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Food Demand, Natural Resources, and Nature

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Abstract

Solutions to the dilemma of satisfying the food demands of the current 7 billion people, including the hunger and unfulfilled food needs of about 2 billion poor people, while at the same time overcoming the loss of nature and adverse impacts on the environment, requires new actions. Transformative changes supported by science on the supply and demand side of the food equation, are needed. The selective emphasis in this paper is on the demand side. Excessive food consumption contributes to the destruction of nature and over-exploitation of natural resources, especially waters, soils and atmosphere. Three complementary approaches are proposed here to address this dilemma: (1) incentives for consumption change, controls, and regulations, (2) information, labeling, and nudging approaches to stimulate consumers' behavioral change, and (3) "biologizing" the economy, building economies around bio-based product- and process-innovations and reducing the dependency on fossil fuels. An appropriate code of ethics suggests that in a world of high and growing income inequality, more sharing is called for, and different sustainability standards should apply to rich and poor people: the rich must accept harder sustainability standards than the poor, be it through voluntary adjustments or regulations. A framework is presented that defines these broad directions more specifically.

1. Introduction: on food demand, nature, and the environment

The global population will be approaching 9 billion people in the next generation (UN 2007). This casts a long shadow over nature and environment, especially because the associated increases in food demands would further strain nature and natural resources (Godfray *et al.* 2010, Wheeler and von Braun 2013, IPCC 2007). Food demands differ widely by income, region, and culture. Preferences vary around the world: poor consumers demand more calories and long for more diverse diets. Middle class and rich

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consumers demand "consumer friendly" (prepared) yet "wholesome" and "natural" foods.

The food system and the eco-systems are connected through forward and backward linkages along the food chains, fraught with various externalities. Backward linkages to the use of natural resources for food production are critical; externalities of processing and transportation play a significant role; disposal of wastes and by-products are important forward linkages and their related material flows shape adverse externalities with concentrations in peri-urban areas. Moreover, environmental impacts of human food demand are only part of the larger human impacts on "nature" as a whole.

"Nature" and "Environment" are not synonymous (at least in English, German, and Hindi). Nature (Natur, Prakarati) is understood as "the phenomena of the physical world collectively, including plants, animals, the landscape, and other features and products of the earth, *as opposed to* humans or human creations", whereas Environment (Umwelt, Vatavaran) is "the natural world, as a whole or in a particular geographical area, especially *as affected by* human activity" (Oxford Dictionary 2014;[2] italics added). Nature is intrinsic, whereas environment provides (public) goods. People's relationships with nature are shaped, in addition to resource use, by other interactions, including sensory, identity-related aspects and knowledge acquisition (Berghoefer *et al.* 2010). While laws of nature have considerable stability (i.e. genetics), changes in the shapes of nature have always occurred in the history of Earth, but until relatively recently happened independently of humans. Only since about two centuries human actions have become significant forces of influence on the shapes of the entire planetary nature, identified by Paul Crutzen (2002) as the age of "Anthropocene".

Food demand impacts on nature, but there is also demand for nature. In fact, geographically there are many natures. In the more crowded and wealthy world, even an end of natures may occur, while environmental changes also create new natures. In this changing context and with rising incomes, the "natural" is in high demand, and that is especially so when it comes to food. The environmental change induced by humans' food demand may be more or less sustainable, depending on modes of production technology, land and soil use, water use, biodiversity protection and conservation. While an environmentally sustainable food system may be more in harmony with nature, it still replaces "nature" as it used to be.

[2] http://www.oxforddictionaries.com/definition/english/environment (accessed on 5.4.2014).

While there is a competition between human food demand and nature, a general debate over "food first" versus "nature first" is not helpful without considering specifics of local circumstances and distributional effects, i.e. poverty. At national and international levels, there is neither an ethical nor an ecological foundation to put a nature protection before poor people's survival. At a local level, e.g. in the context of preserving parks and nature reserves, people – nature conflicts are real, and need to be resolved through inclusion of local communities and their fair compensation for sustainable livelihoods.

