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Saving Seeds

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Synonyms

Brown-bagging; Heirloom seed saving; In situ agricultural biodiversity; Open-pollinated seed saving; Semi-subsistence cultivation

Introduction

Saving seeds is an ancient and universal practice that has both grounded and propelled agriculture for millennia. The widespread transition from "hunter-gatherer" to "agriculturalist" among humans – dated these days at 12,000 years ago – centered on the domestication of edible wild plants into cultivated crops: in short, the selecting and saving of seed with desired traits so as to replant later and/or elsewhere. The practice of saving seeds has always entailed complex social and cultural dimensions, as seeds have physical as well as metaphysical currency in many agrarian societies. The people in a community who held the responsibility of saving seeds – often women, often elders – were endowed with a critical social obligation and function. This is still the case in traditionally agrarian communities across the continents. As agriculture became more industrialized in the twentieth century, the practice of seed saving receded in import; more growers turned to annually purchased seed stock (be it hybrid, or later, genetically modified). More recently, however, for a variety of reasons, the ethical dimensions of seed saving have reemerged, and these ethical dimensions have taken on an explicitly political framework.

This brief introduction to the rich topic of seed saving begins with a biological overview of the practice. It then moves to an historical survey of major twentieth-century changes in agriculture, emphasizing in particular ethical issues regarding the evolution of intellectual property rights, the widespread decline in agricultural biodiversity, and the ex and in situ attempts to conserve this cultivated diversity. (Of note, this essay has a US focus, but the basic phenomenon are not unique to the United States.) The essay ends with a discussion of ethical debates regarding the politics of seeds and their saving.

Biological Basics

Seeds are mobile, self-sustaining packages; they carry all enzymes required for the embryo to convert the stored nutrients to tissue-building sustenance. They also carry all the genetic information of the plant, including genetic traits that were expressed in previous generations as well as genetic potential to express other traits in response to new abiotic contexts and pressures. This genetic blueprint is encoded in the

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deoxyribonucleic acid (DNA) molecules, which determine the genetic traits therein and how and when they will be actualized.

Botanically speaking, a seed is a ripened and fertilized ovule that contains the plant in embryonic form as well as nutrients for the embryo during its indefinite dormancy. This embryo and stored nutrients are encased in a seed coat. Yet, many seed savers select, save, and sow parts of the plant that are technically fruits, though they act like seeds – such as corn kernels. All seeds contain one or more cotyledons or folded, rudimentary leaves, which themselves contain stored fat, protein, and carbohydrates. The cotyledon(s) is partially wrapped around the tiny leaf bud. Next to the cotyledon(s) and tiny leaf bud rest both a rudimentary stem and a root tip, which – when the seed germinates – extends to become the plant's first root. If a seed contains two cotyledons, it is called a dicot; if one, a monocot. Squash, beans, cucumbers, tomatoes, celery, cabbage, and most other vegetables that bear seed are dicots and send forth two small seed leaves upon germination. Onions and garlic are monocots, and, once germinated, send forth a single spear-like blade of grass. Also, most grain crops in the grass family (*Gramineae*) – including corn, wheat, buckwheat, rye, amaranth, quinoa, rice, and other cereal crops – have one cotyledon and are thus monocots (Bubel 1988).

In some seeds, the stored nutrients are not contained in the cotyledon, but in the endosperm, the layer of starchy seed flesh that surrounds the embryo. For many major grain crops, the endosperm nourishes the embryo – but it also feeds the human or animal eating the seed as food, as in the case of corn, wheat, rye, buckwheat, and other cereal grains. Endosperm results from the fertilization of the plant: when a male gamete fuses with a pair of female nuclei in the embryo sac, endosperm is produced. It consists of three layers: the aleurone, which breaks down starch; the transfer layer, which absorbs nutrients for the plant itself; and the larger, internal layer, which provides the bulk of the starch.

The act of saving seed depends upon the phenomenon of dormancy, during which the seed produces chemicals that inhibit germination. Seeds are self-sufficient and self-protected during dormancy – which can last for days or millennia. The seed coat provides a water-resistant, impermeable physical protection to the seed embryo and nutrients inside. Seed coats also protect against parasites, minor injuries, and, to some degree, high or low temperatures. When dormant, the seed's metabolic function operates slowly and efficiently, drawing nutrients from the cotyledon or endosperm at a significantly lower rate than after germination.

Dormancy culminates with the pivotal moment of germination, when a seed awakens to begin taking root and sending forth cotyledon. The first sign of germination is absorption of water, which activates an enzyme that speeds respiration and catalyzes plant cells to duplicate. This increases the size of the embryo, which ultimately must break out of its seed coat and unfurl itself. The root tip extends downward to anchor the growing plant. The mobile stage of the plant ends here, as it takes root and begins its place-bound life. Besides spatially fixity and balance, the root tip serves to absorb water and nutrients from the soil, as that by now, the embryo needs more than what its seed content could provide.

A seed germinates depending on surrounding conditions, from temperature to moisture, to light, to oxygen supply. A viable seed might not germinate if the conditions are unfavorable. Some seeds need to be coaxed out of their protective dormancy at times, such as lettuces; gardeners sometimes use fluorescent plant lights to convince a lettuce seed to emerge into a lettuce plant. Some wildflower growers "scarify" the seed coats of certain wild legumes to encourage the seed to begin germination. Most wild plants and wildflowers require a period of dormancy before they will germinate, while cultivated garden flowers usually do not. To test viability, growers run germination tests on their stored and saved seed; the percentage that sprouts indicate the overall viability rates of the seed. The grower can continue exchanging, storing, and/or sowing the seed.

Once sown, the seed germinates and grows, developing into a plant that flowers, becomes pollinated, and bears fruits – and more seeds. Whether self-pollinated or wind-, insect-, or hand-pollinated, the flowering plant produces seed that can be saved. Annual seeds produce seed each year, while perennials do not necessarily, and so must be propagated through cuttings or plant division. Seed savers usually save from more than one plant, so as to avoid inbred stock and to maintain overall genetic diversity and vigor. In most plants, seeds are gathered at the end of the growing season to make sure the seed has developed a sufficiently mature embryo and endosperm. Timing is key, since growers must gather seed at the right stage of seed development and at the right temperature and moisture level: seeds that are too wet could mold. Fleshy fruits, such as melon, cucumbers, tomatoes, eggplants, and peppers, need to be slightly overripe before harvesting them for seed saving. If the fruit begins to rot, excessive heat from decomposition could damage the seed. Also, diseased vegetables often pass along pathogens to their offspring. Once harvested, some seeds (peas, snap beans, soybeans) need to be threshed to remove the pods. Saved seeds need a postharvest drying period to allow any accumulated moisture to evaporate (Ashworth and Whealy 2002).

Genetic vigor is determined by parental lines and passed along genetic traits. Physiological vigor depends upon the conditions within which the seeds were formed: temperature, sunlight, moisture levels, and soil nutrient availability. The vigor of a seed cannot be improved with correct storage, but it can be hindered with poor storage. Seeds should be kept cool and dry, since heat and moisture activate premature internal embryonic metabolism. Also, cold and dry conditions inhibit growth of bacteria, fungus, mold, diseases, and insects. A note of caution given by seed savers far and wide is to avoid planting all of one seed variety at one planting. Saved seeds are valuable for their productive and reproductive capacity; they are saved for present and future plantings and are not all to be replanted in one season in case of crop failure.

Agricultural Changes: Historical Politics of Seeds and Intellectual Property Rights

Throughout history, seed saving has served as a chief means of obtaining seed. Even growers with access to seed markets and networks would save the best seeds from their own fields to replant later and/or exchange with or sell to other growers. Yet, during the past century, the propensity toward seed saving has decreased in the Global North and even in the Global South, as formal seed markets have grown and as seed types – be they hybrid or transgenic – have prohibited their saving.

This transition toward laboratory-based breeding drew in large part upon the early twentieth-century applications of mid-nineteenth-century hereditary discoveries of Gregor Mendel. The scientific field of genetics developed rapidly throughout the twentieth century, transforming agriculture in the process. In the USA, public and "land-grant" universities explored and developed hybrid varieties of corn and wheat – among other crops. These seeds were unusually productive during the first generation (F1) after cross parent lines. But due to intensive inbreeding, these "high-yield" hybrids did not produce a productive – or even reliable – second generation of plants (F2). Therefore, biologically speaking, they were the first single-season, annually purchased seed input. The hybrids generated high yields per hectare of commodity crops; they also generated considerable income for the private industries that took an increasingly share of research and development from public institutions. American Seed Trade Association, formed in 1883, lobbied, successfully, to end the US government's decades-long practice of distributing free seed to growers so as to encourage their field-breeding experimentation. By the 1930s, the private seed industry had established its market and begun a century of exponential consolidation and growth (Kloppenburg 1988).

The "vigor" of hybrid seeds – along with their affiliated spate of irrigation, chemical fertilizer, and chemical pesticide inputs – led to unprecedented yield per hectare increases in commodity crops during the middle of the twentieth century. This "Green Revolution" produced massive harvests of cereal grains for the global market but heralded notorious ecological and social effects, ranging from massive biodiversity loss, soil erosion, and water pollution to consolidated land tenure and input companies. Where these profound agricultural changes took root, the practice of seed saving moved to the margins.

All the while, seeds – and the genes therein – became subsumed within a growing network of intellectual property legislation. The 1930 US Plant Protection Act helped usher in this new era of seed breeding by establishing patent systems for asexually reproduced plants (be they grafted or cloned). European law followed suit with the *Union internationale pour la protection des obtentions végétales* (UPOV) in 1961, which established plant breeders' rights. The 1970 US Plant Variety Protection Act (PVPA) extended this framework by granting certificates of protection for sexually reproduced crops – those reproduced through seed. The 1970 PVPA clarified that farmers would maintain the right to save seed, but this exemption was repealed by congress in 1994. The UPOV maintained a corresponding exemption provision – until 1991 – when it deferred the right to save seed to national discretion and dramatically increased plant breeders' rights (Aoki 2008).

Then, in 1980, the US Supreme Court decided the landmark case *Diamond v. Chakrabarty*, which held that people or companies could obtain utility patents on living organisms that they had genetically altered themselves. Subsequent lawsuits upheld this expansion of proprietary germplasm commodification. All the while, advances in agribiotechnology allowed plant breeders to isolate, extricate, and modify specific gene sequences, creating transgenic seed varieties that were protected by extensive intellectual property policy. Unlike their hybrid counterparts, transgenic seeds reproduce their defining hereditary traits and thus, biologically, can be saved. To protect their investment, plant-breeding industry has lobbied (successfully) to preclude seed saving through intellectual property rights (IPR) regimes. The logic here is that IPR provides incentives for research and innovation and serves as a means of recouping costly investment.

According to US and European patent law, "naturally occurring products" cannot be patented, but if a person or company discovers an "isolated, purified, or altered form" of this naturally occurring product, they can claim a patent on it. Phenotypic and genotypic organism traits thus can be patented if proven to be (1) newly discovered or created, (2) distinct, (3) uniform, and (4) stable. These guidelines were then exported to other regions of the world through the 1994 Agreement on Trade-Related Aspects of Intellectual Property (TRIPS), a key component of the General Agreement on Tariffs and Trade. TRIPS enshrined extensive plant breeders' rights by requiring that all countries involved in the World Trade Organization "harmonize" their intellectual property protections through either UPOV, US patent laws, or a corresponding sui generis system (Aoki 2008).

This trajectory toward proprietary ownership of germplasm has escaped neither controversy nor contention. Seeds and the genes therein have existed as a worldwide commons for millennia. Global agricultural biodiversity unfolds as seeds travel from field to field, continent to continent, adapting anew with each season. This flow has been appropriated at times for private gain: imperial enterprises sought to collect exotic seed stock from colonized outposts and capitalize upon its valuable new traits. Botanical gardens housed accessions of such exotic varieties, but, in general, germplasm remained commonly held and openly accessed.

By the beginning of the twenty-first century, however, over half of the global commercial seed market is controlled by three agribusiness conglomerates: Monsanto, DuPont, and Syngenta. This unprecedented level of private industry consolidation – accomplished through two decades of intense company mergers and acquisitions – reflects a global political economy of corporate consolidation, but the seed industry has come to embody this concentration – of revenue, resources, access, control, and political leverage. During the rise of agribiotechnologies such as genetically modified seeds, the price of seeds has increased considerably, Meanwhile, food prices spiked in 2008 and have risen subsequently. Moreover, both seed and food prices are subject to financial volatility that has only increased as food has become a more prominent future commodity for financial speculation. Accordingly, growers, advocates, and policy makers have begun to bring the issue of seeds – and seed control – to more mainstream debates.

Agrobiodiversity Decline

As agriculture became increasingly industrialized in the twentieth century and the monocultural mode of production expanded, overall levels of agricultural biodiversity declined. Growers and plant breeders alike noted the precipitous erosion of crop diversity. The crisis has unfolded across and between all major and minor crop species: during the twentieth century alone, the UN Food and Agriculture Organization (FAO) chronicled a 75 % global loss of agrobiodiversity. Tens of thousands of plant species growing in the world are edible, and humankind has cultivated several thousands throughout history for nourishment. Presently, however, only about 150 species are grown for food, according to FAO research, while 30 crops provide over 95 % of human consumption, and only three of these (wheat, maize, rice) supply over 60 % human foods. Concurrently, each of these three staple crops has become more genetically homogenous. At all known scales of reference, the variety and variability of domesticated foods and their wild relatives are diminishing (Fowler and Mooney 1990).

Though it has not garnered the public attention of other environmental crises – with the lack of charismatic megafauna in the heirloom seed world – the larger ecological emergency of global climate change has brought its importance to the fore (or at least more to the fore than before). The standard international methods for addressing the problem of agrobiodiversity erosion are through ex situ (off-site) conservation and storage of seeds, especially through research centers, such as the mega-gene banks of the Consultative Group on International Agricultural Research (CGIAR). The CGIAR began in 1971 as a means of connecting, streamlining, and strengthening the conservation and research capacities of individual International and National Agricultural Research Centers. Working with hundreds of government and civil society organizations around the world – as well as with private industries – this "strategic partnership of diverse donors" supports and coordinates the 15 international centers – 11 of which house mega-gene banks. These banks play an important role in facilitating agricultural researches on and for agricultural biodiversity conservation. Yet, growers, scholars, scientists, indigenous rights activists, and even international agencies have called for increased attention to and support for in situ (on-site) cultivation, such as in farmer fields and home gardens.

Despite lip service to small-scale growers and their farming skills, the politics of seeds and genetic conservation continue to favor ex situ strategies of collection and preservation. Moreover, increasingly such conservation measures serve and are subservient to certain sectors of agricultural research, such as those recently dominated by private (rather than public) plant breeding. Consequently, this research is usually funded by and oriented toward highly consolidated agribusiness corporations and expressly committed to "improving" seed stock through genetic modifications and subsequent de rigueur intellectual property rights.

Subsequently, farmers and sustainable agriculture advocates have become more pointed in their analyses of the political ecology of agrobiodiversity loss and conservation through ex situ conservation; they argue that food security is itself fundamentally dependent on viable, resilient, sustainable agriculture, which is itself predicated upon a viable, resilient, and biodiverse crop base: in short, in situ agricultural biodiversity. Accordingly, increasing numbers of small-scale growers and agrarian activists, such as those in Via Campesina, have come to argue that food security entails food – and thus seed – "sovereignty" and that the crisis of agrobiodiversity erosion and the methods to address this problem are more than merely ecological.

Though often framed dichotomously, the delineation between in and ex situ blurs somewhat upon closer inspection. After all, at times, cultivation partakes of both in and ex situ strategies. Community seed banks gather seed varieties so as to circulate them for wider cultivation in the local community, and home gardens can serve in situ needs of semi-subsistence along with ex situ objectives of "growing out" seeds for nearby community seed collectives. US-based Seed Savers Exchange serves as an ex situ hub for a wide network of in situ growers. Nevertheless, efforts that focus solely on ex situ means of conservation often belie a different understanding of agrobiodiversity, its conservation, and its value than that of initiatives focusing on in situ cultivation as the chief means of reversing, or at least mitigating, its decline.

These debates parallel a broader dispute regarding the commons of plant genetic resources: ex situ gene banks conserve this genetic treasury as a "common heritage of humankind," even as the holdings are subsumed within growing networks of proprietary IPR. Global contestations on the asymmetrical flow of genetic resources from the gene-rich South to the gene-poor North – and the latter's disproportionate financial benefit – spurred the 1983 International Undertaking on Plant Genetic Resources, wherein countries gathered to safeguard the genetic commons. The Undertaking was not binding, though, and its commons framework was subsequently undermined by the 1992 Convention on Biological Diversity, which upheld *national* sovereignty of respective genetic resources.

The international debates persisted and ultimately led to the 2001 International Treaty on Plant Genetic Resources for Food and Agriculture, which, when implemented in 2004, instigated a Multilateral System of Access and Benefit Sharing, such that (most) gene bank holdings could not be patented – at least not in the form received by the bank itself. Loopholes remain, but the Treaty did highlight and strengthen "Farmers' Rights," which formally recognized the critical contribution of farmers to past, present, and future plant genetic resources for food and agriculture. Farmers' Rights' proponents advocated for: 1) the right of farmers to grow, breed, sell, and swap open-pollinated and laboratory-bred seeds; 2) open access to seeds and genes kept in ex situ collections; 3) established systems of compensation to recompense and encourage in situ agricultural biodiversity cultivation; and 4) increased participation of farmers in decision-making policy forums.

Ongoing Tensions: Rising Interest in Seed Saving, Amidst Increased IP

After generations of systemic devaluation, there has been a resurgence of interest in the act of saving seed. This has emerged on the margins of conventional agriculture for a variety of reasons. Ecologically, seed saving revitalizes cultivated biodiversity and, often, crop wild relatives as well. Open-pollinated seeds adapt to changing environments and thus constitute a means of cultivating climate-resilient food production. Seed saving usually occurs in gardens and small farms, where growers, over a few seasons, can acquire particularly strong, well-adapted, prolific, high-quality desirable varieties. Seed-saving growers select for ecological resilience as well as for specific agronomic traits (early-germinating, frost-resistant, heat-tolerant varieties with deep roots that survive well on steeper slopes or sandy soil) or culinary attributes (taste, nutrition, storage capacity, cooking preference).

Seed savers make the commitment to keep heirloom varieties alive and adapted for social reasons, finding cultural identity or continuity in a seed line or in the practice of seed saving itself. Seed savers also highlight the social bonds afforded through seed swaps, gardening networks, and agricultural communities. The seemingly innocuous act of seed saving has taken on explicitly political overtones among seed sovereignty initiatives throughout the Americas and the Asian, European, and African countries. Whether they identify their intentions as "seed sovereignty" or not, seed-saving initiatives and networks have emerged in urban and rural areas, across and throughout the continents of the

Global South and North. These growers swap, keep, and breed landraces so as to extricate from an increasingly concentrated seed industry that has gained a striking level of political-economic control over germplasm during the last generation.

In addition to political autonomy and cultural regeneration, some have (re)turned to seed saving for health and aesthetic/taste reasons, so as to assure themselves increased access to fresh produce. In urban and rural areas where fresh fruits and vegetables have become prohibitively expensive, growers with access to land might grow from saved seed as a form of bolstered food security. At the other end of the economic spectrum, growers and restaurateurs might opt to cultivate heirloom seeds due to their increased gourmet status. Rise of heirloom strains of vegetables, which can only be perpetuated through saving. Also a grower might decide to save seeds to assure herself seeds that have not been pretreated with herbicide or pesticides.

Amidst these diverse reasons for and forms of seed-saving resurgence, political tensions around the act have only increased. In the USA, for instance, the 2013 Supreme Court case *Vernon Bowman v. Monsanto* brought the controversies of intellectual property and seeds to the highest judicial review. Bowman, a 75-year-old Indiana farmer, was sued by Monsanto for IP infringement; Bowman contested that all he did was purchase and plant soybean from a local grain elevator. The grain elevator was selling undifferentiated grain seed – some of which was trademarked Roundup Ready soy. Dozens of groups filed amicus briefs on behalf of Bowman, alleging that the seed, under the doctrine of "patent exhaustion," should be free of intellectual property, since Bowman himself did not sign a company technology contract with Monsanto (that would have legally prohibited the saving of the purchased seed). Meanwhile, numerous amicus briefs were filed siding with Monsanto (including many by public and land-grant universities), alleging that self-replicating technologies need to be an exception to patent exhaustion, so as to assure ongoing agribiotechnology investments. The Supreme Court ruled unanimously to uphold indefinite patents on genetically modified seeds. All the while, however, the growing national and international attention to such seed policy has helped bring the complicated and contested politics and ethics of seed saving to light.

Summary

For a wide variety of reasons, the act of saving seed is reemerging as an important and powerful practice. People and communities have elected to begin, continue, or resume seed-saving networks for food security reasons, health and nutrition priorities environmental concerns, cultural identity, social interdependence, and political independence. Meanwhile, controversies have grown recently as intellectual property protection of new agribiotechnologies increases – and as corporate consolidation of the seed industry reaches unprecedented levels. Seed saving has become a political act – even for those who simply wish to grow a crop from existing seed stock. The ethical dimensions of seed saving encompass larger questions of the commons and its encroachment. The ethical aspects of seed saving also entail questions of food security – and what has come to be known as food and seed "sovereignty" or autonomy. All the while, the extensive knowledge and skills required for effective seed saving have been devalued for generations but, increasingly, are being re-recognized and revalued as critical for cultivating ecologically resilient, bountiful, and diverse agricultural systems.

Cross-References

▶ Biodiversity
▶ Biotechnology and Food Policy, Governance
▶ EU Regulatory Conflicts over GM Food
▶ GMO Food Labeling
▶ Home Gardening
▶ Intellectual Property and Food
▶ Intellectual Property Rights and Trade in the Food and Agricultural Sectors
▶ Islam and Food and Agricultural Ethics
▶ Transgenic Crops

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School Lunch and Gender

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Synonyms

Ancillary school services; Gender differences; School food

Introduction

School lunch and gender research examines whether, how, and why eating differs among girls and boys and whether or not women and men are differently involved in feeding students at school. It is a subfield of school food research. The school food literature is concerned with understanding the underlying values and related behaviors associated with food in schools and with analyzing the goals and implementation of school food policy. This entry uses the terms school food, school lunch, and school meals interchangeably to refer to food or nutritional supplements available to students and the related policies governing the purchase, distribution, and consumption of food in and around schools. Publications delved into all possible scenarios for student eating: breakfast, lunch, snacks, supplemental nutrition, and take-home-from-school food staples for the poorest of students. The literature reflected on the experiences of children who ate food prepared and served from the cafeteria, who received micronutrients distributed by transnational organizations, who brought lunch from home, and older students who left school during designated breaks.

Gender was the most prevalent variable applied in school food research. The term gender was operationalized in two different manners. The most common way to deploy gender to understand the dynamics surrounding school meals was as a headcount of girls and boys in a sample size. Less prevalent in the research was the use of gender to signify socioculturally defined difference that shaped patterns of eating; food choices; feelings toward the self, school, or school performance; and involvement in school meal administration (Robert 2014). In other words, rather than counting girls and boys, researchers who applied the latter meaning of gender to their analysis examined why girls and boys selected different items to eat or why girls were sent to school when a lunch program was initiated.

Paying attention to gender did not provide explanations for all patterns related to school lunch. Many researchers took account of other identity markers and societal factors in conjunction with gender. These included socioeconomic status (SES), which in the United States was equated with student's access to free or reduced school meals but also was reflected in who brought lunch to school or was able to purchase food during lunchtime. Race and/or ethnicity also was identified in research studies and linked to SES and gender to understand student choices and the physiological impacts of particular feeding programs.

School lunch and gender research grew exponentially over the first decade of the twenty-first century due to four overlapping concerns for the health and well-being of children. The first concern was with rising rates of childhood obesity and type II diabetes. The second concern was with interrogating the purpose of feeding students at school. The third was a concern for understanding the qualitative impact of eating at school on students' well-being or attitudes toward schooling. The fourth is the smallest group of studies and explores how research on school lunch and gender was constructed. The rest of this entry elaborates these four concerns attending to the analytic schema laid out by Sandler (2011) to critically examine school food or school food research: "who feeds whom, what, how, and for what purpose" (p. 25). Suggestions for further research are included at the end of each subsection.

Health Impacts

Researchers from across academic disciplines are concerned with halting the worldwide epidemic of obesity and type II diabetes in children. The underlying physiological patterns of consumption or who eats (and does not eat) what and with what health outcome are the concern of these investigations. Rates of obesity and type II diabetes continue to increase worldwide across socioeconomic groups. Researchers concerned with understanding why the diseases were on the rise aimed to determine what was eaten at school that may contribute to the epidemics. Most studies observed what girls and boys consumed or recorded in food journals. Caine-Bish and Scheule (2009) examined food preferences of girls and boys across grades to determine what foods might be incorporated into school lunches to improve healthy eating at school. Their study is of importance to this entry because of the findings: girls and boys have different food preferences and those preferences change across elementary, middle, and high school. Further studies also measured body mass index (BMI) to ascertain who eats what and with what physiological outcomes. However, as Galloway (2007) showed in her examination of rural Canadian girls and boys, overweight and obesity measures were not statistically significant over a 24-h period of recall but differences in energy and nutrient intake could not be ignored. Lopez-Frias et al. (2005) similarly found boys in Southern Spain consumed more calories than girls when lunch was consumed at home though not statistically significant. "It is clear that there is a pattern of dietary intake in this sample that produces greater energy and micronutrient intake in boys" (p. 783). Galloway hypothesized that sociocultural assumptions that favor boys when decisions were made about health-care access, quality of food consumed, and amount of food served may have shaped the differences and urged further research. Studies also examined what parents sent in packed lunches and noted differences between what was sent for girls and boys. Boys were sent more food in general perhaps reflecting the cultural assumption that boys require more overall calories without regard for the items consumed (Jones et al. 1999). The same study found that fat content of bag lunches (lunches brought from home) correlated with ethnicity and gender but not with socioeconomic status (SES). Future research needs to consider how gender and ethnicity shape what is eaten at school whether brought from home or selected at school. Girls were found to consume more fruits and vegetables than boys, a marker of healthy eating habits (Reynolds et al. 1999). Girls also were found to have more fruits and vegetables sent in packed lunches from home (Brennan et al. 2010). Few studies critiqued why girls and boys consumed different items, leaving many questions about eating behaviors that have an impact on health and the values that shape girls'/boys' choices for future researchers to answer. While not addressing ethical questions, many of the studies that related to school lunch health impacts laid the foundation for future studies to do so.

Why Eat at School?

Whether or not students should be fed at school is not a debated issue: governments around the world will feed students if funds are available (Bundy et al. 2009). In developing or high poverty contexts, school lunch draws boys and girls to school. Pertinent to this study, serving food at school encourages poor families to send their daughters and keeps them coming back. Why students were being fed, what, and for what purpose can be a driving force behind differences in school access. Studies also compared lunches eaten at home with meals available at school.

For example, Lopez-Frias et al. (2005) found students consumed more nutritious foods at school than at home where, they postulated, children influenced what was served more than at school. In particular they found boys ate more food of lower nutritional value than girls at home. Nichols et al. (2009) found that when urban middle school (grades six through eight) girls and boys did not eat lunch at school, both groups engaged in problem behaviors ranging from marijuana use (boys) to smoking cigarettes (girls). Governmental directives aimed at meeting caloric and nutritional needs of children were credited with improving calcium intake among girls (Weible 2013) and fruit and vegetable consumption among all children, particularly US minority populations in different regions (Reynolds et al. 1999). The majority of the studies in this literature grouping found positive correlations could be created between government-sponsored food policies and girls'/boys' improved lunchtime eating whether related to nutrient and caloric intake or offering lunch and keeping students in school for it. Future studies will continue to build on these findings, interrogating school food policies at national and subnational levels.

The Qualitative Impact of Eating at School

A third force behind school food research is to understand what qualitative impact eating at school has on school performance and satisfaction with learning. The concern is whether or not eating at school (and what is eaten) improves the school experience. Ask et al. (2009) probed whether weight and academic performance might be affected by a healthier in-school lunch. They found that girls dropped weight and were more satisfied with school performance. This type of study conducted in Norway, a developed nation, and with a group of students whose SES was not identified, should not be confused with research and programming from the field of development that aimed to increase nutrient intake for the poorest of the world's school-aged children. Studies probed emotional outcomes of eating at school in relation to academic achievement or body image (Zullig et al. 2006). Research revealed links between school lunch and the learning of a variety of social behaviors such as healthy eating habits or the consumption of fruits and vegetables. When lunch was consumed at school, drug/alcohol use decreased (Nichols et al. 2009). Zullig et al. (2006), however, found that offering free breakfast did not mean high school students ate. In this case, every group except one (African American young women) cited dissatisfaction with their bodies and practiced unhealthy eating practices including skipping breakfast. Thus eating and eating at school, specifically, was a give-and-take proposition impacted by how adolescents "digested" broader sociocultural messages about gender-body type/image. More studies are needed related to this concern; particularly absent was the impact of advertising and branding of food and food products in schools.

Constructing Research for Validity and for Gender

Research design was a fourth concern identified in extant literature. Many studies on school meal consumption were identified in preparation for writing this entry. However, the variable of gender (signifying girls and boys by N sample size) was left to the wayside as the research and/or write-up was completed. That is, the number of girls and boys was identified as a variable in the abstract and first tables or graphs only to be ignored in the discussion of findings and conclusions.

A small number of studies critiqued methodological designs (though none addressed the problematic noted above). They are important to acknowledge because of their potential impact on what is known about the relationship of school lunch and gender. The vast majority of school food studies relied on student recall, or memory of what was consumed, to measure food preferences, eating behaviors, and nutritional intake. Lyng et al. (2013) questioned the accuracy of qualitative recall measures among girls and boys. Their findings, that girls more accurately reported what was brought from home for lunch and what was consumed, suggest a need for concern about how school food is measured in future research. These types of studies are a testament to the growth and necessity of well-crafted school lunch and gender research.

