associated ecosystem stress ~~associated~~ rather than displace it to other countries: this makes it easier to account for the stress, and could provide an incentive to reduce it.

An indicator of self-reliance is food production as a percentage of supply. An overall percentage is not meaningful because it can be distorted by large exports of a single commodity. For example, Malaysia's total food production is 106% of its total supply, yet it produces less than half its supply of cereals, vegetables and dairy products. The distortion is due to a huge surplus of palm oil (FAO 1996a). To avoid this problem, production as a percentage of supply has been assessed separately for nine food groups: cereals, starchy roots, sugar and sweeteners, nuts and oils, pulses and vegetables, fruit, meat and eggs, dairy products, and fish and seafood. If production in any group exceeds supply, it is recorded as 100% (not 110% or whatever it may be). The indicator is the mean of the nine groups. On this basis, self-reliance ranges from India's 100% to the Netherlands Antilles' 3% (data from FAO 1996a).

Ecosystem stress due to food consumption depends on how much food is consumed, the modes of production and consumption, the distance between the points of production and consumption, and the amount and type of processing. The food sector's biggest impacts are during production and transportation. In British Columbia, virtually all of the sector's impacts on the land, water and biodiversity and most of those on the air and atmosphere are due to agriculture rather than to processing (Prescott-Allen 1997b).

Three measures of ecosystem stress are used here: the percentage of the land area occupied by cropland and permanent pastures; the extent and severity of land degradation; and fertilizer consumption per unit of arable land. The first of these indicates how much of the land area has been converted to agriculture, the second whether the productivity of the land is being maintained or is declining, and the third the intensity of resource inputs. Some food production regimes are low input but extensive, converting and modifying habitat over wide areas. Some are intensive, requiring a relatively small area but subsidizing production with large imports of energy and chemicals. Some are a bit of both. A substantial amount of production (in British Columbia more than 40% by value [Prescott-Allen 1997b]) now comes from crops and livestock raised in buildings: dairy products, poultry and eggs, pigs, mushrooms, and glasshouse vegetables. These appear to occupy less space than traditional agriculture, but the feed supply comes from farms and fisheries, and pollution tends to be high.

The percentage of the land area occupied by cropland and permanent pasture ranges from less than 1% in Suriname to 85% in Uruguay (FAO 1996a). Fertilizer consumption per hectare of arable land ranges from 0.3 kg in Niger to 4,800 kg in Singapore (FAO 1996a).

The main forms of soil degradation are erosion, loss of nutrients and organic matter, salinization, pollution, and physical deterioration (such as compaction). Estimates of degradation have been made using the Global Assessment of Soil Degradation (GLASOD [Oldeman *et al.* 1991; UNEP/ISRIC 1990) and other studies (Baitullin & Bekturova 1997; FAO-UNDP-UNEP 1994). GLASOD classifies areas by type of degradation (if any) and by degree and extent of each type. As a large scale assessment it was not intended for use at country level. Although inaccurate for small countries, GLASOD provides a good idea of the extent and severity of land degradation in countries of 10 million hectares and above. For the present paper, the land area subject to different degrees of degradation (see Table 3) was estimated and expressed as a percentage of the combined area of cropland and pasture. The percentages were multiplied by a factor according to the severity of degradation (Table 3) and then added to provide a rough index of soil degradation. The index is very rough: agricultural land is not the only land that may be degraded (forest land may be as well); GLASOD's estimates of degradation are approximate and not intended for country level analysis; and the estimates of cropland and pasture are not always reliable.

The three measures of ecosystem stress are categorized by severity (Table 4) and given a score. They are then combined into a simple index by adding the scores (Table 5).

DEGREE	DEFINITION	SCORE FOR EACH %
Light	land with somewhat reduced agricultural suitability: restoration to full productivity possible by modifying management; original biotic functions still largely intact	¼
Moderate	land with greatly reduced agricultural suitability; major improvements required to restore productivity; original biotic functions partly destroyed	½
Strong	land non-reclaimable at farm level; major engineering works required for restoration; original biotic functions destroyed	1
Extreme	land unreclaimable and beyond restoration; original biotic functions fully destroyed	2

Table 3. Classification of the degree or severity of soil degradation.

CATEGORY	SCORE	CROP + PASTURE AS % LAND	INDEX OF LAND DEGRADATION	FERTILIZER CONSUMP. KG/HA
Very low	1	<10	<10	<20
Low	2	10-19	10-19	20-49
Moderate	3	20-39	20-39	50-99
High	4	40-59	40-59	100-199
Very high	5	60-100	60-100	200-1000

Table 4. Categories and scores for degrees of ecosystem stress: area of cropland and permanent pasture as a percentage of the total land area, index of land degradation, and fertilizer consumption (kilograms per hectare).

CATEGORY	COMBINED SCORE
Low	3-6
Moderate	7-9
High	10-12
Very high	13-15

Table 5. Index of ecosystem stress.

Degrees of food insufficiency and self-reliance are also grouped into categories (Table 6).

CATEGORY	% POP UNDERNOURISHED % LOW BIRTH WEIGHT BABIES	CATEGORY	PRODUCTION AS % SUPPLY
Low	<10	High	>80
Moderate	10-19	Moderate	80-61
High	20-39	Low	60-41
Very high	40-80	Very low	40-0

Table 6. Categories of food insufficiency and self-reliance.

Countries whose food insufficiency is measured directly are analyzed first (Tables 7-16), followed by those for which it is measured indirectly as percentage of babies with low birth weight (Tables 17-19).

Countries with low food insufficiency and high self-reliance have either moderate or high indices of ecosystem stress (Table 7). The best performers (moderate stress) are Tunisia, Brazil, Argentina and Uruguay. Two countries (Lebanon and Cuba) have low insufficiency, moderate self-reliance, and moderate ecosystem stress (Table 8); five countries (Myanmar, Indonesia, Ecuador, Paraguay, Morocco) have moderate insufficiency, high self-reliance, and moderate ecosystem stress (Table 10).

Among countries with low indices of ecosystem stress, the best performers are Algeria, with low insufficiency and moderate self-reliance (Table 8), and Papua New Guinea which has moderate insufficiency and moderate self-reliance (Table 11). Other countries with low ecosystem stress have high or very high insufficiency: Guyana, Guinea, Zaire (Table 13); Congo, Côte d'Ivoire, Gabon, Gambia (Table 14); Mauritania (Table 15); Central African Republic, Chad, Malawi, Zambia (Table 16). All except Guyana are African and are characterized by extensive low input food production systems that do not meet basic needs (partly due to inefficient and inequitable distribution).

Most of the countries for which insufficiency data are lacking are developed, and the percentage of babies with low birth weight is below 10% (Tables 17-19). Among those with high self-reliance, Canada and Russia have low indices of ecosystem stress, and Bulgaria and Australia have moderate indices (Table 17). Among those with moderate self-reliance, Belize has a low index of ecosystem stress, and Finland, Norway and Japan have moderate indices (Table 18).

COUNTRY	SC	% LOW FOOD	% LOW BIRTH WT	PROD. AS % SUPPLY	ECO STRESS INDEX	CROP + PAST. AS % LAND	DEGR.. AS % CROP + PAST.	FERT. CONS. (kg/ha arable)
Brazil	6	06	11	96	m 333	27.9	28	93.3
Tunisia	5	03	07	86	m 431	51.8	36	18.0
Argentina	6	09	08	99	m 511	61.8	09	14.7
Uruguay	5	08	08	98	m 513	84.8	02	82.8
Egypt	6	06	06	81	u 145	3.5	47	243.3
Korea, DPR	5	09	01	86	u 245	17.0	50	376.5
Iran, Islamic R	6	07	08	85	u 353	38.0	69	56.1
Mexico	6	08	12	85	u 433	52.0	26	62.0
Turkey	5	03	08	98	u 443	52.2	54	54.3
Syrian Arab R	5	03	09	94	u 533	75.2	20	63.6

Table 7. Countries with low food insufficiency (<10%) and high self-reliance (>80%).

SC = size class of country: 7 = ten millions of km^2; 6 = millions of km^2; 5 = hundred thousands of km^2; 4 = ten thousands of km^2; 3 = thousands of km^2; 2 = hundreds of km^2; 1 = tens of km^2.

% low food = percentage of the population with insufficient food [1990-92] (FAO 1996b).

% low birth wt = percentage of babies with low birth weight (<2500 g) [1991-93] (WHO 1997).

Prod. as % supply = food production as a percentage of supply [1992] (FAO 1996a).

Eco stress index = index of ecosystem stress: l = low; m = moderate; u = high; v = very high; digits are the scores for the three measures of ecosystem stress (one digit score per measure) from which the index is obtained (in the same order as the last three columns) (Table 7).

Crop + past. as % of land = area of cropland and pasture as a percentage of the total land area [1994] (FAO 1996a).

Degr. as % crop + past. = index of degraded land area as a percentage of the area of cropland and pasture [1987-1990] (Baitullin & Bekturova 1997; FAO-UNDP-UNEP 1994; Oldeman *et al.* 1991; UNEP/ISRIC 1990). The degraded land area is adjusted for the severity of degradation (see text for explanation). Note the index is particularly unreliable in size classes 1-4. The index may be greater than 100 because of this unreliability, because non-agricultural land is also degraded, or both.

Fert. cons. = fertilizer consumption (kilograms per hectare of arable land) [1994] (FAO 1996a).

COUNTRY	S C	% LOW FOOD	% LOW BIRTH WT	PROD AS % SUPPLY	ECO STRESS INDEX	CROP + PAST. AS % LAND	DEGR. AS % CROP + PAST.	FERT. CONS. (kg /ha arable)
Algeria	6	09	08	64	1 231	16.6	30	15.3
Lebanon	4	05	10	70	m 313	30.9	05	91.5
Cuba	5	09	08	71	m 432	57.7	22	36.8
Malaysia	5	07	08	65	u 334	24.0	38	158.6
Korea, R	4	01	04	65	u 335	21.7	35	467.2

Table 8. Countries with low (<10%) food insufficiency and moderate (61-80%) self-reliance. For key and sources, see Table 7.