2. Food Demand: Status, Trends, and Outlooks

This section takes a brief look at the food demand[3] and highlights related environmental consequences. Assessing the food demand from an environmental perspective brings its supply side consequences more into focus. All relevant policies need to take note of the main drivers on the demand, supply and market sides (Figure 1).

Food demand is linked with environmental impacts in two interrelated ways: first, through the type of food products demanded, such as staples, proteins, animal products, i.e. the link here is via production levels and patterns, and, second, through food consumption preferences, which partly associate with storability, processing, waste, etc. (Foster *et al.* 2007).

Demand-side	**=**	**Supply-side**
Income growth		Investment in agric. technology
Population growth		Investment in agric. infrastructure
High and variable energy prices		Land and water availability
Biofuel subsidies and mandates		Costs of inputs and transport
Income inequality		Weather variability and climate change
Changing consumer preferences		

Trade and markets
Exchange rates
Stock depletion
Trade controls and protectionism
Speculation and expectations

Figure 1. Food demand drivers in the context of the food equation. Source: Devised by author, adapted from von Braun (2012).

[3] Demand, consumption and needs are different concepts. When reviewing food *demand*, i.e. the market purchases or otherwise acquired (say, by home production or by transfers) foods, we ought to distinguish this from food *consumption* (final personal use), and from food *needs* (dietary needs, which may be less or more of a diverse set of nutrients, not just desired or demanded, but needed according to requirements).

Demand

We need to keep in mind that the world is confronted with a diverse set of consumption and nutrition problems, especially of the poor (table 1). There is no one-size fits all to address this set of diverse issues ranging from hunger to obesity.

Undoubtedly, human consumption is large in proportion to biological material growth and profoundly affects the Earth's ecosystems. An aggregate measure of humanity's cumulative impact is the consumed share of the planet's net primary production (NPP). NPP is the net amount of solar energy converted to plant organic matter through photosynthesis (measured in units of elemental carbon). It represents the primary source for the world's ecosystems. Human appropriation of NPP is estimated at about 32 percent, with large regional variances (Africa 12 percent, Europe 72 percent; sources in Imhoff *et al.* 2004). This large share claimed by humans leaves less for other species, alters the composition of the atmosphere, reduces levels of biodiversity and constrains ecosystem services. NPP is implicitly traded in the form of food, feed, fibers, wood, and other bio-based materials, such as bioenergy. Increasing populations have increasing demands for NPP. Already in many regions of the world, high population densities are leading to significant losses of NPP and land degradation (Nkonya *et al.* 2011). Quite often, these areas with NPP losses are also those with higher levels of poverty, making the goal of providing for the food and nutrition needs of the poor more challenging (Nkonya *et al.* 2011).

Problems	Numbers of people	Consequences
Hunger (Under-Nutrition, calories)	ca. 0.8 Billion (crude estimate)	acute deficiency, political conflicts
Hidden Hunger (deficiencies in micronutrients, vitamins, iron etc.)	ca. 2 Billion (crude estimate)	diseases, reduced productivity
Children's under-nutrition (the first 1000 days)	ca. 165 Mill.	stunting, reduced physical, cognitive development. 3.1 Mio. death p.a.
Obesity and resulting chronic diseases	ca. 1 Billion	high costs of public health

Table 1. Nutrition Problems at Global Scale.

Trends

In the current decade, demand for most high-value and processed food items such as butter, milk, poultry, oilseeds, sugar are projected to grow between 20 and 25 percent (between 2010 and 2021); cereals are projected to grow between 15 and 20 percent. Growth will continue until mid-century. Not only diet quantities, but also quality is changing (Beatty *et al.* 2014, Unnevehr *et al.* 2010). Income, health and environmental impacts of consumption are particularly protracted in relation to livestock products (Steinfeld *et al.* 2006).