Summary

The need to take account of who is involved in school lunches, how, when, from where, with what physical and/or emotional outcomes, and why is crucial to support healthy eating practices and development in all children. Such research also encourages the equitable distribution of resources to meet the needs of student populations, supporting education for all. This entry explained school food scenarios analyzed in the literature. Also described were the differing ways that gender is applied in studies as either means of sorting girls and boys/women and men or as varied patterns that shape the school lunch dynamic. The literature addressed four concerns: rising obesity and type II diabetes among all students, critiquing the purpose of feeding at school, understanding the qualitative impact of eating at school, and, finally, how to improve school lunch and gender research.

Cross-References

- ▶ Body Image, Gender, and Food
- ▶ Child Nutrition Guidelines and Gender
- ▶ Feeding Children
- ▶ Food and Choice
- ▶ Food-Body Relationship
- ▶ Food, Class Identity, and Gender
- ▶ Food's Purposes
- ▶ Gender and Dieting
- ▶ Gender, Obesity, and Stigmatization
- ▶ Gender Norms and Food Behavior

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Seed Banking, Seed Saving, and Cultivating Local Varieties

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Synonyms

Ex situ plant genetic resource conservation; Gene banking; Seed saving

Introduction

A seed bank is an organization or facility used to store and preserve plant seeds, in particular varieties that are rare, have fallen out of commercial use, and/or may have unique desirable genetic characteristics.

Over the course of the twentieth century, each year, farmers worldwide grew fewer varieties of any given crop, instead choosing from a small pool of varieties that could ensure crop uniformity that contributes to efficiency and mechanization of harvest, transport, and commodity exchange. While this resulted in unprecedented agricultural yields, the focus on a few highly productive varieties also led to decreased genetic diversity in any given farm field and thus increased vulnerability- absent genetic diversity, a single pathogen or pest can obliterate entire harvests. The United Nations Food and Agriculture Organization estimates that 75% of the world's food product diversity has been lost since 1900 (Anonymous 1999).

In response to this trend, since the 1940s, governments, coalitions of governments, and nongovernmental entities have actively saved and banked seeds as a means of preserving the genetic foundation of agro-biodiversity. The world's estimated 1,500 public and private seed banks – also commonly called gene banks – store an estimated six million seed accessions (not including tubers, cuttings, or seedlings which are protected in other kinds of institutions) (Brush 1999). These seed banks are widely regarded as insurance policies against global food insecurity in the face of disasters such as drought, climate change, famine, political instability, or war. Banked ▶ biodiversity is, in essence, a genetic arsenal poised to protect humanity against future unknowns. And in preserving that diversity, scientists, governments, and others preserve potential for future medical and agricultural developments.

Over generations, climates and landscapes change, and seeds adapt. As a result, seeds hold genetic resources that are suited and specific to a given place. Seed genetic diversity is also a record of farmers' experiences and decisions over the course of centuries, as they saved seeds from plants that exhibited the most desirable traits: frost resistance, high yields, pest resistance, strong nutritional profile, excellent flavor, or hardiness on marginal cropland. These locally adapted varieties are also called landraces and make up a portion of what seed banks preserve, in addition to (for example) crop wild relatives, such as the wild wheat grasses from which cultivated wheat has been selected and bred.

Agricultural systems, genetic science, factors influencing food supply chains, and international politics governing natural resources preservation are irreducibly complex. The promotion and protection of crop genetic resources including local seed varieties can be sensitive, nuanced work that engages the fields and issues of biotechnology, corporate consolidation, trade relations, agricultural policy, cultural memory, gender differentiation in agricultural systems, heritage, and intellectual property rights.

In Situ Versus Ex Situ Agro-biodiversity Preservation

The successful preservation of seed genetic diversity through seed banking is predicated on successful long-term storage under optimal, controlled conditions, including steady cold temperatures and minimal humidity. Seed banks tend to be infrastructure-heavy, with seed-drying machines, seed germination incubators, medium- and long-term cold storage facilities, test fields, and sufficient staff (primarily scientists and technicians) to store the seeds themselves as well as information about those seeds (in databases), to conduct germination tests, and to grow out the collection when necessary to resave seed in order to regenerate and grow the bank's collection. When stored in banks, seeds do not last forever, and each year fewer and fewer stored seeds will germinate (or sprout). Without dependable cold storage, regular germination tests, and regeneration efforts, a seed bank can become a tomb.

Funding is thin for agro-biodiversity preservation efforts around the globe, and thus maintenance of seed bank infrastructure is challenging for most regions and countries. It is particularly a struggle for those countries that ride an economic line, those that are categorized as "more developed" but in actuality, lack the resources to fund their own work and infrastructure (such as Greece, a country in a region of disproportionately high biodiversity, yet with limited national, European Union, or international resources to devote to agro-biodiversity).

Media attention to seed banking spiked in 2008 with the creation of the Svalbard Global Seed Vault, built into a mountainside in the permafrost on a Norwegian island between the mainland of Norway and the North Pole. The Vault is considered a "backup" seed bank, invulnerable to man-made disasters (such as political instability that would lead to seed banks being looted for seed for cultivation and for food) or natural disasters (even in a power outage the permafrost exterior of the Vault would keep the collection frozen). Seed banks that send backups of their accessions to the Vault retain ownership of those accessions, much like a traditional financial banking institution. The Svalbard facility is unmanned and, unlike traditional seed banks, its accessions are not shared with breeders, researchers, or farmers.

As a complement and counterpoint to ex situ (off-site) seed banking conservation efforts are in situ, on-site, methods. In situ methods for agro-biodiversity conservation take place on farm and depend on well-trained farmers to cultivate, regenerate, and save seeds. Some see in in situ conservation programs the potential to improve farmers' livelihood through increased market opportunity, by empowering farmers as the stewards and curators of both seed genetic diversity and of the knowledge base it takes to cultivate those varieties. In in situ preservation methods, farmers stand to benefit from the process of conservation, particularly when farmers are given access to gene bank materials and are well-trained in cultivation for seed saving and in seed storage techniques and when investments are made in local agricultural infrastructure to bring agricultural yields to market (Brush 1999).

In comparison with banked seed, seed conserved in situ is in a constant state of change, adapting to weather, soil, and pest conditions. Farmers' priorities and preferences in seed selection also influence the pace and kind of change seen in seeds over plant generations. While most conservationists agree that both ex situ and in situ methods have a place in a broad agro-biodiversity strategy, advocates of ex situ conservation note that certain plant characteristics and gene expressions are lost in in situ approaches (through continued seed adaptation and farmer selection), while in situ advocates note that in ex situ approaches, seed genetics remain too static and unresponsive to the conditions in which they might someday be called upon to grow.

Participatory plant breeding (PPB) has emerged as a collaborative model that engages producers as plant breeders, enabling farmers to set the goals and target outcomes of the breeding process and define the characteristics they need, granting them control over plant genetic resources, building their technical expertise, and often resulting in new products, markets, or supply chains. It is a response to the lack of agency many farmers experience in the mainstream seed marketplace, in which approximately five companies control an estimated 75% of the global vegetable seed market. PPB commonly brings together seed bankers, plant breeders, consumers, policy makers, and players across food supply chains (distributors, processors, marketing experts). This approach is most often implemented in and is most impactful in agricultural systems that are heterogeneous, smaller scale, and operating on marginal lands/ soils or otherwise high-risk farming systems (Brush 1999).

Community Seed Banking, Gender, Knowledge, and Memory

In addition to national, multinational, and university research stations and breeding programs, there are numerous NGOs internationally that store and catalogue seeds; cultural organizations that celebrate and promote agricultural products and practices surrounding local varieties; and grassroots networks of farmers and their advocates who actively preserve, save, and distribute traditional seed varieties. Though these groups' motivations and strategies may vary, they share the goal of preserving agro-biodiversity for its known and unknown future potential uses. Community seed banking is a broad term that covers a range of seed saving/banking organizational typologies, including those described above. Community seed banking, seed saving, or seed library initiatives are a complement and a counterpoint to formal seed banks, the infrastructure and accessions of which are not open to or available to the public at large.

Researchers and agro-biodiversity advocates describe the concept of formal vs. informal seed systems as a framework for understanding seed-saving networks, approaches, and impacts. A "seed system," whether formal or informal, includes all stakeholders involved in a variety of functions related to seeds, including breeding, processing, storage, packing, quality assurance, marketing, research, distribution, certification, cataloguing, growing, and regeneration. These complex systems also encompass the technology, policy, organizational structures, logistics, infrastructure, and regulations that define seeds, from development to sale to use (Mgonja 2011).

Social scientists who study seed systems (particularly those of developing nations) have noted that formal seed systems include formal organizations, agencies, entities, and infrastructures (in the sectors of education, government, business, and science). These formal systems are described as predominantly men's domain and tend to disproportionately benefit men. Conversely, women are seen operating primarily in informal or traditional seed systems that function primarily at the community or household level: globally, in family farming operations, the labor shifts that have followed increased farm mechanization have often resulted in a shift of seed selection, saving, and management responsibilities to women. Recent research has shown that many women-operated informal seed systems Sperling et al in less developed countries are transforming into small-scale seed businesses that are increasingly resulting in high-quality, consistent seed.

These differences are significant for reasons of access, economics, agency, and power; they are also significant drivers of seed variety selection and, thus, which plant genetic resources are conserved. Farmer seed selection preferences as well as the kind of knowledge retained about those varieties/selections are differentiated by gender and other demographic factors (including age, socioeconomic profile, religion, and ethnicity). For example, a multi-sited study in Africa and Asia conducted by the United National Food and Agriculture Organization revealed that men tend to select for varieties that mature early, form strong seed heads, and other characteristics that better serve commercial marketplaces. Women on the other hand selected based on characteristics more relevant to family food security than markets, including how plants performed and adapted to climate conditions, nutritional qualities, taste, and high yields (Mgonja 2011).

Since the 1980s, there has existed a movement advocating for cultural memory banking alongside seed banking, to acknowledge and record (often through oral history and interview processes) the intimate connections people and communities have with their crops and crop practices. A memory bank includes detailed information on a community's agricultural methods, planting, harvesting, postharvest technologies, seed variety characteristics, tools, storage methods, soil types, and uses of specific crops (Nazarea 2006). This movement is particularly significant as most seed banks lack sufficient resources to adequately collect and database ethnographic information about seeds. As a result, banks often know little about the characteristics of their collection, how those seeds perform when planted, or whether multiple accessions might be genetically identical yet referred to by different names in different regions. When seed banks collaborate with farmers on in situ or participatory plant breeding initiatives, this lack of information effectively means that farmers themselves must absorb the financial risk and invest the time in learning the behaviors of seed varieties that, in comparison with modern improved plant varieties commonly sold by seed companies, are likely to require more farmer labor.

Ethics and Rights in Seed Breeding and Banking

A geopolitical reality is that crop biodiversity is not distributed evenly across the globe; rather, it is concentrated in what the early twentieth-century Russian scientist Nikolai Vavilov identified as centers of biodiversity (Nabhan 2011). In terms of plant genetic resources (PGR), regions that are rich in financial or infrastructural resources tend to be "gene poor," and vice versa. As a result of this imbalance, there has been a long history of thought and policy related to whether and how maintainers of plant genetic resources ought to be compensated for their work and their contribution to PGR management (Fowler and Mooney 1990; Cummings 2009).

These market-based approaches to compensation however are complicated by the fact that most of the benefits that PGR maintainers' work confers are public, whereas the seed and genetic resource industry is deeply concentrated and driven by intellectual property and patent law that favors "improvement" over preservation (Fowler and Mooney 1990). Fundamental to American property rights law (and shared by the laws of many more developed nations) is the argument that it is labor applied to resources, not the resources themselves, that creates value. Within that conceptual framework, compensation would not be due to farmers who protect and maintain raw plant genetic resources that end up as accessions to seed banks. But once breeders access that raw material and develop newly bred strains with it, the material is considered improved and thus valuable. Of course, in the case of PGR, landraces are the result of not just generations of adaptation to nature but also generations of farmer labor and selection. These legal structures limit not just compensation potential for PGR maintenance but also farmers' access to seeds and genetic materials themselves.

Several policy-related highlights from the US and global history of the flow of rights to plant genetic resources follow.

In 1930, the United States passed the Plant Patent Act, which for the first time gave plant breeders patent control over newly bred varieties of plants that asexually reproduce. In 1970, the Plant Variety Protection Act passed in the United States. This intellectual property statute granted plant breeders 25 years of control over plant varieties that sexually reproduce, based on the breeders' ability to prove ability to prove that the variety was novel, uniform, and stabile. Perhaps the most significant exemption written into this Act granted farmers the right to save their own seed from these bred varieties and even to sell seeds to each other. As a result of these exemptions, in the United States, there were high rates of farmer seed saving, even among farmers of commodity crops, through the early 1980s (Kloppenburg 2005).

Around the same time, in 1971, on an international scale as part of the Green Revolution, the Consultative Group on International Agricultural Research (CGIAR) was created with support from the Rockefeller and Ford Foundations. Headquartered in Rome but operating autonomously, the CGIAR built 15 research centers around the world, centralized in Vavilov's centers of biodiversity and, thus, concentrated in the global geopolitical south. CGIAR was and is devoted to increasing global food security through management of natural resources, especially plant genetic resources. While advances at CGIAR research stations have been much celebrated (including breeding programs that improved yields and in some cases nutritional profiles of a range of crops), the organization has also been criticized for institutionalizing the flow of plant genetic resources, power over those resources, and access to the value of those resources from less to more developed countries (Kloppenburg 2005).

In 1983, under pressure from the developing world, the United Nations FAO drafted an International Undertaking on Plant Genetic Resources for Food and Agriculture that included a clause that identified plant genetic resources as the "common heritage of mankind." In practice, this clause was a strike against efforts for compensation to producers and maintainers, as plant genetic resources found within one nation's borders or one community's property lines could not necessarily be considered privately owned (Fowler and Mooney 1990).

Meanwhile in the United States, in 1985, the first utility patent (a patent structure that exists outside of the Plant Patent Act) was granted on a plant: corn. This was significant because utility patents cover not just the plant variety itself but all the component parts of that variety and because, unlike the Plant Patent Act, utility patents do not include exemptions for farmer seed saving. The farmer seed saving exemption was then removed from the Plant Variety Protection Act in 1994, severely limiting US farmers' right to select and save seed and paving the way for the patent-based and litigation-heavy system that has defined the implementation of biotechnology and plant genetic modification (as opposed to traditional seed breeding methodology which has been the subject of this article) (Kloppenburg 2005).

In 1989, a UN FAO resolution made landrace maintenance worthy of compensation, and an international fund was created to fund that compensation. However, contributions to that fund were voluntary and never significant. In 1992, the International Convention on Biodiversity was drafted without inclusion of provisions for farmers' rights (seed saving rights, specifically), a move that some historians have noted effectively ended the international discussion on "common heritage" and compensation. The UN FAO's International Treaty on Plant Genetic Resources for Food and Agriculture, entered into law in 2004, sought to harmonize and update the 1983 International Undertaking for Plant Genetic Resources for Food and Agriculture with the Convention on Biodiversity. The treaty includes stronger language on farmers' rights than the undertaking that preceded it, as well as a mandate on profit sharing for cultivar developed from genetic materials borrowed from gene or seed banks. However, it does not cover all key food and forage crops (Cummings 2009).

Marketing Landrace Seeds and the Foods They Yield

Internationally, the seed trade is a very tightly controlled and standardized industry in order to guarantee farmers and seed buyers a uniform, consistent, reliable, and predictable product. Since the 1970s, the European Union, for example, has overseen the marketing and dissemination of seeds in its member countries through its Common Catalogue. Each member country produces a national catalogue of seeds that has passed rigorous uniformity standards, and these national catalogues are then compiled into the Common Catalogue. Seed that does not pass these rigorous standards and does not appear in the Common Catalogue cannot be sold. Though landrace seeds possess characteristics that plant scientists, farmers, and consumers celebrate (such as drought resistance, ability to perform well in marginal soils, or unique tastes, shapes, or colors), few perform in a uniform or predictable way. Thus trade of landrace seed itself – and opportunities to employ market-based solutions to increase trade of landrace seed – is limited and at times illegal (Cohen 2011).

Absent international political or financial structures to compensate maintainers of plant genetic resources or to develop strong markets for landrace seed, several market-based solutions have arisen to promote the foods these seeds yield, the most notable of which is geographic indication (GI) standards and labeling. Country by country, there are different legal structures under which GI is practiced. Ultimately, a geographic indication scheme is a legally defined set of standards for food and beverage products, the goal of which is to enable producers (farmers and producers of value-added products) to differentiate their products in the marketplace based on place, origin, heritage, production processes, and tradition, rather than making them compete on traditional market criteria of volume, marketing, or pricing. For consumers, the purpose of a GI label is to guarantee a link between a product's origin; that place of origin's natural resources, culture, processes, and practices; and overall product quality.

While landrace conservation, plant genetic resource maintenance, and agro-biodiversity are not explicit objectives of GI, some economic research has drawn links between genetic resource conversation and the creation of strong GI-based value chains. GI schemes have been found to support agro-biodiversity by making crop varieties and the unique food products they contribute to be economically viable, and when those varieties are economically viable, farmers plant and preserve them. There have also been documented instances where GIs have resulted in negative impacts for plant genetic resources, for example, by highlighting products that specialize in certain landraces to the exclusion of others (Larson 2007). Still, successfully marketed GIs can result in recovery and reinvigoration of endangered plant genetic resources themselves and markets for products utilizing those resources, in particular, when genetic and crop management is a close cross-sector collaboration between the producer, a gene bank, food supply chain stakeholders, and regional agricultural research institutions.

Summary

The world's estimated 1,500 seed banks hold millions of accessions representing the plant genetic resources that form the foundation of plant breeding and cultivar development for agriculture's future. In light of the dearth of international resources devoted to maintaining seed bank infrastructure and shifting climate patterns that impact agricultural performance and seed variety choice, formal seed banking alone is essential but insufficient. In combination with participatory plant breeding, in situ preservation methods, informal seed saving and distribution networks (and international policy that supports farmers' right to engage in seed saving and trade), memory banking of agricultural ethnographic and plant physiology data, and strong value chain development for the foods these banked varieties can yield, seed banks are the crucial foundation of an integrated plant genetic resources preservation strategy.

Cross-References

- ▶ Biodiversity and Global Development
- ▶ Climate Change, Ethics, and Food Production
- ▶ Farmer-Scientist Knowledge Exchange
- ▶ Food and Place
- ▶ Intellectual Property Rights and Trade in the Food and Agricultural Sectors
- ▶ Political Consumerism: Consumer Choice, Information, and Labeling
- ▶ Saving Seeds

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Slash-and-Burn Agriculture

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Synonyms

Shifting cultivation; Swidden cultivation

Introduction

Slash-and-burn agriculture (Peters and Neuenschwander 1988; Palm et al 2005), also called swidden (Mertz et al 2009) or shifting agriculture or cultivation (Nye and Greenland 1960; Robison and McKean 1992; Aweto 2013), typically refers to land uses where a cropping period is rotated with a fallow period that is long enough to enable the growing of dense, woody vegetation and where the biomass is eliminated from the plot by cutting, slashing, and burning it, prior to the next cultivation cycle. It is generally considered an extensive land use, maintained through time by expansion over uncultivated land following population growth (extensification), in contrast with more intensive land uses, where the biomass is incorporated to the soil through plowing or other practices. It encompasses a great variety of systems (Schlippe 1956; Conklin 1957; Miracle 1968; Rappaport 1984; Dove 1985; Fresco 1986; Ramakrishnan 1992; Schmidt-Vogt 1999; Denevan 2001; Shaoting and Fiskejo 2001; Whitmore and Turner 2001; Palm et al 2005; Pollini 2007; Cairns 2007; Saxena et al 2007; Mertz et al 2009; Trân et al 2009; Cairns 2014) that differ by the ecosystems being cleared, the landscapes being produced, the duration of cultivation and fallow periods, the management of fallow land, the crops being cultivated, and the techniques being used.

The terms slash-and-burn, swidden, and shifting cultivation are often used interchangeably, although they outline different aspects of the system. Slash-and-burn refers to the way the biomass is eliminated after clearing: by setting it afire, in contrast with slash-and-mulch systems (Thurston 1997), usually practiced in areas with no dry season, where the biomass is left to decompose. The term "swidden" refers to the act of burning a biomass in order to cultivate it. It is the closest synonym to slash-and-burn and is often preferred to this term, because it does not outline the acts of "slashing" and "burning," which would be conducive to negative prejudices. But it is rarely used in cases of slash-and-burn systems with short fallow. Shifting cultivation evokes the idea that fields are shifted from one location to another and that the land is not permanently cultivated. It encompasses both slash-and-burn and slash-and-mulch systems but, like for swidden cultivation, is rarely employed in case of systems with short fallow, where cultivation is close to permanent. It is also misguiding as it suggests that the land is abandoned and idle after a few years of cultivation, which is generally not the case. In this entry, the term slash-and-burn agriculture is adopted in order to encompass systems with long or short, herbaceous or woody fallow, where the biomass is actually being slashed and burnt.

Characterization

Slash-and-burn agriculture is a widely adopted and sometimes inescapable strategy to practice agriculture in forested landscapes. Most staple annual crops require full exposure to the sun in order to grow; hence areas of forest need to be cleared to establish new fields. This offers great sanitary conditions to crops because their main competitors (weeds) and threats (pests and diseases) are destroyed, except for wild animals if some forest remains around the field. Burning the biomass further provides nutrients that deposit on the soil in the form of ashes. After one to a few years of cultivation, weeds, pests, and diseases start to appear and nutrients are washed away or have been utilized by the crop. The field is then temporarily left to fallow, but will be cleared and cultivated again once a secondary forest or sufficient biomass will have regrown.

The fallow period usually lasts 3–25 years, depending on climate and edaphic conditions and the techniques being used. Its purpose is to reconstitute a stock of biomass that can be mobilized again through burning and to eliminate weeds, pests, and diseases. A longer period is technically unnecessary and would result in additional burdens for cutting larger trees. A shorter period is usually conducive to disappearance of woody vegetation, which triggers a fertility crisis or significant technical changes. When the vegetation is dominated by grasses, the use of fire is abandoned or a slow burning is practiced in order to reduce nutrient and carbon losses. Vegetation is peeled off the land together with its root mat, stacked into heaps, sometimes covered with soil, and charred. This technique, called "paring and burning," differs from slash-and-burn and is not considered in this entry.

Crops cultivated in slash-and-burn agriculture systems vary greatly. Several crops are associated, which gives to the field a messy appearance, with stumps, incompletely burnt logs, and spared canopy trees littering the field. But there is order in this heterogeneous environment. Farmers adapt to the heterogeneity of their fields by varying crop associations and spacing. They can plant shade-tolerant species (bananas, plantain, taro) under remaining trees, pumpkins and other vegetable on the most fertile spots, and cereals (corn, sorghum) and legumes in open areas.

Perennial woody crops can also be planted, in which case they continue to grow during the fallow period. Useful natural trees are also favored, by being spared during the clearing and weeding, given some care during the fallow period, and sometimes actively planted. There is thus no straight line separating slash-and-burn agriculture from more intensive cultivation systems. Perennial crops like cocoa or coffee can be associated with annual crops after clearing. They succeed to these crops in the same way as would the fallow vegetation otherwise, until the aging plantation, which often takes the form of a forest with a closed canopy, is rejuvenated by starting a new cycle or remains as a permanent agricultural system called agroforest.

In spite of its suitability to forest environments, slash-and-burn agriculture is rarely practiced alone. Most farmers combine it with other land uses like home gardens, irrigated fields, or permanent fields of perennial crops. Slash-and-burn farmers also typically practice hunting, gathering, and fishing, activities whose importance is proportional to remaining forest cover.

Economic Rationality

Slash-and-burn agriculture is practiced all over the world in forest land with wet climates and low population density. This is not a coincidence. It is often the most rational land use in these conditions, and it can be maintained in spite of population growth as long as forest land remains, through extensification.

When population density is low, land is abundant while labor is usually a strong limiting factor to put more land into production. Like other economic agents, slash-and-burn agriculture farmers search for the maximization of output for a given level of input of the scarce resource, labor in their case. Slash-and-burn agriculture enables maximizing labor productivity for three main reasons: First, slash-and-burn agriculture with long fallow

does not require much work once the crops have been sown. Clearing the forest requires heavy work but is done by men, who do not have to carry significant domestic tasks, and is not constrained by tight deadline as it is done off season, during the dry period. Once the biomass has been burnt, crops are typically sown by men and women, the latter being often in charge of most maintenance operations until harvest, at least in African countries. Slash-and-burn agriculture with long fallows limits weed invasion because weeds typically grow less abundantly in primary or old secondary forests. This is probably the main advantage of the system and the main cause of its high labor productivity. This advantage is progressively lost with the reduction of the fallow period. The reason for abandoning the field after a few years of cultivation is often weed invasion, rather than or as well as decreasing soil chemical fertility. Weeds may thus be the key constraint to adopting permanent cultivation, because of the labor required for weeding.

Second, slash-and-burn agriculture does not imply plowing the land, an operation that requires a lot of work if done manually. Crop roots do not need to penetrate deep into the soil as nutrients are concentrated close to the surface after the burning. Plowing would anyway be impossible or excessively burdensome because of the dense root mat and the many stumps that cover the soil.

Third, even though yield (output per acre) maximization is not the purpose, slash-and-burn systems usually have quite high yield at least when practiced with long fallow. Fertility depends on the amount of biomass that can be burnt, as much as on the soil's chemical properties. Even soils reputed to be infertile like ferralsols can yield high if a long fallow can be practiced.

The Limits of the System

Slash-and-burn agriculture is generally regarded as a sustainable land use when long fallow can be practiced, that is, when the initial fertility can be reconstituted after the cultivation cycle. This is generally possible with a population density below 35 inhabitants per square kilometer (Mazoyer and Roudart 2006), although it greatly depends on ecological conditions. When population density increases, which can be caused by high birth rate and/or migration, the fallow period typically decreases. Fewer nutrients accumulate in the biomass and are returned to the soil in the form of ash. With a very short fallow (1–3 years), the vegetation is dominated by herbaceous plants whose roots do not penetrate deep into the soil. This root mat can slow down leaching by capturing nutrients, but it does not bring additional nutrients to the soil, as do trees whose roots access the bedrock where mineralization occurs. A shorter fallow period also favors weed invasion, pests, and diseases. The addition of these effects can trigger a fertility and/or a labor crisis. Yield per acre decreases, while labor requirement to cultivate the same surface increases. Beyond a certain threshold, the system cannot be sustained. It does not produce enough food to provide the caloric intake required for the work of the next growing season, unless technical changes occur. The system must evolve. New techniques and strategies are thus required, and created or adopted, to escape the dead end.

The Evolution of Slash-and-Burn Agriculture Systems

Slash-and-burn agriculture is probably one of the oldest agricultural land uses. It has been practiced worldwide, from the tropics to temperate regions, and is still practiced widely in the tropics. But in many regions, it has been abandoned, sometimes for centuries or millennia, and alternative land uses developed (Boserup 1965; Angelsen and Kaimowitz 2001; Brookfield 2001; Mazoyer and Roudart 2006; Cairns 2007). Looking at history and ongoing changes enables us to anticipate future land-use changes in areas where slash-and-burn agriculture is still practiced.

Two main strategies are adopted by farmers when they face the limits of slash-and-burn systems. They combine slash-and-burn agriculture with other land uses and activities, and they progressively transform the slash-and-burn system itself. They usually combine these two strategies, which we will detail separately here.

The Combination of Slash-and-Burn Agriculture with Other Land Uses and Activities

Slash-and-burn systems provide staple plus a broad range of other products. But they are often practiced alongside other land uses and activities, even in the absence of crisis. Fruit trees are frequently planted in proximity to dwellings, while permanent gardens of vegetable and sometimes staple crops are established on the most fertile soils. Slash-and-burn farmers typically practice hunting, fishing, and gathering and raise animals. Livestock substitutes to wild animals when hunting success is low, that is, when higher population density increases. Women (or, in some groups, men) make and sell various crafts like baskets or woven mats, an activity that requires a lot of work but not a lot of energy as it is done at home. The search for seasonal jobs and temporary or permanent outmigration are also common practices. When the fallow period reduces and slash-and-burn agricultural fields do not produce enough, all these activities, except hunting, fishing, and gathering who decrease when forest resources decline, can become the most important sources of food and income.

A frequent pattern is that when the crisis occurs, farmers move down to cultivate bottom land. Slash-and-burn agriculture is mostly practiced on hillsides because this type of land drains better, which is an asset in wet climates. Bottom land, to the contrary, is often avoided because of flooding risk and heavy wet soils. But when erosion occurs, nutrients are lost on slopes and accumulate on bottom land, which becomes increasingly attractive. To cultivate bottom land typically requires heavy labor investment, though, in order to drain the excess water or to irrigate the land, in order to escape dependence on rain and avoid flooding risk. But cultivation can then be done during the dry season, which spreads the labor burden more evenly over the year.

A second frequent pattern, which often combines with the first, is the establishment of perennial crops on eroded slopes not suitable anymore for slash-and-burn agriculture. Perennial crops are often cash crops like cocoa, coffee, palm oil trees, rubber trees, cloves, and cinnamon. This strategy is often associated with the development of infrastructure and better connection to markets.