COUNTRY	S C	% LOW FOOD	% LOW BIRTH WT	PROD AS % SUPPLY	ECO STRESS INDEX	CROP + PAST. AS % LAND	DEGR. AS % CROP + PAST.	FERT. CONS. (kg /ha arable)
Libyan Arab J	6	03	04	52	m 152	8.8	77	30.6
Jordan	4	03	07	53	m 252	13.4	>100	34.6
United Arab Emirates	4	04	06	25	u 155	2.9	>100	907.7

Table 9. Countries with low (<10%) food insufficiency and low (<60%) self-reliance. For key and sources, see Table 7.

COUNTRY	S C	% LOW FOOD	% LOW BIRTH WT	PROD AS % SUPPLY	ECO STRESS INDEX	CROP + PAST. AS % LAND	DEGR. AS % CROP + PAST.	FERT. CONS. (kg /ha arable)
Myanmar	5	12	24	98	m 241	15.8	46	17.2
Ecuador	5	19	11	96	m 323	29.4	14	54.6
Indonesia	6	12	08	94	m 333	23.2	35	84.8
Paraguay	5	15	08	97	m 521	60.3	10	10.1
Morocco	5	10	04	87	m 522	67.9	10	31.2
Pakistan	5	17	30	96	u 344	34.2	43	102.3
Panama	4	19	10	86	u 352	28.7	>100	48.1
Colombia	6	18	10	88	u 424	44.3	10	107.7
China	6	16	06	96	u 435	53.2	24	308.8
Costa Rica	4	12	06	91	v 455	56.2	96	258.5

Table 10. Countries with moderate (10-19%) food insufficiency and high (>80%) self-reliance. For key and sources, see Table 7.

COUNTRY	SC	% LOW FOOD	% LOW BIRTH WT	PROD AS % SUPPLY	ECO STRESS INDEX	CROP + PAST. AS % LAND	DEGR. AS % CROP + PAST.	FERT. CONS. (kg /ha arable)
Papua New Guinea	5	10	16	64	l 122	1.1	18	31.3
Swaziland	4	13	07	67	m 513	73.3	04	69.6
El Salvador	4	19	11	77	v 554	64.7	83	132.5

Table 11. Countries with moderate (10-19%) food insufficiency and moderate (61-80%) self-reliance. For key and sources, see Table 7.

COUNTRY	SC	% LOW FOOD	% LOW BIRTH WT	PROD AS % SUPPLY	ECO STRESS INDEX	CROP + PAST. AS % LAND	DEGR. AS % CROP + PAST.	FERT. CONS. (kg /ha arable)
Saudi Arabia	6	12	06	38	m 423	57.6	16	94.7
Kuwait	4	16	10	17	u 155	8.0	66	200.0
Trinidad & Tobago	3	11	10	49	u 352	25.9	78	49.2
Mauritius	3	18	10	50	u 415	55.7	04	275.4

Table 12. Countries with moderate (10-19%) food insufficiency and low (<60%) self-reliance. For key and sources, see Table 7.

COUNTRY	S C	% LOW FOOD	% LOW BIRTH WT	PROD AS % SUPPLY	ECO STRESS INDEX	CROP + PAST. AS % LAND	DEGR. AS % CROP + PAST.	FERT. CONS. (kg /ha arable)
Guyana	5	24	18	90	l 132	8.8	27	30.2
Zaire	6	39	16	84	l 231	10.1	25	0.5
Guinea	5	25	07	82	l 411	46.5	04	1.5
Laos	5	24	13	93	m 151	7.4	77	2.3
Suriname	5	21	12	86	m 153	0.6	>100	63.2
Niger	6	37	12	89	m 251	11.1	>100	0.3
Mali	6	34	10	95	m 331	26.6	35	8.4
Benin	5	20	12	86	m 331	21.0	32	9.1
Chile	5	22	07	91	m 333	23.8	25	97.9
Cambodia	5	29	18	95	m 341	30.2	45	3.3
Tanzania, UR	5	38	18	97	m 421	43.6	13	11.4
Sudan	6	37	15	99	m 431	51.8	22	5.6
Nicaragua	5	25	15	82	m 432	55.8	26	24.4
Uganda	5	32	07	99	m 441	43.1	40	0.4
Madagascar	5	31	10	96	m 441	46.6	51	3.6
Nigeria	5	38	17	84	m 531	79.8	28	12.0
Philippines	5	21	11	85	u 343	35.1	40	65.5
Nepal	5	29	23	98	u 352	31.8	86	38.4
Honduras	5	21	09	96	u 352	31.9	77	28.1
Viet Nam	5	25	12	96	u 354	22.5	>100	174.5
Sri Lanka	4	26	22	81	u 354	35.9	62	113.1
Guatemala	5	26	14	82	u 443	41.6	51	95.8
Thailand	5	26	08	81	u 453	42.3	82	61.5
India	6	21	33	100	u 533	60.9	27	79.7
Bangladesh	5	34	27	91	u 534	79.1	23	108.1

Table 13. Countries with high (20-39%) food insufficiency and high (>80%) self-reliance. For key and sources, see Table 7.

COUNTRY	S C	% LOW FOOD	% LOW BIRTH WT	PROD AS % SUPPLY	ECO STRESS INDEX	CROP + PAST. AS % LAND	DEGR. AS % CROP + PAST.	FERT. CONS. (kg /ha arable)
Congo	5	34	09	65	l 311	29.8	05	11.2
Gabon	5	24	06	65	l 321	20.0	10	0.9
Gambia	4	29	30	62	l 321	36.2	19	4.7
Côte d'Ivoire	5	22	09	76	l 411	52.5	06	17.0
Venezuela	5	20	09	80	m 323	24.6	16	61.3
Togo	4	30	32	69	m 431	48.4	36	4.6
Senegal	5	30	09	80	m 441	41.8	48	8.5
Iraq	5	21	18	71	u 353	22.3	>100	65.4
Jamaica	4	23	11	65	u 434	44.0	25	118.7
Dominican R	4	32	14	75	u 523	74.0	14	64.2

Table 14. Countries with high (20-39%) food insufficiency and moderate (61-80%) self-reliance. For key and sources, see Table 7.

COUNTRY	SC	% LOW FOOD	% LOW BIRTH WT	PROD AS % SUPPLY	ECO STRESS INDEX	CROP + PAST. AS % LAND	DEGR. AS % CROP + PAST.	FERT. CONS. (kg /ha arable)
Mauritania	6	20	24	59	1321	38.5	17	19.2
Yemen	5	24	--	56	m 331	33.4	31	7.4
Botswana	5	29	08	30	m 421	45.9	13	2.4
Mongolia	6	32	06	51	m 511	75.6	06	4.2
Lesotho	4	35	10	37	u 541	76.4	43	18.8

Table 15. Countries with high (20-39%) food insufficiency and low (<60%) self-reliance. For key and sources, see Table 7.

COUNTRY	SC	% LOW FOOD	% LOW BIRTH WT	PROD AS % SUPPLY	ECO STRESS INDEX	CROP + PAST. AS % LAND	DEGR. AS % CROP + PAST.	FERT. CONS. (kg /ha arable)
Bolivia	6	40	12	90	m 331	26.6	28	4.5
Ghana	5	40	07	81	m 421	55.9	14	2.3
Burkina Faso	5	41	12	91	m 351	35.0	88	6.5
Zimbabwe	5	41	08	77	m 423	51.8	11	59.3
Zambia	5	43	10	91	1411	47.5	09	11.2
Cameroon	5	43	13	90	m 251	19.4	81	4.3
Kenya	5	46	13	91	m 422	45.4	18	30.5
Rwanda	4	47	16	90	u 541	75.8	44	0.9
Malawi	5	49	04	90	1312	37.6	09	21.4
Peru	6	49	11	85	m 333	24.4	27	50.5
Burundi	4	50	--	96	u 541	84.5	41	2.6
Angola	6	54	15	76	m 421	46.1	15	2.9
Sierra Leone	4	55	17	87	m 331	38.3	22	5.6
Chad	6	61	11	99	1321	38.3	17	2.1
Central African R.	5	62	20	87	1121	8.1	17	0.6
Ethiopia	6	65	15	98	m 351	31.0	67	4.2
Mozambique	5	66	13	83	m 511	60.2	05	2.2
Haiti	4	69	15	72	u 451	51.0	>100	5.6
Afghanistan	5	73	19	96	m 421	58.4	11	6.1

Table 16. Countries with very high (≥40%) food insufficiency. For key and sources, see Table 7.

COUNTRY	SC	% LOW FOOD	% LOW BIRTH WT	PROD AS % SUPPLY	ECO STRESS INDEX	CROP + PAST. AS % LAND	DEGR. AS % CROP + PAST.	FERT. CONS. (kg /ha arable)
Canada	6	--	06	84	l 112	8.0	04	49.0
Russian Fed.	7	--	05	94	l 221	13.0	15	11.6
Bulgaria	5	--	06	95	m 432	54.4	28	44.9
Australia	6	--	06	93	m 512	60.4	06	35.2
France	5	--	06	91	u 415	54.8	07	241.8
USA	6	--	09	97	u 424	46.6	10	102.7
Denmark	4	--	05	86	u 514	63.4	03	197.1
Spain	5	--	05	84	u 523	61.7	14	91.6
Greece	5	--	09	85	u 524	67.9	17	152.8
Romania	5	--	08	87	u 532	64.2	34	38.9
Poland	5	--	08	92	u 533	61.4	28	97.6
Hungary	4	--	09	90	u 533	66.3	21	63.1

Table 17. Countries with high (>80%) self-reliance. For key and sources, see Table 7.