Expanding livestock production in developing countries is an important way to help poor people increase their incomes and improve their food security and nutrition. Micronutrient status among low-income people is strongly dependent on the consumption of animal products. However, excessive consumption of animal products and fats is also a part of growing obesity problems. As incomes rise, people tend to consume more meat and other animal products. To illustrate, North Americans and Europeans consume more than 83 kilograms of meat per person yearly, compared with 58 kilograms in Latin America, 28 kilograms in East Asia, and 11 kilograms in Africa. In the future all growth in demand for meat is expected to come from the developing countries. The projections by Msangi and Rosegrant (2011) suggest an increase to 77 kilograms in Latin America, 52 kilograms in Asia, and 24 kilograms in Africa by 2050.

Demand trends are affecting natural resources partly in opposite ways: first, some elements of world food demand are moving towards more efficient production in terms of land and water use, i.e. higher yielding grains (rice, maize) and more efficiently produced animal products; for example, poultry instead of beef: poultry production has expanded by a factor of 4 in the past five decades, while the more resource demanding global cattle herd has been stagnating recently. These shifts are caused by changes in relative prices. Secondly, however, diversification of world food demand away from grains and other staples towards higher-value products such as vegetables, fruits, meat, dairy, and fish, make the consumer baskets more resource-intensive, because these products require more land and water (feed for animals, irrigation, etc.; Khourya *et al.* 2014). The resource-saving structural demand transformation is by far out-weighed by this diversification and its pressures on the resources. Rising consumer incomes and population growth are among the long-run drivers that have led to the increase in food prices. Biofuel demand came on top of this and is estimated to have triggered a 30 percent increase of weighted average international grain prices from 2000 to 2007 (Rosegrant 2008).

Waste and Losses

There is significant waste and losses affecting the availability of food. Consumers are part of the problem and need to be part of the solution. Waste mainly occurs in rich countries at the consumer and retail ends of the value chain; losses occur mainly in low income and emerging economies at the beginning of the value chain, i.e. in farmers' fields, in handling, and storage. The factors encouraging food waste range from subsidies that promote inefficient food production to ill-designed regulations of food labeling, to discarding of valuable foods by wealthy consumers. Both, food waste and food losses are not trivial quantities (Kummu *et al.* 2012). The global volume of food losses and wastage is estimated by FAO (2013) to be 1.6 giga tonnes of "primary product equivalents", while the total wastage for the edible parts of food is 1.3 giga tonnes (total agricultural production for food and non-food uses is about 6 giga tonnes). The carbon footprint of food produced and not eaten is estimated to be about 3.3 giga tonnes of CO_2 equivalent, making food losses and waste a top emitter after USA and China (FAO 2013). Among the components of waste and losses, the top-most are wastage of cereals (in Asia), meat (even though volumes are comparatively low, but generating a substantial impact on the environment), and vegetables and fruit (a source of water loss in Asia, Latin America, and Europe; FAO 2013). It must be pointed out however, that calculation of wastes and losses in terms of tons is neither a sound ecological nor a useful economic concept, because very different resource losses and costs are hidden behind the various lost products. More comprehensive economic-ecological concepts of loss analyses are needed to design incentives and regulations for prevention of losses.

Supply

The responses to demand on the supply side are central for environmental consequences as already pointed out above. Today, technological change contributes about 70 percent to the overall world agricultural productivity growth (Fuglie 2010). Growth in output is no longer driven by increasing use of land, water and other inputs. The share of technological change in the output growth was less than 30 percent at the time of the Green Revolution in Asia in the 1960s and 1970s, which had shown that rapid increases in agricultural production are possible when technology is combined with much higher resource use and inputs (water, fertilizers). Nowadays, a more science- and innovation-based approach to sustainable agricultural productivity is called for. However, investments in agricultural science are currently not at a sufficiently high level to guarantee the increase in agricultural productivity needed under the emerging scenario of lower resource availabilities. Global land use for agriculture has been more or less constant for about two decades. At the same time land degradation is progressing (Nkonya *et al.* 2011). Much of the environmental consequences of demand are through land use change. To halt global biodiversity loss, we need to halt cropland expansion, argues UNEP (2014). New forms of agricultural land use that facilitate biodiversity conservation should also be considered. According to UNEP scenarios, the demand driven expansion of global cropland area would overshoot the "safe operating space" for land use (UNEP 2014).