The Progressive Transformation of Slash-and-Burn Agriculture Systems

Alongside this diversification, reduced fallow periods can trigger, or contribute to trigger, a deep transformation of the slash-and-burn systems themselves. Under a certain threshold, the fallow is too short to enable the development of woody perennials. The stumps of large trees rot progressively, and the root mat becomes less dense. Hence it becomes possible to practice paring and burning and/or to plow the land. When this situation occurs, plowing tools are usually already known, because plowing is practiced in neighbor villages with higher population density, or in one of the systems that farmers practiced already alongside slash-and-burn agriculture.

Plowing enables extirpating the roots of the most invasive remaining perennials. This cleaning of the underground through plowing constitutes, after clearing, a “second step” in the long-term process of preparing land for permanent, intensive cultivation. The field is then cleansed from both aerial biomass, which is eliminated through slashing and burning, and soil woody biomass, eliminated through short fallow and plowing. After the colonization of the forest frontier, a “second frontier,” the soil, has been opened and is ready to be exploited at greater depth, which compensates for the lower nutrient level produced by burning a short fallow. Typically, farmers then adopt a more complex and longer crop rotation. They often plant cereals, followed by or associated with legumes, followed by tubers, before leaving the plot into a short fallow dominated by grasses and other herbaceous plants. In certain condition, however (fragile soils, steep slopes, heavy rain), plowing requires improvements like terracing in order to be practiced.

As intensification proceeds, new strategies to maintain soil fertility need to be adopted. In slash-and-burn systems, nutrients are brought to the plot by fallow vegetation, which pumps them deep into the soil. They are made available to the crops in the form of ash, through burning. With short herbaceous fallow or no fallow, this nutrient supply is lost. At first, a more efficient nutrient management (crop rotation, plowing, paring and burning, zero burning) can suffice to maintain decent yield. But in the long term, a new source of nutrients needs to be provided. Typically, farmers develop animal husbandry, taking advantages of the new grazing resources of short fallow dominated by grasses, and start to use animal manure. At first, they observe that crops yield more when cultivated in a coral so they rotate corrals and fields. But with increasing pressure on land and nutrient need, they start to actively manage manure by collecting it in corrals and transporting it to fields. If animals graze in fields, this represents an improved nutrient management but not a significant net gain since nutrients are taken from grass growing on the same land as the crops. If they graze in uncultivated pastures, this represents a net gain through horizontal transfer of nutrients by animals from pastures to agricultural land, in the form of manure, which replaces the vertical transfer by fallow trees, in the form of ash Mazoyer and Roudart 2006.

Constraints to the Evolution of the System

The evolution of farming systems outlined above has been observed, with very similar patterns, in many regions of the world. It is encouraged by necessity when population density increases. But it does not automatically occur as it also faces strong constraints.

One key constraint is the low investment capacity of slash-and-burn farmers. The practice of slash-and-burn agriculture relies on bestowed natural capital. It simply requires an ax and a machete and generates a high output for a relatively low labor input, at least when long fallow can be practiced and when hunting and gathering contribute to food security. Other land uses require more efforts, to plow the land, eliminate the weeds, and proceed to land improvements. As long as they are practiced with a hoe and other manual tools, they typically require more work for the same output. More efficient tools need to be adopted (such as a plow, a cart, and a pair of oxen to produce manure and pull these tools), or significantly higher yields need to be obtained (through the use of chemical fertilizers, pesticides, and herbicides) to render the new systems more labor efficient. The acquisition of such equipment or inputs, that is, the substitution of a human-made productive capital for the natural capital, is probably the main constraint to phasing out slash-and-burn agriculture. It is rendered difficult by the fact that slash-and-burn agriculture is often practiced in remote areas with limited connection to market and few income generation opportunities to farmers, although this is not a rule. There are many cases where slash-and-burn agriculture has been abandoned without adopting animal draft or chemical inputs, but farmer communities in this situation are usually very poor and food insecure.

The development of perennial crops, however, is an exception to this general pattern. When perennial cash crops are available and can be sold a good price, they can sustain a family with limited labor input and using a relatively small surface. As long as land is not an overly scarce resource, perennial crops can be associated with indigenous species that provide a broad range of goods and services and render the system more resilient to ecological stresses and economic shocks. Such systems, called agroforests, are developed progressively out of slash-and-burn systems and do not need significant investments. But when land becomes scarce, they tend to be abandoned in favor of more intensively managed plantations that face the investment constraints described above.

A second important constraint is the risk factor. The development of new systems creates new risks and requires the production and mastering of new knowledge in order to reduce these risks. This explains the preference of farmers to diversification rather than specialization, and for a progressive transition during which both slash-and-burn agriculture and the new system are practiced, rather than large investments and elimination of their traditional land uses.

A third important constraint is the discount rate. When slash-and-burn systems are in a situation of crisis, food security is usually hardly achieved. In this context, investing labor for late reward is not an easy option, which often explains the reluctance to adopt conservation farming techniques.

Environmental Impact

The environmental impact of slash-and-burn agriculture is a very controversial issue, biased by political positions on both sides of the debate. Slash-and-burn agriculture requires clearing primary forest and leaving a secondary forest growing before clearing it for repeating the cycle. This clearing of forests is often criminalized by states and receive strong opposition and critique from organizations committed to biodiversity conservation, while the mosaic of primary and secondary forests that is typical of slash-and-burn agriculture landscapes is praised by social scientists and activists having sympathy for community or "traditional" ways of life.

If one escapes this political ground, the reality is in fact quite simple. Slash-and-burn farmers clear primary forests, just like any other farmers willing to grow staple crops that demand sunlight. They clear more areas to obtain a given output than farmers practicing more intensive systems, but they do not clear the land permanently. For a given population with a given level of needs, slash-and-burn agriculture landscapes may have less primary forests and more secondary forests than more intensively cultivated ones. The environmental impact of each system, for a given output (*ceteris paribus*), thus depends on the value given to primary versus secondary forests. If biodiversity is to be conserved, it would be more rationale to cultivate less land, permanently, by adopting more intensive systems: the so-called "land-sparing" model. Primary forests are indeed mosaics of primary and secondary vegetation. They are pieces of land at various stages of vegetation development, because secondary succession occurs after the death and fall of large trees, so both early and late successional species would be conserved. Young secondary forests like those found in slash-and-burn agriculture landscapes, on the other hand, lack large stands of late successional species, because the complete secondary succession typically lasts a century or more in tropical forests.

The reality is quite simple, but not that simple, however, which puts into question the land-sparing model. The *ceteris paribus* clause makes sense if the purpose is to outline specific processes in a closed system, which is only the first step of understanding realities, which are open systems. Variables cannot be isolated from each other in the real world, meaning that at some point, the *ceteris paribus* clause needs to be abandoned if science is to inform policy makers (Pollini 2007).

In other words, the evolution from slash-and-burn agriculture to alternative systems is not simply a change from using more land to using less land for the same output. Other changes can occur, like an increase in farmers' needs and total output. Once investments are done and the labor productivity bottleneck mentioned above disappears, output per household can be doubled or more, and benefits can be reinvested in the expansion of cultivated land. The formerly slash-and-burn agriculture landscape then becomes suddenly attractive. Outmigration decreases, while immigration increases, sometimes with the support of government incentives, and the forest frontier is pushed forward. The poorest farmers, who do not have sufficient resources to follow this path, are often outcompeted by the most economically favored segments of the population. Poor farmers become socially marginalized and move to the first line of the frontier where they continue practicing slash-and-burn agriculture with long fallows, which perpetuates the blame put on this land use, whereas the whole process was triggered by the combined effects of increasing cultivated area per farm and attracting more farmers, two frequent corollaries of intensification. In the worst case, the development of infrastructure attracts large-scale international investors who establish plantations to satisfy a virtually infinite global demand, like palm oil plantations established for biofuel production.

In sum, the transition from slash-and-burn agriculture to alternative land uses is part of an historical process that has multiple facets and is to be considered holistically if social and environmental improvements are to be achieved. Within this broader framework, slash-and-burn agriculture can be a cause of as well as a buffer against deforestation. Moreover, beyond the issue of deforestation, it must also be pointed out that slash-and-burn cultivation in self-sufficient societies does not require a single drop of fossil fuel to be sustained, contrary to most of its so-called alternatives.

Policies

In most regions of the world where slash-and-burn agriculture is practiced, it is targeted by policy makers who aim to eliminate this practice, because of blames and prejudices regarding its environmental impact (Fairhead and Leach 1998), because of willingness to allocate forest land to other land uses and stakeholders, and because of ignorance about the context within which farmers cut trees. The domains of ignorance that characterize policy making are briefly reviewed here.

First, the proposed alternative land uses are usually designed based on the assumption that yield per acre matters, because obtaining high yield is the goal of most agronomists and extension agents working in agricultural projects. This is what they have been trained to do. The labor and investment bottlenecks and the risk and discount rate factors evoked above are usually overlooked, which leads to non-adoption of the proposed techniques, except for local elites, quite often foreigners or recent migrants, who already have some investment capacity. "Support" to slash-and-burn farmers then can favor a social differentiation or resource capture that contributes to the marginalization of slash-and-burn agriculture farmers and the persistence of their dependence on tapping natural resources, while the "successful" farmers who adopt intensive techniques invest their income in land acquisition and encourage further forest clearing.

A second frequent mistake, or at least a counterproductive approach, is that the techniques being proposed are framed within a sustainability paradigm that assumes that resource stocks should be kept constant. It is argued, for instance, that forest biomass and the nutrient content of soils should not be reduced. This is at odd with the logic adopted by most economic agents, including smallholder farmers, who are committed to substituting resources once they are depleted, rather than maintaining their stock constant. If the shift to a new resource (B) can be achieved before the previous resource (A) is completely depleted, then the crisis can be avoided. Once resource B is adopted, resource A is relieved from pressure and can recover. This is what happens, for instance, in cases of forest transitions. If they adopted a more flexible conception of sustainability, conservation and sustainable development organizations could provide support that help farmers to shift to resource B before resource A is completely depleted. Moreover, if it was accepted that the stock of resource A does not need to stay constant, then tapping into this stock could generate the means to build resource B. Nobody knows how long a given resource can last, and certainly no resource can last forever, but within policy time frames, this point should be taken into consideration.

To illustrate this with a practical example, resource A can be land on hillsides where slash-and-burn agriculture is typically practiced. Resource B can be bottom land. Farmers often shift from hillsides to bottom land when slash-and-burn agriculture is in a situation of crisis because of short fallows. The depletion of resource A (nutrient losses through erosion) contributes to the building of resource B through the accumulation of nutrients in bottom land. If projects attempt by all means to maintain farming activities on hillsides, by designing new systems like contour lines, improved fallow, or other technologies that farmers do not adopt because of labor, investment, risk, and/or discount rate issues, then innovation and investment opportunities can be lost, and the transition to bottom land cultivation can be hampered. If support is allocated to improving bottom land instead, by realizing investments that farmers were already envisioning (terracing, irrigation schemes, supply of equipment like animal draft, development of livestock husbandry), then the transition can accelerate. With higher support to bottom land cultivation, the shift to new land uses will be faster, and more resources will remain on slopes in the end. Land will not be degraded to the point that vegetation cannot recover, and forest fragments will remain from where the original ecosystem will be able to recolonize space. In a false paradox, hillside vegetation would recover better if nobody cared about it and supported denaturalizing further the bottom land instead.

Third, fallow land in slash-and-burn system is often considered idle land by policy makers, as reflected in the misguiding term shifting cultivation. Fields do not exactly shift in “shifting” (slash-and-burn) agricultural systems. They are permanently established but alternate periods of cropping with periods of fallowing, with fuzzy boundaries between the two. Fallow land is often actively managed, through enrichment with useful trees and care of remaining cultivated perennials. It is typically managed by the same individual families who grow the crops, unless it remains uncultivated beyond the typical fallow period, in which case the plot can be reintroduced into community land. Overlooking this fact, policy makers are tempted to deny the right of slash-and-burn farmers over fallow land, which is conducive to misguided policies that further marginalize them.

How, then, should slash-and-burn agriculture be addressed by policy makers? First, it should not be criminalized or blamed and should not even be considered as a land use which, comparatively with others, deforests more land. There is quite a broad agreement that large-scale deforestation is mostly triggered by commodity booms and large-scale agribusiness investments on forest frontiers, from the development of cattle ranching and soybean cultivation in the Amazon to palm oil production in Southeast Asia. In this context, securing the rights of local farmers practicing slash-and-burn agriculture could be a buffer against large-scale deforestation, like is securing the rights of hunting and gathering groups. Second, the transition to more intensive land uses could be favored by increasing the range of land-use options available to smallholder farmers, from access to new tools and inputs to the so-called ecological intensification. The latter has the great advantage of relying on human labor and natural capital rather than financial investments and further artificialization of the environment. But it remains doubtful whether it could maintain a satisfactory level of labor productivity, and hence a satisfactory livelihood, unless high-value products can be sold and/or fair trade markets can be captured. Smallholder farmers can be more easily seduced by productivity leaps permitted by animal draft and the use of chemical inputs than by ecological intensification. They are willing to buy more goods, send their children to good schools, access healthcare, reach middle-class livelihood, and enter into “modernity” like other citizens. There is a risk that an excessive emphasis on ecological intensification leads to denying them the right to engage more conventional, straightforward pathway to “development,” and one has to be cautious about this pitfall.

Summary

Slash-and-burn agriculture is a land use that represents an early step in agricultural history. It is practiced in locations where forest resources are still abundant. It typically implies the conversion of primary forests into a mosaic of secondary forests at various stages of development, but not the definitive elimination of forest. Primary forest clearing occurs progressively, though, as a way to maintain the same fallow period in spite of

population growth. When no primary forest remains (or when the remaining primary forests are all protected, by local customs or conservation policies), the fallow period reduces, secondary forests eventually disappear too, and new techniques emerge or are adopted. The natural capital is progressively replaced by man-made productive capital, or the system enters into a crisis, depending on whether the constraints to these changes can be levered. In theory, the new land uses that emerge enable preserving more forest, because they require the use of less land for producing the same output. In practice, they trigger or are accompanied by a series of more radical changes like the development of infrastructure, migrations, financial investments, and new consumption patterns, which typically provoke larger-scale deforestation.

In spite of this, slash-and-burn agriculture continues to be blamed for being the main cause of deforestation. Shortsighted policy makers fail to contextualize the act of cutting trees and are biased by modernization myths that see slash-and-burn agriculture as a primitive land use. Slash-and-burn agriculture is a primeval land use in the sense that it preceded others in many regions of the world. But no value judgment should be attached to this statement. At a time of increasing doubts about mainstream development pathways, slash-and-burn agriculture should be seen as an opportunity not to fall into productivist, unsustainable models. But this is not to say that slash-and-burn farmers should remain trapped with this "primeval" land use. They have the right to evolve and change, as did other societies before. In our globalized society, they should be given access to the same range of economic and technical options that are made available to other farmers.

In between the quest for sustainability and attempts to escape from poverty, smallholder farmers practicing slash-and-burn agriculture must be paid a great attention as they will continue to be key targets of conservation and development programs. If proper decisions are to be taken, that is, if they are to be given the possibility to control their future and increase their production while generating public goods, they will have to be listened to, away from prejudiced views that criminalize or idealize their choices, depending on which political agenda frames the debate.

Cross-References

- ▶ Biodiversity
- ▶ Brazilian Agriculture
- ▶ Conservation Agriculture: Farmer Adoption and Policy Issues
- ▶ Economy of Agriculture and Food
- ▶ Food Security in Systemic Context
- ▶ Political Agronomy
- ▶ Resource Conflict, Food, and Agriculture
- ▶ Sub-Saharan African Agriculture

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Slow Food

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Introduction

Slow food is a recent food movement. Unlike other food movements, however, such as the campaigns to "eat organic" or "eat local," slow food is closely associated with and influenced by the programs and policies of an international organization which is itself called "Slow Food" founded in Europe in 1989 (Irving 2008; Malatesta et al. 2006). One need not, however, be an official member of Slow Food to follow the movement's ethos. Slow food is primarily a rejection of fast food and fast-food culture, and its followers claim that food that is "slow," that is, food that is carefully prepared using minimally processed ingredients according to time-honored cultural traditions, is superior in taste and quality to the highly processed, generic, and standardized fare that typifies much of the fast and processed food industries. Adherents of slow food also maintain that food is more properly enjoyed when it is consumed at a leisurely rate in the company of others, as opposed to the frenetic and solitary eating that is motivated by fast-food culture.

Since its inception, slow food has inspired similar movements beyond the purview of food, and its core principles have been applied to things such as local economies and urban planning (Parkins and Craig 2006). So, for example, proponents of Slow Cities (*Cittaslow*) encourage the implementation of measures that would promote "slow living," restrictions on vehicular traffic, improved park systems, etc.

As for slow food, its followers are particularly concerned with the quality of food, slow vs. fast, but they also express interest in other issues related to food, in particular, environmental factors related to food production and worker rights.

This wider array of concern is especially evident in the organization Slow Food which in its platform promotes food that it describes as "good, clean, and fair" (Malatesta et al. 2006; Petrini 2005). While the movement itself offers no explicit philosophical or ethical foundation for its various practices, parallels can be drawn between its position regarding food and food consumption and the ethical theories defended by figures such as David Hume, Epicurus, and Aristotle. The movement, however, has also been subject to a variety of criticisms and has been accused, among other things, of being elitist and anti-environmentalist.

Philosophy and ***Ethics***. Identifying a complete and coherent set of ethical principles underlying slow food is difficult insofar as there are informal followers of the movement and an official organization, all of whom do not necessarily defend or place an emphasis on the same set of values. Insofar as the organization plays an influential role in guiding the philosophy and practices of slow food, attention will be focused in what follows on the ethical motifs underlying Slow Food.

According to its mission, Slow Food defends three central values in relation to food, maintaining that it should be "good," "clean," and "fair." "Good" refers to food's quality, its flavor and taste. "Clean" food is food that is produced using sustainable farming and production practices that do not cause unnecessary harm to the environment. "Fair" food is food that reflects a commitment to social justice and to fair compensation for farmers and food producers.

Good food. Slow Food's concern with what they understand as "good" food has been dominant in the movement from its very beginning. As its name implies, Slow Food perceives itself as a response to "fast food" and "fast-food" culture. For the founders of Slow Food, the problem with "fast food" and the "fast life" within which it is consumed is not necessarily the speed with which food is produced per se (i.e., there can be "good" fast food in their sense) but its standardization and homogenization, features of food that, they believe, mark much of contemporary food culture and industry. Food in a "fast-food" society is, they argue, transformed from something to be enjoyed and savored in the company of others to something that merely serves to sustain us physically while eaten quickly on the go. Moreover, the rise of industrial and global agriculture they maintain has been accompanied by a concomitant fall in the diversity of food as food varieties and local food traditions vanish in the face of things such as monoculture and corporatization.

For defenders of slow food, fast food thus prevents people from experiencing true pleasure in their food. They view fast food as basically bland and tasteless, highly processed and standardized fare, produced with quantity in mind over quality, lacking any real connection to a particular culture or place, designed to be eaten quickly and mindlessly. Recovering true gastronomic pleasure, they believe, can be achieved by pursuing food that is, in Slow Food's terms, "good."

"Good" food, according to Slow Food, is food that is produced with quality in mind, food that is delicious, distinctive, and flavorful. Proponents of Slow Food recognize that taste in food is subjective and that different individuals will ultimately find enjoyment in different foods and flavors, but they contend that, in general, certain food and food products can be identified as "good" (Petrini 2005). These would be foods that produce pleasant taste sensations and are, generally, as "natural" as possible, respecting the product's original characteristics. Such criteria, they contend, rule out much "fast" or industrialized food insofar as it is often flavorless and highly processed.

Slow Food's contention that judgments about "good" food can be made despite the subjective nature of taste recalls the position on aesthetic judgment defended by David Hume (1963). For his part, Hume also acknowledges that, when it comes to matters of taste, there exists a variety of opinion as to what different individuals and different cultures deem to be beautiful or good. This leads him to recognize the distinction between objective matters of fact and subjective feelings or sentiments about objects, where beauty, it would seem, is entirely in "the eye of the beholder." Nevertheless, Hume maintains that general standards in regard to aesthetic taste can be defended, that we can justifiably deem some things to be superior to others, and that we make these kinds of aesthetic judgments all the time.

This ability to pass aesthetic judgment, Hume argues, is made possible insofar as all humans as humans share a "universal structure" that typically leads them to be pleased by certain experiences and displeased by others. This does not mean that everyone will always appreciate the same things. The proper appreciation of an art object, according to Hume, requires certain conditions, e.g., serenity and attentiveness, but it also requires, in his estimation, the possession of "delicacy" or "sensitivity," the ability to discern or recognize the aesthetic traits or features in a given object. Such aesthetic sensitivity, Hume argues, can be developed in individuals by training and practice. Repeated exposure to a variety of artworks, he contends, can help individuals gain the sensitivity required for a discerning taste.

Following Hume, some sense can be made then of Slow Food's defense of "good" food. While acknowledging the fact that not everyone is going to be drawn to certain tastes and flavors, followers of Slow Food maintain that we can nevertheless judge certain foods to be "good" or superior to others, e.g., artisanal cheeses over processed cheese food. Recognizing such superiority, however, requires a certain amount of discernment, and the focus on taste education in Slow Food, the "Taste Workshops" it conducts with both children and adults, can be understood in these terms, as an attempt, not only to acquaint individuals with different foods and a variety of flavors but to provide them with the training and experience by which they can identify "good" foodstuffs.

While "good" primarily refers, in Slow Food's analysis, to the quality, taste and flavor of food, the movement also emphasizes the settings in which food is prepared and consumed. Thus, defenders of Slow Food not only deride the quality of "fast food" but the ways in which such food is designed to be eaten, mindlessly, quickly and, often, in isolation from others. Thus, along with the pleasure of "good" food, slow food stresses the pleasure of conviviality or commensality, the joy of sharing food in leisurely company with others. Local chapters of Slow Food are called "convivia" (from the Latin for "feast" or "banquet") for this very reason.

In upholding the enjoyment and pleasure of "good" food, defenders of Slow Food seek to counter the asceticism that, they believe, characterizes both much of Christian society and traditional leftist politics, wherein the pleasures of eating are often derided for being either sinful or bourgeois (Petrini 2001, 2005). The approach to pleasure embodied in Slow Food hearkens back to the hedonic philosophies put forth in ancient Greek thought and, in particular, the position defended by Epicurus and the Epicureans. For Epicurus, happiness, understood as pleasure, represents the ultimate and highest intrinsic good in life, and so, he argues, we should strive to experience as much pleasure in life as is possible (Epicurus 1964). In promoting the pursuit of pleasure, however, Epicurus does not advocate profligacy or base hedonism, arguing that indulging in too many physical pleasures will ultimately result in excessive pain. Rather, Epicurus maintains that the "good life" is ultimately a life of tranquility, attained by pursuing simple and modest pleasures, including those of good food and friendship.

Proponents of Slow Food construe of pleasure and the pursuit of pleasure in terms similar to those found in Epicurean thought. The pleasures of food and company are extolled as central features of the "good life." Such pleasure, however, should not be pursued to excess. Borrowing a notion from the Renaissance humanist Bartolomeo Scappi, figures in Slow Food like to speak of "*honesta voluptate*" or "sober pleasure" (Petrini 2009). This is a pleasure that, in contrast with gluttony, is aware of its limits and is pursued in moderation.

Parallels can also be drawn between the vision of the "good life" put forth in Slow Food and that defended by Aristotle's virtue ethics (Aristotle 1999). Like Epicurus, Aristotle maintains that happiness or eudaimonia is the end of life. For his part, Aristotle argues that such fulfillment can be attained by practicing the virtues, habitual traits of character, that, avoiding excess and deficiency, adhere to the "golden mean." As does Epicurus, Aristotle rejects a life of pure hedonism which he likens to a life for "grazing animals" (Aristotle 1999). Nevertheless, Aristotle does not advocate asceticism, maintaining that physical pleasure is a critical ingredient of the "good life." Such pleasure, however, must be pursued in moderation and the relevant Aristotelian virtue as regards the pleasure of food is temperance. Likewise, Aristotle also maintains that friendship is a central feature of the good life.

In promoting the value of pleasure, Slow Food nevertheless seeks to counter the elitism and gourmandism that they believe marks that tradition, arguing that "the right to pleasure" is one that is universally shared and open to everyone (Petrini 2009). Despite their reference to the notion of "rights," however, Slow Food does not appear to have any fully developed sense of political rights, and at best, the "right to pleasure" can be understood as a right in the negative sense. When alluding to rights, Slow Food seems to conceive of them more in terms of consumer rights, as opposed to civil rights, and this may explain the organization's reluctance to engage in and seek substantial political and economic reform.

Clean food. As Slow Food has evolved, its concerns have broadened such that its initial focus on good food and gastronomic pleasure is now accompanied by an interest in the environment and environmental issues. So, along with "good" food, Slow Food promotes food that it defines as "clean" (Petrini 2005). This is food that is produced and grown sustainably, in ways that protect and respect the environment, and is prepared in ways in which processing is as limited as possible. For defenders of Slow Food, there is a close connection between "good" and "clean" food as food that is "clean" often tastes better.

In the estimation of Slow Food, judging whether food is "clean" requires scientific expertise, but they generally believe that the use of chemical pesticides and fertilizers should be avoided, that intensive, highly industrialized modes of agriculture should give way to traditional farming practices and techniques, and that local plant varieties and breeds should be given preference over monocultures and standardized varieties and breeds. Slow Food also opposes the use of genetically modified organisms. Slow Food is not opposed to the transportation of food but argues that the environmental implications of food transport should be kept in mind when determining whether food is "clean" or not.

In combining their interest in the flavor of food with its environmental impact, Slow Food likes to describe their culinary philosophy as "eco-gastronomy," a pursuit of gastronomic pleasure that is informed by environmental awareness (Petrini 2005). Given the principles of "eco-gastronomy," the follower of Slow Food is not necessarily going to limit themselves to eating organic food or practicing locavorism. While organic food may be "clean," it may not be "good," and it is not clear, according to Slow Food, that food must be organic to be "clean." When it comes to locavorism, Slow Food does promote local food varieties and traditions as evidenced by its Ark of Taste and Presidia programs (Irving 2008; Malatesta et al. 2006). However, Slow Food's interest in local foods is not motivated by concerns regarding "food miles" or the environmental impact of transporting food great distances but by the impact that the loss of local foods, due to homogenization and standardization, has on gustatory pleasure. In fact, many of Slow Food's projects and initiatives involve seeking broader, international markets for local products.

In discussing Slow Food's notion of "clean" food, it is perhaps appropriate to point out that the organization has little to next to nothing to say about issues concerning animal rights or animal welfare. While Slow Food espouses a universal "right to pleasure," this right is not understood as extending to nonhuman animals. And while Slow Food may be critical of certain practices in regard to animal husbandry, factory farming, CAFO's, etc., their concerns are more a product of the quality of such foods, their "goodness" in their terms, than they are response to any animal pain or suffering they may cause.

Fair food. As with "clean" food, Slow Food's defense of "fair" food has evolved over time as the movement has grown. According to Slow Food, "fair" food is that involves equitable and proper remuneration for farmers, farm workers, and food producers (Petrini 2005). In this regard, Slow Food's interest in "fair" food parallels the recent fair-trade movement. When discussing "fair" food, leaders of Slow Food often refer to what they call "virtuous globalization" (Petrini 2009). As noted above in reference to locavorism, Slow Food is not, in principle, opposed to the transport of food over long distances and welcomes globalized food markets. It is critical not of globalization itself but of tendencies in globalization toward standardization and homogenization.

The Slow Food movement is not inherently anti-capitalist and much of its work focuses on securing markets for what it believes are high-quality foodstuffs. It believes it can achieve this by, on the one hand, educating consumers and raising awareness in them, through programs such as "Taste Workshops" and food fairs, about "good" food and, on the other hand, by forming cooperative networks among small-scale producers. In its activities, Slow Food eschews tactics such as boycotts and direct action as utilized by groups like José Bové's Confédération Paysanne.

In summary, the ideal eater for Slow Food is someone who possesses a series of virtues. They appreciate good food in moderation while at the same time being cognizant of the impact that their food choices have on the environment and, guided by a sense of justice, respect the rights of those involved in food production.

Criticisms. This somewhat eclectic collection of values and virtues has led some to criticize Slow Food of being guilty of certain contradictions (Chrzan 2004; Donati 2005; Gaytán 2004; Jones et al 2003; Labelle 2004; Laudan 2001; Lotti 2010). Some critics argue, for example, that there is a conflict between Slow Food's promotion of "good" food and its concern for "clean" food insofar as raising the demand for certain products is environmentally unsustainable. Similarly, some critics maintain that while Slow Food avows that pleasure is a universal right and that food should be "fair," the movement's reluctance to demand substantial political and economic reform opens the group up to charges of elitism, especially insofar as the typically expensive foodstuffs it seeks to promote remain beyond the reach of many consumers. It would appear that the future success of Slow Food depends on its ability to respond to these criticisms and articulate a coherent, ethical vision.

Cross-References

▶ Epicureanism and Food
▶ Virtue Theory, Food, and Agriculture

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Sub-Saharan African Agriculture

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Synonyms

Africa; Agriculture

Introduction

Agriculture employs two-thirds of Sub-Saharan Africa's (SSA) workforce and a majority of the continent's poor (IFPRI 2004). As a result, agricultural productivity growth offers a singularly powerful lever for raising incomes and reducing poverty across the continent (Thirtle et al. 2003; de Janvry and Sadoulet 2010; Christiaensen et al. 2010). Recent estimates from Kenya and Rwanda, for example, indicate that a 1 % increase in national income coming from the agricultural sector leads to three to four times as much poverty reduction as comparable income gains in nonagricultural sectors of the economy (Diao et al. 2012).