COUNTRY	SC	% LOW FOOD	% LOW BIRTH WT	PROD AS % SUPPLY	ECO STRESS INDEX	CROP + PAST. AS % LAND	DEGR. AS % CROP + PAST.	FERT. CONS. (kg /ha arable)
Belize	4	--	06	72	l 114	4.6	00	108.8
Finland	5	--	04	74	m 134	8.9	39	148.4
Norway	5	--	06	62	m 135	3.4	34	229.7
Japan	5	--	06	67	m 215	13.5	03	403.2
Sweden	5	--	04	71	u 154	8.2	85	114.8
Netherlands	4	--	04	67	u 415	58.9	08	545.4
Italy	5	--	07	79	u 424	53.3	18	169.7
Switzerland	4	--	05	61	u 425	40.0	10	336.4
Portugal	4	--	05	62	u 433	42.4	28	87.6
Austria	4	--	06	77	u 434	42.6	26	168.5
Belgium + Luxembourg	4	--	06	63	u 435	45.2	36	410.6
Albania	4	--	07	80	u 452	41.1	>100	25.4
New Zealand	5	--	06	78	u 514	64.6	07	160.8
United Kingdom	5	--	07	69	u 515	70.7	07	383.7
Ireland	4	--	04	66	u 515	63.7	01	571.8

Table 18. Countries with moderate (80-60%) self-reliance. For key and sources, see Table 7.

COUNTRY	SC	% LOW FOOD	% LOW BIRTH WT	PROD AS % SUPPLY	ECO STRESS INDEX	CROP + PAST. AS % LAND	DEGR. AS % CROP + PAST.	FERT. CONS. (kg /ha arable)
Bahamas	4	--	08	39	l 112	1.2	00	20.0
Kyrgyzstan	5	--	06	--	l 411	51.7	03	19.7
Bahrain	2	--	07	--	m 1x5	8.7	--	300.0
Tajikistan	5	--	08	--	m 313	31.4	04	81.4
Israel	4	--	08	53	m 315	28.1	04	239.1
Estonia	4	--	04	--	m 322	34.4	10	36.2
Georgia	4	--	05	--	m 412	40.4	04	27.5
Lithuania	4	--	04	--	m 421	54.3	11	12.5
Azerbaijan	4	--	06	--	m 421	48.5	11	19.5
Belarus	5	--	04	--	m 423	44.6	12	99.5
Turkmenistan	5	--	05	--	m 513	67.0	02	84.5
Kazakstan	6	--	06	--	m 531	83.0	32	3.5
Oman	5	--	09	--	u 154	5.0	>100	158.7
Brunei Darussalam	3	--	05	15	u 155	2.5	>100	500.0
Singapore	2	--	07	--	u 155	1.6	>100	4800.0
Qatar	4	--	08	--	u 155	5.3	>100	750.0
Cyprus	3	--	09	60	u 254	15.9	66	184.2
Slovenia	4	--	06	--	u 355	39.2	82	286.0
Latvia	4	--	05	--	u 433	40.9	23	54.8
Slovakia	4	--	06	--	u 433	50.9	25	68.5
Croatia	4	--	08	--	u 454	41.3	94	148.2
Barbados	2	--	08	45	u 4x4	41.9	--	168.8
Malta	2	--	06	40	u 4x5	40.6	--	76.9
Moldova, R	4	--	07	--	u 523	79.3	18	52.8
Uzbekistan	5	--	06	--	u 524	61.1	12	107.3
Ukraine	5	--	06	--	u 532	72.3	34	34.9
Iceland	5	--	03	46	v 355	22.7	74	3666.7

Table 19. Countries with low (≤60%) self-reliance or self-reliance not known. For key and sources, see Table 7.

The 21 countries with the best combinations of self-reliance, food insufficiency and ecosystem stress show a wide range of consumption patterns (Table 20): calories per person per day from 2245 (Cuba) to 3266 (Norway); protein from 47 g per person per day (Papua New Guinea) to 102 g (Australia); animal foods from 34 kg per person per year (Indonesia) to 438 kg (Finland). The mix of animal foods includes high meat, high fish, low dairy (Papua New Guinea); high meat, high dairy, low fish (Uruguay), mostly dairy (Algeria), mostly meat (Paraguay), and an almost exact balance of meat, dairy and fish (Japan).

Country	calories/ person/ day	% calories as animal	g protein/ person/ day	% protein as animal	kg animal/ person/ year	% animal as meat	% animal as dairy	% animal as fish
HLL								
Canada	3080	30	97.9	60	352.1	32.8	60.6	6.6
Russia	2919	27	90.3	50	242.8	29.1	64.5	6.4
HLM								
Argentina	3085	29	95.5	64	299.3	35.1	62.2	2.7
Australia	3097	36	102.4	70	427.8	29.9	65.9	4.1
Brazil	2829	17	69.2	46	172.4	38.5	58.2	3.4
Bulgaria	2902	22	83.0	44	222.8	33.0	65.9	1.1
Tunisia	3073	9	78.9	22	101.4	24.7	67.5	7.9
Uruguay	2765	36	85.1	65	272.1	43.1	54.0	2.9
MLL								
Algeria	2976	10	82.7	24	137.3	18.7	78.4	2.8
Belize	2659	24	63.7	45	182.1	30.0	66.2	3.8
HMM								
Ecuador	2478	16	50.7	44	138.2	27.2	67.0	5.8
Indonesia	2616	5	60.1	17	34.3	36.4	17.8	45.8
Morocco	3171	6	85.1	17	65.1	39.5	49.2	11.4
Myanmar	2676	4	67.1	13	37.5	22.9	35.2	41.9
Paraguay	2417	23	72.2	54	159.6	58.4	39.2	2.3
MLM								
Cuba	2245	18	54.4	43	161.5	20.8	72.2	7.0
Finland	3014	38	93.6	65	437.6	16.7	75.8	7.5
Japan	2899	20	95.5	55	201.4	32.0	34.5	33.5
Lebanon	3265	12	82.6	30	135.5	35.4	64.0	0.6
Norway	3266	34	101.6	61	384.4	18.6	68.7	12.7
MML								
Papua New Guinea	2267	11	47.1	40	62.4	50.2	14.6	35.3

Table 20. Per capita consumption of calories, protein, and food from animal sources; and percentages of animal food contributed by meat (including offal, animal fat except dairy, and eggs), dairy (milk, butter, cheese, yogurt), and fish (including all seafood) [1994] (FAO 1996a).

HLL = high self-reliance, low insufficiency, low ecosystem stress.

HLM = high self-reliance, low insufficiency, moderate ecosystem stress.

MLL = moderate self-reliance, low insufficiency, low ecosystem stress.

HMM = high self-reliance, moderate insufficiency, moderate ecosystem stress.

MLM = moderate self-reliance, low insufficiency, moderate ecosystem stress.

MML = moderate self-reliance, moderate insufficiency, low ecosystem stress.

Many of these countries consume significant amounts of fish and seafood, a potential source of ecosystem stress that has not yet been considered. The simplest indicator of pressure on fisheries is the condition of the stocks that are fished. However, this information is only patchily available. One proxy indicator is the amount of fish caught per unit of fish catching capacity, although strictly speaking it is a measure of abundance and does not indicate pressure unless the maximum size of the resource is known. However, excess capacity is a common cause of overfishing, and changes in abundance are a concern even if it is not known how much they are due to fishing pressure and how much to natural events.

An indicator of marine fishing intensity is fish catching capacity per unit of continental shelf, the main fish producing area. It ignores differences in productivity, notably the effect of upwellings which are rich in nutrients. However, it provides a way of taking account of fleets that use the shelf areas of other countries, since their capacity is likely to be higher in relation to their national shelf area.

Both indicators are used here. The maximum sustainable yield (MSY) of the total world marine fishery is estimated to be 82.8 million tons taken by a world fleet of 23.7 million tons (adjusted for improvements in technology) (Garcia and Newton 1994). The average is 3.5 tons of catch per ton of capacity. The global average potential catch per km^2 of shelf is estimated to be 3.0-4.5 tons (Grainger and Garcia 1996). This is what could be caught at MSY by 0.9-1.3 tons of capacity. Moderate pressure on fisheries is defined here as around these levels: 2.6-4.5 tons of catch per ton of capacity; and 0.7-1.3 tons of capacity per km^2 of shelf area.

The indicators have been combined to give a reading of pressure on marine fisheries (Table 21). Brazil, Uruguay, Myanmar and Finland perform better with fisheries than with the other indicators of ecosystem stress. Argentina, Australia, Ecuador, Indonesia and Norway perform about the same. All the other countries (except Paraguay, excluded because it is landlocked) perform worse.

TONS CATCH PER TON FLEET CAPACITY	TONS FLEET CAPACITY PER KM^2 OF CONTINENTAL SHELF				
	0.0-0.2	0.3-0.6	0.7-1.3 Moderate	1.4-2.9	≥3.0
>10	LOW Myanmar				
10-4.6	LOW Brazil Finland Norway	MODERATE Norway			
4.5-2.6 Moderate	LOW Argentina Australia Papua New Guinea Indonesia		MODERATE Ecuador	HIGH Algeria Japan	
2.5-1.1	MODERATE Canada		HIGH Tunisia		HIGH Morocco
1.0-0.0	MODERATE Belize		HIGH Russia Cuba Lebanon		VERY HIGH Bulgaria

Table 21. Pressure on marine fisheries [1992] (FAO 1994, 1995a, 1995b, 1996a).

Conclusions and policy implications

The data are not current (early 1990s), witness North Korea's place in Table 7. They vary greatly in reliability. They hide as much as they reveal, since people eat meals (and snacks) not ingredients, and their food behaviour can only be glimpsed from commodity statistics. Nonetheless, the information is good enough to support some observations:

1. Food consumption patterns that meet requirements of low insufficiency, high self-reliance and low ecosystem stress are possible. It is doubtful that any country has achieved this combination (given the fisheries performance of Canada and Russia), but enough are close to it to show that it can be achieved with a wide variety of consumption patterns.

2. It is easier for large countries than for small countries to achieve this combination. However, some small countries are high in self-reliance (Hungary, Denmark, Panama, Costa Rica, Sri Lanka), and some are low in food insufficiency (Switzerland, Netherlands, Portugal, Austria, Ireland, Malta, Iceland, South Korea, Jordan, United Arab Emirates). Some may also be low in ecosystem stress (Bahamas, Gambia), but the scale of the analysis is too coarse to tell. These results, together with the relatively good overall performance of Belize and Lebanon, suggest that small countries could also develop sustainable food consumption patterns.