There are feedbacks between production, environment, and future consumption opportunities. A critical one in the long run may be the narrowing of diversity in crop species – partly driven by demand, partly by technology choices (Tilman *et al.* 2011). Over the past 50 years national food supplies worldwide became more similar in composition, correlated particularly with an increased supply of a number of globally important cereal and oil crops, and a decline of other cereal, oil, and starchy root species. Between 1961 and 2009, country-to-country variation of commodity composition (i.e., homogenization) decreased by about 69% (Tilman *et al.* 2011). As these trends into homogeneity may establish increased risks for food security in the future, e.g. by reducing resilience of crops and diminishing resources for plant breeding, they need to be addressed by *in situ* and *ex-situ* conservation of plant genetic resources and more open sharing of genetic resources across borders.

Prices

Addressing the dilemma of competition between food demand and nature simply by making food more expensive is not a solution, because of the critical livelihood role of food for nutrition and health of the poor. Land and water scarcity and constraints of other environmental resources can be expected to make production more expensive in the future and may lead to a food equation at higher price levels. Scenario outlooks suggest a 40 to over a 100 percent price increases for main staple food commodities by mid century (Msangi, Rosegrant *et al.* 2012). Low-income consumers are sensitive to high and variable food prices since a large proportion of their income is spent on food. Poor people's responsiveness is also linked to liquidity and credit constraints as well as limited resilience to cope with shocks. Consumption response to food prices tends to be robust and predictable, with marked differences between rich and poor people. Estimates of consumer price responses to price changes in 114 countries show that food demand in low-income countries is twice as responsive compared to middle- and high-income countries with price elasticity of about -0.6 for the former and about -0.3 for the latter (Seale, Regmi, and Bernstein 2003). As the poor spend up to 70 percent of their income on basic food commodities, increasing food prices can reduce real incomes dramatically, at least for net buyers of food items. Most of the poor are net buyers. The challenge of feeding the world's growing population has greatly increased. Since the time of notoriously high food prices in the 1870s, world population has increased more than five times (von Braun 2011).

Food shortages are manifested through increased volatility of prices (von Braun *et al.* 2014). Volatility of food prices has adverse effects on the prevalence of child nutrition. The food price spikes in 2007-08 and 2011 were partly caused by rising consumer demand due to population and income growth, coupled with factors such as high and variable energy prices, rise in use of grain for biofuels, slow agricultural supply response, and malfunctioning financial system and commodities markets (Tadesse *et al.* 2014). These causes can be broadly separated into slow onset forces, such as population growth, consumption change, and resource scarcity, on the one hand, and fast onset forces, such as acute production shocks or trade disruptions, on the other hand. The predictable slow onset forces reach tipping points, when they interact with fast onset forces, and translate into unpredictable market effects and food security crises. Policymakers are torn between high food prices which encourage agricultural production, and low food prices which benefit poor buyers of food. However, when food prices change implicit re-valuations of nature happens, because the food price change is passed on as an increased demand for land, water and other inputs, leading to losses in nature and putting more pressure on the environment.

In sum, the food demand challenges for environmental resources and nature need to be assessed in a context of supply-side and demand-side forces. The simultaneity of these forces, long-term lag structures, and the price effects of any supply and demand side actions for the poor are of considerable importance when attempting to internalize the externalities of food demand for the natural resources and for nature (von Braun, Gatzweiler 2014).