Agricultural growth is, likewise, a key driver of economic growth and structural transformation. Because agriculture accounts for 25 % of Sub-Saharan Africa's gross domestic product, and up to 50 % in poor countries, productivity gains in agriculture translate directly into broad-based per capita income gains (IFPRI 2004; Diao et al. 2012). Over the long run, improved agricultural technology, agronomic practices, and marketing systems will enable a minority of well-managed smallholder farms to transition into high-value commercial agriculture. In contrast, the majority of today's smallholder farmers will follow an alternate pathway, as elsewhere, gradually exiting agriculture in favor of nonfarm occupations. But in Africa, as in other settings before, this exit will require prior broad-based agricultural productivity growth on small family farms (Lipton 2005). Even the continent's many noncommercial, primarily subsistence farmers require early, sustained productivity gains in agriculture so they can free their children from farm labor obligations, generate the surpluses necessary to send them to school, and help them transition into successful nonfarm career trajectories over the next generation (Chapoto et al. 2013).

Sub-Saharan African Agriculture, Table 1 Productivity differentials across regions

	Sub-Saharan Africa	Developing Asia	Latin America
Value of agricultural production (US$)			
Per agricultural worker	315	457	3,018
Per hectare	140	1,111	381
Cereal yields (tons/ha)	1.4	3.1	3.9

Source: FAOSTAT (http://faostat.fao.org/site/339/default.aspx)

Despite the importance of agricultural growth to African economies and to the welfare trajectories of its people, farm productivity remains generally low in SSA. Labor productivity, as measured by the value of agricultural output per worker, stands at roughly two-thirds of the level prevailing in developing Asia. Land productivity, as measured by cereal yields, lies closer to one-half of the levels attained in Asia and Latin America (Table 1).

Why has African agriculture underperformed? In part, Africa's historical land abundance has allowed African governments to underinvest in agricultural research, extension, and other key drivers of agricultural productivity growth. For many decades, African leaders have spent half as much (per $100 of agricultural output) as Asian countries on the core public goods that drive agricultural growth – rural roads, irrigation systems, agricultural research, and extension (World Bank 2007). Donors have, likewise, contributed to low agricultural spending, cutting aid flows for African agriculture in half, from over US$2 billion to around $US1 billion per year between the mid-1980s and the early 2000s (GAO 2008).

Recent world events have restored interest in Africa's agricultural potential. Back-to-back world food crises – in 2008 and 2011 – have focused the attention of African leaders, donors, and outside investors on the considerable potential and importance of Africa farming. Food riots from West Africa to Mozambique have reminded African political leaders that food security remains critical for political stability, lending new urgency the African leaders' Maputo commitment of 2003 to increase their budget allocations for agriculture from 6 % to 10 % of total spending as part of the AU's Comprehensive Africa Agricultural Development Programme (CAADP) (AU/NEPAD 2003; Fan et al. 2008). Donors have likewise placed agricultural growth at the top of the aid agenda. After two decades of neglect, when global aid for African agriculture fell roughly in half, the 2009 Group of Eight (G-8) meeting in L'Aquila, Italy, committed $20 billion over 3 years for agricultural development and related efforts to reduce world hunger (G-8 2009; G-20 2010). Private investors have also piled onto the bandwagon. In 2009, large agribusiness investors laid claims to nearly 40 million hectares of African farmland, greater than the agricultural land of Belgium, Denmark, France, Germany, the Netherlands, and Switzerland combined (Deininger and Byerlee 2012). Highly publicized large-scale land investments in Africa by institutional investors have focused world attention on Africa's considerable unexploited agricultural potential and on the ethical issues involved in allocating these valuable resources among domestic and international constituencies.

As policy attention returns to focus on African agriculture, this entry aims to explore key opportunities and key challenges facing African farmers and policy makers. The entry begins by highlighting two key opportunities that will likely drive future interest and investments in Africa's agricultural and food system growth. Discussion then turns to a series of structural and ethical challenges that policy makers and stakeholders will need to address in order to realize Africa's considerable yet under-exploited agricultural potential.

Seizing Opportunities

Growing Urban Markets

Africa's food markets will grow rapidly over the coming decades. Projections suggest that Africa will be become a majority urban continent by 2030 when urban population surpasses that in rural areas (UN 2012). As a result, marketed food shares will grow more rapidly than overall population. Consumption patterns will also change dramatically. Rising urbanization and growing per capita incomes will translate into dramatically increased demand for processed, packaged, and prepared foods. Because of increasing urban demand for marketed foods, the post-farm segment of Africa's food systems will grow twice as fast at farm production over the coming 40 years (Haggblade 2011). Demand for nutrient-dense high-value foods such as dairy products, meat, fresh fruits, and vegetables will increase as well. Food products, which accounted for about three-fourths of total agricultural output in the year 2000, will increasingly dominate agricultural markets (Diao and Hazell 2004). As a result, domestic and regional food markets within Africa offer farmers their largest single market opportunity over the coming decades.

Spatially, growing domestic food markets will trigger rapid growth in the rural towns that house assembly markets linking agricultural production zones with major urban centers. In terminal markets, the often uncontrolled growth of Africa's large cities rapidly engulfs surrounding peri-urban zones, while growing marketed volumes and commercial traffic quickly outgrow the existing capacity of urban transport arteries and market infrastructure. As a result, early investments in urban planning, zoning, road quality, and urban food market infrastructure and management systems can significantly improve the efficiency of urban wholesale markets, reducing losses and improving sanitation and public health. A focus on market improvements in Africa's rapidly growing secondary cities offers early opportunities for quick wins.

Cross-border flows of food commodities will, likewise, assume increasing importance as Africa's urban food markets grow. In part, the growing opportunities for intra-African regional trade arise because the partition of Africa has left 25 % of its countries landlocked. Moreover, arbitrary boundaries established during the colonial period result today in complex jigsaw puzzle of political borders that often separate breadbasket regions from the deficit market they would most naturally serve (Haggblade 2013). Livestock surpluses from West Africa's Sahel serve coastal markets across the region, while South Africa's consistent maize surpluses serve intermittently deficit markets throughout Eastern and Southern Africa. These complementarities motivate growing interest in knitting together intra-African agricultural markets through regional trade agreements and strategic development corridors (ECOWAS 2004; Hazell 2012; World Bank 2012). Expansion of the East African Community (EAC) in 2007 provides a recent example of growing African interest in regional economic integration.

Supply Responsiveness: Surplus Land, yet Growing Land Pressure in Communal Areas

Historically land-surplus, Sub-Saharan Africa today contains 45 % of the uncultivated potential cropland in the world (Deininger and Byerlee 2012). The continent's 200 million hectares of uncultivated, unforested potential cropland roughly equals the 210 million hectares currently farmed. Potentially, African farmers can double cropped area. These large blocks of underutilized land have triggered a worldwide land rush since the first world food crisis of 2007–2008, as large agribusiness firms have scrambled to secure access to fertile land. In 2009 alone, African governments allocated 39 million hectares of cropland to large institutional investors (Deininger and Byerlee 2011).

Africa's generally egalitarian land distribution and low levels of rural landlessness have historically provided a broad safety net for its rural populations. Unlike large Latin American countries, where fewer than 15 % of farmers control over 80 % of cropland, large farms of over 500 hectares control at most 5–10% of cropland in most SSA countries (Lipton 2012). The Republic of South Africa and other settler economies in Kenya, Rhodesia, and Zambia are the notable exceptions due to historical policies providing preferential treatment and special land allocations for large farms. In the presence of growing demographic pressure over the past four decades, average farmland per capita in communal areas has fallen by about 40 % (World Bank 2007; Eastwood et al. 2010; Jayne et al. 2012). Paradoxically, Africa's dual land tenure system has resulted in growing land pressure inside communal areas while at the same time governments are allocating large blocks of new land, outside the communal areas, to large institutional investors.

Given current low yields and surplus land, African farmers can potentially unleash an enormous agricultural supply response. Moving from yields of 1 ton per hectare to 2 tons is quite feasible (InterAcademy Council 2004). Renewed investments in agricultural research, extension, regional input supply platforms, and rural roads provide the key to closing this yield gap.

The second key ingredient for enabling this supply response revolves around land consolidation in communal areas and the opening up of new lands in ways that facilitate farmer transitions from small-scale holdings in communal areas to medium and large farms on existing or newly developed state lands. Much of the recent furor surrounding "land grabs" by large institutional investors revolves around ethical concerns, particularly the perception that outsiders may be receiving special access to large land blocks, while progressive smallholder farmers in communal areas do not enjoy comparable opportunities to graduate to larger-scale farming (Deininger and Byerlee 2011). Several possible models exist for making new farmland available to successful smallholders. Development of new farm blocks with roads, electricity, and communications infrastructure and with mixed farm sizes offers one model under which large farms serve as anchor tenants enabling cost-effective recovery of initial infrastructure investments while at the same time medium and small farms relieve pressure on communal lands by providing outlets for the more commercially oriented smallholders to grow. Together, investments in agricultural productivity and improved land allocation and tenure systems offer prospects for unleashing a substantial supply response from African farmers.

Confronting Key Challenges

Small Countries

Africa faces an endemic small-country problem. Sub-Saharan Africa houses 49 countries, half with populations under ten million. The continent's patchwork of highly arbitrary, inherited political borders constrains agricultural growth in several key ways: (1) hampering technology transfer and disease control; (2) cutting the continent's many breadbasket zones from the cross-border markets they would most naturally serve; (3) increasing transport and transaction costs that, in turn, lower farmgate prices and raise input costs such as fertilizer and seed; (4) and limiting sale economies in research, input supply, and output marketing (Haggblade 2013).

Research and development on improved agricultural technologies remains critical for accelerating agricultural growth. Yet new agricultural technologies spread slowly in Africa where multiple small countries partition common agroecological zones. West Africa's root crop zone, for example, cuts across ten different countries while its millet belt transits seven. As a result, differing languages, phytosanitary controls, and seed certification processes at each border constrain the free flow of new technologies. In addition, agricultural pests and diseases – such as cassava mealybug, trypanosomiasis, and foot and mouth disease – powerfully affect agricultural productivity. Because these pests easily cross political borders, carried on the wind and wild animals, individual countries face chronic difficulties in raising farm productivity in the absence of effective regional collaboration.

Equally constraining, political borders frequently separate Africa's many surplus food production zones from cross-border deficit markets they would most naturally serve. They separate surplus millet and sorghum producers in southern Mali and Burkina Faso from deficit markets in half a dozen surrounding countries; surplus maize grown in South African from deficit markets throughout southern and eastern Africa; breadbasket zones in northern Mozambique and southern Tanzania from intermittently deficit markets in Malawi, Zimbabwe, and eastern Zambia; and livestock exporters in Mali, Mauritania, and Niger from coastal markets across West Africa.

The resulting high transaction costs restrict trade flows, raise transportation costs, disrupt market signals, and reduce farmer incentives to expand food production in breadbasket regions. Poor perimeter infrastructure and a high density of border controls contribute to exceptionally high transport costs in Africa, roughly four times higher per ton kilometer than in other developing regions (World Bank 2010). Along major West African trade corridors, the informal rent seeking that accompanies cross-border transactions results in cattle traders paying twice as much for cross-border shipments of cattle as for domestic transportation, despite better transportation infrastructure (Borlaug 2012). Similarly, analysis of food price differentials along the Democratic Republic of the Congo-Rwanda border suggests that border controls enlarge spatial price spreads in food prices by the equivalent of a staggering 1,600 km in market distance (World Bank 2012). These high transaction costs, in turn, reduce farmgate prices, raise input costs, and increase consumer prices in cross-border markets.

Economies of scale offer the potential to lower unit costs of most agricultural inputs, including electrical power, banking, insurance, transport, communications, agro-processing, and fertilizer distribution. But, conversely, diseconomies of scale result when a constellation of separate, small countries must administer, equip, and staff individual national power grids, research and agricultural education systems, and agribusiness networks. Given the considerable economies of scale in electric power generation, small African countries pay electric generation costs roughly double what would be necessary under large-scale power plants, regional power pools, and regional power-sharing arrangements (World Bank 2010). Similarly, prices of imported fertilizer increase roughly 30 % under the current patchwork of multiple small-country markets and small lot purchases compared to what would be attainable under regional systems of bulk fertilizer imports coupled with intra-Africa regional trade (Gregory and Bumb 2006; Morris et al. 2007). Economies of scale also exist in agricultural research and education, where investments in specialized staffing and equipment all become possible. “Because of small country size, agricultural research systems in Sub-Saharan Africa are fragmented into nearly 400 distinct research agencies, nearly four times the number in India and eight times that in the US. This prevents realizing economies of scale in research” (World Bank 2007, p. 168). For Africa’s many small countries, “Very often, the only viable – and efficient – solution is regional collaboration” (Beintema and Stads 2011, p. 28).

In general, feasible solutions to the agricultural inefficiencies embedded in Africa’s patchwork of small countries revolve around regional collaboration in scientific research, education, trade, power generation, and corridor development programs (Haggblade 2013).

Sustainable Intensification

In past generations, Africa’s agricultural growth has relied on area expansion, while farmers have maintained soil fertility through shifting cultivation, natural fallows, and soil mining. Low rates of fertilizer application – less than 10 kg/ha in Africa compared to 100 kg in Asia – have led to decades of soil mining, generating annual nutrient losses of over 20 kg of nitrogen, 15 kg of potassium, and 2.5 kg of phosphorus per hectare from African soils (Smaling et al. 1997; Morris et al. 2007).

Looking forward, this system will become increasingly unsustainable. Continued demographic pressure on farmland, particularly in communal areas, will stimulate incentives to intensify farm production. These growing land pressures have given rise to a growing body of research and experimentation on alternate methods for sustainable soil fertility management (Sanchez et al. 1997; Conway 1999; Pretty and Hine 2001; Morris et al. 2007; Haggblade et al. 2010). Most of these efforts involve increased doses of mineral fertilizer coupled with improved soil and water management practices, typically involving some combination of water harvesting, dry season minimum tillage, crop residue management, leguminous crop rotations, organic soil amendments, and short, managed fallows with selected leguminous shrubs.

In the past, most agricultural research in Africa has focused on breeding improved varieties of crops and livestock and delivering improved input packages to farmers. In the future, improved agronomic practices will become increasingly important. Given the diversity of farming conditions prevailing in rural Africa, future farm technology development will need to include site-specific adaptive research coupled with strong farmer involvement in design and testing.

Changing Structure of Agricultural Education and Research

Increasing urbanization and changing food consumption patterns hold important implications for the human skills required to manage Africa’s changing food systems. To scale up processing of local foods such as cassava, maize, sorghum, yam, and banana from artisanal to industrial scales, the food industry will need to undertake research on the biochemistry of basic food fermentations and on nutritional outcomes under alternate processing and packaging technologies. To serve increasing demand for packaged, processed, and prepared foods, Africa’s future food system will require a steady flow of trained scientific and technical manpower trained in the science of increasingly input intensive farm production, feed industries, storage systems, supply chain management, and food processing industries (Haggblade 2011).

In response, Africa's agricultural education and research institutions will need to adapt in order to effectively serve this changing food system. In the past, Africa's agricultural universities have trained primarily extension staff and researchers for the public sector. In the future, they will need to prepare students for private sector employers in post-farm segments of the supply chain. Africa's agricultural research and education institutions will increasingly need to build expertise in the post-farm areas of food processing, storage, food biochemistry, and food safety in order to prepare students with skill sets required by the continent's rapidly expanding private agribusiness firms. This institutional double pivot – from public to private sector clients and from on-farm to post-farm segments of the food system – will require a major shift in faculty skill sets, in laboratory facilities, and in systems for actively engaging with private sector employers in the food system (Minde 2012).

Financing the Public Goods Required for Agricultural Productivity Growth

African governments have historically underinvested in the public goods that drive productivity growth in agriculture – rural roads, irrigation systems, agricultural research, education, and extension. While transforming agricultural countries in Asia and Latin America have invested 10 % of agricultural GDP in agricultural support institutions and rural infrastructure, African governments have spent less than half as much over many decades (World Bank 2007, p. 41). During the early years of their Green Revolution, India and other Asian countries spent 10–20 % of their total government budgets on agriculture, investing heavily in agricultural research, extension, agricultural education, irrigation, and rural roads (Lipton 2012; Hazell 2012). In contrast, African governments currently spend an average of only about 6 % of their budgets on agriculture and livestock. As a result, over the three decades between 1970 and 2000, Africa's spending per agricultural scientist fell roughly in half (Beintema and Stads 2006).

Given the high returns to public investments in agricultural research, rural roads, and related public goods, African leaders will need to substantially increase the quantity and quality of their agricultural spending (Fan 2008). While a handful of African governments have delivered on their Maputo commitment to increase public investments in agriculture, most have not yet done so (Fan et al. 2008).

Summary

Agricultural growth over the next generation will be critical to Africa's efforts to accelerate economic growth and achieve broad-based poverty reduction. But where will the political will come from to fund regional agricultural research and regional trade corridors; reform agricultural research, education, and extension systems; and finance the additional public goods necessary for driving agricultural productivity growth? Skeptics might argue that in the year 2013, 10 years after the AU's commitment to raise funding for agriculture from 6 % to 10 % of total spending, only a handful of African governments have met this goal. Donor commitments of additional billions in funding for African agriculture have likewise faltered since 2009, in the face of an international financial crisis, recessions in the major donor countries, and severe budget crises in Europe and the USA. As a result, Africa's public sector underinvestment in agriculture persists.

In contrast, the private sector has responded with alacrity to rising food and energy prices by investing heavily in African farmland. This new scramble for African farmland by large domestic and foreign investors has raised alarm bells and elicited considerable press coverage in Africa and abroad. Many observers fear that large estates may displace opportunities for commercial smallholders to expand while at the same time diminishing rural employment opportunities through premature mechanization. These highly publicized political and ethical debates may, nonetheless, prove productive if they spur public sector action and motivate African governments and donors to deliver on their prior commitments to agriculture.

African governments and donors, diverted by recent recessions, political turmoil, and budget crises, now have the opportunity to restore their funding commitments to agriculture, thereby enabling Africa's farmers to seize the considerable opportunities available in Africa's rich natural resource base and growing regional markets. Looking forward, a program of vigorous investment in the public goods that drive agricultural productivity growth and market development offers Africa its best chance for rapid, broad-based poverty reduction.

Cross-References

- ▶ African Food Security Urban Network (AFSUN)
- ▶ Conservation Agriculture: Farmer Adoption and Policy Issues
- ▶ Farms: Small Versus Large

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Substantial Equivalence

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Synonyms

Equivalence of GM and non-GM foods

Introduction

The expression "substantial equivalence" stands for a key concept introduced to evaluate the risks and the means of production and consumption of novel foods. In particular, the concept has famously been employed to evaluate the risks for human health of consuming genetically modified (GM) foods, that is, of genetically modified organisms raised for human consumption as well as foods that contain these organisms as ingredients (cfr. Andrée 2007; Gupta 2013; Shahin 2007). In a nutshell, that the GM food is substantially equivalent to its non-GM ("natural"; see entry on "► Metaphysics of Natural Food") counterpart is an important reason to regard the GM food as safe to be consumed.

For instance, if a variety of GM corn is substantially equivalent to the non-GM corn variety from which it was engineered, then the GM corn is likely to be considered as safe to be consumed as the non-GM counterpart. Derivatively, and more generally, the *doctrine of substantial equivalence* holds that, from the perspective of human health, GM foods are as safe to be consumed as their non-GM counterparts.

The doctrine has been endorsed by a number of agencies worldwide, starting with the United States Department of Agriculture and the United States Food and Drug Administration; other notable endorsements include the Canadian Food Inspection Agency, the Food and Agriculture Organization of the United Nations, the World Health Organization, and the Organization for Economic Co-operation and Development. Although the doctrine owes its name and makes reference to two eminently metaphysical concepts, namely, substance and identity, metaphysicians devoted little or no attention to the underpinnings of the doctrine.

The Doctrine of Substantial Equivalence

GM foods constitute a particularly interesting category of *novel foods*. Their novelty, indeed, stems from their different genetic makeup. As the modification of a genome takes place in a laboratory and is thus the product of human intellectual ability and artifice, the resulting novel organism is oftentimes awarded a patent, in recognition of its intellectual specificity. Questions arise, however, regarding the potential threats to human health of the novel food. For instance, it is unclear whether the novel genome will alter the production of the nutrients provided by the food, such as proteins, amino acids, or carbohydrates. It is also unclear whether the novel food will contain vitamins, minerals, potential toxicants (e.g., solanine in potatoes, erucic acid and glucosinolates in canola), and allergenic proteins. Thus, before introducing a novel food into a marketplace, competent food safety agencies need to assess the food's risks to human health. It is at this stage that the doctrine of substantial equivalence finds employment.

To regard a GM food as substantially equivalent to its counterpart, a number of properties of the novel food are examined. If the properties are found to be fundamentally identical to the corresponding properties of the non-GM counterpart, then the food is regarded as safe, from a nutritional point of view. The GM food and its non-GM counterpart are "equivalent," hence, because they are *identical in some key nutritional properties*. They are "substantially" equivalent, instead, because not all of the foods' properties are taken as relevant to justify the equivalence claim: only those properties that are fundamental from a nutritional point of view are salient to determine the matter.

Disagreement has risen among the international scientific community on which properties shall constitute the basis of comparison between a given GM food and its non-GM counterpart. Typically, the fact that the GM food and its non-GM counterpart have different genomes – fact that is crucial to award a patent to the inventor of the GM food – will be deemed as irrelevant from the point of view of human nutrition and health. Thus, in light of the doctrine of substantial equivalence, it is possible that a GM food is considered a novelty within a country's patent office, but standard within that country's food safety agency.

Upon presenting the doctrine, it is important to clarify its scope. Ascertaining the substantial equivalence of a GM food with respect to its non-GM counterpart is only one part of the process of evaluating whether and how to produce a GM organism and to introduce it in the marketplace. Following the EU regulations circa the production and marketing of GM organisms (see entry on "▶ EU Regulatory Conflicts over GM Food"; "▶ GMO Food Labeling"), we may divide up the evaluation of a GM organism in four categories.

Substantial equivalence contributes in different manners to the evaluation of a food in each of the four categories.

(i) *Biosafety*. Substantial equivalence pertains primarily to the assessment of the *biosafety* of the GM organism. In particular, it concerns the safety of consumers, as opposed to – for instance – the safety of biodiversity within an area of production. The appeal to substantial equivalence has thus served to argue that GM foods raise no distinct threat to human health because they do not deliver novel nutritional constituents to the organism.

(ii) *Labeling*. Substantial equivalence influences also the practices of food labeling. If a GM food is substantially equivalent to its non-GM counterpart, from a nutritional standpoint there is no reason why the two sorts of foods should be distinctly labeled.

(iii) *Traceability*. The doctrine of substantial equivalence has arguably jeopardized the possibility of tracing the effects of GM foods on human health. Countries that have endorsed the doctrine, and where GM foods are not distinctly labeled, have rendered impossible for consumers to study whether the emergence of certain allergies (e.g., food allergies and intolerances) and diseases has been influenced by the consumption of GM foods.

(iv) *Freedom of choice*. By blurring the distinction between GM organisms and their non-GM counterparts, the doctrine of substantial equivalence has weakened the freedom of producers and consumers to choose what sort of product they wish to, respectively, eat or deliver to the market.

Substantial equivalence has an underlying role also in the 2003–2006 debate within the World Trade Organization on the measures that are necessary to protect human, animal, or plant life or health. The debate eventually led to the so-called SPS Agreement – the Agreement on the Application of the Sanitary and Phytosanitary Measures (see the entry on "▶ The 2003–2006 WTO GMO Dispute: Implications for the SPS Agreement"). If GM organisms are deemed as substantially equivalent to their non-GM counterparts, then countries that buy into the SPS Agreement have no reasons pertaining to the safety of human nutrition for impeding production of GM organisms or for distinctly labeling GM foods.

Empirical Evidence Against the Doctrine

The doctrine of substantial equivalence is of dubious scientific rigor. In their seminal 1999 article on the topic, Millstone, Brunner, and Mayer remarked that:

> The concept of substantial equivalence has never been properly defined; the degree of difference between a natural food and its GM alternative before its 'substance' ceases to be acceptably 'equivalent' is not defined anywhere, nor has an exact definition been agreed by legislators. It is exactly this vagueness which makes the concept useful to industry but unacceptable to the consumer. Moreover, the reliance by policymakers on the concept of substantial equivalence acts as a barrier to further research into the possible risks of eating GM foods. (Millstone et al. 1999a, p. 525; cfr. also Millstone et al. 1999b for a sequel)

After nearly 20 years, a good deal of empirical and theoretical evidence against substantial equivalence has been amassed. From a more practical point of view, a first criticism concerns the looseness of the concept of substantial equivalence. Little has been done to tighten it. Rather than being treated on a par with novel chemical compounds such as food additives, pesticides, and pharmaceuticals, GM foods were regarded as safe once a few basic data on their biochemical properties had been provided.

Specific data have recently been collated to show important nutritional differences between GM foods and their non-GM counterparts. In a study of the variation of nutritional values among three sorts of soybeans on the market – GM, non-GM conventionally farmed, and non-GM organically farmed – researchers were able to discriminate "all the individual soy samples . . . into their respective agricultural practice background" (Bøhn et al. 2014, p. 14). Other strategies for the analysis of transgenic foods suggest that, contrary to the prevalent view held so far, even from a nutritional standpoint, non-negligible differences exist between GM foods and their non-GM counterparts (cfr. Valdés et al. 2013). The equivalence, that is, was apparent in that the wrong cluster of properties had been selected. But, there is more to the story, which relates to broader theoretical presuppositions within the doctrine of substantial equivalence.

Theoretical Evidence Against the Doctrine

The doctrine of substantial equivalence employs, in an unorthodox fashion, a conceptual tool of Aristotelian descent – the theory of substance. In Aristotelian philosophy, the identity of a substance is defined on the basis of some essential properties, which are selected among a larger cluster of properties, including both essential and accidental ones. Thus, for instance, a human is essentially a rational animal, while accidentally it may be tall or short, sitting or standing, and bold or hairy.

The doctrine of substantial equivalence, however, seems to adopt a double-standard approach to a given food that is questionable. In order for a food to count as both novel (at a patent office) and standard (at a food safety agency), one of the two following views has to be held. Either what is presented to the two offices is not the same entity or, if it's the same entity, one of the two agencies (or both) overlooks some of the food's essential properties. Call the first the *miracle view* (it multiplies entities), while the second the *deflationary view*. Both of them face considerable difficulties.

The deflationary view is suitable to those that take a deflationary attitude regarding governmental procedures of sorting and labeling. This is an attitude that weakens the ontological presumptions of such procedures. For instance, suppose a governmental agency registers a citizen as a Caucasian male. The deflationist will hold that such a classification says little with respect to the real racial profile and sexuality of the citizen. Analogously, suppose a food safety agency claims that a GM food is substantially equivalent to its non-GM counterpart. The deflationist will regard such a claim as saying little real with respect to what the food is. While "Caucasian male" and "substantially equivalent" may partially capture the real identity of a person or a food, their role is to serve a specific practical purpose for a government and its citizens.

The deflationary attitude has two significant drawbacks. First, it promotes a form of skepticism towards food labels. The skepticism runs against those who take food labels seriously. Second, in the debate over the palatability of the doctrine substantial equivalence, the deflationist leaves open a worrisome possibility: that the double standard applied by the patent office and the food safety agency is motivated by practical purposes, which run against the purposes of the citizens, who demand that the label be as close to describing the real food as possible.

The shortcomings of the miracle view, on the other hand, are more obvious: it is in striking contradiction with ordinary talk. The miracle view can be savaged only by suggesting that the judgments of the patent office is not on the *food*, but rather on a specific DNA sequence, while the judgment of the food safety agency pertains to the food and not to the DNA sequence. While such an analysis may be accurately describing extant practices, at once it points out the lack of a comprehensive and systematic treatment of regulations pertaining to GM foods (cfr. Andrée 2007).

The theoretical tenability of the doctrine of substantial equivalence has been criticized from another significant angle. The claim, in this case, is that the doctrine leaves no room for certain qualitative considerations of the food that are of importance to consumers. As Sylvie Pouteau writes in a classic paper:

> The misuse of equivalence points to the fact that food quality cannot be restricted to mere substance and that food acts on human beings not only at the level of nutrition but also through their relationship to environment and society. Besides chemical, toxicological, and immunological issues, ethical issues should also be addressed. Beyond substantial equivalence, "qualitative equivalence" and "ethical equivalence" are to be found as ethical counterparts. (Pouteau 2000, p. 276)

According to Pouteau, the doctrine of substantial equivalence should be replaced by a doctrine of *ethical equivalence* (cfr. Pouteau 2000, 2002; Madsen et al. 2002). What matters to citizens and consumers is that GM foods and their non-GM counterparts are equivalent from an ethical standpoint. Judgments of ethical equivalence will be based not solely on the biochemical properties of the foods, but on additional properties of the foods that are ethically relevant. Pouteau's position has been rounded off by studies that point out the importance of familiarity, risk, and method of production in assessing the equivalence of GM foods and their non-GM counterparts (cfr. Siipi and Launis 2009; Meghani 2009; Gupta 2013).

The suggestion, ultimately, is that governmental agencies should base their respective guidelines regarding the production and marketing of GM foods not simply upon some (disputable) biochemical properties of the foods, but also upon relevant ethical properties. Through appropriate labeling requirements, consumers should be consented to make an informed choice about their diet: a choice that allows tracing back potential sources of allergies, intolerances, and diseases and a choice that reflects the consumer's ethical commitment to a tradition, to a system of production, and to a specific risk-taking conduct.

Summary

According to the doctrine of substantial equivalence, from the perspective of human health, GM foods are as safe to be consumed as their non-GM counterparts. While a number of governmental agencies and institutions worldwide have endorsed the doctrine, important criticisms have been raised against it. After rehearsing the key tenets of the doctrine, the entry surveys its major practical and theoretical shortcomings. From a practical point of view, not only is "substantial equivalence" loosely understood in national and international regulations, but some recent studies point out to some nutritional differences between GM foods and their non-GM counterparts too. The theoretical shortcomings of the doctrine, then, rest on its problematic use of some classic metaphysical concepts (i.e., substance and identity) as well as on its lack of consideration for ethical properties that are of importance to consumers, such as risk, familiarity, tradition, and method of production.