3. There is no perfect food consumption pattern, but a wide variety of cuisines have the potential to be sustainable. In particular, the common view that consumption of meat and other animal food is "ecologically unsound" is false. Meat and dairy products raised on existing pastures and distributed over limited distances are an efficient and sustainable use of the ecosystem. The most stressful use is intensive livestock production based on feeds transported over large distances (for example, cassava from Thailand to the Netherlands, or soybeans from Brazil and the USA to Austria). Impacts include land degradation in the feed producer's fields, pollution during transportation, and often considerable pollution from the feedlots and broiler houses where the livestock are produced. Extensive systems on the agricultural frontier are another concern as they continue to convert tracts of tropical forest to rangeland. Increasing fish and seafood consumption is not an option because almost all stocks are being fished at or above capacity, and increases in aquaculture production are possible only through intensification.

4. Ecological concerns about intensive livestock production (high demand for feed and high output of wastes) are matched by health concerns. Free range animals (whether wild fish, poultry in a yard, or cattle that spend their entire lifetime on open pasture) have high levels of long chain unsaturated fats and low levels of short chain saturated fats, whereas the reverse is the case with animals that are confined. The latter include fish raised by aquaculture and fed protein concentrates.

5. Many European countries, as well as the USA, New Zealand, and some small island states (Barbados, Malta, Mauritius), have food production systems that are both extensive and intensive. These countries face the conundrum of how to maintain domestic food production—or increase it in countries with moderate or low self-reliance—while reducing (or not increasing) the area of cropland and pasture, and changing to agricultural practices that are more management-intensive and less resource-intensive.

6. Countries with high to very high insufficiency (Tables 13-16) obviously need to raise production and improve distribution. In many of these countries, particularly in Africa, there is scope for adopting improved technologies and increasing inputs. The policy status of rural development is generally low and needs to be enhanced.

7. In all countries it is time to question two long-standing historical trends: declines in the agricultural work force and abandonment of food production in rural areas for manufacturing and services in towns; and reductions in the proportion of disposable income that is spent on food. Increasing local food production while reducing ecosystem stress probably requires increasing (or arresting the decline in) the number of people producing food. These and other measures would increase the price of food. This is a major obstacle for as long as people expect food to be extremely cheap and their expectation exceeds concerns about food quality (currently fairly high but highly confused), ecosystem stress (currently low), and self-reliance (currently non-existent). Otherwise, there is no reason why people with adequate incomes should not spend more on food (if they did, they might value it more).

8. However, if food prices reflected the ecological costs of production and distribution, poverty and undernutrition would increase. Although poverty levels are unacceptably high, they are artificially low in the sense that they are lower than they would be if the ecological costs of food supply—and perhaps other issues as well—were being addressed. Accordingly, policies and programs to reduce poverty may require review to ensure that they have been designed and budgeted at an adequate scale.

Water

The ideal water consumption pattern is one in which everyone has access to safe water and pressure on the resource is low. These aspects are examined on the basis of data for Africa, Europe, and West and Central Asia. In these regions, the percentage of the population with access to safe drinking water, ranges from 100% (many countries in Europe) to 12% (Afghanistan) (WHO 1997).

Pressure on the resource is measured by two indicators: per capita water consumption; and water withdrawals as a percentage of supply. Water withdrawals mean the total gross volume of ground and surface water extracted for domestic, agricultural and industrial uses each year. They include losses during transport. Water supply means the amount of water available each year from precipitation plus river flows from other countries. It includes renewable sources of groundwater, but excludes nonrenewable or fossil groundwater supplies. Water withdrawals as a percentage of supply indicates how much pressure there is on available water, the degree of water scarcity, and the likelihood of competition and conflict among different water uses and users. Rapid increases in water withdrawals—especially in drylands and coastal areas—are likely to add to salinization and other water quality problems. High rates of water consumption also threaten aquatic species and degrade freshwater ecosystems.

Water withdrawals as a percentage of supply range from less than 0.05% (several African countries) to 2,700% (Kuwait). Withdrawals greater than 100% of supplies are achieved either by desalting sea water or by extracting fossil groundwater (the equivalent of mining a nonrenewable resource and therefore unsustainable) or both. Annual per capita consumption ranges from 9 m^3 (DR Congo) to 6,346 m^3 (Eurostat *et al.* 1995; FAO 1995c, 1995d, 1997). Being national averages, these indicators take no account of local differences in consumption and supply, or of annual and seasonal shortages which are often very marked.

Only ten countries provide everyone with access to safe drinking water and withdraw less than 10% of supply (Luxembourg, Switzerland, Ireland, Denmark, Austria, Belarus, Sweden, Iceland, Norway, Finland). Their per capita consumption ranges from 156 to 605 m^3. Among countries with 100% access to safe water the lowest per capita consumption is Malta's (152 m^3), and the next lowest is Luxembourg's (156 m^3). Malta's withdrawals, however, are 300% of supply, whereas Luxembourg's are 1.2%. Luxembourg's relatively low pressure on the resource contrasts with Belgium's high pressure: per capita consumption 917 m^3, and withdrawals 72% of supply (Table 22).

The most impressive performance is the Gambia's, which provides 86% of the population with access to safe water on a per capita consumption of only 29 m^3 and using only 0.3% of supply (Table 23).

Leaving aside the extremes, average per capita consumption declines from countries providing access to safe drinking water to more than 90% of the population to countries that provide access to 60% or less of the population (Tables 22-24). However, high pressure on the resource is no guarantee that people will get enough water. Per capita consumption is more than 1,000 m^3 in Afghanistan (12% access) and Madagascar (23% access). Withdrawals are 57% of supply in Iraq (44% access) and 87% of supply in Cape Verde (52% access) (Table 24).

COUNTRY	% WITH WATER	SUPPLY km^3	WITH-DRAWALS km^3	W-D. AS % SUPP.	PER CAP. m^3	% DOM.	% AGR.	% IND.
Croatia	96	47.6	0.56 (90)	1.2	120			
Malta	100	0.02	0.06 (95)	300.0	152	87	12	1
Luxembourg	100	5.0	0.06 (89)	1.2	156	95	0	5
Switzerland	100	54.0	1.17 (89)	2.2	175	67		
Ireland	100	50.0	0.79 (80)	1.6	233			
Denmark	100	13.0	1.20 (88)	9.2	234	52	30	18
Jordan	97	0.9	0.98 (93)	108.9	246	22	75	3
United Kingdom	100	120.0	14.24 (90)	11.9	248	52		
Austria	100	92.0	2.12 (89)	2.3	278	33		
Belarus	100	58.0	3.00 (89)	5.2	293	20	37	43
Cyprus	100	0.9	0.21 (93)	23.3	331	24	74	2
Sweden	100	168.0	2.93 (90)	1.7	343	33		
Kuwait	100	0.02	0.54 (94)	2700.0	348	37	60	2
Mauritius	100	2.2	0.36 (74)	16.4	409	16	77	7
Iceland	100	168.0	0.10 (85)	0.1	415	50		
Lebanon	94	4.4	1.29 (94)	29.3	444	28	68	4
Bahrain	100	0.1	0.24 (91)	240.0	465	39	56	4
Norway	100	392.0	2.03 (83)	0.5	491			
Qatar	100	0.05	0.28 (94)	560.0	528	23	74	3
Hungary	98	120.0	6.26 (90)	5.2	593	9		
Finland	100	108.0	3.00 (89)	2.8	605	19	1	80
Ukraine	96	212.7	33.03 (90)	15.5	637	12	34	54
France	100	198.0	37.73 (90)	19.1	665	16		
Greece	98	58.6	6.95 (80)	11.9	720			
Portugal	93	73.0	7.29 (89)	10.0	737	8	53	39
Romania	96	219.0	20.34 (89)	9.3	879	9	57	34
Belgium	100	12.5	9.03 (80)	72.2	917			
Albania	97	41.0	2.97 (89)	7.2	928			
Spain	99	117.0	36.90 (90)	31.5	947	16	55	29
Italy	100	175.0	56.20 (90)	32.1	980			
Netherlands	100	91.0	14.48 (86)	15.9	994	16		
United Arab Emirates	98	0.15	2.11 (95)	1406.7	1,107	24	67	9
Bulgaria	99	190.0	11.00 (88)	5.8	1,225	4	21	75

Table 22. Access to safe drinking water; water supply; water withdrawals; and water consumption: countries where >90% of the population has access to safe drinking water, ranked in order of per capita consumption (all water uses).

% with water = percentage of the population with access to safe water [latest year available] (WHO 1997).

Supply km^3 = amount of water available each year from precipitation plus river flows from other countries, including renewable sources of groundwater but excluding nonrenewable or fossil groundwater supplies(Eurostat *et al.* 1995; FAO 1995c, 1995d, 1997).

Withdrawals km^3 = total amount of water withdrawn or extracted by all uses (Eurostat *et al.* 1995; FAO 1995c, 1995d, 1997).

W-D. as % supp. = withdrawals as a percentage of supply.

Per cap. m^3 = annual per capita consumption (all uses) [same year as shown in withdrawals column] (Eurostat *et al.* 1995; FAO 1995c, 1995d, 1997).

% dom./agr./ind. = percentages of total withdrawals by domestic and municipal uses/agriculture/ industry (Eurostat *et al.* 1995; FAO 1995c, 1995d, 1997).