3. Frameworks for Actions and their opportunities and constraints

Reconciling consumption of food and nutritional needs with sustainable resource use and nature is not just a matter of making individual products and processes sustainable. A broader framework is needed and would integrate final demand for food (and other goods) with the related derived demand for environmental resources, and would embrace implications for nature, i.e. integration between socio-economic and bio-physical framing. A whole set of different disciplines such as psychology, neuroscience, economics, politics, sociology, and anthropology need to be part of conceptualizing consumption, empirically test theoretical predictions, and use these to inform policy-makers across the private, and public sectors on how to make consumption more sustainable (Ulph and Southerton 2014). Drawing on diverse disciplines, three complementary approaches are proposed here to facilitate reconciliation of food demand with sustainable resources use and nature: (1) incentives for consumption change, controls, and regulations, (2) information, labeling, and nudging approaches to stimulate consumers' behavioral change, and (3) "biologizing" the economy, building economies around bio-based product and process innovations and reducing dependency on fossil fuels.

1) Incentives and regulations. The example of animal product demand

The impacts of high and increasing consumption of animal products on environmental resources use (land, water, and atmosphere), and on loss of nature (biodiversity, forests, landscape) are widespread. A call for cutting excessive meat consumption is justified, but its translation into action is difficult. Foley *et al.* (2011) compare basic food production (calories available if all crops were consumed by humans) and delivered food production (calories available based on today's allocation of crops to food, animal feed, and other products) and estimate the potential to increase food supplies by shifting 16 major crops to 100% human food. This, they state, could add over a billion tons to global food production (a 28% increase). They point out that such wholesale conversions of the human diet are not realistic goals, but that even incremental steps could be beneficial. Such calculations of potential savings of food through consumption change are useful to identify orders of magnitude, but more realistic estimates of the potential role of consumption change for sustainability must consider human behavior and market forces.

More comprehensive model-based analyses of the scope of consumption change for sustainable resource use demonstrate that any implementation of related policies must consider indirect effects through markets. Global substitution among some consumers who might cut their consumption versus others who might not is high, because of equilibrium price effects. For instance reduced meat consumption by rich segments of global society (i.e. in a scenario where in high-income countries, and Brazil and China meat consumption is cut to 50 percent below baseline levels by 2030) would reduce world meat prices by about 33 to 59 percent (depending on type of meat) but boost meat consumption in low income developing countries (e.g. in Africa and some Asian countries) by about 50 percent (Rosegrant and Msangi 2011). Due to the overall cut in global meat consumption the pressure on environmental resources and nature would be reduced, but the reduction is only a small fraction of the reduced meat consumption in the high-income countries, together with China and Brazil.

While expectations of lower meat consumption might have a less than expected impact on the environment in the short term, this does not mean that steps in the direction of a more environmentally sustainable consumption should not be aggressively pursued. Ultimately, they are essential. There is, however, also evidence about the limitations of financial reward strategies to change nutrition behavior (Spahn *et al.* 2010).

2) Informing and nudging consumers. The example of footprints and labeling

Information and the capacity to process and respond to it are central for forming consumption behavior. Food-related behavior is formed early in life and adjusts slowly. Still, recent changes in consumer behavior are due in part to better health and diet information dissemination through educational programs, nutrition food labels, and the media. The knowledge about externalities of one's own consumption is rapidly expanding, too, at least among the wealthy and IT-connected populations. While consumers may also choose to be imperfectly informed if the price of the information is high relative to the perceived marginal benefit, the "excuse" of not having known about negative externalities of one's consumption patterns is diminishing.

Environmental footprint (EFP) analyses are mainly biophysical concepts. EEP analyses have evolved by product and by resource, such as CO_2 emissions or fresh water use of a certain product (Chenoweth *et al.* 2013; Tukker and Jansen 2006). Assessments are done over whole product life cycles. Such life cycle analyses (LCA) trace the physical flows of produce and by-products from used resources to production and consumption, including waste and re-use opportunities and post-consumption, relating consumption to the resource use and externalities. LCA is a useful approach for identifying gross environmental problems in a value chain and can help recognize points of entry for analyses of externalities. From a socio-economic perspective, LCA is not a satisfactory valuation and choices are not connected to any economic concept, consumer behavior remains in the dark, and distributional effects are not traced. Relevant information for consumers is difficult to distil from LCA, given the hugely diverse and fast changing consumer baskets and off-home food consumption components. Electronic self-monitoring of food consumption (with apps, etc.) is rapidly evolving, but so far mainly focused on personal health attributes, not environmental impacts. However, that can change, and might actually assist in overcoming the so far mostly ineffective labeling attempts of environmental effects of consumption.