Cross-References

▶ EU Regulatory Conflicts over GM Food
▶ GMO Food Labeling
▶ Metaphysics of Natural Food
▶ The 2003–2006 WTO GMO Dispute: Implications for the SPS Agreement

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Sustainability and Animal Agriculture

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Synonyms

Animal production; Animal welfare; Environment; Food safety; Public health; Sustainability

Introduction

The sustainability of current global agricultural practices is an ethical issue that is attracting greater public awareness. There is increased societal concern regarding the crucial harmonic balance between feeding an ever-growing human population and minimizing environmental damage for the planet's future inhabitants (Broom 2010). Sustainability refers to the long-term success of a system. In order to keep animal agriculture sustainable, changes must be implemented to allow animal production to continue in an efficient and environmentally conscious manner. Such strategies should assess the potential benefits and consequences for all stakeholders involved. These considerations will help to ensure the viability of animal agricultural systems in the years to come.

The overall sustainability of animal production reflects the collective viability of a variety of agricultural aspects including animal welfare, food quality, the environment, and human health. Ethical concerns pertaining to the quality of life for the animals arise from the visible suffering and unnatural behaviors exhibited in intensive farming conditions. Food quality and safety considerations associated with certain agricultural practices have resulted in decreased consumption of animal products by the general public. The concept that a healthy environment is a vital aspect of sustainability has become significantly more widespread, and a larger population of consumers is beginning to demand responsible practices that minimize contamination and preserve the quality of the earth, water, and air. A scientifically established correlation between the consumption of certain animal products and public health has garnered more attention as chronic metabolic problems, such as diabetes or cardiovascular disease, threaten the public ideal of reaching old age in a healthy state.

With these concerns, comes the need for change. In order to maintain a sustainable system, the animal agriculture industry must first reflect on its responsibilities owed to the public, as well as its negative effects exerted on the environment. Modifications in the use of both new and existing resources should be continually reevaluated in an effort to limit the impact of the industry on the planet and its foreseeable future.

Sustainable Animal Agriculture

Sustainable animal agriculture must address important issues in the production, marketing, and consumption of livestock, poultry, and fish. The concept of sustainability refers to the pressing need to feed a growing human population without damaging the environment beyond repair for future generations, while doing so in a manner that guarantees both functional and moral long-term acceptance (Broom 2010). An animal production system is sustainable if it can be continued successfully in its current form without the need for future modification. A system becomes unsustainable once it begins to use methods that are environmentally, economically, socially, or ethically unviable.

Historically, the use of animals for food complemented the harvesting of crops in ways that added value to plant agriculture and improved the continuous supply of protein for humans. Harvesting of plants is a seasonal event, and thus it presented difficulties associated with the storage of produce prior to modern preservation techniques. The use of animals was advantageous because animals could be harvested over extended periods of time in contrast to plants. Grazing animals, which consume available vegetation, were essentially viewed as storage units of plant nutrients that could be collected by humans at a later time. The possibility of hunting animals was seen as a strategy to supplement both plant and animal agriculture. The year-round availability of animals to hunt presented a more promising supply of protein and nutrients throughout all seasons. With the arrival of animal agriculture, humans no longer depended exclusively on the animals they hunted. Adequate protein sources could also be provided to society beyond the narrow window of harvest season by storing milk from sheep, goats, and cattle as cheese or yogurts and preparing fish and livestock meat as dried or salted.

Animals have been used to convert plant products unfit for humans into desirable food products, thus broadening the use of plant material and prolonging the availability of food. Ruminants eat grasses and parts of plants such as stalks and shells and can utilize spoiled plant materials that otherwise are not suitable for human consumption. The extension of food availability throughout the different seasons via animal intermediates, along with the primitive desire for animal products, created added value to plant agriculture. Animals have also been used for purposes other than food, such as providing power for work and transportation. Animal skins and fibers have been used for clothing and shelter. Due to the aforementioned reasons, animal agriculture has been market driven ever since its initial establishment during early civilization.

In modern times, concern about the sustainability of animal agriculture in developed countries has increased as animal production systems have transitioned from extensive to intensive systems. Driven by market forces, competition, regulation, and economic subsidies, the intensification of animal agriculture has resulted in the more efficient consolidation of production systems over the last century. Subsequent cost reductions have made the availability of abundant and cheap food of animal origin possible. Increased productivity, however, has not come without a price, and oftentimes, the animals' interests are hampered. In the majority of cases, it is the animals that are forced to carry most of the burden, which results in a decreased quality of life for animals and the subsequent increased ethical concerns of humans.

Small farms typically have multiple crops and livestock types integrated into production and harvest systems that maintain income over seasons by utilizing natural and seasonal resources. Historically, small farms have remained pasture based or have relied on local sources of feed for livestock, which has limited the livestock density in an area to the carrying capacity of the local environment. Large farms often produce one or two crops and a single type of animal and have competitive advantage in commodity food production through the economic strategies of scale and more efficient use of capital. By sourcing feed from outside the region, large farms can accommodate more animals but consequentially produce more manure than the local environment can handle without strict environmental regulations. The consolidation of farms has occurred in response to decreased marginal profitability in commodity food production, increased consumer demand due to population growth, and heightened public awareness about food quality and safety.

Issues regarding the sustainability of contemporary intensive animal agriculture have been brought to light because the management of animals and animal waste in large-scale animal farming conflicts with the values and ethics of certain sectors of society. While animal production may still add economic value to crops, like corn and soybeans, the historical need to maintain protein in the human food supply over different seasons via the use of animals as intermediates is now a lesser concern due to the development of enhanced long-term storage techniques for grains and other plant protein sources. Recent improvements in the storage of healthy and nutritious foods have resulted in an increased ability to transport food products globally. While upgrades have been made, such systems are not flawless and inadequate storage continues to contribute to resource wastefulness. Approximately one third of the food produced around the world is never consumed because it is instead spoiled or destroyed by pests during transport (Gustavsson et al. 2011).

Concentrated housing of large numbers of animals burdens local environments and can exceed the buffering capacity of ecosystems to utilize nutrients from manure and control pathogens. While fecal matter from a relatively small number of animals can be absorbed into a local ecosystem, feces and urine from a large number of animals can result in local environmental damage and runoff to surrounding ecosystems. Concentrated animal housing can also promote an increased pathogen load of both animal and zoonotic pathogens, which results in potential health hazards to humans and other animals.

The primary challenges regarding the sustainability of contemporary intensive animal production systems are concerns in the areas of animal welfare, environmental conservation, and resource competition.

Sustainable Animal Agriculture and Animal Welfare

Each animal species has its own biological limitations and needs. If pushed beyond certain physiological limits, animals will start to suffer. Dairy cows, selected for high milk yields and fed a high-energy diet to meet the demands of production, experience decreased immune function and decreased metabolizable energy, which leads to the increased presence of health problems such as mastitis, lameness, and infertility. Sows are social animals and, in natural conditions, live in stable sow groups. When housed in solitary gestation crates, the ability to engage in natural social behavior is prevented. This negatively impacts a sow's emotional state, causing frustration. A manifestation of such frustration is the development of stereotypies, such as bar biting or weaving, which are repetitive obsessive behaviors that serve no clear purpose. The housing of laying hens in tightly confined battery cages inhibits the expression of natural behaviors, like nest building or dust bathing, and can actually lead to the development of unwanted behaviors such as feather pecking or cannibalism. The presence of any of these examples suggests a decreased quality of life for the animals.

Increasing public concerns about animal welfare and the care of captive animals, particularly agricultural species, affects whether or not the use of animals for these purposes is considered sustainable (Broom 2010). A rise in productivity over the last 50 years has occurred hand in hand with a decreased quality of life for farm animals and an increased societal awareness of industrial farming systems (Harrison 1964). Certain husbandry practices, such as gestation crates or battery cages, are becoming more unacceptable to consumers. As a result, these farming methods become unsustainable, forcing the agricultural industry to modify current systems in order to adapt to consumer demands.

In a market-driven economy, public opposition to the consumption of a certain product diminishes the market success of that particular product. Consumer surveys completed in recent years have demonstrated that the general public is willing to pay more and change traditional shopping habits in order to specifically purchase animal products manufactured using animal welfare conscious practices (Special Eurobarometer 2007). Recent reports indicate that animal welfare concerns extend beyond consumer intent to change shopping habits and have actually resulted in decreased demand for certain foods such as poultry and pork products (Tonsor and Olynk 2011).

The proliferation of faux-meat products over the last few years has presented an additional threat to animal agriculture. These meat analogs use plant proteins to create animal-free products that look and taste similar to meat. With the existing uneasiness about current production standards, the availability of these imitation meat products may create a shift in market trends and further impact the sustainability of certain practices and the future of animal agriculture.

Sustainability of Food Quality and Safety

In addition to animal care and well-being, consumers have expressed concerns about food quality and safety. Decline in the consumption of food goods believed to be unhealthy or unsafe has caused certain products to become less sustainable. An example of this is the outbreak of bovine spongiform encephalopathy in 1980s, which resulted in decreased beef consumption in Germany and other European countries (Becker et al. 2000). If a certain practice or system is deemed unacceptable, consumers will boycott the purchase of items produced by such means, consequently limiting the viability of a given farming system. Legislation and food vendor standards for farm animal care directly reflect the impact of consumer concerns regarding acceptable food quality and safety. Dismissing and neglecting to address such concerns can have a detrimental effect on a particular sector of the agricultural industry, making it unsustainable.

In market-driven economies of democratic societies, sustainable animal products are those that are manufactured in a manner consistent with consumer acceptance rather than science-based facts and findings. Public perception of agricultural practices, whether accurate or not, determines what standards are considered adequate, and thus, sustainable products are those that are produced in line with the morals, values, and ethics of the consumers who purchase them.

Sustainability of Environmental Impact

Increasing public interest in environmental ethics has popularized the idea that animal agriculture should have a minimal impact on climate and the environment while still providing for the basic needs of the animals. As a whole, the public remains generally accepting of the use of animals for food, but the overall consensus is that production should meet certain standards of both food safety and animal welfare.

The negative impacts that many agricultural practices have on the environment and wildlife contribute to societal uneasiness. Increased production of greenhouse gases, soil erosion, and contamination of waterways are examples of detrimental outcomes that the general public may find troubling and ethically difficult to accept (Tilman 1998).

There is increasing discussion about sustainable balance – a harmonic interaction between animals, caretakers, producers, consumers, general public, and the environment. While such a balance is ideal, it may prove challenging to accomplish in some locations. For instance, it would not be sustainable to raise large numbers of farm animals near highly populated areas due to the competition associated with the coexistence of both populations in relatively close quarters (McGlone 2001).

Biodiversity is an important conservational tool, and the presence of monocultures can result in catastrophic disease outbreaks and adverse environmental conditions. When acres of land are dedicated to a limited number of species, problems more frequently result in damage that is difficult to repair. Similarly, the concentration of a limited variety of farm animal species in a single geographic region may increase the potential for disease transmission as well as other management problems. These outcomes can have a devastating impact on the agricultural industry and its sustainability.

Excessive use of fertilizers and management of manure associated with large-scale production have lead to exacerbated nitrogen and phosphorus contamination of the environment in certain parts of the world (Foley et al. 2011). Contamination of the underground water table with these waste products has long-term consequences that are not sustainable for the environment. There are also documented concerns about the presence of genetically modified organisms in food products (Burton et al. 2001). Regardless of whether or not this uneasiness is based on scientific evidence related to product safety, it still possesses the ability to make a particular production model undesirable to the public.

A stressful environment impairs immune function, and thus, providing less stressful farming conditions for animals can indirectly prevent pathogen proliferation (Rostagno 2009). Humane husbandry and treatment help lessen the risk of both disease development and spread through a farm. Not only do humane practices address ethical concerns regarding the well-being of farm animals but are also important to ensuring public safety. Many animal pathogens such as *Salmonella* spp. and *Escherichia coli* O157:H7 are zoonotic. Even on farms where antibiotics are not routinely administered, enhanced biosecurity measures can help control the levels of such microorganisms and subsequently reduce the likelihood of transmission to humans.

The expansion of agriculture over the last few decades has resulted in an increase in greenhouse gas emissions (Foley et al. 2011). Greenhouse gases in the atmosphere help maintain the surface temperature on earth by acting like a blanket that traps warm air close to the surface. This form of environmental temperature regulation is essential for all life on the planet. As concentrations of greenhouse gases increase, more solar radiation becomes trapped within the blanket of gases causing temperatures to rise. This results in global warming, which has been documented to adversely affect environmental living conditions (Intergovernmental Panel on Climate Change 2007). There is a definitive need to reduce greenhouse gas emissions (United Nations 1998). Agriculture as a whole is responsible for over 30 % of global greenhouse gas emissions, and livestock farming alone accounts for 18 % of such emissions (Food and Agricultural Organization 2006). Considering the impact of greenhouse gases on global warming, it is clear that current practices of animal agriculture are both environmentally and ethically unsustainable.

Energy is lost in the form of heat when animals convert protein from vegetables to meat or other forms of animal protein, which is an inefficient use of resources (McMichael and Butler 2010). Development of land to grow corn or other grains, which can be directly and adequately consumed by humans, is not sustainable when such crops are instead used to feed animals. Simply put, there is a two-step process that must take place in which (1) animals eat the crops and (2) humans eat the animals. The addition of a "middle man," which in this case is the animal, creates another outlet for energy loss when instead those plant resources could be utilized directly and more efficiently by humans.

Swine and poultry are food animals that may be considered less sustainable from a production standpoint. These animals act more in direct competition with humans when it comes to plant energy because neither species contains a specialized digestive system that allows for the breakdown of unique plant material. Alternately, ruminants graze pastures or browse bushes that cannot be directly utilized by humans. While ruminants play a minor role in the release of methane, carbon dioxide, and other greenhouse gases (via eructation), the fact that humans and ruminants do not use the same energy sources makes the production of these animals a more sustainable practice (Murgueitio et al. 2011). In this context, animal agriculture allows plants to be metabolized by humans (Bradford 1999).

Sustainability of Public Health

Population expansion brings with it an increased demand for food and water. A rise in meat consumption occurs in areas of sustained economic growth. The shift from plant to animal protein that occurs as countries develop is referred to as a *nutrition transition* (Popkin 2003). This transition does not come without consequences, as human health is affected by excess consumption of saturated fats of animal origin. The American Heart Association currently recommends a daily amount of less than 6 oz of meat, including fish and chicken (American Heart Association 2013), when in reality, average intake is much higher. Significant levels of saturated fats acquired through meat consumption have been linked to the development of chronic health problems like obesity, cardiovascular disease, and diabetes (World Health Organization 2003).

Increased public awareness has resulted in greater concerns involving the possible contamination of animal products with antibiotics and hormones that are routinely administered to most farm animals for nontherapeutic reasons. Consumers may begin to rely on nonanimal sources of protein in order to avoid the potential health risks associated with the consumption of foods contaminated with such chemicals. There may also be a trend shift in what consumers find acceptable from a health standpoint. An example is the possibility of using more natural feed additives, from chicken manure to restaurant waste, instead of chemicals, antibiotics, or hormones.

Summary

Changing societal values are forcing those involved in animal agriculture to reassess certain practices that have become standard over the last few decades. Intensification of animal production has resulted in increased public awareness regarding the ethics of such practices and the potential effects on the environment, animal welfare, food quality, and human health. The long-term sustainability of animal agriculture relies on the industry's ability to respond to consumer concerns and maintain practices that are socially, economically, and environmentally sound.

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Sustainability of Food Production and Consumption

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Synonyms

Climate change; Convention on Biological Diversity; Economic impact; Environmental impact; Food miles; Kyoto protocol; Social impact

Introduction

The modern use of the concept of sustainable development refers to management of the use of natural resources aimed at balancing availability of natural resources with consumption with a view to promote economic growth and social well-being. Sustainable development has played a central role in international governance of food production and consumption throughout the last 25 years. The concept of sustainable development is implemented in two international governance frameworks: the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC).

The scope of this entry is to examine the concept of sustainability and sustainable development and its role in governance and policy of food production and consumption. Section "Sustainable Development as an Ethical Ideal in International Policy" examines the concept of sustainable development as an ethical ideal and how different environmental ethics approaches together with cultural and political values influence the task of determining the focus of a sustainable development and how it should be obtained; section "Three Dimensions of Sustainability: The Convention on Biological Diversity" examines the complex interrelation between economic, social, and environmental sustainability in food production in light of the governance principles for sustainability outlined in the CBD and its protocols. Section "Climate Change as a Challenge to Sustainable Development of Food Production and Consumption" addresses the challenges of climate change to sustainability in food production and consumption and examines these in light of the objectives of adaptation and mitigation set out in the UNFCCC and the Kyoto Protocol; different governance approaches with view to promote climate sustainability in food production and consumption including the concept of food miles and carbon footprint are discussed. The entry concludes with a suggestion of some key principles for governance of importance to sustainability in food production and consumption in the future.

Sustainable Development as an Ethical Ideal in International Policy

The term sustainability, as it is used today, has its origin in the outline of sustainability in *Limits to Growth*, a report for the Club of Rome's project on the Predicament of Mankind from 1972 where sustainability is described as "a world system that is: (1) sustainable without sudden and uncontrolled collapse; and (2) capable of satisfying the basic material requirements of all of its people" (Meadows et al. 1972, p. 158). While the industrialization of agricultural and livestock production in the 1960s brought tremendous economic growth, the negative impacts on the environment and their long-term consequences for social and economic development became a growing concern among scientists, philosophers, and policy makers during the1970s and 1980s.

In 1987 the United Nations World Commission on Environment and Development published the report "Our Common Future" (the Brundtland Report). The report examines the relation between societal development and degradation of species and genetic resources. The Brundtland Report argued in favor of a "sustainable development," which was defined as a development which seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future (World Commission on Environment and Development 1987, p. 84).

The Brundtland Report laid the ground for the adoption of Agenda 21 at the Earth Summit on environment and development held in Rio in 1992. Agenda 21 (http://www.un.org/esa/dsd/agenda21/) is an international agreement of actions to achieve sustainable development. The Rio Earth Summit also led to adoption of the Rio Declaration on environment and development (http://www.unesco.org/education/information/nfsunesco/pdf/RIO_E.PDF).

Furthermore, the CBD was opened for signature during the Rio meeting, and the UNFCCC was agreed. Both conventions play an important role aiming at environmental sustainability in food production and consumption with a view to ensure economic growth and promote social well-being.

The Brundtland Report's definition of sustainability/sustainable development plays a central role in these frameworks. The concept can best be described as an ethical ideal concerned with the ethical relation (a) between humans and nonhuman nature and (b) between present and future generations. The ethical motivation behind the concept of sustainable development reflected in the Brundtland Report echoes an anthropocentric-oriented ethical approach to environmental protection. The idea of sustainable development is based on the common interest of humankind to protect nonhuman nature as the foundation for our human existence and well-being (World Commission on Environment and Development 1987, pp. 71–86). The concept of sustainable development reflects the idea of inter-generational justice; it advocates an ethical responsibility of present generations to ensure that their pursuit of economic and social development, does not compromise the possibility for future generations to meet their needs and aspirations. However, the motivation for establishing sustainability and determining what sustainable development should entail depends on the cultural, ethical, and political values embedded in different worldviews or perceptions of the relationship between humans and nonhuman nature. Environmental value-based ethics approaches such as biocentrism or ecocentrism represent an alternative to the anthropocentric approach. According to these approaches life and/or ecosystems as a whole represent an autonomous intrinsic value which human beings ought to respect in and by itself (Rolston 2012, p. 110, 116). Thus, a biocentric or an ecocentric approach may be less prone to accept trade-offs in terms of compromising protection of biodiversity or specific habitats or endangered species for the sake of promoting social and economic sustainability, for example.

Determining Sustainability: Implications of Cultural, Ethical, and Political Values

The concept of "sustainable development" as it applies to governance of food production and consumption has three dimensions: an economic, a social, and an environmental dimension (World Commission on Environment and Development 1987, pp. 174–175). These three dimensions are likely to conflict. Ideally sustainable development is to take into account all three dimensions, without compromising one over the other. In reality, however, initiatives to establish sustainability in one dimension may involve trade-offs in another. For example, food production may be sustainable in terms of providing enough food and ensuring distribution so to avoid food shortage in vulnerable regions of the world, but it may not be environmentally sustainable. Similarly there may be trade-offs within the same dimension of the concept. For example, it is not difficult to imagine that a production method can be sustainable in terms of protecting specific aspects of biological diversity, but not in terms of the energy output and contribution to anthropogenic climate change.

Determining what is required to establish sustainable development in a specific context and the acceptance of trade-offs does not only depend on the primary objective of sustainability, i.e., whether the goal is to establish climate sustainability or social sustainability, but also on the cultural and ethical values of the various stakeholders.

Likewise, political values and beliefs play an important role for determining what governance instruments are necessary to establish sustainable development. At least three major governance approaches to sustainability are reflected in international policy on food production and consumption: (1) a neoliberal approach to sustainable development in food production and consumption argues that market mechanisms can ensure sustainability because an increase in price of scarce resources is likely to encourage more efficient use or use of alternative resources. (2) A conservationist approach emphasizes the necessity of living in accordance with the natural environment, respecting the limits that is set for human activity and for economic growth. A sustainable use of resources for food production in this context would include careful management of existing resources including development of environmentally friendly agricultural methods, focusing on promoting small-scale and local farming. High-tech or large-scale farm industry approaches to solve problems of food security or environmental problems are usually not associated with sustainability in this context. (3) An institutional approach emphasizes the importance of environmental protection through changes in both production and consumption patterns encouraged, for example, by market-based instruments introduced by governments. Changes in production and consumption patterns have to happen through institutional changes, which could involve regulation of multinational companies, or introduction of taxes that may push production and consumption in more eco-friendly and environmentally sustainable directions (Oosterveer and Sonnenfeld 2012, pp 41–44).

Over the years the concept of sustainability and sustainable development has been criticized for being vague. However, it must be emphasized that the way the concept is implemented in the two key international governance frameworks for sustainability in food production and consumption, the CBD and UNFCCC, represents an ethical ideal, which frames international policy and requires interpretation. Ethical and political debate about sustainability including debate on governance approaches and specific strategies is crucial in order to balance actions according to different values and economic, social, and environmental interests. The interrelatedness of these three dimensions of sustainability together with the complex challenge they represent to the objective of sustainability in food production and consumption is examined in the following Section.

Three Dimensions of Sustainability: The Convention on Biological Diversity

The development of the CBD began in 1987 and was an attempt to harmonize existing conventions with relevance to biodiversity. The convention came into force on 29 December 1993 and now has 193 parties according to its official website (http://www.cbd.int/). Today the CBD is the main international instrument addressing issues related to conservation of biological diversity. The CBD has three major objectives: conservation of biological diversity, sustainable use of biological diversity, and fair and equitable sharing of benefits from its utilization. It was established with the aim to protect global biological diversity, recognizing that natural resources necessary for economic development are not unlimited (Secretariat of the Convention on Biological 2005, Sect. 1, CBD Preamble). A number of thematic work programs are established under the convention to promote conservation and sustainable use of biological diversity in specific areas including marine and coastal areas, agriculture, forests, inland waters, and dry and subhumid lands (Secretariat of the Convention on Biological Diversity 2005, p. xxx).

The convention reflects a holistic approach to sustainability, where a sustainable use of natural resources can be summarized as one that takes into account the need for economic and social development through production and consumption without jeopardizing the value of biological diversity (Secretariat of the Convention on Biological 2005, Sect. 1, CBD, Article 1). The motivation for establishing sustainability is the recognition of the value of biological diversity, which is referred to as both an intrinsic value and a multifaceted value that includes the ecological, social genetic, economic, scientific, educational, cultural, recreational, and aesthetic value that the diversity may represent to a nation, to a society, or to the individual. The convention reflects a perception of biological diversity as a collective good which is of "common concern of humankind" (Secretariat of the Convention on Biological 2005, Sect. 1, CBD Preamble). To protect this collective good, the convention sets out egalitarian governance principles for protection of biological diversity while not jeopardizing the objectives of socioeconomic sustainability. Efforts to protect biological diversity and ensure sustainable use of genetic resources are to be carried out according to principles of justice emphasizing the need for socioeconomic sustainability through a fair and equal distribution of resources and sharing of benefits and costs related to protection and use of biological diversity as part of the effort to ensure human well-being through social and economic development (Schroeder and Pisupati 2010, p. 5).

Two protocols have been added to the CBD since 1993:the *Cartagena Protocol on Biosafety* (adopted in 2000) and the *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising From Their Utilization to the Convention on Biological Diversity* (adopted in 2011) (Secretariat of the Convention on Biological Diversity 2000, 2011).

Both protocols illustrate the complex challenge of balancing the environmental, social, and economic dimensions of sustainability in food production and consumption.

Economic Development and Environmental Sustainability: The Cartagena Protocol

The central policy objective of the Cartagena Protocol (2000) is to establish a balance between the interests in exploiting modern biotechnology as a means to economic development, with the potential environmental and social impact in terms of negative risk to human health and the environment. This policy is based on the precautionary principle, which is outlined in the Rio Declaration's principle 15 which states that

> Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-efficient measures to prevent environmental damage (http://www.unesco.org/education/information/nfsunesco/pdf/RIO_E.PDF).

The Cartagena Protocol sets out criteria for risk assessment of the environmental impact of new biotechnologies for use in food production, in agriculture, and in healthcare where there are potential adverse effects to human health and the environment (Secretariat of the Convention on Biological Diversity 2000, pp. 1–2).

The Cartagena Protocol is also concerned with the socioeconomic impact of establishing biosafety. Distributive justice and justice in the exchange of knowledge and research play an important role in this context. The principles of fairness and equality are promoted both with respect to the distribution of benefits from biotechnology to human health or to agricultural production among the parties of the convention and with respect to the sharing of research and know-how of importance for the establishment of the necessary precautionary measures that allows for safe use, for example, application of genetically modified (GM) crops for food and feed should include appropriate assessment of risk to human health and to the environment in local communities.

When GM crops were first introduced in the 1990s, they were promoted by large multinational companies, as a potential solution to problems of food security. Nevertheless, application of GM crops in food production has been met with skepticism among consumers in many countries and especially in the countries of the European Union, where the lack of obvious consumer benefits and biosafety concerns has been the main reason for rejection of GM crops for food production (Gaskell et al. 2006). Among the major critiques are that GM crops, due to the fact that these are primarily produced by large multinational companies who protect their economic interests through patents, contribute to socioeconomic disparity and to an unsustainable development in food production altogether. However, scenarios outlined among others in the Intergovernmental Panel on Climate Change (IPCC), working group II's report from 2007 assessing *The Impacts, Adaptation and Vulnerability including* the impact of climate change on *Food, Fibre and Forest Products* (Easterling et al. 2007, pp. 275–303), have given rise to renewed debate on the potential benefits of GMOs to the aim of food security and environmentally sustainable food production.

The necessity of policy actions to promote justice in distribution and exchange of research and technology including new ways of approaching the problem of patenting and intellectual property rights in relation to development of GM crops has been mentioned as crucial for the establishment of sustainability with respect to food production and environmental protection (The Royal Society 2009, p. 45, 50).

Environmental Protection and Economic and Social Sustainability: The Nagoya Protocol

The Nagoya Protocol (2010) is concerned with the social and economic impact of technology development in food production. The protocol has as its central objective the promotion of social justice in terms of fairness and equality in access to genetic resources and their utilization. The protocol has its provision in article 8(j) and article 15 of the convention and sets out governance provisions with respect to the legal rights of providers of genetic resources and requirements with a view to promote and strengthen use of traditional knowledge and technologies that can be applied to protect biological diversity (Secretariat of the Convention on Biological 2005, Sect. 1, CBD Art 15 and 2011, p. 1). The Nagoya Protocol illustrates how the convention's principles of justice tie in with the concept of sustainable development. The protocol emphasizes

> the importance of genetic resources to food security, public health, biodiversity conservation, and the mitigation of and adaptation to climate change (Secretariat of the Convention on Biological Diversity 2011, p. 3).

A steadily growing world population, poverty, together with local food insecurity, and lack of access to sufficient food and water for nearly 1 billion people are factors challenging sustainability in global food production (Oosterveer and Sonnenfeld 2012, p. 31). Ensuring availability of a variety of affordable food options is important to avoid problems with food insecurity or malnutrition among economically underprivileged population groups. Even a small increase in food prices may lead to further social inequity among specific population groups or between developing and developed countries in general (Oosterveer and Sonnenfeld 2012, pp. 50–51). Legal instruments for governance, such as those set out in the Nagoya Protocol, to support local and indigenous farming methods that contribute to conservation of biological diversity through sustainable production, and ensure transfer of knowledge and technology between developed and developing countries, not only set the framework for economic and social sustainability but are also crucial to obtain global food security. It is a complex challenge to govern biological diversity as a collective good with a view to protect biological diversity through conservation while at the same time ensuring food security for a growing world population with huge social disparities. This challenge is further enforced by the problem of climate change. Recent review of scientific data by the Intergovernmental Panel on Climate Change shows that agricultural and food production is likely to be influenced negatively by anthropogenic climate change. In particular, global warming is projected to cause an increased frequency and severity of extreme weather events such as increased frequency of droughts and flooding, which have negative impact on both crop yield and livestock production (Easterling et al. 2007, p. 275, 299). Expansion of land use with view to sustain or increase food crop production may lead to loss of biodiversity and resources altogether (Easterling et al. 2007, p. 275).