COUNTRY	% WITH WATER	SUPPLY km^3	WITH-DRAWALS km^3	W-D. AS % SUPP.	PER CAP. m^3	% DOM.	% AGR.	% IND.
Benin	70	25.8	0.15 (94)	0.6	28	23	67	10
Togo	63	12.0	0.91 (87)	7.6	28	25	62	13
Gambia	86	8.0	0.02 (82)	0.3	29	7	91	2
Burkina Faso	78	17.5	0.38 (92)	2.2	40	19	81	0
Gabon	67	164.0	0.06 (87)	0.0	57	72	6	22
Côte d'Ivoire	82	77.7	0.71 (87)	0.9	64	22	67	11
Botswana	77	14.7	0.11 (92)	0.7	85	32	48	20
Malawi	77	18.7	0.94 (94)	5.0	86	10	86	3
Rwanda	66	6.3	0.77 (93)	12.2	102	5	94	2
Zimbabwe	74	20.0	1.22 (87)	6.1	135	14	79	7
Algeria	79	14.3	4.50 (90)	31.5	180	25	60	15
Tunisia	86	4.1	3.08 (90)	75.1	382	9	89	3
Poland	89	59.0	15.10 (90)	25.6	395	13	11	76
Turkey	80	183.8	31.60 (92)	17.2	541	16	72	11
South Africa	70	50.0	13.31 (90)	26.6	561	17	72	11
Sudan	77	88.5	17.80 (95)	20.1	633	4	94	1
Oman	68	1.0	1.22 (91)	122.0	728	5	94	2
Libyan Arab J	90	0.6	4.60 (94)	766.7	880	11	87	2
Egypt	80	58.3	55.10 (93)	94.5	913	6	86	8
Mauritania	72	11.4	1.63 (85)	14.3	923	6	92	2
Syrian Arab R	84	26.3	14.41 (93)	54.8	1,017	4	94	2
Saudi Arabia	76	2.4	17.02 (92)	709.2	1,040	9	90	1
Iran, Islamic R	84	137.5	70.03 (93)	50.9	1,091	6	92	2
Kyrgyzstan	75	11.6	11.04 (90)	95.2	2,527	2	95	3
Turkmenistan	65	71.0	22.80 (89)	32.1	6,346	1	91	8

Table 23. Access to safe drinking water; water supply; water withdrawals; and water consumption: countries where 90-61% of the population has access to safe drinking water, ranked in order of per capita consumption (all water uses). For key and sources, see Table 22.

COUNTRY	% WITH WATER	SUPPLY km^3	WITH-DRAWALS km^3	W-D. AS % SUPP.	PER CAP. m^3	% DOM.	% AGR.	% IND.
DR Congo/Zaire	27	1019.0	0.36 (90)	0.0	09	61	23	16
Guinea-Bissau	27	27.0	0.02 (91)	0.1	17	60	36	4
Congo	60	832.0	0.04 (87)	0.0	20	62	11	27
Burundi	58	3.6	0.10 (87)	2.8	20	36	64	0
Uganda	42	66.0	0.20 (70)	0.3	20	32	60	8
Djibouti	24	3.0	0.01 (85)	0.3	20	13	87	0
Central African R.	18	141.0	0.07 (87)	0.0	26	21	74	5
Lesotho	52	5.2	0.05 (87)	1.0	31	22	56	22
Cameroon	41	268.0	0.40 (87)	0.1	31	46	35	19
Chad	33	43.0	0.18 (87)	0.4	34	16	82	2
Ghana	57	53.2	0.30 (70)	0.6	35	35	52	13
Nigeria	40	280.0	3.63 (87)	1.3	37	31	54	15
Mozambique	24	216.0	0.61 (92)	0.3	39	9	89	2
Tanzania, UR	49	89.0	1.17 (94)	1.3	40	9	89	2
Liberia	46	232.0	0.13 (87)	0.1	55	27	60	13
Angola	32	184.0	0.48 (87)	0.3	57	14	76	10
Niger	52	32.5	0.50 (88)	1.5	69	16	82	2
Cape Verde	52	0.3	0.26 (90)	86.7	70	10	88	2
Kenya	49	30.2	2.05 (90)	6.8	87	20	76	4
Sierra Leone	34	160.0	0.37 (87)	0.2	96	7	89	4
Somalia	31	15.7	0.81 (87)	5.2	99	3	97	0
Guinea	54	226.0	0.74 (87)	0.3	139	10	87	3
Mali	49	100.0	1.36 (87)	1.4	161	2	97	1
Namibia	57	45.5	0.25 (91)	0.5	171	29	68	3
Zambia	59	116.0	1.71 (94)	1.5	186	16	77	7
Senegal	52	39.4	1.36 (87)	3.5	201	5	92	3
Yemen	52	4.1	2.93 (90)	71.5	251	7	92	1
Morocco	59	30.0	11.05 (91)	36.8	436	5	92	3
Swaziland	60	4.5	0.66 (80)	14.7	1,161	2	96	2
Pakistan	59	418.3	155.60 (91)	37.2	1,277	2	97	2
Madagascar	23	337.0	16.30 (84)	4.8	1,638	1	99	0
Afghanistan	12	65.0	26.11 (87)	40.2	1,702	1	99	0
Iraq	44	75.4	42.8 (90)	56.8	2,367	3	92	5

Table 24. Access to safe drinking water; water supply; water withdrawals; and water consumption: countries where ≤60% of the population has access to safe drinking water, ranked in order of per capita consumption (all water uses). For key and sources, see Table 22.

Conclusions and policy implications

Water consumption does not appear to have been constrained by the size of the renewable supply. Several countries in arid and semi-arid regions with limited water supplies have very high rates of per capita consumption (e.g., Pakistan, Afghanistan, Syria, Saudi Arabia, Iran, Kyrgyzstan, Turkmenistan). The limiting factors have been effective economic demand and public policy. Countries that have the money supply their people and farming systems with however much water they think they need, whether the country is water rich (e.g., Norway) or water poor (e.g., Malta).

Industry is a major user (>20%) in rather few countries (Belarus, Finland, Ukraine, Romania, Belgium, Spain, Bulgaria, Poland, Gabon, Congo, Lesotho), usually where the chief industrial use is electrical cooling. Domestic uses have a major share of consumption in most countries that provide safe drinking water to all or virtually all of the population. Agriculture is the major consumer of water in countries where access to safe water is 90% or less, the only exceptions being Poland, Guinea-Bissau, Gabon, DR Congo, Congo, and Cameroon. In many cases, agriculture's share is more than 80%.

The scope for reducing domestic consumption is restricted largely to industrial countries where a significant proportion of domestic consumption is devoted to non-essential uses such as watering lawns and washing cars. In most of the countries listed in Tables 23 and 24, access to safe drinking water needs to be made universal and domestic consumption to increase. In countries already withdrawing a large proportion of the renewable supply (say 20% or more), it is particularly necessary to increase the efficiency of water use by agriculture and probably to reduce overall agricultural demand. However, many countries in this group also need to increase agricultural production to improve self-reliance and reduce food insufficiency. These include Afghanistan, Saudi Arabia, Yemen, Sudan, Libyan AJ, Mauritania, and all of the subSaharan African countries in Tables 23 and 24.

Energy

Societies use energy for cooking, heating, lighting, transport, and to power the extraction of materials, their transformation into products, the distribution of materials and products, and any recycling of materials. As defined by the UN Statistical Division (annual), a country's total energy requirement (TER) is its apparent consumption of commercial energy (production + imports − exports − bunkers ± stock changes) plus traditional fuels (fuelwood, charcoal, plant and animal wastes). It is the energy that a country uses directly, and does not include the energy embodied in imported goods.

Per capita TER ranges from 2 gigajoules in Comoros to 1035 gigajoules in Qatar (UN Statistical Division, Annual). The range narrows but is still wide when countries are grouped by HDI (Table 25). In general, a very low TER is a symptom of low human development. But the range is sufficiently wide to suggest that energy consumption is not tightly linked to human development. The weak association may be due in part to the nature of the HDI, which includes longevity and educational attainment, and heavily discounts income above PPP$5,835 (in 1994). A closer relationship would be expected between energy consumption and real per capita Gross Domestic Product (GDP).

HDI	LOWEST TER PER CAPITA gigajoules	HIGHEST TER PER CAPITA gigajoules
≥ .900	50 Barbados	342 USA
.899 - .800	14 Dominica	1035 Qatar
.799 - .700	10 Sri Lanka	182 Saudi Arabia
.699 - .500	5 Cape Verde	127 Ukraine
.499 - .300	2 Comoros	24 Zambia
< .300	6 Chad	13 Gambia

Table 25. Total energy requirement (TER) grouped by Human Development Index (HDI) [1994] (UNDP 1997; UN Statistical Division, Annual).

REAL GDP PER CAPITA PPP$000	LOWEST TER PER PPP$000 gigajoules	HIGHEST TER PER PPP$000 gigajoules
>20	5.6 Switzerland	15.9 Brunei Darussalam 15.5 Canada
19-10.1	2.1 Mauritius	56.2 Qatar 13.1 Finland
10.0-5.1	2.3 Dominica	26.9 Trinidad & Tobago 18.8 Slovakia
5.0-2.6	3.1 Sri Lanka	53.9 Kazakstan
2.5-1.1	1.5 Comoros	46.1 Azerbaijan
≤1.0	8.6 Chad	31.2 Rwanda

Table 26. Total energy requirement (TER) per $PPP000 per capita real Gross Domestic Product (GDP) grouped by per capita real GDP [1994] (UNDP 1997; UN Statistical Division, Annual).

Energy consumption per thousand $PPP per person of real GDP ranges from 1.5 gigajoules (Comoros) to 56.2 gigajoules (Qatar). The range narrows considerably when countries are grouped by real GDP per capita, especially above $5000 and when petroleum exporting economies (Brunei Darussalam, Qatar, Trinidad & Tobago) are excluded (Table 26).

It is easier for small countries than for large countries to be energy efficient, because population densities are greater and transportation distances shorter. Small countries such as Mauritius have energy consumption patterns similar to a city and its hinterland in a large country. This generalization is borne out by Tables 27-32, which cover countries with real per capita GDPs of, respectively, more than PPP$20,000, PPP$20,000-10,100, PPP$10,000-5,100, PPP$5,000-2,600, PPP$2,500-1,100, and ≤PPP$1,000, and order the countries by size class.

COUNTRY	SIZE CLASS	POP./ KM^2 1995	HDI 1994	REAL GDP PER CAPITA PPP$ 1994	ENERGY 1994 per capita requirement gigajoules	PPP$/ gigajoule 1994	gigajoules/ PPP$000 1994
USA	6	029	.942	26,397	342	77.2	13.0
Canada	6	003	.960	21,459	332	64.6	15.5
Japan	5	333	.940	21,581	147	146.8	6.8
France	5	106	.946	20,510	153	134.1	7.5
Iceland	5	003	.942	20,566	195	105.5	9.5
Norway	5	014	.943	21,346	221	96.6	10.4
Switzerland	4	178	.930	24,967	139	179.6	5.6
Austria	4	097	.932	20,667	126	164.0	6.1
Denmark	4	123	.927	21,341	157	135.9	7.4
Belgium	4	332	.932	20,985	202	103.9	9.6
Kuwait	4	093	.844	21,875	269	81.3	12.3
Luxembourg	3	157	.899	34,155	378	90.4	11.1
Brunei Darussalam	3	054	.882	30,447	excl solid fuels (0 in 1992) 483	63.0	15.9
Singapore	2	4896	.900	20,987	245	85.7	11.7

Table 27. Income, size, and energy consumption: countries with real GDP per capita of >PPP$20,000.