Alternatively to bottom up calculations of footprints, the top-down approach uses multi-country input-output tables to trace, for instance, water footprints across products, sectors and economies through product transformations and trade and thereby virtual water trade. It uses data on sectoral water use (within countries), inter-sectoral monetary transactions and trade between countries or regions (Munksgaard *et al.* 2005). These analyses are of huge interest for environmental policies. Multi-country interlinked input-output models can approximate a nation's direct and indirect water footprint. Lenzen *et al.* (2012) added a critical dimension to this type of economy-wide footprint analyses in the case of water by distinguishing the source of water from scarce and abundant water environments, and found that USA, Japan, Germany, France, UK, and Italy are the top five importers of water from water-scarce countries through their processing industries and final consumption.

When aiming for sustainable consumption, not only private consumption should be considered, but also government consumption through public procurement. National and local government procurement is a very large public expenditure item in rich economies. Rarely are environmental implications of the level and structure of this demand taken into account. It might actually send a strong signal to private consumption if government procurement would consider environmental effects explicitly in procurement policies and if that were to enter the political discourse.

3) Biologizing the economy: the Bioeconomy Framework

Single product and single resource environmental footprint analyses are neither sufficient, nor can they be embedded into a theoretically founded socio-economic framework of peoples' wellbeing such as developed by Dasgupta (2001). Moreover, all actors – consumers, retailers, producers, processors, and regulators – need to be captured in integrated frameworks that trace and optimize the nexus between demand and natural resource uses. Ideally, one would like to have a comprehensive environmental footprint assessment of all consumer items, composed of all relevant environmental public goods (atmosphere, water, soils, biodiversity) and powerfully communicate this information to consumers with the intent to facilitate adjustment to more sustainable consumption, be it through self-restraint or "nudging", or incentives, or regulations. There are actually tendencies to move to such frameworks. In recent years numerous countries – mostly high income countries and some emerging economies – have designed and adopted bioeconomy strategies.[4] Bioeconomy understood as "biologisation" of the economy is a societal and economic strategy for sustainable consumption and production. It should not be misunderstood as "economizing nature" but to re-integrate nature into the economy. It is defined as the knowledge-based production and use of biological resources to provide products, processes and services in all economic sectors within the frame of a sustainable economic system (Bioeconomy Council 2013). Bioeconomy is driven by changed factor price structures and related price expectations, technological innovations, and changed consumer preferences.[5] Bioeconomy draws not only on biomass as a basic resource, but includes innovation in biomass production; refinement in industrial biotechnology in the chemical industries is a critical part of bioeconomy, as is the utilization of carbon etc. generated from CO_2 or other sources as innovative raw materials. Bioeconomy entails an interlinked set of value chains forming the bioeconomy value web. This cuts across agriculture, food, forestry, fisheries, large parts of chemical and pharmaceutical industries, fiber and textiles, bio-based construction materials, and energy sector components. It also entails comprehensive re-carbonization of the biosphere (Lal *et al.* 2012).

Analytical frameworks of bioeconomy draw on systems approaches, in which drivers of the bioeconomy would be related to change in system components. Competition among goals and complementarities of instruments should be explicitly modeled. The usual limitations of systems modeling apply, for instance, difficulties of systems boundary definition, and dynamics of innovation and technological change. Bioeconomy must ultimately be understood in a context of larger changes of societal, technological, and economic transformations toward sustainable development strategies. The essence of such transformational strategies are not only technological (new science) and behavioral (adjusted consumption), but the central issue may very well be institutional, i.e. providing the frameworks and long-run incentives for industry and consumers to transition to sustainable economic systems, of which bioeconomy is a significant component.