Climate Change as a Challenge to Sustainable Development of Food Production and Consumption

The problem of climate change is perhaps the most urgent environmental problem the global society faces to date. The Intergovernmental Panel on Climate Change's Fourth Assessment Report (AR4) draws a complex image on the challenges to socioeconomic and environmental sustainability of food production and consumption over the next 50–100 years. An average rise of local average temperatures between 1 °C and 3 °C may lead to an increase of food production overall, but an increase on average above 3 °C is predicted to cause a global decrease in food production. Additionally, agricultural and livestock production is also likely to face challenges from climate change in terms of increased frequency of extreme weather events, such as drought and flooding. Similarly, negative impact of climate change for distribution and productivity in the marine environment is likely to cause extinction of some fish species, which can impact fishery in several regions (Easterling et al. 2007, p. 275).

Climate change represents a major challenge to sustainability in food production and consumption. It is a challenge the objectives of conservation and sustainability in use of genetic resources as these are spelled out in the CBD, as well as to the objectives outlined in the United Nations Millennium Development Goals (http://www.un.org/millenniumgoals/) which were established to fight poverty and hunger. There is an urgent need for climate adaptation strategies in food production to establish a sustainable development of food production and consumption. In this context, sustainability involves intensification of production to ensure food security and socioeconomic development, conservation of biological resources, and mitigation of GHG emissions at the same time (The Royal Society 2009, p. xi).

Sustainability as Mitigation and Adaptation: The Climate Convention and the Kyoto Protocol

Production and consumption of food generate GHG emissions, for example, from deforestation to expansion of land use for agricultural and livestock production purposes, livestock production, use of energy from fossil fuels in food production and farming, heating of greenhouses or livestock farms, packaging, transport and cold storage, cooking, and processing of food waste (Oosterveer and Sonnenfeld 2012, pp. 90–91). However, if a development in food production is to be sustainable, it must not only include mitigation and adaptation measures to protect the environment but also at the same time aim at reducing rather than increasing inequalities on a global scale with view to ensure social and economic development in production and consumption (The Royal Society 2009, p. 11).

The climate convention promotes the idea of intergenerational justice as part of the ethical motivation for the conventions' objectives of climate protection and sustainable development (United Nations 1992. UNFCCC art 3, principle). Similar to the CBD, the climate convention reflects a holistic approach that emphasizes the need for sustainable environmental, economic, and social development (United Nations 1992. UNFCCC preamble). However, balancing the objectives of the two conventions, i.e., conservation of biological diversity (CBD) and conservation of the atmosphere (UNFCCC), in itself is a potential challenge to sustainable development. While mitigation of GHG may contribute positively to conservation of biological diversity overall, there may be cases where the effort to establish mitigation and adaptation can involve trade-offs in terms of negative impact on conservation of biological diversity in local areas. With respect to development of economic and social sustainability, the convention implements the same egalitarian governance principles for justice in distribution and sharing of responsibilities as those included under the CBD.

The principles of fairness and equality lay the ground for the Kyoto Protocol, which concerns the distribution of responsibilities in terms of GHG emission reductions according to the parties' respective capabilities. The Kyoto Protocol was developed in light of the concerns and projections of future impact of GHG emissions outlined by the IPCC in their Second Assessment Report (AR2) from 1995. The protocol was adopted as a legal instrument under the UNFCCC in 1997 (Oosterveer and Sonnenfeld 2012, p. 95). A summary of the emission goals of the Kyoto Protocol is outlined on the official website (http://unfccc.int/kyoto_protocol/items/2830.php). The protocol sets out legally binding emission reduction targets during the period 2008–2012 for the 37 developed countries who have signed up, to reduce their emission of GHG to an average of 5 % compared to the emission levels from 1990. The parties of the convention have been negotiating new targets since 2008, but different interests of stakeholders including social, economic, and environmental interests complicate the task of reaching an agreement.

Citizens' Awareness, Consumer Policy, and Sustainability: Food Miles and Carbon Footprints

The Kyoto Protocol includes three major governance mechanisms: emission trading/carbon market, clean development mechanism (CDM), and joint implementation (JI), all of which are summarized on the protocol's website (http://unfccc.int/kyoto_protocol/items/2830.php/). These mechanisms are to promote mitigation in production in a market-based and cost-effective way. With regard to food production, possible strategies to promote mitigation were discussed at the COP 15 climate meeting in Copenhagen and included strategies for sector-specific mitigation through establishment of collaborative research and development and implementation of technologies aiming at mitigation (Oosterveer and Sonnenfeld 2012, p. 95). None of the mentioned strategies were agreed, due to concern for the impact of such governance instruments on international trade (Oosterveer and Sonnenfeld 2012, p. 96).

Other governance approaches may include taxation on products, introduction of standards in food production to promote sustainable and environmentally/climate-friendly food products, or regulations on wastage to promote recycling, etc.. However, the successful implementation of such policy approaches relies on public support and awareness of the impact of climate change and the necessity of adaptation measures on international, national, and individual levels.

Concepts such as food miles and carbon footprints have been introduced with the aim to raise consumer awareness about where food products come from and how food production impacts the environment. The concept of food miles was introduced by Prof. Tim Lang in 1996 (Lang 2005). The idea behind food miles is simple: the amount of miles that a food product has traveled gives an indication of its impact on the environment. The concept supports local farming and promotes a few basic principles that may contribute to lower the negative impact of consumer patterns on the environment: (a) shop local and buy local produce as it would require less miles of traveling from farm to fork; (b) buy seasonal produce as it would require less energy to produce than food products produced in heated greenhouses, for example; and (c) buy fresh produce because it is more likely to state where it is grown. While food miles may be a useful instrument to measure sustainability, focusing on the environmental burden stemming from transport of food products, taking into account miles traveled from farm to fork, the concept also has its limits. Calculating food miles in food products with many different ingredients may be practically impossible, and the concept also does not take into account the environmental impact of the production of packaging used for food transportation (Lang 2005).

Critics of the concept argue that it is too simplistic and gives a skewed picture of the environmental impact of production and consumption of food products. For example, food miles do not take into account how the product is produced or the mode of transportation used. An alternative concept, "carbon footprint" measures the contribution of emission of Co_2 throughout the production chain (Oosterveer and Sonnenfeld 2012, p. 98). Measuring carbon contributions only may not provide a full picture of the environmental impact, and other types of GHG, such as methane from cattle farms, would also need to be taken into account. Yet, while the measuring of carbon footprints is far more complex than food miles, it may provide a more nuanced picture of environmental sustainability in the production of specific food products. Common for these approaches is their appeal to the individual consumer's ethical responsibility to contribute to a more sustainable development in food production and consumption. Examples of governance approaches to promote public awareness include campaigns such as "One Tonne Less" or NGO's campaigns promoting a change to vegetarian diet. Changes towards a more climate sustainable development in food production and consumption are unlikely to happen by way of market-based mechanisms. In fact such changes are unlikely to happen without regulatory measures. However, consumer and citizen awareness about the impact of climate change and recognition of the need for adaptation in production and consumption patterns are crucial for such governance instruments to be successful.

Conclusion

The modern use of the term sustainability or sustainable development can best be described as an ethical ideal which requires interpretation.

The task of determining how a sustainable development can best be obtained is challenged by various ethical and cultural values and by different political beliefs and approaches to governance. The two major international frameworks with relevance for governance of sustainability in global food production and consumption, namely, the CBD and the UNFCCC, set out a holistic approach where sustainability refers to economic growth, promotion of social well-being, and environmental protection. What may be environmentally sustainable may not always be socioeconomically sustainable and vice versa, and thus an important part of establishing a sustainable development is to ensure that while trade-offs are to be expected, these are not to compromise justice in terms of fair and equal distribution of costs and benefits from environmental protection.

While the CBD and the UNFCCC set out similar principles for governance to obtain social, economic, and environmental sustainability, they are established with different objectives in mind. The scope of the two conventions is not conflicting; however, the urgent need for mitigation and adaptation to climate change increases an already complex challenge of ensuring economic growth and social well-being in an environmentally sustainable way.

Transparency in governance approaches, research into the environmental, social, and economic impact of specific governance measures, as well as public debate and engagement are therefore founding criteria for the establishment of sustainable development in food production and consumption in the immediate and distance future. In particular there is a need for more research and debate on how mitigation and adaptation measures can be combined with already existing initiatives to promote environmental protection and sustainable use of genetic resources. Similarly there is a need for more debate about possible governance instruments to promote sustainable development. The power of consumer campaigns to promote citizen awareness about the impact of individual consumption patterns on the global problem of establishing sustainability in food production and consumption in light of the challenge from climate changes must not be underestimated in this context because the success of governance instruments that can promote changes in local production and consumption practice is reliant on citizens' support of such instruments.

Summary

The idea of sustainability and sustainable development has come to play a central role in governance of food production and consumption over the past 25 years. Sustainability refers to the balancing of availability of environmental resources with consumption with a view to promote economic growth and social well-being. The three sections of the chapter outline the characteristics of the concept and its role in governance and policy of food production and consumption. Sustainability is described as an ethical ideal with a threefold scope aiming at economic, social, and environmental sustainability. Determining what constitutes sustainability in a specific context and how it is best obtained is subject to interpretation and influence from ethical, cultural, and political values and beliefs. The two key international governance frameworks for food production and consumption are examined: the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change. The three dimensions of sustainability represent a complex challenge to governance. While the motivating concern is environmental protection and sustainability, both conventions implement egalitarian principles for justice, emphasizing fairness and equality as a mode of promoting social and economic sustainability. Climate change is addressed as the major challenge to sustainability in food production and consumption in the future, which is predicted to threaten global food security. The impact of anthropogenic climate change on the availability of genetic resources requires mitigation and adaptation to climate change if food security is to be ensured in the future. Consumer awareness of the impact of production and consumption patterns on climate change plays an important role for support and successful

implementation of governance instruments with view to promote sustainability in food production and consumption.

Cross-References

- ▶ Biotechnology and Food Policy, Governance
- ▶ Food Ethics and Policies
- ▶ Food Labeling
- ▶ Food Security

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Sustainable Consumption and Gender

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Synonyms

Gendered analysis of consumption patterns; Responsible consumer behavior; Sustainable consumption strategies and gender justice

Introduction

If population and consumption trends continue, the equivalent of two Earths will be needed to support humanity by 2030 (Global Footprint Network 2012). The social, environmental, and economic impacts of global consumptive trends are well documented in the sustainable consumption literature. This entry discusses some of the major food-related sustainable consumption trends and does so by using a gender lens to better understand the gender factors and realities within these trends. The term "sustainable consumption" is used in accordance with the United Nations Environment Programme's working definition: "The use of goods and services that respond to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic materials and emissions of waste and pollutants over the lifecycle, so as not to jeopardize the needs of future generations" (Ofstad 1994). Note that the term "consumption" is used herein in its broadest sense, including all three stages of the consumption cycle: the purchase, use, and disposal of products and services. The term "gender" refers to both the perceptual and material relations between women and men, and the term "gender analysis" is taken to mean research that aims to answer questions such as "who does or uses what, how and why?" (FAO 1997). This entry provides a background to gendered perspectives in sustainable consumption discourses before focusing on three key gender aspects of sustainable food consumption. It then finishes off by looking at gender-sensitive strategies for promoting sustainable food consumption.

Background of Gendered Perspectives in Sustainable Consumption Discourses

History to Gender Studies as a Source of Information

In order to understand how gender has permeated the sustainable consumption discourses over the years, it is first useful to briefly overview the history of gender studies. Four waves have been identified in the development of gender studies and a summary of these stages is presented by Casimir and Dutilh (2003). Firstly, in the early 1970s "liberal individualism" prevailed where the focus of attention was on enabling women, through education and individual support, to minimize differences with men. Secondly, in the late 1970s, the focus shifted to "liberal structuralism," an approach which addresses the structural or environmental factors (e.g., legislative and policy responses) that prevent equal opportunities. Thirdly, "value difference" or "women's standpoint" characterized this wave (peaking in the 1980s) and promoted feminine values and alternative ways of living and valuing things. Fourthly, in the 1990s "post equity" or "resisting the dominant discourse" drew attention to post-structuralist thinking and to the ongoing social construction of gender relations. Although gender studies as an interdisciplinary academic field of study dates back over 40 years, it is only in the last 15 years that gender scholars have really started engaging with issues of sustainable consumption.

The Institutional Context

Although a review of international gender policies is outside of the scope of this entry (see Food Policy and Gender entry instead), it is important to understand that much of the agenda setting on debates about gender and sustainable consumption has happened at an international policy/institutional level. Much of this debate has taken place at United Nations world conferences, most notably, the United Nations Conference on Environment and Development (UNCED) that took place in Rio de Janeiro in 1992. Agenda 21, the program for sustainability for the twenty-first century that resulted from UNCED, concluded that environmental degradation is largely an outcome of overconsumption in the Global North, which is in contrast to the Global South, where it is largely poverty that restricts peoples' consumption choices and leads to environmentally degrading consumption patterns. Gender-related issues were a major focus of Agenda 21, in particular, the commitment to overcome gender inequalities and to ensure equal participation from women.

In terms of gender and consumption analyses focused specifically on food, one of the major institutional players has been the Food and Agricultural Organization (FAO), the United Nations agency that is responsible for agriculture, forestry, and fisheries worldwide. In 1995 they adopted the Plan of Action for Women in Development (1996–2001) (FAO 1995) which presents a framework for ensuring that gender issues become an integral part of their organizational work. The mission driving this Plan of Action was to ensure that all women and men have the support and access to resources that they need to pursue sustainable livelihoods and an improved quality of life.

Following Rio, a Commission on Sustainable Development was established to report on the progress of implementations of the UNCED agreements. In 1999, a report was submitted to the Commission of Sustainable Development which explicitly focused on "Gender and Sustainable Consumption" (Grover et al. 1999). In this report the authors identified the main aspects of the gender and sustainable consumption debate of the time. For example, they state that more poor and illiterate women than men in developing countries have been left out of the "consumption explosion," that the gender perspective has not been properly integrated into international discussions on sustainable consumption, and that the inclusion of gender indicators in sustainable consumption research is recommended. These issues, identified in the late 1999s, are still relevant today (Schultz and Stieß 2009). Part of the reasoning for this is explained by the fact that sustainable consumption, in the Northern context at least, is still often perceived by policy makers and funding agencies to be gender-neutral, though, as gender scholars explain, this is a really a misconception (Vinz 2009).

The Sustainable Food Consumption Literature

A gender focus has infused the consumption literature on food choice and food practices over the years in a range of academic fields including marketing, history, sociology, anthropology, philosophy, and nutrition. However, much of the literature to date on gender and food is what Weller (2004) refers to as "explicit" gender analyses, that is, gender-specific disaggregated data drawn retrospectively from studies that were not in fact designed to focus specifically on gender issues. This is in contrast to works that utilize an "implicit" gender analysis to specifically address gender issues such as "what degrees of power and influence do different types of consumers have?" The following section considers data on sustainable food consumption drawn from both explicit and implicit gender analyses.

Gender Aspects of Food Consumption

This section is divided up into three parts: (1) the gendered division of labor-work; (2) the gendered body, health, and the social organization of intimacy; and (3) empowerment and access to decision making of women and men (Verloo and Roggeband 1996).

(1) The Gendered Division of Labor-Work

This first dimension refers to "norms, rules and practices in the field of labor, where asymmetrical distinction is produced between women and men, between paid and unpaid labor, between work inside and outside the home, and between male and female tasks and professions" (Verloo and Roggeband 1996, p. 6). Women and men have different employment patterns and socioeconomic situations, both which have direct and indirect implications on food consumption patterns. For example, with regard to employment, in industrialized countries, the proportion of men of working age in paid employment exceeds that of women. Of the population of working women, however, considerably more work part-time hours than men. Wages are lower on average and women of working age are more likely to live in households at risk of poverty (women who live alone with a dependent child are particularly venerable).

Time budget surveys conducted in European countries show that despite increasing participation of women in the paid labor market, and a resulting decrease of traditional gender roles, women still are assigned the core of housework management activities and, as a result, suffer more from time scarcity than men. Empirical research shows, for example, that on average women are responsible for 80 % of the consumption decisions made in private households and are the person that is primarily responsible for meal planning, buying, and preparing food. In developing countries, it is also women who are primarily responsible for the provision and preparation of food for the family, though the tasks involved in these processes are obviously of quite a different scope and nature to that of women in developed countries. In this case, it is food poverty that leads to peoples unsustainable food consumption patterns, due to a lack of options and choices available to them.

Increased participation of women in the workforce in the Western world has resulted in a sharp rise in demand for convenient foods. Meal planning is now often done late in the day, and the supermarket is increasingly used as a pantry, with consumers stopping off on the way home to get whatever they feel like having for dinner that night. As well as the obvious increased negative environmental effects on increased travel to shops, lack of meal planning is often touted as one of the key reasons for the huge amount of food that is wasted at a household level. In addition, the foods that are bought late in the day for meal that evening are often time-saving products that are quick and easy to cook but that often come with a higher environmental price tag due to factors such as increased processing, transportation, and packing.

Empirical studies in industrialized countries have compared consumers' attitudes, values, and preferences toward sustainable food products, and clear gender differences have been repeatedly detected. Women, for example, have been shown to have a higher level of environmental awareness than men, despite the fact that they tend to report that they feel less informed than men about climate change and environmental issues. Women also generally tend to express a higher level of engagement with environmental issues generally and for environmental issues surrounding food consumption more specifically. Not only do they tend to have more environmentally friendly attitudes, they also are more inclined to act in a more environmentally friendly manner in their consumption behaviors. Research in different countries has repeatedly shown, for example, that women are most likely to buy organic food products (especially middle-aged women, with dependent children, who have high incomes and are well educated). Women have also been shown to be more skeptical than men regarding new technologies and their potential impacts and risks. Research indicates that women generally do not favor genetically modified (GM) food products and that they are more willing than men to pay a premium for products that are GM-free. Early ecofeminism writings attempted to provide some justification for such gender differences in environmentally friendly attitudes and behaviors. In such writings, women are depicted as nurturing and peaceable (due to their domestic and reproductive capacities) in contrast to men who are considered to be powerful and destructive. In fact, nature is even sometimes referred to in this body of literature as a "feminine principle."

(2) The Gendered Body, Health, and the Social Organization of Intimacy

Health, reproductive health, vulnerability, and bodily needs are all important aspects in this dimension.

The concept of intimacy is described as "norms and institutions around sexuality, extending to the social organization of personal relationships, procreation and motherhood" (Verloo and Roggeband 1996, p. 6).

Given that women are the both the lead providers of food and have higher care responsibilities than men in the household, they play a crucial role in managing the families nutritional status and overall health. This responsibility is reflected in research results which repeatedly show that women tend to pay higher attention to hygiene standards in food preparation and provision. However, development interventions, especially in the Global South, aimed to improve access to safe food, often bypass women (FAO 1997). Programs designed to suit women's needs, education, and cultural backgrounds that provide technical information on improving the quality, nutritional status, and safety of food at the household level are needed. Such programs might focus, for example, on home gardens and livestock rearing, which improve access to suitable, low cost, good quality, safe, and nutritional foods. Foods grown at this local level not only lead to greater opportunities for food sovereignty but also increase consumption of sustainable, environmentally friendly foods (that tend to require much lower levels of pesticide and have reduced food miles than alternative products).

Another issue affecting some women in the Global South is health during pregnancy and lactation. In reproductive years, women have special nutrient requirements in order to assure their own health and that of their child though many societies fail to recognize these specific needs. For example, in some societies, discriminatory practices still exist which prioritize feeding male members of the family before females (often including young girls). Such consumption patterns are obviously unsustainable (in the broad sense of the word) as they have the potential to affect health and do not contribute to improved quality of life for women.

There is much literature which discusses gender-specific differences in eating behaviors (see the entry on ► Gender Norms and Food Behavior), though this for the most part does not have an explicit sustainability focus. Nevertheless, sustainable consumption strategies must take into account the fact that women and men do eat in a different way. Gender differences in food preferences seem to begin during childhood. Findings from studies on this phenomenon suggest that females and males assign different meanings and values to different types of foods which results in females and males eating differently. Women tend to eat healthier, have higher nutritional knowledge, and show higher preference for eating foods that are included in common dietary guidelines, which means they tend to eat more fruit and vegetables than their male counterparts. This concern for health issues can in part be explained by the fact that women are primarily responsible for care duties. Another explanatory factor for why women are more food literate than men is due to the fact that women are often involved much earlier than men in food-related activities. Men, in contrast, are often cited as tending toward pleasure foods that taste good. They also eat more meat (both more often and in larger quantities) than women, which is significant from a sustainable consumption viewpoint, given that meat production accounts for almost a fifth of all greenhouse gasses according to FAO data. Though this is in part due to role orientation, in the cultural identity literature, this has also been explained by the symbolic meaning of meat (which infers strength and power). An interesting study that highlights an example of gendered differences toward certain food types is a study on comfort food choices (Wansink et al. 2003). Results showed that most men prefer hot meals to snacks (the three foods most men considered to be their favorite comfort foods were ice cream, soup, and pizza or pasta, which was in contrast to women for whom it was ice cream, chocolate, and cookies). Many men reported that when they ate these foods, they felt "spoiled," "pandered," "taken care of," or "waited on," indicating that generally they associated these foods with being the focus of attention from either their mother or wife. Women, on the other hand, seem to have the opposite preference for a similar reason (i.e., they liked snack-like foods that were hassle-free).

(3) Empowerment and Access to Participatory Decision Making of Women and Men

The kind of aspects that are related to this third gender dimension include empowerment of women and men as consumer-citizens, participation of women and men in implementation of sustainable consumption instruments in all stages of the policy cycle, access as consumer-citizens to decision making, and participation of consumer-citizens in institutional settings of implementation. This dimension is particularly relevant for changing consumers' food behaviors (Schultz and Stieß 2009). It is important that more women become involved in decision making at both governmental level and at the level of international policy making, to find solutions to sustainable food consumption issues. Greater representation of women is also needed in food industry boardrooms and in food companies themselves (especially in scientific positions) to help address food sustainability issues from a women's perspective.

As has been mentioned, worldwide, women are still primarily considered to be the household manager, especially in terms of food provision and preparation. As such, they continue to play a key role to controlling a considerable share of the total carbon emissions produced by a household. This means that they are, and must continue to be, key actors for sustainable consumption strategies (WEN 2007). The most obvious way that consumers can act to promote sustainable food consumption is by voting with their shopping dollars (i.e., by "boycotting" or "buycotting") when they purchase food products and services (note that this is referred to in the literature as engaging in political consumerism). It is important to empower all consumers so that they are able to engage in acts of political consumerism in an informed manner. This can be done in many ways, the most obvious being providing them with full information about the sustainability credentials of the product on its label.

Governments, industry, and consumer groups alike promote this sort of "bottom-up" approach to achieving sustainable consumption, where the consumer is positioned as the all-powerful decision-maker and the mandate is for industry to provide as wide of a choice of products as possible, so that the customer can decide which one to purchase. The problem, however, with this sort of approach is that it places the responsibility for sustainable consumption on the shoulders of individual consumers. As has been already stated, in many cases when it comes to food buying, these individuals tend to be women, many of whom are already feeling under immense time pressure due to juggling domestic, care, and paid-labor activities. The image of the confused consumer standing in front of the fresh salad section of the supermarket trying to work out if it is more "sustainable" to buy the organic lettuce, packed in a plastic bag and flown in from overseas, or the conventional (nonorganic), but local, alternative is all too familiar. Without providing full information about the total amount of materials used in the production, transportation, and storage of these products (e.g., water, energy, and pesticides) and the total amount of waste outputs generated in these same process (e.g., greenhouse gas emissions, food wasted), the consumer is, in reality, inadequately equipped to make this sort of decision with any accuracy. A move away from total privatization of responsibility, that is, from leaving it completely up to the consumer to bear the burden for being sustainable in their consumption choices, requires that some of the responsibility for sustainability is pushed back onto other players in the food industry. Cases of this happening can be seen already. Examples include retailers "editing out" (i.e., not stocking) unsustainable food brands and products such as cafes that choose not to stock coffee that is not Fair Trade certified and supermarkets that choose not to stock certain types of unsustainable fish. Other institutions (e.g., governmental bodies) could also take more responsibility for helping people to consume sustainably, again lifting some of the burden off the shoulders of consumers. Examples of ways they could do this include developing criteria that would allow food products to be more accurately evaluated based on sustainability criteria, devising policies that would encourage the reduction of overall consumption levels or encourage sustainable buying, or by outright banning certain unsustainable food products in some circumstances.

Gender-Sensitive Strategies for Promoting Sustainable Food Consumption and Future Research Needed

Gender differences must be taken into account in order to be able to successfully implement sustainable food consumption strategies. Although strategies and campaigns promoting sustainable food consumption are often devised to be gender-neutral, research shows that gender responsiveness to these campaigns can be remarkably different. The sustainable campaigns which do contain a gendered aspect are generally targeted specifically at women because of their more environmentally friendly consumption attitudes and behaviors.

Given this, it would be useful to search for and communicate specifically sustainable consumption behaviors around food that are more gender available to men (Schultz and Stieß 2009). Furthermore, these same authors argue that it is important that sustainable consumption campaigns are checked to make sure that they do not contain any implicit moralization of women's responsibility (i.e., by fading out gendered patterns of responsibility for paid and unpaid labor and housework).

There is much scope for further research on creating gender-sensitive strategies for sustainable food consumption. Areas particularly worthy of further attention include the following:

- Finding ways to ensure that gender perspectives are better integrated into international-level discussions on sustainable consumption
- Generating gender disaggregated databases and gender-sensitive indicators of food consumption
- Conducting gender-specific surveys about environmental motivation and behavior in relation to food behaviors
- Considering how sustainable consumption patterns are shaped by the relationship of gender with further variables such as lifestyles, values, and other sociodemographic variables (e.g., age, marital status)
- Considering gendered income allocation for nutrition
- Using gender disaggregated data on food and nutrition in the design of polices, programs, and interventions for sustainable food consumption
- Supporting the development of gender-sensitive strategies for sustainable food consumption in order to not increase women's workload

Summary

The consumer behavior literature quite clearly indicates that gender is a strong determining factor for many different types of food attitudes and behaviors. Consumption has historically been associated with women and the private sphere. Even today, women are responsible for on average 80 % of the consumption decisions made in private households and are the person that is primarily responsible for meal planning, buying, and preparing food. While this does put them in a good position to be able to do something to improve the sustainability of food consumed by private households, there are a number of ethical issues which are of concern as this entry has highlighted. Three of the key ethical issues related to gender and sustainable food consumption discussed in this entry are ensuring that (1) all women and men have access and support to resources they need to pursue sustainable livelihoods and improved quality of life; (2) the responsibility for achieving sustainable food consumption is shared equally between women and men, as well between individual consumers and other players in the industry such as retailers and governmental agencies; and (3) sustainable consumption campaigns do not contain implicit moralization of women's responsibility and that ways are found to better communicate messages about food-related sustainable consumption behaviors to men.

Cross-References

▶ Gender Norms and Food Behavior
▶ Sustainability of Food Production and Consumption

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Synthetic Biology and Biofuels

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Synonyms

Biodiesel; Biogas; Biological engineering; Biomass; Crop fuel; Energy; Genetic engineering; Genetically modified; GM; Green energy; Renewable; Renewable energy

Introduction

Synthetic biology is a field of research that concentrates on the design, construction, and modification of new biomolecular parts and metabolic pathways using engineering techniques and computational models. By employing knowledge of operational pathways from engineering and mathematics such as circuits, oscillators, and digital logic gates, it uses these to understand, model, rewire, and reprogram biological networks and modules. Standard biological parts with known functions are catalogued in a number of registries (e.g., Massachusetts Institute of Technology Registry of Standard Biological Parts). Biological parts can then be selected from the catalogue and assembled in a variety of combinations to construct a system or pathway in a microbe. Through the innovative reengineering of biological circuits and the optimization of certain metabolic pathways, biological modules can be designed to reprogram organisms to produce products or behaviors.

Synthetic biology is what is known as a "platform technology." That is, it generates highly transferrable theoretical models, engineering principles, and know-how that can be applied to create potential products in a wide variety of industries. Proponents suggest that applications of synthetic biology may be able to provide scientific and engineered solutions to a multitude of worldwide problems from health to energy. Synthetic biology research has already been successful in constructing microbial products which promise to offer cheaper pharmaceuticals such as the antimalarial synthetic drug artemisinin, engineered microbes capable of cleaning up oil spills, and the engineering of biosensors that can detect the presence of high concentrations of arsenic in drinking water.

One of the potential benefits of synthetic biology research is in its application to biofuel production. It is this application which is the focus of this entry. The term "biofuel" has referred generally to all liquid fuels that are sourced from plant or plant by-products and are used for energy necessary for transportation vehicles (Thompson 2012). Biofuels that are produced using synthetic biological techniques reengineer microbes into biofuel factories are a subset of these.

Entry Road Map

This entry begins with a short historical background that focuses on the initial ethical support and justification for synthetic biofuel research, the impact of this research on public discussion of synthetic biology, and the distinction between it and genetic engineering. The distinction between *first-* and *second-generation biofuels* is introduced. This is followed by a survey of current research innovations using various *microbial factories*, including bacteria, yeast, and oil (oleaginous) algae.

Ethical considerations associated with synthetic biology research in general and its application to biofuel production in particular will be reviewed. General responses by opponents of all forms of synthetic biology include the claim that this type of technology aims to "play God" and that the unnaturalness of it intervenes in the natural world in ways that are unethical and should therefore be avoided. This justification has been used to attempt to restrict or stop new approaches to biofuel technology that aim to control and co-opt natural selection in order to produce a stable product.

Proponents of this synthetic reengineering suggest that these ethical concerns are unfounded. Synthetic biology merely extends the mechanisms by which artificial selection can be controlled and modified beyond traditional approaches to selective breeding.