SC = size class of country: 7 = ten millions of km^2; 6 = millions of km^2; 5 = hundred thousands of km^2; 4 = ten thousands of km^2; 3 = thousands of km^2; 2 = hundreds of km^2; 1 = tens of km^2.

Pop./km2 = population density (FAO 1996a).

HDI = Human Development Index (UNDP 1997).

Real per capita GDP: UNDP 1997.

Energy data: UN Satistical Division, Annual.

COUNTRY	SIZE CLASS	POP./ KM² 1995	HDI 1994	REAL GDP PER CAPITA PPP$ 1994	ENERGY 1994 per capita requirement gigajoules	PPP$/ gigajoule 1994	gigajoules/ PPP$000 1994
Australia	6	002	.931	19,285	234	82.4	12.1
Italy	5	195	.921	19,363	119	162.7	6.1
Spain	5	078	.934	14,324	89	160.9	6.2
Germany	5	234	.924	19,675	162	121.5	8.2
United Kingdom	5	242	.931	18,620	156	119.4	8.4
Greece	5	081	.923	11,265	96	117.3	8.5
New Zealand	5	013	.937	16,851	172	98.0	10.2
Sweden	5	021	.936	18,540	213	87.0	11.5
Finland	5	017	.940	17,417	228	76.4	13.1
Oman	5	010	.718	10,078	156	64.6	15.5
Portugal	4	108	.890	12,326	63	195.7	5.1
Bahamas	4	028	.894	15,875	excl trad fuels 88	180.4	5.5
Israel	4	268	.913	16,023	97	165.2	6.1
Ireland	4	052	.929	16,061	125	128.5	7.8
Slovenia	4	099	.886	10,404	98	106.2	9.4
Korea, R	4	454	.890	10,656	112	95.1	10.5
Netherlands	4	456	.940	19,238	213	90.3	11.1
United Arab Emirates	4	029	.866	16,000	532	30.1	33.2
Qatar	4	059	.840	18,403	1035	17.8	56.2
Mauritius	3	556	.831	13,172	28	470.4	2.1
Cyprus	3	079	.907	13,071	89	146.9	6.8
Barbados	2	607	.907	11,051	50	221.0	4.5
Malta	2	1163	.887	13,009	60	216.8	4.6
Bahrain	2	836	.870	15,321	excl solid fuels (0 in 1992) 504	30.4	32.9

Table 28. Income, size, and energy consumption: countries with real GDP per capita of PPP$20,000-10,100. For key and sources, see Table 27.

COUNTRY	SIZE CLASS	POP./ KM² 1995	HDI 1994	REAL GDP PER CAPITA PPP$ 1994	ENERGY 1994 per capita requirement gigajoules	PPP$/ gigajoule 1994	gigajoules/ PPP$000 1994
Colombia	6	035	.848	6,107	34	179.6	5.6
Brazil	6	019	.783	5,362	39	137.5	7.3
Argentina	6	013	.884	8,937	67	133.4	7.5
Algeria	6	012	.737	5,442	47	115.8	8.6
Mexico	6	048	.853	7,384	64	115.4	8.7
Iran. Islamic R	6	039	.780	5,766	55	104.8	9.5
Libyan Arab J	6	003	.801	6,125	100	61.2	16.3
Saudi Arabia	6	009	.774	9,338	182	51.3	19.5
Uruguay	5	018	.883	6,752	31	217.8	4.6
Tunisia	5	058	.748	5,319	27	197.0	5.1
Chile	5	019	.891	9,129	49	186.3	5.4
Turkey	5	079	.772	5,193	34	152.7	6.5
Syrian Arab R	5	077	.755	5,397	37	145.9	6.9
Thailand	5	114	.833	7,104	52	136.6	7.3
Malaysia	5	061	.832	8,865	68	130.4	7.7
Venezuela	5	025	.861	8,120	134	60.6	16.5
Costa Rica	4	067	.889	5,919	31	190.9	5.2
Panama	4	035	.864	6,104	33	185.0	5.4
Fiji	4	042	.863	5,763	32	180.1	5.6
Belize	4	009	.806	5,590	48	116.5	8.6
Hungary	4	111	.857	6,437	97	66.4	15.1
Czech R.	4	134	.882	9,201	147	62.6	16.0
Slovakia	4	112	.873	6,389	120	53.2	18.8
Trinidad & Tobago	3	251	.880	9,124	245	37.2	26.9
Dominica	2	099	.873	6,118	14	437.0	2.3
St Vincent & Grenadines	2	285	.836	5,650	18	313.9	3.2
Seychelles	2	169	.845	7,891	27	292.3	3.4
St Lucia	2	272	.838	6,182	21	294.4	3.4
Grenada	2	268	.843	5,137	22	233.5	4.3
St Kitts & Nevis	2	114	.853	9,436	49	192.6	5.2
Antigua & Barbuda	2	157	.892	8,977	62	144.8	6.9

Table 29. Income, size, and energy consumption: countries with real GDP per capita of PPP$10,000-5,100. For key and sources, see Table 27.

COUNTRY	SIZE CLASS	POP./ KM^2 1995	HDI 1994	REAL GDP PER CAPITA PPP$ 1994	ENERGY 1994 per capita requirement gigajoules	PPP$/ gigajoule 1994	gigajoules/ PPP$000 1994
Russian Fed.	7	009	.792	4,828	176	27.4	36.5
Egypt	6	058	.614	3,846	21	183.1	5.5
Peru	6	019	.717	3,645	20	182.2	5.5
Indonesia	6	107	.668	3,740	22	170.0	5.9
Bolivia	6	007	.589	2,598	17	152.8	6.5
Mongolia	6	002	.661	3,766	41	91.9	10.9
China	6	129	.626	2,604	29	89.8	11.1
Kazakstan	6	006	.709	3,284	177	18.6	53.9
Morocco	5	060	.566	3,681	14	262.9	3.8
Guatemala	5	098	.572	3,208	21	152.8	6.5
Paraguay	5	012	.706	3,531	24	147.1	6.8
Philippines	5	230	.672	2,681	19	141.1	7.1
Ecuador	5	041	.775	4,626	37	125.0	8.0
Papua New Guinea	5	009	.513	2,821	23	122.7	8.2
Guyana	5	004	.649	2,729	26	105.0	9.5
Suriname	5	003	.792	4,711	59	79.8	12.5
Cuba	5	100	.723	3,000	46	65.2	15.3
Iraq	5	046	.531	3,159	excl solid fuels (0 in 92 & 93) 53	59.6	16.8
Poland	5	127	.834	5.002	104	48.1	20.8
Belarus	5	050	.806	4,713	98	48.1	20.8
Gabon	5	004	.562	3,641	81	45.0	22.2
Bulgaria	5	076	.780	4,533	101	44.9	22.3
Romania	5	099	.748	4,037	94	42.9	23.3
Korea, DPR	5	198	.765	3,965	135	29.4	34.0
Turkmenistan	5	010	.723	3,469	139 [93]	25.0	40.1
Ukraine	5	089	.689	2,718	127	21.4	46.7
Sri Lanka	4	280	.711	3,277	10	327.7	3.1
Albania	4	119	.655	2,788	14	199.1	5.0
Dominican R	4	162	.718	3,933	24	163.9	6.1
Jordan	4	047	.730	4,187	30	139.6	7.2
Lebanon	4	391	.794	4,863	55	88.4	11.3
Jamaica	4	233	.736	3,816	53	72.0	13.9
Macedonia, f. Yugoslav R	4	083	.748	3,965	59	67.2	14.9
Croatia	4	085	.760	3,960	60	66.0	15.2
Lithuania	4	057	.762	4,011	94	42.7	23.4
Latvia	4	041	.711	3.332	84	39.7	25.2
Estonia	4	035	.776	4,294	147	29.2	34.2
Samoa	3	059	.684	2,726	18	151.4	6.6

Table 30. Income, size, and energy consumption: countries with real GDP per capita of PPP$5,000-2,600. For key and sources, see Table 27.