Ethical-economic framing of consumption

Exploring food demand in the context of the above food equation and positioning demand in a bioeconomy context is helpful to identify synergies

[4] Australia, Brazil, Denmark, Germany, EU Commission, Finland, Ireland, Canada, Malaysia, Netherlands, Russia, Sweden, South Africa, UK, USA.

[5] *New Perspectives on the Knowledge-Based Bio-Economy*, Conference Report, European Commission, Brussels 2005.

and externalities and to identify strategic directions. But in order to guide food demand toward the these desired directions, i.e. a) sharing the means to access food more with the food deficient poor, b) do no harm and respect for nature and c) environmental sustainability, some criteria are needed. This brings us to ethical considerations related to economics of food consumption and production (von Braun and Mengistu 2007). A framework for an equity-oriented attempt to reconcile valuation of choices of actions between food consumption, nature conservation, and use of natural resources shall be discussed. Other important ethical considerations, for instance consumption related to lack of animal welfare shall only be mentioned here.

Many societies have ethical foundations and principles related to food consumption, but they have hardly been transmitted into the study of food consumption economics. The lack of ethical perspective in food consumption results partly from the neglect of ethics in mainstream economic theory.[6] The medical field has some similar ethical issues, comparable to those in the food and nutrition system, due to information asymmetries between suppliers and consumers (physicians and patients). But, unlike the food sector, the medical field has enjoyed a dynamic tradition of ethical dialogue since the days of Hippocrates. The long tradition of ethical discourse has enabled the creation of institutional mechanisms to mitigate the associated externalities of change and technological advancement (Stiglitz 2000, Arrow 1963).

Evaluating whether a deed, such as a certain consumption behavior, is ethical is not always a straightforward task, and there is a considerable disagreement on how exactly one should define ethical behavior.[7] The ethical

[6] Although the economics profession originates from both ethics and engineering, it has evolved concentrating heavily on the engineering approach (Sen 1987). Further, economic theory for long times largely ignored the environmental and social limitations that humans face (Barham 2002). "To understand the moral relevance of positive economics requires an understanding of the moral principles that determine this relevance" (Hausman and McPherson 1993). It is important for the economist to make his/her underlying value judgments (or "point of view") apparent and clear in order to make them subject of discussion. As stated by Weber, "in the method of investigation, the guiding 'point of view' is of great importance for the construction of the conceptual scheme which will be used in the investigation" (Weber 1897). While the fundamental theorems of welfare economics contain a "do no harm" principle, they also distance welfare economics from ethics.

[7] There are at least two opposing schools of thought. On one side, 'Consequentialism', to which the utilitarian school belongs, argues that a deed's ethical value should be defined based on the consequences it brings with the ultimate objective being the maximization of welfare for all stakeholders. On the other side, (neo-) Kantian philosophers argue that an action is ethical if the individual feels he/she has the right or duty to execute such an

underpinning of the structure in Table 2 explicitly considers the need for sharing and implicitly considers past and current wealth related weights of environmental footprints. Reflections on the proposed structure in Table 2 would start from the premise, let long-term human wellbeing be determined by man-made capital (C_m), environmental resources (environmental capital: C_n), and the existence of nature (N, defined as in introduction above); whose and what food consumption should be brought in line with what sustainability criteria? Should all – the rich and the poor – adjust consumption by equal shares or if not, in what ways? These are questions that require ethical considerations and value judgments.

Whose and what food consumption	**Group 1: Excessive food consumption by wealthy**	**Group 2: Balanced consumption by the food secure**	**Group 3: The under-consuming hungry and food deficient**
Which sustainability paradigm[8]	"very strong" N unchanged and C_n = constant	"strong" C_n = constant	"weak" $C_n + C_m$ = constant
Substitutability between C_n & C_m	No	very limited	not limited
Discount rate	DR ≤ 0	DR ≈ 0	0 < DR < interest rate
What action to consider (examples)	limit human impact of related consumption activities (regulations re N; trace environmental footprints)	Efficient use and conservation of natural resources (apply environmental standards)	Efficient use of natural resources; incentives for conservation (taxes, benefit from payments for their eco-system services)

Table 2. What sustainability for what and whose food consumption? Some value judgments applying variant conditions of sustainability. Note: Let long-term human wellbeing assume to be determined by man-made capital (C_m), environmental resources (environmental capital: C_n), and the existence of nature (N).

action. This view derives from Kant's "Categorical Imperative", which defines an ethical action "as objectively necessary in itself, without reference to another end" (Kant 1785). In practice, this school of thought emphasizes obligation, duty and rules.