Ethical considerations that apply specifically to synthetic biofuel research and technology include issues in the design, construction, implementation, marketable production, and assessment of synthetic biofuel production when compared to food crop biomass-based biofuels. Motivations for synthetic applications that focus on the growing concerns over the high cost of production of crop biomass-produced biofuels and the subsequent food shortages that followed, widely framed in terms of the food versus fuel debate, will be discussed. In addition to these, the ethical issues surrounding the potential impact on human health and the environmental consequences of intentional and accidental release of synthetic products of biofuel research will also be covered.

Ethical discussion surrounding synthetic biology and biofuels is, like the research and technology itself, still emerging. An outline of the current efforts of commissions and consortia set up in the United States and the United Kingdom that have promoted the scientifically informed open exchange of ideas between scientists and the public on ethical issues relating to synthetic biology research and application are discussed.

Historical Background

Synthetic biofuel production seeks to provide less expensive, cleaner, and greener sources of energy than currently used traditional fossil fuels. Perhaps because of this, it has been one of the most publically accepted and perhaps most promising applications of synthetic biology. In a field of research where descriptions of the products of synthetic biology are frequently reported as "designer organisms," "Frankencell," or the result of "playing God," discussion of synthetic biofuels seems less controversial. Its potential benefits are often weighed up against its potential costs: "synthetic biology poses a conundrum because of its double-edged ability to both wreak biological havoc and perhaps wean civilization from dirty twentieth century technologies and petroleum-based fuels" (Weiss 2007).

Although sometimes referred to as genetic engineering, synthetic biology differs from genetic engineering in terms of scale, techniques of manipulation, and application. Genetic engineering focuses on the alteration or manipulation of a few characteristics of an organism that results in transgenic hybrids or genetic chimeras that possess genes inserted from other organisms. Whereas, synthetic biology seeks to reconfigure, design, and construct new pathways, whole processes, or novel systems for the purpose of achieving some desired biosynthetic activity or phenotype (Alper and Stephanopoulos 2009).

First-Generation Biofuel Production Strategies

Current research aims at producing a cleaner biofuel alternative to those that are currently agriculturally produced using food crops. These crop-based biofuels, often referred to as *first-generation biofuels*, rely on agricultural crops as biomass to produce sugar or starch from corn, wheat, or barley and convert this to ethanol through fermentation and distillation processes or rely on oilseed crops to produce triacylglycerols that are then chemically converted to biodiesel.

One of the most heated recent ethical discussions focusing on the use of first-generation biofuel production has been the so-called food versus fuel debates. These have typically centered on discussions about the appropriate use of agricultural land – should agricultural land be used for generating fuel instead of food? The decisions of some farmers to plant food crops such as maize for the purpose of harvesting the biomass to sell to biofuel producers have been controversially linked with an increase in food cost and food shortages.

In addition to the fuel versus food debates, discussion has also focused on the production costs themselves and their impact on the environment. First-generation agricultural crop-based biofuel production demands arable land use and water use in irrigation and provides a fuel source that may not be as cost-effective or renewable as the potential second-generation biofuels which do not require either arable land, irrigation, or the displacement of food crops (Börjesson and Mattiasson 2008; Preston 2008).

Second-Generation Biofuel Research Strategies

Instead of relying on food crops as the source of fuel, synthetic engineered alternatives, or *second-generation biofuels*, rely on using the redesigned microbial cell as the source of biofuel production. Synthetic biological engineering is sometimes referred to as *white biotechnology* due to its focus on renewable energy sources and the reduction of negative environmental effects and the potential biodegradability of its engineered products.

In providing more sustainable avenues of biofuel production, these second-generation synthetic biofuel alternatives present a way to circumvent the controversial fuel versus food debates that have been widely discussed in the various news media and in local and global ethical discussions.

These and other debates have led private and public support of synthetic biology research into carbon-neutral synthetic biofuel alternatives that may not only provide solutions to the energy crisis but also provide a way to circumvent the continued degradation of the environment through the burning of fossil fuels and greenhouse gas emissions (Martin et al. 2003).

Microbial Factories of Biofuel Production: Prospects and Problems

Synthetic biology builds on past successes and failures – what works in terms of both modules that are highly interchangeable as well as methods and pathways are reused in new projects. Earlier research on another application of synthetic biology research, the production of synthetic artemisinin, provided guidance on how microbes can be used and their tolerance of different types of chemical products. Synthetic artemisinin is perhaps one of the most widely discussed success stories of synthetic biology research. Artemisinin is an antimalarial drug which is now sold commercially by Amyris Biotechnologies which now uses similar technology in the search for a scalable renewable biofuel (Amyris Biotechnologies 2013).

Development of second-generation biofuel requires the use of a microbial factory organism such as the yeast, *Saccharomyces cerevisiae*, the bacterium, *Escherichia coli*, or the single-celled green alga, C*hlamydomonas reinhardtii*, which is then redesigned to produce certain products. To do this, synthetic biology researchers use parts with known functions from a variety of organisms. A catalogue of these parts is used to choose which components can be put together in the cell to build new pathways and as a result produce new chemical products.

One of the initially most promising organisms to construct a potential biofuel factory was the yeast *S. cerevisiae*. This is widely used to produce ethanol from sugar in the brewing of beer. As it is also an organism frequently used in genetics and synthetic biology research, its metabolic pathways and functions are well characterized. Its ability to produce ethanol made it appear to be a good beta test for a new biofuel factory. *E. coli* is another common organism for use in synthetic biological research in virtue of its proven ability to accept genetic modification with the introduction of foreign genes, the tendency to maintain hybrid networks, and the production of a variety of products (Martin et al. 2003). For instance, Fuzhong Zhang, James Carothers, and Jay Keasling have successfully designed a strain of *E. coli* that implements a biosensor for a metabolite that plays a role in the production of biofuel products using glucose (Zhang et al. 2012). By adding the biosensor to the engineered pathway, their new strain of *E. coli* is capable of trebling the amount of fuel produced (Zhang et al. 2012).

Relying on the knowledge of these and other microbial pathways and modules means that these parts can be both modified and transferred into other organisms to reengineer it to produce a higher ethanol yield or to produce ethanol by consuming a different sugar (such as hexose or xylose) rather than what it would normally utilize (e.g., glucose).

The current research trend in publically and privately funded projects is to investigate the potential use of various species of algae for biofuel production. Algae produce lipids (oil) as a by-product of the process of photosynthesis. The hope is that once the means of harnessing this store of energy is found, algal biofuels may provide an inexpensive alternative source of fuel that can be produced with little more than sunlight, carbon dioxide, and a small amount of water. While advances in synthetic biology research and the understanding of algal alternatives increases, the scaling up of these fuels requires significant further research resolving the problems of system optimization and photosynthetic efficiency as well as solving ways of producing these synthetic biofuels in quantities suitable for commercial use (Georgianna and Mayfield 2012).

A number of other possible organisms have also been considered as particularly suitable for research into the production of synthetic biofuels. Cyanobacteria are another that initially appears promising. Cyanobacteria, like Synechocystis sp. PCC 6803, can provide a highly efficient organic system for producing biofuels as they can convert solar energy and carbon dioxide into biofuel molecules (Wang et al. 2013). Cyanobacteria are particularly good candidates because they possess naturally occurring biosynthetic pathways that produce alkane (a key component of gasoline, diesel, and jet fuel). At present, research into the use of cyanobacteria for synthetic biofuel production is still in the very early stages and well behind that of algae research. However, research focused on reconfiguring these to create an organism that produces alka(e)ne at a rate that is double that of the wild type has been shown to be possible. Synechocystis mutants have been constructed that overexpress alkane biosynthetic genes. This research demonstrates proof of concept for the potential use of cyanobacteria for biofuel production. If their photosynthetic pathways were reengineered, cyanobacteria may be able to produce alka(e)nes at a highly efficient rate (Wang et al. 2013).

Synthetic biofuel production relying on either cyanobacteria or algae may provide a possible alternative to fossil fuels. The ethical consequences on the environment have primarily focused on how this new technology would (by reducing the reliance on the burning of fossil fuels and anthropogenic climate change) contribute to a cleaner, greener planet. Other ethical impacts concerning the potential negative effects (to not only the environment but also on human health) have been raised by Friends of the Earth (2013). Exposure to synthetic biological materials by lab technicians raises a particular set of concerns that centers on both the kinds of products produced by synthetic biology and their potential risks. The potential for accidental ingestion (e.g., breathing aerosol versions of synthetically produced algae biofuel), the unintended transfer of genetic materials through viral and bacterial elements, the inadvertent contamination or dispersal of nanomaterials and nanoparticles by lab technicians, or the potential escape into the environment of such products has been discussed. These are a concern because of the projectible negative consequences but more so for the unexpected and potentially catastrophic impact on human health (e.g., that ingestion of synthetic materials may lead to disastrous unintentional modifications of the human genome, epigenome, and microbiome) (Hoffman et al. 2013).

Production Problems and Solutions: Tricking Biological Systems to Redirect the Process of Evolution

Although promising, the reengineering of biological pathways to produce high-yield microbial biofuel factories has encountered some formidable obstacles in virtue of their biological basis. Synthetically engineered organisms, circuits, parts, and systems, like their organic counterparts, have the capacity to adapt to new environments and to evolve over generations. Because these engineered synthetic microbes are biological systems that continue to have the propensity to evolve and mutate, understanding how to design an organism that has predictable behavior is difficult. Their functioning is designed according to the interests of the particular application (e.g., biofuel production) within the lab.

If these built circuits prove cumbersome for the organism once it is in the natural environment, they will be replaced by more evolutionarily suitable pathways. Engineered circuits created in them that do not provide a benefit to the organism may be disposed of in subsequent generations. That is, if producing the high-yield by-products that they are designed to produce does not provide the organism with an evolutionary advantage or increased fecundity, it is likely that this pathway may be lost in subsequent generations. Once a mutation occurs in a later generation that removes part of the biologically taxing pathway responsible for the high-yield production, these mutated organisms may gain an evolutionary advantage over those with the engineered pathway (Kendig 2012, 2013). Over generations, this would eventually lead to a population that would lack the engineered pathway and one where the mutation would be common. As a consequence of this natural selection, the resulting population would produce a lower biofuel yield (Kendig 2012, 2013).

To solve this problem, researchers are currently seeking ways to *trick* the biological system and redirect the process of evolution for the purposes of producing a higher yield product than the organism would produce (Jia et al. 2010). Finessing the organism's circuitry so that it is stable in a variety of environmental conditions and continues to produce high-yield products is of paramount importance. Ethical and environmentally responsible release of an organism that is fully characterized in the controlled context and known parameters of the lab to a new and changing context of the environment requires prior knowledge not only of the organism or circuit's design and functionality but also its potential mutability and evolvability in an uncontrolled environment.

Ethical Concerns Over the Unpredictability of Potential and Irreversible Impacts on Ecosystems

Evolvability and the co-opting of mutability is not just a production problem; it also opens up a number of ethical considerations. These questions make up a more nuanced set of issues that relate specifically to synthetic biofuel production. Rather than the more often broadly referred to ethical concerns mentioned when discussants claim that this kind of technology should not be advance because it involves scientists "playing God," these concerns are directly informed through an understanding of the specifics of biofuel research and production. Much of the worry with regard to co-opting of evolvability is the downstream effects or unforeseen consequences of "meddling" with nature.

A frequently used rebuttal to worries that synthetic biologists are "playing God" is the suggestion that farmers have been crossing and breeding livestock, companion breeds of animals, and food crops for a long time and that synbiology is just a technological extension of this. As such, proponents conclude ethical concerns over biologists overreaching in the creation of these synthetically reengineered organisms are thought to be unfounded. The morality of these kinds of synthetic interventions has already been treated to a long and relatively unproblematic beta test in the thousands of years of artificial breeding. Opponents counter that the new technology is dissimilar enough to cause ethical concerns unrelated to that history.

Coalitions such as those that make up the undersigners of the *Principles of oversight for synthetic biology* (2013) – a document of the International Center for Technology Assessment, ETC Group, and Friends of the Earth – have also been instrumental in the initial ethical discussion surrounding synthetic biology research and concerns about the unpredictability of risks and worries over their possible impacts. This coalition includes civil, social, labor, as well as religious groups concerned with multiple potential impacts that include those economic and environmental.

It raises concerns about the rapidity of scientific research and innovation in synthetic biology without appropriate regulation or consideration of potential risks. They advocate the explicit use of the precautionary principle, specific regulations on synthetic biology, assessment of harm to public health and environment, increased access to synthetic biology research and active participation of public fora, liability and accountability of manufacturers of synthetic biology technology, and increased effort to protect the economic interests of environmentally vulnerable groups and countries (Hoffman et al. 2013).

The undersigners suggest that in order to preclude potential damage that could result from the products of synthetic biology research, "Governmental bodies, international organizations and relevant parties must immediately implement strong precautionary and comprehensive oversight mechanisms enacting, incorporating and internalizing these basic principles. Until that time, there must be a moratorium on the release and commercial use of synthetic organisms and their products to prevent direct or indirect harm to people and the environment"(Hoffman et al. 2013). This moratorium is justified by the coalition because of the potential for long-term harm to the environment. The document suggests that the risks to niche degradation may be long-lasting. For instance, synthetic organisms could be the new super-invasive species crowding out other native species within a particular ecological niche. If synthetic organism parts are highly modular, their genes may lead to the contamination of other species by virtue of their high level of transferability within the environment through horizontal gene transfer.

The Shape of Ethical Discussion So Far

Ethical discussion surrounding synthetic biofuels has come in two sorts so far. The first suggests that the ethical issues that synthetic biology addresses are the same as other emerging technologies and fundamentally contiguous with those that have been and continue to be discussed. These are the traditional ethical questions of moral behavior, rights and responsibilities, and questions of moral agency. The other suggests that emerging technologies each present fundamentally new sets of ethical issues.

The latter suggests that the resolution to these issues requires consideration not only of the ethical reasoning supplied to us by reading Kant, Aristotle, Bentham, Mill, Anscombe, or Hobbes' approaches to the questions of how should we act or questions concerning what kinds of characteristics are good for someone to have. But they also require engagement with the specific scientific research and technology itself in order to fully inform ethical reasoning. Both are required to answer questions such as the following: What are the limits of human intervention within the natural world? Should we intervene and co-opt the selective processes of evolution and bend these to our will? How should we behave as researchers? What responsibilities do we have for the society, the environment, and for the unintended effects of the new technology created? Who owns the products of these types of research or the rights to use the technology once patented?

Insofar as synthetic biology is a relatively new form of scientific research and the applications to biofuel in their early stages, ethical discussion surrounding these is still in the investigative stages of development relying on panoply of reference points to gain traction on new ethical questions.

The ethical discussions of synthetic biology research in general and the application to produce biofuels in particular have progressed along very different routes to that of the discussions surrounding genetically modified foods. The most striking difference has come in the public perception of this new technology and the encouraged exchange between research bodies and the public in open forums. Commissions and research units such as the aforementioned US Presidential Commission for the Study of Bioethical Issues, the Hastings Center Ethical Issues in Synthetic Biology project (launched in 2009 and funded by the Alfred P. Sloan Foundation), and the SYNBIOSAFE consortium (set up in 2007 and funded by the European Commission) have promoted scientifically informed ethical discussions that bring together key researchers, policy makers, academics, and the public with the goal that through dialogue there can be increased understanding and appropriate regulation of this new biotechnology in a way that is responsive to the interests of scientific innovation and public concern.

In doing so, these cross-disciplinary bodies aim to focus less on the speculative ethical debates of the potential problematic products or misuses of synthetic biology research. Instead, their foci are on current research problems and issues with practical applications in the not-too-distant future. Open debates which inform the public about current research, objectives, and technological applications rather than spurious conjecturing based on worries derived from science fiction and hypothetical slippery slope arguments have been the goal of these commissions and consortia.

Towards Scientifically Informed Ethical Discussion

The promise of a cheaper, greener alternative to fossil fuels is an attractive application of synthetic biology research. But with the capability to construct organisms for this and other applications comes a veritable flotilla of ethical considerations. Including those already discussed in the foregoing, these concern each stage of development, from research and design to the production, use, regulation, impacts on the environment, modes of release and dissemination, public perception, and marketing.

In response to the J. Craig Venter Institute's 2010 announcement that they had created "synthetic life" by digitally crafting DNA and inserting it into a living bacterium to produce a new self-replicating bacterium, *Mycoplasma mycoides JCVI-syn1.0*, the US Presidential Commission for the Study of Bioethical Issues produced the report, *New Directions: The Ethics of Synthetic Biology and Emerging Technologies*. This report provided guidance and consideration of policies, governance, and practices that would enable synthetic biology research and applications of it to be pursued in an "ethically responsible manner" but did not endorse further federal regulations on synthetic biology research (Presidential Commission for the Study of Bioethical Issues 2010). In doing so, the Presidential Commission followed the recommendations already laid out by the Engineering and Physical Sciences Research Council, the Biotechnology and Biological Sciences Research Council, the Economic and Social Research Council, and the Arts and Humanities Research Council of the United Kingdom (Anderson et al. 2012).

In the *New Directions* report, the Presidential Commission set out five principles to guide discussion of the ethical and social impacts of synthetic biology research and technological applications. The report's recommendations are framed in terms of these five principles. These are as follows: intellectual freedom, democratic deliberation, responsible stewardship, and considerations of justice and fairness. With intellectual freedom, responsibility for the implications of synthetic biology research and technological applications is put largely in the hands of the researchers to self-regulate rather than promoting a top-down approach for regulating practice. The US and UK initiatives stress prudence and responsiveness with regard to the emerging area of research still in its infancy.

Crucial issues mentioned within the US report focus on responsible stewardship to the world and its occupants, including considerations of nonhuman animals, plants, and future generations, as well as the environment as a whole. Consideration of these groups within the context of a discussion of obligations is not new. Although not cited, the report's main ethical foci seem to rely significantly on philosophical ideas similar to those laid out in 1990 by Edith Brown Weiss in her seminal article, "Our Rights and Obligations to Future Generations for the Environment." To summarize, Weiss suggests that the rights of each generation are to receive the planet in no worse condition than did the generation that came before it. This would mean that each generation should inherit comparable natural diversity and have similar access to the environment and its resources as did the previous generation. She suggests that rights and obligations do not arise de novo, but instead derive from an intergenerational relationship that each generation shares with those in the one preceding it as well as those in the subsequent generation yet to come (Weiss 1990).

Summary

Scarcity of resources and the unsustainability of the continued use of fossil fuels drive the synthetic biological engineering of biofuels. The initial sources of biofuels based on collecting and fermenting the biomass of food crops (such as corn) proved highly controversial. The growth of corn ethanol producers and the increase in food shortage attributed to the subsequent worldwide backlash and contributed to much critical discussion. These first-generation biofuel discussions concentrated on the ethical impacts of agricultural land use for biofuel crops and limited water supplies previously used to produce food that were now being used to produce fuel instead.

Despite the problems with first-generation biofuels, investment in second-generation synthetic biofuels by private companies as well as government support of research (especially in the United States) has been significant (Tyner et al. 2011). If the demand and pursuit of liquid transportation fuels continues, synthetically reengineered alternatives which provide functional equivalents to fossil fuels may be the greenest option as they may offer a more renewable avenue to the production of fuel.

Although synthetic biofuel production shows much promise as an alternative energy source that does not require the use of non-sustainable feedstocks or expensive carbon sources, its ability to replace fossil fuel consumption rests on developing the technology to produce it economically while reducing any negative environmental impacts. Despite their overuse, contribution to anthropogenic climate change, and the source of frequent international disputes, the replacement of fossil fuels will still rely overwhelmingly on economic production of an efficient, high-yield alternative source of energy (Georgianna and Mayfield 2012).

As synthetic biology is still a new field of research and only some of the potential applications are just being realized, open discussion with scientists, policy makers, and the public may provide the best prospects according to many commissions and consortia in the United States and United Kingdom. Discussion of the actual scientific research and its accurate dissemination to media and the public would allow productive and democratic exchanges of a well-informed public and a responsive scientific community collaborating to evaluate the direction of new research. The goal is for these discussions to stimulate active enlightened deliberation directed towards navigating the best route(s) for ensuring the pursuit of this research, critical evaluation of its potential positive and negative impacts.

Cross-References

- ▶ Agricultural Sciences and Ethical Controversies of Biofuels
- ▶ Biofuels: Ethical Aspects
- ▶ Hybridity in Agriculture
- ▶ Land Acquisitions for Food and Fuel
- ▶ Water, Food, and Agriculture

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Synthetic Meat

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Synonyms

Cultured meat; Hydroponic meat; In vitro meat; Shmeat; Test-tube meat; Victimless meat

Introduction

The goal of creating viable synthetic meat in the laboratory and eventually in the factory has been driven by economic, environmental, and ethical concerns about the current state of animal agriculture. Livestock production ranks as one of the leading causes of deforestation, global warming, pollution, and water depletion, problems that will be exacerbated as the expanding middle classes in countries like China and India demand a Western-style, meat-heavy diet. The United Nations Food and Agricultural Organization estimates that "Global production of meat is projected to more than double from 229 million tons in 1999/01 to 465 million tons in 2050" and that the "environmental impact per unit of livestock production must be cut by half, just to avoid increasing the level of damage beyond its present level" (UNFAO 2006).

This technology, currently in its infancy with, as yet, no viable commercial product, takes animal fat and protein cells grown on a collagen scaffold in a nutrient medium and then shapes the cells into a product resembling its predecessor in conventional agriculture. Most likely, hamburgers and nuggets would be lab grown long before steak, since growing complete muscle tissue, with its complex network of membranes and filaments, would require a three-dimensional architecture and not just a single layer of cells. Advocates suggest that animal welfare and environmental considerations would be addressed using this process and that nutritional value could also be improved, since the composition of synthetic meat could be completely predetermined. A number of obstacles must be addressed before laboratory-based meat reaches the grocery store: the procedures must be perfected and brought up to scale, and the public must be reassured that synthetic meat is every bit as "real" as meat grown on an animal.

History and Technique

Winston Churchill first wrote about lab-grown meat in his 1932 book, *Thoughts and Adventures*, musing that it would be much more efficient to simply grow a chicken breast rather than a whole chicken. Churchill had probably heard of Alexis Carrell at the Rockefeller Institute, who kept a piece of chicken heart tissue alive in the laboratory for 20 years (Levine 2008). Cultured meat has appeared in a number of science fiction novels, including Frederik Pohl and C.M. Kornbluth's *The Space Merchants* (1952), William Gibson's *Neuromancer* (1984), and Margaret Atwood's *Oryx and Crake* (2003). While never reaching the widespread use depicted in novels, the technology needed to produce meat in the laboratory continued to advance throughout the twentieth century.

In vitro techniques have been a standard part of laboratory-based science since 1907, when Ross Harrison cultivated frog nerve cells in a lymph medium at Johns Hopkins University (Corning Life Sciences 2007). Since then, many practical and research applications for the much-improved technique have been discovered, including investigating the normal growth and development of cells, testing new drugs and products for toxicity and effectiveness, producing biological factors like proteins for therapeutic use, and growing tissues for treatment of wounds and diseases (Chaudry 2011). The chief difference between earlier forms of cell tissue and the technology needed for laboratory-based meat is the sheer scale necessary to produce food from this procedure, although industrial levels of biological compounds have been created in the past, as in the polio vaccine of the 1950s and its other vaccine successors.

Notable attempts have already been made to take in vitro cultivation of cells into the domain of food production. The first patent on in vitro meat for human consumption was recorded by the European Patent Office in 1999 on behalf of three citizens from the Netherlands. Several experiments have taken place to make the technology viable. Morris Benjaminson at Touro College in New York experimented with growing goldfish fillets in research funded by NASA, with the hope that eventually astronauts could grow their own food in space without the need for processing animal excrement in addition to human waste (Sample 2002). Benjaminson took strips of flesh from very large goldfish and kept them in a serum derived from fetal cows and successfully coaxed the strips of muscle into growth (Sample 2002). Benjaminson dreams of a day when countertop bioreactors, "like a coffee maker," will produce meat for consumers right in the home (McIlroy 2006).

Research conducted by Mark Post at Maastricht University in the Netherlands uses muscle stem cells in the hope that one day an artificial hamburger could be created by blending these cultured muscle cells with cultured fat cells. The already differentiated muscle stem cells, which repair muscle damage in a normal organism, do not reproduce indefinitely, so new cells (harvested from living animals) would need to be added continually to make the procedure work commercially (Krijnen 2012). After some problems initially with the pale color of the experimental product, Post held the first public taste test of a lab-grown hamburger in August of 2013.

Now that the concept of lab-grown meat has been proven in labs, future generations of researchers will need to build the technology on a larger scale, ensure that the appearance and flavor of the product meet consumer demand, and find partnerships with companies and investors to bring the product to market. Especially important will be the development of serum-free techniques, as the existing fetal bovine serum presents concerns about animal ethics as well as cost. The serum substitute Ultroser G, although also costly, has shown some promise in research trials: a mushroom-based growing medium could theoretically be developed as a low-cost alternative (Dattar and Betti 2010).

A Potential Solution to Inefficiency

Confined Animal Feedlot Operations (CAFOs) and even more traditional grazing practices have a low rate of conversion from silage or feed to the eventual meat that makes it to the dining table. Although estimates vary widely, "beef" has an approximately 8:1 feed ratio, taking 8 lb of feed to produce 1 lb of flesh, with "pork" more efficient at a 3:1 feed ratio, and chicken and fish falling in line at about 2:1. The eventual cost to producers will change from season to season with the cost of grain, the cost of petroleum, and prevailing interest rates. Factors like nutritional balance, air temperatures, and daily exercise also affect the amount of food necessary to produce meat. Traditional agricultural practices like rotational grazing reduce the need for processed and transported food, but such practices constitute a small minority of the meat that goes to market. Even lacking humane and environmental factors, meat producers have economic incentives to increase the bulk of the animal with a lower amount of feed.

Lab-produced meat advocates suggest that an in vitro life form, devoid of the need for locomotion and sensation, would "waste" less energy compared to traditional farm animals. Sewage lagoons and other manure management problems created by intensive livestock farming would be eliminated, and with them methane pollution, a large contributor to global warming. Experts project that the process of growing lab-based meat would be faster than the time required to bring a living animal to maturity at the time of slaughter, and because such facilities could be stacked vertically, land use would also be reduced (Dattar and Betti 2010).

By growing only muscle and fat cells necessary to produce a reasonable simulacrum of the meat-based products that consumers want, the amount of inputs (such as water and nutrients) needed to produce in vitro meat would be reduced. Animal agriculture has already industrialized to a great degree, and lab-produced meat continues this process even further by shifting from an animal with biological habits to industrial tissues that can be readily tailored to the needs of the factory. The labor-intensive and comparatively slow process of slaughter and dismemberment can be eliminated altogether in favor of a completely streamlined production of "steaks," "nuggets," and "cutlets" that resemble and taste like their predecessors in the old agriculture. Transportation costs would be reduced by bringing the growth process to the same physical location as production and packaging, eliminating the need for the shipment of live animals. Nutrient material would presumably still need to be shipped, but savings could be enacted by bringing in vitro facilities closer to grain producers who would presumably still be needed to produce the nutrient bath needed by the in vitro life form.

Reduction of Animal Suffering

Proponents of artificial meat consider it to be a "victimless," harm-free form of agriculture (McHugh 2010). Indeed, People for the Ethical Treatment of Animals (PETA) has offered a one million dollar reward to the first lab that can produce a "real artificial" chicken nugget

(PETA 2012; McHugh 2010). It should be noted that in vitro procedures are not and probably will never be fully free from ties to living animals, as the stem cells used in the process, which have already differentiated into tissue types, must be harvested from somewhere. The techniques also use serum derived from living animals in order to instruct the cultured cells to replicate. To date, lab-based meat experiments actually amount to animal-intensive undertakings. The perfection of the technology may reduce this dependency but will probably not sever all ties to traditional, living organisms. PETA support notwithstanding, many vegan animal advocates will not accept the claims of lab-produced meat as "harm-free."

Vegan and vegetarian critics of animal agriculture insist that feeding something already edible to animals constitutes an inherently wasteful practice that should be eliminated. Food crops like corn and soybeans could be fed directly to humans, resulting in much less waste than converting foodstuffs into meat. The cultural habit of meat eating dies hard, however, and many animal advocates would be willing to accept lab-grown meat as a way of transitioning long-term meat eaters away from conventionally grown meat products. Lab-grown meat would likely result in the continued use of animals in its production, but nowhere near the number of animals killed in current agricultural practices. Ethical arguments about animal suffering are intrinsically linked to the above-mentioned questions of efficiency, as the increased efficiency of lab-grown meat would reduce the need for industrial farming.

Containment of Disease and Reduced Use of Antibiotics

Unlike conventional animal agriculture, in vitro meat could be grown in a sterile environment, reducing the risk of animal-borne pathogens and removing the need for antibiotics (Dattar and Betti 2010). Food scares like the outbreaks of bovine spongiform encephalopathy (BSE, popularly known as mad cow disease) and instances of *E. coli* contamination have raised concerns about the safety risks of today's food systems, which tend to aggregate plant and animal foods from many different points of origin, increasing the risk of cross-contamination (Jin et al. 2004; Centers for Disease Control and Prevention 2012). Lab-grown meat could be cultivated, processed, packaged, and sealed at the point of origin, significantly reducing the potential for the spread of disease.

Animal agriculture currently accounts for upwards of 70 % of all antibiotic use, which contributes to the development of antibiotic-resistant strains of bacteria (Hielig et al. 2002). Although the exact amount of "epidemiologic 'spillover'" from farms to humans of resistant strains is uncertain, "there is no question that the phenomenon does exist" (Hielig et al. 2002). Such heavy antibiotic use stems from feeding cattle – ordinarily ruminants – corn and soybeans that they cannot digest easily, resulting in ulceration and infection that must be treated. The stress of crowded and unsanitary confinement also renders animals more susceptible to illness. Antibiotic use makes meat production more profitable, but it has a tremendous negative impact on public health (Hielig et al. 2002). Doctors and researchers must continually search for new drugs as bacteria become more and more resistant to the existing antibiotics.