COUNTRY	SIZE CLASS	POP./ KM² 1995	HDI 1994	REAL GDP PER CAPITA PPP$ 1994	ENERGY 1994 per capita requirement gigajoules	PPP$/ gigajoule 1994	gigajoules/ PPP$000 1994
Angola	6	009	.335	1,600	8	200.0	5.0
Sudan	6	011	.333	1,084	11	98.5	10.1
India	6	313	.446	1,348	14	96.3	10.4
Mauritania	6	002	.355	1,593	18	88.5	11.3
Laos	5	021	.459	2,484	10	248.4	4.0
Bangladesh	5	920	.368	1,331	6	221.8	4.5
Pakistan	5	169	.445	2,154	12	179.5	5.6
Uganda	5	096	.328	1,370	8	171.2	5.8
Benin	5	049	.368	1,696	11	154.2	6.5
Cambodia	5	057	.348	1,084	excl solid fuels (0 in 1992) 7	154.9	6.5
Myanmar	5	069	.475	1,051	7	150.1	6.7
Senegal	5	044	.326	1,596	11	145.1	6.9
Cameroon	5	029	.468	1,960	14	140.0	7.1
Guinea	5	027	.271	1,103	8	137.9	7.3
Viet Nam	5	226	.557	1,208	9	134.2	7.4
Congo	5	008	.500	2,410	19	126.8	7.9
Ghana	5	075	.468	2,120	19	111.6	9.0
Honduras	5	053	.575	2,050	excl solid fuels (0 in 1992) 19	107.9	9.3
Côte d'Ivoire	5	044	.368	1,668	16	104.2	9.6
Nigeria	5	122	.393	1,351	13	103.9	9.6
Cent. African R.	5	005	.355	1,130	11	102.7	9.7
Nepal	5	157	.347	1,137	12	94.7	10.6
Zimbabwe	5	028	.513	2,196	28	78.4	12.7
Kenya	5	047	.463	1,404	19	73.9	13.5
Nicaragua	5	036	.530	1,580	23	68.7	14.6
Kyrgyzstan	5	024	.635	1,930	29	66.6	15.0
Uzbekistan	5	055	.662	2,438	87	28.0	35.7
Tajikistan	5	042	.580	1,117	46 [93]	24.3	41.2
Vanuatu	4	014	.547	2,276	6	379.3	2.6
Togo	4	075	.365	1,109	5	221.8	4.5
Solomon Is	4	013	.556	2,118	14	151.3	6.6
Bhutan	4	015	.338	1,289	9	143.2	7.0
Djibouti	4	027	.319	1,270	9	141.1	7.1
Equat. Guinea	4	014	.462	1,673	15	111.5	9.0
Armenia	4	133	.651	1,737	17	102.2	9.8
El Salvador	4	271	.592	2,417	28	86.3	11.6
Georgia	4	077	.637	1,585	31 [93]	51.1	19.6
Moldova. R	4	132	.612	1,576	46	34.3	29.2
Azerbaijan	4	087	.636	1,670	77	21.7	46.1
Comoros	3	224	.412	1,366	2	683.0	1.5
Cape Verde	3	094	.547	1,862	5	372.4	2.7
Maldives	2	850	.611	2,200	8	275.0	3.6
S.Tomé & Princ.	2	172	.534	1,704	8	213.0	4.7

Table 31. Income, size, and energy consumption: countries with real GDP per capita of PPP$2,500-1,100. For key and sources, see Table 27.

COUNTRY	SIZE CLASS	POP./ KM² 1995	HDI 1994	REAL GDP PER CAPITA PPP$ 1994	ENERGY 1994 per capita requirement gigajoules	PPP$/ gigajoule 1994	gigajoules/ PPP$000 1994
Chad	6	005	.288	700	6	116.7	8.6
Niger	6	007	.206	787	7	112.4	8.9
Mali	6	008	.229	543	6	90.5	11.0
Ethiopia	6	056	.244	427	9	47.4	21.1
Zaire *now* DR Congo	6	019	.381	429	11	39.0	25.6
Mozambique	5	021	.281	986	10	98.6	10.1
Madagascar	5	023	.350	694	8	86.7	11.5
Yemen	5	029	.361	805	10	80.5	12.4
Burkina Faso	5	038	.221	796	10	79.6	12.6
Malawi	5	104	.320	694	12	57.8	17.3
Tanzania, UR	5	034	.357	656	13	50.5	19.8
Zambia	5	012	.369	962	24	40.1	24.9
Guinea-Bissau	4	038	.291	793	7	113.3	8.8
Haiti	4	260	.338	896	10	89.6	11.2
Burundi	4	244	.247	698	8	87.2	11.5
Gambia	4	111	.281	939	13	72.2	13.8
Sierra Leone	4	059	.176	643	9	71.4	14.0
Rwanda	4	259	.187	352	11	32.0	31.2

Table 32. Income, size, and energy consumption: countries with real GDP per capita of ≤PPP$1,000. For key and sources, see Table 27.

Conclusions and policy implications

Tables 27-29 show clear and consistent series, with (apart from a few exceptions) the lowest and highest figures for energy consumption per income declining from the biggest to the smallest countries. Within each size class and income bracket, there is a range of performance, except where a size class is represented by only one or two countries. For example, the differences between Japan and Norway, Switzerland and Belgium (Table 27); Italy and Finland, Portugal and Netherlands (Table 28); Colombia and Mexico, Uruguay and Malaysia, Costa Rica and Slovakia, and Dominica and Antigua & Barbuda (Table 29). These differences indicate a substantial potential for improving efficiency, notwithstanding differences in energy needs (for example, some countries are hot, some cold, some temperate).

Petroleum exporting economies are invariably less efficient than other countries in the same income bracket and size class, as are nations of the former communist bloc in Europe and Asia. They are not included in the above examples.

Tables 30-32 show an even wider range of performance within size classes, because the extremes of poor performance are greater than in Tables 27-29. The contrast between the two sets of tables suggests that almost all countries in all size classes and income brackets have plenty of room to increase energy efficiency. But that, in addition, for countries with real per capita GDPs of PPP$5,000 and below, an important way of improving performance is to expand the economy.

Materials

Material consumption may be viewed from two angles. One is the "thingness" of societies—the number and importance of artifacts and technologies, which ones have greatest social and symbolic value, and their impacts on the ecosystem. Information on this aspect is largely confined to anthropological studies and is not dealt with here. The other angle is total material flow or total material requirement (TMR). TMR has been calculated for only four countries: Germany (by the Wuppertal Institute), Japan (by the National Institute for Environmental Studies), Netherlands (by the Netherlands Institute of Housing, Spatial Planning, and Environment), and the USA (by World Resources Institute).

In their report on the findings, Adriaanse *et al.* (1997) define TMR as direct material input plus hidden material flow. Direct material input (DMI) is the flow of natural resources that enter the economy as commodities for further processing. Examples are grains used in food manufacturing, petroleum sent to a refinery, minerals that go into metal products, and logs for lumber. DMI includes domestic production plus imports, except for imported commodities that pass through a country without being altered or stored there. Exports are not deducted because DMI is a measure of the total thoughput of materials on which a nation's economic activity depends.

Hidden material flow (HMF) consists of the natural resources that are displaced, disturbed or removed to obtain resources that are counted as DMI. One type of HMF is material excavated or disturbed to obtain a natural resource or to construct or maintain infrastructure. Examples are the overburden that must be removed to reach an ore body, soil erosion from agriculture, or material moved to build a highway or dredge a channel. The other type of HMF is material that is extracted with the desired resource and then separated from it and discarded. Examples are the portion of ore that is removed to concentrate it, and vegetation that is harvested along with timber or grain and subsequently disposed of. Unlike natural resources counted in the DMI, the HMF is not assigned a monetary or commodity value, is not included in national accounts, and has hitherto been ignored. HMF was originally dubbed the "ecological rucksack" (Bringezu 1997).

The USA has the highest TMR per capita, closely followed by Germany (10% smaller) and the Netherlands (20% smaller). Japan's TMR per capita is much the smallest of the four, being almost half that of the USA and a third of the Netherlands' (the next smallest). Japan also has a much higher Human Development Index (HDI) and real Gross Domestic Product (GDP) per unit of TMR than the other countries. In general the lower the TMR per capita, the more efficient the performance in relation to both human development and GDP. The single exception is the per capita GDP of the USA which is higher per unit of TMR than those of Germany and the Netherlands, despite the USA's higher TMR (Table 33).

Overall material intensity—the TMR/GDP ratio (GDP measured in constant local currency)—declined in all four countries between 1975 and 1990, suggesting a modest decoupling of natural resource use from economic performance. Since 1990 material intensity has continued to decline in the United States and Japan, although it appears to have levelled off in Japan and may now be rising. In Germany and the Netherlands, it rose sharply in the early 1990s, due to reunification in Germany and for undetermined reasons in the Netherlands. The declines in material intensity roughly correspond to the rising share of the service sector, which between 1977 and 1994 grew from 54% to 60% in Japan, 63% to 70% in the Netherlands, and 63% to 72% in the USA (World Bank 1997b).

Two-thirds of the TMR of Germany and Japan is from domestic production, the remaining third from imports. By contrast, virtually all (95%) of the USA's TMR is from domestic production, but only a quarter of the Netherlands'. This means that—apart from emissions to the atmosphere and water bodies (mostly fossil fuels)—most of the ecosystem stress from material flow in the USA, and much of it in Japan and Germany, occurs within those countries. But most of the stress from material flow through the Netherlands occurs in other countries.

	Germany	Netherlands	Japan	USA
TMR (000 tonnes)	5,753,984	1,031,181	5,657,000	21,947,000
composition (%)				
domestic DMI	20	21	23	22
domestic HMF	44	5	21	73
imported DMI	6	24	12	3
imported HMF	30	50	44	3
TMR per capita (tonnes)	76	67	45	84
HDI (× 100) per tonne TMR per capita	1.2	1.4	2.1	1.1
PPP$ per capita per tonne TMR per capita	259	287	480	314
tonnes TMR per capita per PPP$100 per capita	39	35	21	32
TER (000 terajoules)	13,144	3,271	18,309	90,580
TER per capita (gigajoules)	162	213	147	342
tonnes TMR per terajoule TER	438	315	309	242
terajoules TER per 000 tonnes TMR	2.3	3.2	3.2	4.1

Table 33. Annual (1994) total material requirement (TMR) of Germany, Netherlands, Japan, and USA: total, per capita, and in relation to Human Development Index (HDI), real Gross Domestic Product (PPP$), and annual total energy requirement (TER).

Measuring the weight of materials that flow through an economy is useful for determining the size and composition of its material requirement. However, it is a weak indicator of ecosystem stress, which varies substantially depending on the type of material and the ecosystem affected. Ecosystem stress also depends on the composition of material flow, which differs greatly among the four countries (Table 34). Fossil fuels are likely to be the most damaging group of materials because of their impacts on soil and water (acidification), local air quality and the atmosphere. They contribute from 26% of TMR in Japan to 45% in Germany—and are the biggest component in all countries but the Netherlands. Most of the fossil fuels are domestically produced in the

USA and Germany, and imported in the Netherlands and Japan. The large hidden flows associated with fossil fuels are due to coal mining, which requires the removal of great quantities of overburden.

In Germany, the other major components of material flow are construction materials, imported semi-manufactures, and industrial minerals (such as potash, salt and clay). In the Netherlands, they are renewables (mostly livestock feed, potatoes, sugar beets, and vegetables), imported semi-manufactures, and construction materials. In Japan, they, are construction materials, infrastructure, metals (primarily for the automobile industry), and imported semi-manufactures. In the USA, they are soil erosion, infrastructure, and metals.