[8] Adapting Pearce *et al.* (1996) concept of "very strong", "strong", "weak" sustainability.

The framing as presented in Table 2 is not without caveats: ethical issues may arise from externalities of behavior and from ethics itself. For instance, ethically founded consumption will have spillover effects to production and trade that may adversely impact others through price and income effects, which might have negative repercussions on poor producers. Basically, the framework suggests that those who are positioned in excessive consumption (Group 1) should be faced by strong sustainability criteria (be it through regulations or self-restraint), i.e. their consumption should not impact on nature, and substitutability between natural and man-made capital would not be accepted for / by them, neither would be discounting future value streams (discount rate at zero or below). These sustainability restrictions might come at a cost of their further economic growth. Group 2 would face less harsh environmental criteria for their consumption impact on nature and a less strong sustainability concept (Cn = constant). For the undernourished poor (Group 3), the least strict sustainability paradigm would apply, i.e. substitutability between natural capital and man-made capital. And actions would differ accordingly (see examples in bottom row (Table 2).

4. Discussion of Implications

Policy directions

If the environmental externality problems of food demand were just a problem of wealthy people, solutions with taxation and regulation would in principle be rather easy. But any solution to the problem poses complex consequences because there are serious equity and poverty dimensions. The bundle of instruments for the three distinct but interrelated goals – healthy food consumption, sustainable use of natural resources, conservation of nature – needs to be efficiently applied in a well-targeted goals/ instruments framework. Assuming that there is one tool to achieve all three goals, say by cutting animal product consumption, will not work. Key areas for policy attention are:

1. All consumers need to know more about the implications of their consumption behavior for themselves, for others living far away from them, and for future generations. Creativity in labeling and consumer information is called for. More experimenting should be explored. Targeted taxes and regulations should not be excluded. Incentives and regulations need to go together with new efforts by civil society and cultural leaders, including churches, to change consumer attitudes to factor in consumption externalities, and cut waste.
2. Sharing the burden of adjustment in consumption to reduce negative consumption externalities for natural resources should be quite unequal.

Policies need to take account of the large wealth inequalities and of absolute poverty when attempting to correct the negative externalities of food consumption. "Food first" for the poor implies that much stricter sustainability criteria should apply to the wealthy than to the poor. This does not just relate to richer versus poorer nations but to richer versus poorer households within nations.

3. Much of the environmental impacts of food consumption need to be addressed on the production side. Producing more with less, i.e. sustainable intensification, is needed in agriculture. Prevention of soil degradation, sustainable water use, and zero or negative greenhouse gas emissions from agriculture are key targets for that. Technological innovations along the value chains, and new strategic orientation in a bioeconomy framework should be considered.

Research directions

Priority in food related research should remain the creation of new knowledge that can assist to end hunger and malnutrition problems. Consumers and the environmental externalities of their behavior have been under-researched. Key themes for public research in relation to that are:

Uncovering the determinants of consumer choices with respect to environment and health; assessing the effectiveness of positive 'nudging approaches'; studying the impact of economic incentive systems for environmentally sustainable consumer behavior (e.g. incentives vs. taxes/fees).

Evaluating 'natural experiments' and implementing field experiments created to develop environmentally sustainable consumer behavior and related institutional regimes.

The scope and scale of biologizing the economy (bioeconomy) to facilitate reduction of the large environmental externalities of food consumption (and other consumption, such as related to housing and mobility) connected to fossil fuels, land, and water, and thereby assist a transition toward reconciliation of sustainability of humanity with sustainability of nature.

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