Nutrition and Obstacles to Public Acceptance

A study published in the *Archives of Internal Medicine*, combining the results of two previous studies with over 100,000 subjects followed over decades, reported an increase in mortality from cancer and cardiovascular disease (as well as an increase in overall deaths) as a result of consuming red meat (Pan et al. 2012). Risk of mortality was slightly higher across categories for processed meat than for unprocessed meat (Pan et al. 2012). The study reported that 9.3 % of deaths in men and 7.6 % deaths of women in these cohort groups could be prevented if red meat consumption were kept below 0.5 servings per day (Pan et al. 2012).

Parsing the exact implications of this study for synthetic meat would require additional research, specifically, an isolation of the detrimental nutritional aspects of conventional meat and a comparative nutritional study of traditional and synthetic meat. Lab-grown meat could, in principle, be manufactured according to any nutritional profile, but nutrition would need to be matched against the desired flavor and appearance to meet consumer demand. Reducing fat content, for example, would make the final product tougher and less palatable, particularly for North Americans and Europeans, who have grown accustomed to corn-fed beef and pork.

If the public could be sold on the benefits of lab-grown meat in terms of its nutritional and ethical value (by no means a foregone conclusion), the question would still remain as to the "ick" factor of in vitro meat. Genetically modified foods still spark a great deal of controversy, even though consumers have to date largely lost the fight for labeling requirements. "For more than a decade, almost all processed foods in the United States" have contained ingredients from genetically modified plants (Harmon and Pollack 2012), a fact quietly lost on most shoppers. It could be that the inevitable fight over synthetic meat would proceed initially with a great deal of bluster followed by the same grudging acceptance. Most likely, lab-grown meat would exist alongside traditional meat and plant-based meat substitutes as a new niche in the marketplace.

The question remains as to whether this small segment of the market would be large enough to get the economics of artificial meat to work well enough to sustain production. Consumers have had decades to adjust to vegetable-based meat substitutes, and the available products have improved greatly in taste and texture. Meat substitutes from companies like Morningstar Farms and Gardein have enjoyed increased popularity and appear in the freezer sections of most grocery stores, although unfamiliarity with the products as well as concerns over taste and texture continue to keep meat eaters away (Hoek et al. 2011). Ethical and environmental arguments do not appear to sway meat eaters to try vegetable-based fake meat, and researchers contend that improved taste would be more likely to do the trick (Hoek et al. 2011).

If lab-grown meat approximated the taste of traditional meat no better than plant-based meat substitutes, it seems unlikely to succeed in the marketplace. To overcome consumer reluctance about the newness of the product, it would have to taste virtually identical to traditional meat and compete in price, taste, and appearance with plant-based meat substitutes. These hurdles will be very high, though not impossible, to overcome, although it may take years if not decades for this to happen.

Beyond questions of taste, cultural practices around food and the common table also stand in the way of an acceptance of lab-produced meat. The home and hearth are identified with the organic and the natural and a pastoral ideal that may not reflect the reality of today's factory farming. The idea of producing meat in a sterile facility further removes food from the landscape in a way that many consumers would find unsettling. The nature/culture divide may not exist in an absolute sense, but it still informs the way that people think about food. Wholesomeness of food products is tied to an imaginary sense of naturalness very much related to the family farms of the early twentieth century. Lab-produced meat has some very high, though not insurmountable, cultural barriers to be overcome. Since the public has accepted the industrialization of meat production, the transition to lab-grown meat can be viewed as the next logical step in this process.

Summary

Lab-grown meat has numerous potential advantages over the current practices of large-scale animal agriculture. Environmental problems like deforestation and pollution could be mitigated by a switch to synthetic meat, and the new technology has the potential to alleviate, though perhaps

not eliminate, animal suffering. Additional benefits include lower risk of animal-borne disease and a more nutritious product. The current state of the technology relies on the cultivation of muscle cells in a collagen matrix, using fetal bovine serum as a nutrient bath. If in vitro meat is to become a mainstay, the technology must be scaled upward to produce consumer quantities at a lower cost. Many objections will have to be addressed, including remaining doubts about animal welfare, the perceived unnaturalness of the product, and anxieties about the newness and difference of lab-based food.

Cross-References

- ▶ Aesthetic Value, Art, and Food
- ▶ Agricultural Ethics
- ▶ Animal Welfare: A Critical Examination of the Concept
- ▶ Biopharming
- ▶ Climate Change, Ethics, and Food Production
- ▶ Food Risks
- ▶ Gustatory Pleasure and Food
- ▶ Meat: Ethical Considerations

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Systemic Ethics to Support Wellbeing

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Synonyms

Co-determination; Interconnectedness; Interdependency; Interrelatedness

Introduction

This section makes the case for systemic ethics to guide a new form of democracy and governance to protect the common good and the global commons, based on recognition that caretaking for well-being is “an idea whose time has come” (http://www.health.govt.nz/publication/idea-whose-time-has-come-new-opportunities-health-impact-assessment-new-zealand-public-policy).

The axiom on which systemic ethics for caretaking is based is that we can be free and diverse to the extent that our freedom and diversity does not undermine the rights of others or future generations of life. This section provides an overview of systemic ethics, based on considering the consequences of our thinking and practice for ourselves, others, and the environment. It sums up research on systemic thinking and practice (praxis) on reframing sociocultural values imbedded in not only democratic rights but also democratic responsibilities to others (including the voiceless and sentient beings), the environment, and future generations.

Caring stewardship is a process resulting from thinking and practice based on an understanding that what we do to others and to the environment, we do to ourselves and to our children. The land is placed first by First Nations internationally (Rose 1996). Post-colonialism and Indigenous knowing is important in understanding what stewardship entails for our relationships with others, the environment, and the next generation of life. Systemic ethics underpins the case that citizenship rights need to be scaled up to enable people to think in terms of the global commons on which we *all* depend for our survival. Contractual rights – as defined by the social contract between the citizens and the nation-state – do not go far enough to protect common needs, nor does the social contract protect the global commons (which includes air, water, soil, and the genetic code of life). The understanding of who we are and how we relate to one another is a starting point for exploring “our identity as caretakers.”

Recognition of Our Dependency on the Land

The environment affects people through the quality of the air they breathe, water supplies, and agriculture, and people in turn affect the environment through the way they think and practice. The way we think and practice has ethical implications for the way in which this generation uses the planet’s resources and has implications for future generations of life (see Hulme 2010). We have all heard the expression “Less is more” as applied to unpretentious good taste – rather than poor taste based on ostentatious extravagance and greed which leads to impoverishment – and in all probability life as we know it.

The Ministry of Environmental Affairs and Tourism, South Africa (2004, p. 41), cites Rosenberg:

> current patterns of consumption by 20 % of the world’s richest people indicate that they consume 45 % of the meat and fish, own 87 % of the cars, use 84 % of paper and 75 % of all energy resources.... They also generate 75 % of the annual global pollution.

Different interest groups have different perceptions, emotions, and values about the consumption and the nature of property and power to make decisions ranging from neo-Marxist arguments developed by Noam Chomsky(2005) and John Pilger (2002) about new forms of colonialism to arguments about the crisis and collapse of capitalism, to social democratic arguments about the reform of the market (Held 2004; Wilkinson and Pickett 2009), and to green democratic arguments about the way people can mobilize change (Dryzek 2010) and Indigenous standpoints (Atkinson 2002) on the long-term implications of inequity and greed –some of which have been taken up by communitarian (Etzioni 2004) views on global stewardship and, most importantly, critical reframing (Hulme 2009, 2011; Beck 1997).

Where one places oneself on the continuum of values has implications for the **governance** of people and resources based on the way property and consumption are defined and for the **inclusion** of the marginalized in policy decisions. Furthermore, Urry (2007) highlights the implications of living in a world where the majority are urban based and reliant on the carbon economy for cooling and the transport of their food to the city:

> “... the world went urban on 23 May, 2007, this being ‘transition day’, when the world’s urban

> population exceeded the rural for the first time. One consequence is that the proportion of the world's population that are poor is inexorably rising, with the proliferation of massive 'global slums' . . . ." (Urry 2007: 197)

Urry raises the prospect of 'failed city states:

> "unable to cope with oil shortages and the droughts, heat waves, extreme weather events, flooding, desertification and so on. Their instabilities spread across borders, affecting neighbouring regimes through forced migrations, weakened public health and degraded conditions of life (Paskal 2007; Urry 2010:197)

The Sydney Peace prize winner Vandana Shiva sums up the challenge for this century as one of preventing the commodification of life (see http://www.youtube.com/watch?v=UOfM7QD7-kk, http://www.navdanya.org/news/229-awesome, http://www.vandanashiva.org/).

Multinational companies and the WTO have made it possible to patent the conditions of life, thereby causing almost a quarter of a million suicides by Indian farmers who cannot afford to purchase the seeds and the pesticides that are needed (despite the claims by the manufacturers). Furthermore, the attempt to criminalize farmers who store old varieties of seed could lead to very vulnerable food monocultures. The idea that the very basis for life – seeds and genes – can be patented is part of the process of commodifying people, animals, and the fabric of life.

Crish and Fayne (2010) stress the costs of declining agriculture which are felt by women and children in the cities. Most of whom survive through social support networks and informal trading – estimated to be 500,000 traders in SA (2010, p. 12) and 70 % are women. They cite the International Labour Organization (2003): *Street Traders and Their Organization*. According to the latter, extreme poverty, prostitution, and AIDS are the result of food insecurity, and children have less protein and less micronutrients – iron, iodine, and vitamins.

Agricultural production has contracted in South Africa.

"Life expectancy actually declined over the past 40 years in . . . six states in . . . sub-Saharan Africa: the Democratic Republic of the Congo, Lesotho, South Africa, Swaziland, Zambia and Zimbabwe." 40-year Trends Analysis Shows Poor Countries Making Faster Development Gains. UNDP 4 November 2010 http://hdr.undp.org/en/reports/global/hdr2010/news/title,21577,en.html Accessed 2 February 2011.

In South Africa, Crish and Fayne (2010) argue that cash, not rural, agriculture is the way in which the majority feed themselves in South Africa. For example, "in 2000 only 5 % of all South African households used agriculture to supplement household food. . .." By 2020, the urban populations of less developed countries will exceed rural populations and continue to climb – three billion more will soon be in the cities of the developing world. Food can be the single largest expense in households – 39 % of the average household expenses. Internationally, the global financial crisis combined with the effects of climate change will lead to higher levels of starvation. In South Africa alone, farming jobs have contracted from one million workers in 1993 to approximately 660,000 workers at the end of 2010. The nongovernmental organization coalition found that "life is getting harder for the rural poor" and that female-headed households are amongst the poorest. Stunting and infant mortality have "risen from 48 to 54 per thousand for Africans," while "for whites it fell from 7.4 to 7.3 per thousand."

Ethically, the focus ought not to be merely on poverty and food security, but instead on the extreme wealth of *some* which contrasts with the underfed and the starving two thirds of the world's population. Overconsumption and obesity are a result of *both* life choices and life chances. The link between obesity and capitalism is clearly the result of resource- or time-poor people who do minimal exercise and rely on fast food.

The challenge for developed and developing nations is to achieve or maintain:

Access to safe housing (including energy and water), appropriate education, and employment to enable social and environmental justice; but within

Livable cities that are in turn supported by

Sustainable regions that support agriculture, animal husbandry, forestry, and fishing.

The impacts of climate change (and possible actions to minimize the impacts) present a complex problem to communities and governments around the world. The challenges facing the most marginalized in the community are challenges that could be suffered more widely as the impact of systemically linked social, economic, and environmental challenges leads to accelerated changes to the livability of cities and regions on which they depend. Climate change will affect the standard of living that is taken for granted by the privileged (Fiona Stanley, Hawke Oration lecture 17 November 2008).

Stewardship philosophy needs to be reapplied (see Ottawa Health charter 1986, http://www.who.int/healthpromotion/conferences/previous/ottawa/en/; Brundtland Report 1987, http://www.un-documents.net/wced-ocf.htm).

The social contract protects citizens within the nation-state, but those who do not vote (young people and the disabled) rely on the care of others. Those who fall outside the mantle of the nation-state remain without protection. In more equal societies, people consume less and are less status conscious. Some scholars (Dryzek 2010) propose that not achieving those simultaneous aims affects human rights and the groundswell of democracy that seeks to limit the effects of climate change through social and environmental justice. The Club of Rome research needs to be extended to *engage* with *global citizens*, which is perhaps one of the reasons it did not gain traction. Participants need to consider issues in terms of expanded pragmatism (namely, the consequences for their own children) which could have helped people develop *the will* to make changes in their own lives and to lobby for environmental issues. People need to want and demand "the impossible" (http://www.salon.com/2011/10/24/judith_butler_at_occupy_wall_street/), namely, affordable food and responsible state-market and civil society coalitions.

The Capabilities Approach Guides Systemic Ethics

Systemic ethics (McIntyre-Mills 2010) is based on understanding the social, economic, and environmental consequences of:

The **extreme luxury** enjoyed by the few is at the expense of the majority *in this generation* (Davies and World Institute 2008) and at the expense of the next generation.

The **zero-sum approach of "us/them"** thinking leads to shifting responsibility and blame for resource use and resource management.

The **denial of the links** across the social and environmental system in relation to the consumption of energy through wasteful living. We need to move beyond debate couched in mutually exclusive narratives and recognize that we can be free and diverse to the extent that our freedom and diversity does not undermine the rights of others or the next generation of life. The limits to diversity are set by our dependency on the land of which we are part.

The threefold aim of systemic ethics is to make a case for:

Processes and structures that *enable regional*, *transnational* democratic dialogue on difficult issues of social justice and sustainability

Enabling participants to consider the consequences of socioeconomic decisions for this generation of life and the next

Controlling rights so they cannot override responsibilities to save resources for the next generation

The test for the moral law is being prepared to live with decisions if they were to be applied to oneself and one's own children. This is the basis of social contractualism developed by John Rawls (1999) who explains in "The Law of Peoples" that this "veil of ignorance" approach is the basis for liberal democracy. The problem is that the social contract is too limited to take into account the needs of the powerless, such as the disabled, children, and animals. Compartmentalized thinking undermines accountability and risk management.

'A priori' means ethics based on the moral law and a sense of duty – irrespective of the consequences. Traditionally, idealism and Kantian ethics is considered to be focused on the duty of human beings. In this section, a case is made for duty – based on considering the consequences of decisions for this generation and the next. Kant's "moral law" focused on human beings.

The humanist idea of respect (based on treating people as ends in themselves and not as a means to an end) has been translated into practice in limited ways.

A case needs to be made for extending the social contract, because it is inadequate to protect the environment. Furthermore, it does not address the interests of citizens who are young, disabled, or members of other species (Nussbaum 2006). The contract is not extended to noncitizens. By focusing on the future generation of life, we can extend our time frame and our sense of solidarity. Without power, the potential remains for people to be silenced or treated as commodities. Controlling consumption requires changing bad habits which in turn requires the political will to transform praxis. This has implications for transforming governance and democracy to ensure that the market is not allowed to destroy the life chances of the many for the benefit of the few.

Emergence is the ability to escape the trap of our own thinking, to cite Vickers (in Beer 1974, p. 252): "the trap is a function of the nature of the trapped." According to his theory of "recursive consciousness," we are able to emerge from our entrapment through making connections and realizing that we have the capability to achieve transcendence as we become more conscious.

Consideration of the question "how should we live?" ought to be guided by considering the consequences – not only for our own life, but the consequences for our neighbors and future generations of life. What we decide, how we decide, and who we decide to include in a conversation need to be guided by careful questioning and respectful dialogue. Hulme (2011) characterizes a single focus narrative as reductionist and stresses that we need to be aware of different narratives on climate change, in order to enhance our resilience and our ability to think about our thinking.

> The capabilities approach takes its start from the Aristotelian/Marxian conception of the human being as a social and political being, who finds fulfillment in relations with others. (Nussbaum 2006, p. 85)

Rose (1996, 2004) argues that a first step towards building our capability is to understand our role as caretakers. This requires recognizing the colonial mindset without adopting a naïve approach that one culture has all the answers. The challenge is to understand that "we are the land" – and that measuring a carbon footprint is merely a response to the problems we have created through extraction of surplus from the land and labor. The economic bottom line of profit needs to be replaced with well-being, based on systemic ethics, rooted in respect for personal and planetary well-being. We deny that "we are the land" and that – along with all life – we return to the elements of life when we die. We become the ancestors and nurture the land from which new life grows. Caretaking can also be assisted by the so-called Tuvalu test developed by physicists (Murray et al. 2007) which helps policymakers understand that human beings are systemically interconnected and dependent on the environment. It provides a step towards appreciating social, economic, and environmental accounting and accountability to others. The test suggests that we need to consider how our carbon choices make a difference to others. Carbon choices made in developed nations impact on rising sea levels, for example, that impact on agriculture and food security.

Systemic ethics addresses emotions, values, and perceptions when making decisions, because emotions are one of the building blocks of consciousness (Greenfield 2000). To be able to address complex wicked problems, we need to address values and emotions. Scenarios, narratives, and art can be used to help us explore complexity and our emotions. Ethical literacy can be assisted by asking questions, in order to draw on many kinds of knowledge (see McIntyre-Mills 2010, drawing on and adapting West Churchman 1979), and striving to match areas of concern to areas of knowledge that will enhance well-being by considering the following:

- Subjective ideas that are brought into intersubjective processes.
- Logical relationships across ideas.
- Empirical data for the big (broad) and small (detailed) picture.
- Idealism (not thinking about the consequences), because the moral law states we

need to treat people as ends in themselves and not a means to an end and the capabilities of sentient beings (Nussbaum 2006).

- Intersubjectivity, based on compassion, care for the voiceless, and meaningful communication with those who can engage in dialectical relationships that explore one argument versus another argument and then cocreate shared meanings within context.
- Caretaking considerations are based on considering the consequences for this generation of life and the next which leads to the best integrated response drawn from diverse ideas.

As human animals, we have evolved as *Homo sapiens sapiens*. Human beings are the so-called 'twice wise' who are 'capable of thinking about our thinking' (Banathy 2000). We human beings are the designers – for better or worse. But our appreciation that we are co-determined by the environment no longer guides (our) designs. This also has implications for policy designs that take into account regional considerations and our systemic interconnectedness. Indigenous peoples the world over have expressed a spiritual connection with the environment based on both fear and reverence. Systemic ethics is rooted in an appreciation of our dependency on nature and recognition of Indigenous wisdom, based on an understanding of the notion of caring for the land. Culture, design, and tools must be used to adapt to the environment. Today, the human species tries to adapt the environment to the so-called needs of a deified, reified market. This is unsustainable. Instead, we must use our creativity to protect the land.

Research into participatory governance for social and environmental justice is based on testing out ideas and considering "if-then" scenarios to enhance the capability of people to think about the consequences of their decisions for others and the next generation of life. "If-then" scenarios need to take into account the social, cultural, political, economic, and environmental dimensions of an issue.

The '**enemies within**' refers to human values, namely, religion, morality, politics, and aesthetics (West Churchman 1979) that filter our understanding of the world and that affect our emotional understanding of the world. Ethical decisions need to avoid polarizing *emotion* versus *reason* and to accept that emotions have played an important role in enabling cooperation and communication across the evolutionary continuum. This requires the ability to ask questions and consider 'if then' scenarios (see Ulrich, 1983). Greenfield (2000, p. 21) argues that emotions and feelings are the most basic aspects of consciousness. She calls them "the building blocks," and when we temper our emotions through thinking through implications of "acting out" passions, we are able to become more mindful or conscious. Emotions can limit our consciousness, but they can also alert us to issues that we need to think about. Passion and compassion are the flip sides of one another. The more connections we can make, the better our thinking, our policy processes, and our governance outcomes will be. Nussbaum defines quality of life and development in terms of ideals, and she recognizes the emotional dimension of ethical thinking in both personal and public lives.

A new form of green democracy and governance needs to be designed which takes into account both (a) a priori and (b) a posteriori approaches to promote systemic ethical stewardship (see an example of praxis to reduce consumption by the privileged living in the urban environment; click here for access to the video [http://www.dropbox.com/sh/q5750v9ilibnokc/zEcunDKP6R]).

Both increased equality and increased control could make a difference. The former requires the will to make policy that supports both democracy and sustainability. This requires ethical decisions based on both a priori and a posteriori ethics. Norms need to be institutionalized through governance.

The problem of engaging large groups of diverse interest groups is threefold. The tendency to think in *linear*, *systematic* terms is exacerbated by an attempt to summarize ideas, rather than exploring and engaging with people to enable them to think about their values and about the interconnected consequences of their choices (Hulme 2009; Vickers 1983).

Stiglitz et al. (2010), the past vice president of the World Bank, along with his colleagues have stressed the systemic nature of social, economic, and environmental challenges. Stiglitz et al. (2011, p. 15) use a multidimensional measure of well-being spanning:

1. Material living standards (income, consumption, and wealth)
2. Health
3. Education
4. Personal activities including work
5. Political voice and governance
6. Social connections and relationships
7. Environment (present and future conditions)
8. Insecurity of an economy as well as a physical nature

Stiglitz has stressed (at the invitation of the Australian Productivity Commission) that the bottom line is well-being – this requires building *stocks for the future* (Stiglitz et al. 2010) to protect the basis of life.

Biospheres are regions which are currently protected by the United Nations; they have the potential to be scaled up as overlapping regions. Current forms of engagement on sustainability issues involving large groups of diverse stakeholders have failed. This is evident from the failed United Nations Copenhagen Summit (COP 15) and at the Cancun Conference in 2010 (COP 16) which were unable to draw on the "wisdom of the people" (Christakis 2004) or to achieve significant governance controls. Dahl's (1967) pessimism about choosing nested systems of governance – because democracy was designed for the city-state – has long been overturned by the necessity to develop an understanding of our interconnectedness across many cities and that the cities are dependent upon the land. The Copenhagen Summit (2009), Cancun (2010), and Durban (2011) remain a continuing source of inconclusive discussion. It demonstrates the need to develop a means to enable large groups of people to explore the implications of complex challenges such as poverty, climate change, and competition for resources and then to reach sustainable decisions. The Copenhagen Climate Change Summit illustrates that even when organizations try to include diverse stakeholders and diverse viewpoints, the challenge remains as to how to include diverse viewpoints.

The aim of ethical governance is to find a way to manage consumption through reducing the size of the carbon footprint of businesses, government, and domestic users, as reflected in governance codes that reward living in a sustainable way in each local council area. The next decade requires decisive socioeconomic intervention (Stern 2006, 2009; Lovelock 2009) to discover the processes and governance structures that enable social justice and sustainability, in order to reduce consumption and thus to enhance social and environmental resilience.

Systemic Ethics for Caretaking

Systemic ethics for caretaking requires developing the capability to think through the consequences of decisions for the long term within and beyond the boundaries of the nation-state. It requires extending the spatial and temporal dimensions of our thinking and practice. Furthermore, it requires protecting the next generation of life. The social contract only protects those within the boundaries of a nation-state and excludes noncitizens, those too young to vote, the disabled, and those who are voiceless, including sentient beings (Faist 2009; Nussbaum 2006).

Accelerated climate change will adversely affect well-being and sustainability (Flannery 2010; Lovelock 2006, 2009; Singer 2002) if we continue to live in ways that consume at current rate. The impact is likely (Rockström et al. 2009) to have been underestimated by the Intergovernmental Panel on Climate Change (IPCC) (2001) and the Stern Review on the Economics of Climate Change (2007) (http://webarchive.nationalarchives.gov.uk/+/, http://www.hmtreasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm).

The problem of how to control the use of scarce resources in a sustainable and democratic way is the focus of this section. The IPCC formula that addresses the implications of polarizing people versus the planet is as follows: E (emissions) = population × consumption per person × energy efficiency × energy emissions (Intergovernmental Panel on Climate Change (IPCC), http://www.bing.com/search?q=intergovernmental+panel+on+climate+change&src=IE-SearchBox&FORM=IE8SRC).

The IPCC has concluded that the goal of reducing the carbon footprint should be 387 parts per million of carbon, and Rockström et al. (2009) have argued that it should be less, namely, 350 parts per million.

The United Nations Human Development Index (2003) and World Wildlife Fund (2007) show that (with the exception of Cuba) no country in the world has achieved both the quality of life and a sustainable ecological footprint (Wilkinson and Picket 2009, cites Planet Ark Trust 2004). More equal societies are more sustainable in their attitudes to resource use.

The attitude to what constitutes normal usage of the planet's resources is unsustainable. Democratization to ensure a fairer use of the world's resources needs to ensure that a redesign of living standards occurs – and in the meantime governance controls need to achieve both the contraction of resources (Beck 2010) used by the rich and the greater convergence across living standards for all. In a post consumerist world wealth needs to be re-evaluated, because, to draw on and apply Einstein's well known aphorism: We cannot solve the problems of today with the same ideas of *property and consumption* that created the problem of an *unsustainable* way of life.

Consumption choices have reached a stage where they pose an existential risk (Bostrom 2011). Furthermore, consumption is very unequal, and the gaps between rich and poor become wider and wider. The root cause of consumption is power without responsibility – so whoever comes to power needs to be held to account through mechanisms to develop social, economic, and environmental indicators that secure the well-being stocks for the future. The axiom for systemic ethics is that "we can be free and diverse to the extent that our freedom and diversity does not undermine the rights of others" (McIntyre-Mills 2010). The nation-state has not protected the global commons or ensured social justice for all. This has implications for representation, accountability, and sustainability and the need for a global covenant to protect the global commons (Held et al. 2005).

Balancing Rights and Responsibilities

Too much freedom can be as bad as too much control. Balancing rights and responsibilities is the challenge for *developed* nations that have large carbon footprints and that seek to access the last of the nonrenewable energy supplies as a means to maintain their international positions and for *developing* nations that need to achieve a decent quality of life to meet the United Nations Millennium Goals (http://www.globaleducation.edna.edu.au/globaled/go/pid/3740).

In more equal societies, people consume less and are also less status conscious. Thus, the link "between greater equality and the prevention of global warming involves consumerism" fuelled by advertising. According to their research, greater social and economic equality "gives us the crucial key to reducing the cultural pressure to consume" (Wilkinson and Pickett 2009, p. 221; Hoggett 2010).

"We are part of one space ship, earth" (Buckminster Fuller 1979). We are not in "separate life boats." The difference between these metaphors is at the heart of the systemic versus the compartmentalized "zero-sum" approach to governance. Systemic ethics requires facing up to the implications of living at the expense of others and future generations, by recognizing the limits which are set by the available resources and the "boomerang effect" (Beck 2002) of carbon emissions, excessive consumption, and greed. Us/them worldviews need to be transformed though the desire to identify with others and the environment. This will lead to enhanced well-being. Xenophobia could be redressed through recognizing that we are global citizens in overlapping regional areas. It is possible to address zero-sum approaches to governance if we avoid the mistaken notion that we gain at the expense of others or at the expense of the environment or the next generation of life.

The environment is a living entity which codetermines our very existence. It is not a commodity from which to extract endless profit. Ethical decisions ought to be translated into ethical praxis.

The test for whether thinking and practice is ethical is (a) whether it advances knowledge in the area of environmental politics by addressing the tensions across communities' participation in decision-making (i.e. democracy, human rights) and whether it advances approaches to address both the livability and sustainability of their geographical areas. One of the ways these tensions could be resolved is by applying the United Nations Aarhus Convention 1998 (see http://aarhusclearinghouse.unece.org/resources.cfm?c=1000069) on (a) the right for local people to participate in environmental decision making to address food security for their children (b) through invoking Local Agenda 21 1992 policy, and (c) a through an enhanced and extended form of the United Nations sponsored biosphere approach to support educational, scientific and cultural organization. Ideally people living in an area need to be enabled to take part in decision making and to extend their support for their policy concerns within the wider region.

These are some of the policy challenges locally and internationally that need to be addressed, but the **will** to achieve sustainable human rights across nation states requires an understanding that we need to think beyond "us/them" national competitiveness for resources.

Emotions have an impact on personal and public **desire and the political will to make changes**.

Narrow pragmatism is based on thinking about the consequences only for ourselves and not others. We tend to think that social and environmental considerations are "externalities." Expanded pragmatism (EP) provides a step towards supporting systemic ethics based on extending the capability of humanity to think in terms of the consequences of current social, economic, and environmental choices on resource management for current and future generations of life.

Systemic ethics is the capability to think and practice critically, in order to match appropriate kinds of knowledge to particular areas of concern. Being able to think critically and systemically needs to be buttressed by post-national constitutions that provide the scaffolding to support deep-ranging environmental changes that shape and are shaped by social, cultural, political, and economic thinking and practice.

Summary

To sum up, our environment shapes the life chances of human beings who in turn shape the environment in ongoing recursive cycles (Bateson 1972). Human beings have the capacity to design their relationships in such a way that they rethink representation, accountability, and sustainability in terms of the consequences for others and the next generation of life. This requires a cultural shift in the current understanding of time, space, as well as rights and responsibilities as global stewards. This has implications for democracy and governance.

Wide-ranging and radical change to the structure of society is required to ensure social and environmental sustainability.

Cross-References

- ▶ Biodiversity
- ▶ Centre for Animal Welfare and Ethics
- ▶ Environmental Justice and Food
- ▶ Feeding Children
- ▶ Food and Class
- ▶ Food Ethics and Policies
- ▶ Food Risks
- ▶ Obesity and Responsibility
- ▶ Oxford Centre for Animal Ethics
- ▶ Slow Food
- ▶ Vegetarianism
- ▶ War and Food
- ▶ Water, Food, and Agriculture
- ▶ You Are What You Eat

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