The main impacts of construction and infrastructure are likely to be encroachment on productive agricultural land and on the habitats of wild species. The significant role of infrastructure in Japan reflects the large amount of excavation and levelling required to build settlements in this predominately mountainous country. In the USA, it reflects continued highway repair and expansion, due to the country's size and the value placed on the automobile and independent mobility.

Soil erosion reduces the productivity of the land. It is particularly high in the USA because much of the most productive land is naturally erosive and relatively marginal lands are still being used for agriculture. Although erosion makes up a small proportion of Germany's TMR, the average rate of erosion exceeds the soil regeneration rate by a factor of ten (Adriaanse *et al.* 1997).

Material	**Germany**			**Netherlands**			**Japan**			**USA**		
category	DMI	HMF	**TOT**	DMI	HMF	**TOT**	DMI	HMF	**TOT**	DMI	HMF	**TOT**
Fossil fuels	28.4	50.4	**44.6**	39.2	21.8	**29.6**	19.7	29.4	**25.8**	40.7	36.8	**37.7**
Metals	2.8	4.6	**4.1**	1.7	8.5	**5.5**	6.7	18.6	**14.2**	4.2	11.1	**9.4**
Industrial minerals	3.1	13.1	**10.5**	1.2	0.1	**0.6**	9.6	0.8	**4.1**	2.4	2.0	**2.1**
Construction materials	43.7	3.5	**14.0**	18.1	4.3	**10.5**	52.1	0.0	**19.4**	33.6	1.0	**8.9**
Infrastructure		6.0	**4.4**		7.1	**4.0**		30.8	**19.3**		21.6	**16.4**
Soil erosion		2.6	**1.9**		0.3	**0.2**		0.2	**0.1**		23.1	**17.5**
Renewables	12.5	3.6	**5.9**	31.9	36.8	**34.6**	8.9	5.3	**6.6**	17.2	2.3	**5.9**
Imported semi-manufactures	7.0	16.3	**13.9**	1.9	20.9	**12.4**	2.5	14.8	**10.2**	0.9	2.2	**1.9**
Imported finished goods	2.5		**0.7**	5.9	--	**2.6**	0.5	--	**0.2**	1.0	--	**0.2**
TOTAL	100.0	100.1	**100.0**	99.9	99.8	**100.0**	100.0	99.9	**99.9**	100.0	100.1	**100.0**

Table 34. Composition (%) of combined domestic and imported material requirement of Germany, Netherlands, Japan, and USA: direct material input (DMI), hidden material flow (HMF), and totals (TOT).

Overall conclusions and policy implications

The reviews of food, water, and energy consumption show a diversity of patterns. More importantly they show there is not a one-to-one relationship between consumption and prosperity. Particularly, within country size classes and income brackets, there is ample scope for increasing consumption efficiencies. The sample covered in the review of materials consumption is too small to draw conclusions, but there is no reason to suppose that the patterns of materials consumption differ from those of the other resources.

The range of performance among countries with real per capita GDPs greater than PPP$5,000 show that improvements can be gained not merely by increasing efficiencies but also by reducing consumption overall. This is not true, however, for countries with per capita GDPs below this level or where food sufficiency and self-reliance are low. In these countries, consumption has to be raised—although here, too, efficiency gains are necessary and possible.

Global reviews are adequate to show the potential for increasing efficiency and reducing consumption in broad terms. But more detailed study of groups of countries in the same size classes and income brackets are required to develop practical policy options. Much of the potential lies in improving production practices rather than consumer behaviour. But since production improvements could result in increased prices, policies need also to address consumers to avoid suffering by the poor and resistance by the not-poor.

Consumption has always been influenced by three forces: basic needs, personal preferences, and social norms. The consumer society adds a fourth force: producers and their advertisers, who try to persuade people that they can meet their needs, satisfy their deepest longings and improve their social position if they buy this or that product. In the past, the people who felt the basic needs and personal preferences also shaped the social norms. Now norms are being promoted by an external group (producers and advertisers).

Legislation, prices, and awareness building are the main mechanisms that governments and groups of citizens can use to promote norms that favour reduced and more efficient consumption. The detailed studies called for above would provide essential information for developing those mechanisms.

References

Aaheim, A., & K.Nyborg. 1993. Green National Product: good intentions, poor device? Research Department Discussion Paper 103. Statistics Norway.

Adriaanse, Albert. 1993. *Environmental policy performance indicators*. Sdu Uitgeverij Koninginnegracht, The Hague.

Adriaanse, Albert, *et al.* 1997. *Resource flows: the material basis of industrial economies.* World Resources Institute, Washington, DC.

Baitullin, I., & G.Bekturova. 1997. National strategy to combat desertification in the Republic of Kazakstan. *Desertification Control Bulletin* 30: 19-27.

Bringezu, Stefan. 1997. Accounting for the physical basis of national economies: material flow indicators. In: Bedřich Moldan & Suzanne Billharz. 1997. *Sustainability indicators: report of the project on indicators of sustainable development.* SCOPE 58. John Wiley & Sons, Chichester, New York, etc.

Cobb, Clifford, Ted Halstead, & Jonathan Rowe. 1995. *The Genuine Progress Indicator: summary of data and methodology.* Redefining Progress, San Francisco, CA.

Daly, Herman E., & John B Cobb, Jr. 1989, 1994. *For the common good.* Boston, MA.

Dieren, Wouter van. 1995. *Taking nature into account: a report to the Club of Rome.* Copernicus, Springer-Verlag, New York.

Eurostat *et al.* 1995. *Europe's Environment: statistical compendium for the Dobříš Assessment.* Office for Official Publications of the European Communities, Luxembourg.

FAO. 1994. *Bulletin of fishery statistics, 34: Fishery fleet statistics 1970, 1975, 1980, 1984-1992.* Food and Agriculture Organization of the United Nations, Rome.

FAO. 1995a. *FAO yearbook: Fishery statistics, catches and landings: Vol. 76, 1993.* Food and Agriculture Organization of the United Nations, Rome.

FAO. 1995b. *Aquaculture production statistics 1984-1993.* Food and Agriculture Organization of the United Nations, Rome.

FAO. 1995c. *Irrigation in Africa in figures.* Water Reports 7. Food and Agriculture Organization of the United Nations, Rome.

FAO. 1995d. *Water resources of African countries: a review.* Food and Agriculture Organization of the United Nations, Rome.

FAO. 1996a. Food and agriculture database. Food and Agriculture Organization of the United Nations, Rome.

FAO. 1996b. *The sixth world food survey.* Food and Agriculture Organization of the United Nations, Rome.

FAO. 1996c. Unpublished data, Fisheries Department, Food and Agriculture Organization of the United Nations, Rome.

FAO. 1997. *Irrigation in the Near East region in figures.* Water Reports [advance copy]. Food and Agriculture Organization of the United Nations, Rome.

FAO-UNDP-UNEP. 1994. *Land degradation in South Asia: its severity, causes and effects upon the people.* World Soil Resources Reports 78. Food and Agriculture Organization of the United Nations, Rome.

Garcia, S.M., & C. Newton. 1994. Current situation, trends and prospects in world capture fisheries. Conference on Fisheries Management: Global Trends, Seattle, WA, June 1994. Food and Agriculture Organization of the United Nations, Rome.

Grainger, R.J.R., & S.M.Garcia. 1996. *Chronicles of marine fishery landings (1950-1994). Trend analysis and fisheries potential.* FAO Fisheries Technical Paper 359. Food and Agriculture Organization of the United Nations, Rome.

Hamilton, Kirk, & Ernst Lutz. 1996. *Green national accounts: policy uses and empirical experience.* Environment Department Papers 039. The World Bank, Washington, DC.

IUCN-UNEP-WWF. 1991. *Caring for the Earth: a strategy for sustainable living.* IUCN, Gland, Switzerland.

OECD. 1997. *Sustainable consumption and production: clarifying the concepts.* OECD Proceedings. Organization for Economic Cooperation and Development, Paris.

Oldeman, L.R., R.T.A.Hakkeling, & W.G.Sombroek. 1991. *World map of the status of human-induced soil degradation and georeferenced soils and terrain database.* International Soil Reference and Information Centre, Wageningen, & United Nations Environment Programme, Nairobi.

Prescott-Allen, Robert. 1997a. Barometer of Sustainability: measuring and communicating wellbeing and sustainable development. IUCN, Gland, Switzerland.

Prescott-Allen, Robert. 1997b. Resource use benefits and stresses. In: Tony Hodge & Robert Prescott-Allen. 1997. *Report on British Columbia's progress toward sustainability.* Ministry of Environment, Lands and Parks, Victoria, BC.

Prescott-Allen, Robert. In press. *The Wellbeing of Nations.*

Repetto, R., W.Magrath, M.Wells, C.Beer, & F.Rossini. 1989. *Wasting assets: natural resources in the national accounts.* Word Resources Institute, Washington, DC.

UNDP. 1997. *Human development report.* Oxford University Press, New York, etc.

UNEP/ISRIC. 1990. *World map on status of human-induced soil degradation.* United Nations Environment Programme, Nairobi.

UN Statistical Division. Annual. *Energy statistics yearbook.* United Nations, New York.

UN Statistical Division. 1993. *Integrated environmental and economic accounting.* Handbook of National Accounting. Studies in Methods, Series F, 61. United Nations, New York.

Wackernagel, Mathis, *et al.* 1997. *Ecological footprints of nations.* Centre for Sustainability Studies, Universidad Anáhuac de Xalapa, Xalapa, Mexico, & The Earth Council, Costa Rica.

Wackernagel, Mathis, & William E. Rees. 1996. *Our ecological footprint: reducing human impact on the Earth.* New Society Publishers, Gabriola Island, BC (Canada).

WHO. 1997. Data from country reports on monitoring and evaluation of Health-for-All strategy and WHO regional offices. World Health Organization, Geneva.

World Bank. 1997a. *Expanding the measure of wealth: indicators of environmentally sustainable development.* Environmentally Sustainable Development Studies and Monographs Series 17. The World Bank, Washington, DC.

World Bank .1997b. *1997 World development indicators.* The World Bank, Washington, DC.