Assessing the Environmental Implications of Agricultural Biotechnologies: A Sociological Perspective

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Introduction

Lt. Governor Peeler closed his welcoming speech at this NABC meeting by stressing the importance of family farming to South Carolina, and the fact that much more needs to be done to help save family farms. I agree. Even so, when we discuss research, technology and so on in relation to family farming, there are often clashes among differing groups because competing social values relating to the importance of family farming strike many as being outside of the realm of science or empirical discourse, and difficult to choose between. It is thus ironic, but also instructive, if we recognize that debates over the environmental consequences of agricultural science and technology have been as or more perplexing and just as contested as the matter of the social implications of technology. In this paper I explore some of the reasons why this has been the case, and offer what some appropriate responses from the public agricultural research system should be.

The environmental implications of new agrofood biotechnology products arguably represent today the most socially-salient issue relating to agricultural biotechnology — and, for that matter, to agricultural technology in general. This is not to suggest that the structure of agriculture or the socioeconomic impacts of technology have ceased to be of concern to a good many people, or that there are no longer expectations that agricultural research will contribute to increased productivity, competitiveness, food safety, and so on. With the shift of our national political culture — and most of the rest of the world's — over the past two decades or so, the issue of the socioeconomic consequences of agricultural research and technological change is now on the margins of the political agenda of most governments and agencies. Many of these socioeconomic concerns, however, have been repackaged as environmental issues. In my part of the country, for example, there is a very significant level of resistance to the siting of large-scale, integrated confinement hog operations in rural communities. This issue is, at root, mainly a socioeconomic issue relating to agricultural technology and the structure of agriculture, but it is increasingly being played out on environmental grounds — odor, water quality, the risk of lagoon accidents and spills, and so on. In the developing world, landlessness and land tenure concerns have often been repackaged in the form of indigenous rights or sustainability movements.

Much of this paper will revolve around the symbolic or subjective aspects of environmental quality. Recognizing the fact that the environment is, in part, a matter of subjectivity, perception, and symbolism is not meant to trivialize the importance of the environmental implications of agriculture or agricultural technology. Environmental impacts and constraints are extremely high priority matters for agricultural researchers to address seriously. It is important to recognize that scientific evidence alone, no matter how compelling it might appear to the agricultural research community, will ultimately carry the day only if it is consistent with how various groups in society see their own lives and futures. There must also be societal trust in government, universities, and other institutions generating this evidence. Not only is there a tendency for agricultural scientists' calculations of risks to be different than those of nonscientists, but public environmental concerns do not always coincide well with data from environmental science research.

A Sociological Perspective on the Environment

The classical tradition in sociology and all the other major social sciences has revolved around stressing that the realm of the social can — and must — be understood apart from the natural world. Thus, for most of the nineteenth and twentieth centuries, social scientists thought that an explanation was satisfactory only if it was a social explanation (i.e., in terms of a social variable such as social class, culture, or power). There was deep suspicion and a lack of professional regard if social phenomena were explained in terms of physical or biological forces such as genetic heritage, climate, biophysical environment, and so on. In my discipline it is still the case today that scholars who study societal-environmental relationships, or who try to explain social phenomena by using biophysical variables, are considered more or less out of the mainstream (Harper, 1996).

When the environment rose to prominence as an issue nearly 30 years ago, some sociologists were of the view that their disciplinary tools needed to be dramatically changed if they were to be able to understand the significance of the environment. This has given rise to a substantial community of sociologists who take the environment seriously. There are now a goodly number of sociologists and other social scientists who are exploring the social significance of the natural world as a source of materials, resources, and (ecosystem) services as well as being a decisive constraint on human activities. But it is also very apparent to these environmental sociologists that the significance of the environment to human social life goes beyond the matter of the goods and services that humans obtain from nature, and the impacts that societies have on nature.

For example, the very notion of the environment can be seen as a Western cultural construct that is predicated on the distinction between society and the natural world. However, if we look at how humans have related to the natural world historically and cross-culturally, it becomes clear that the Western distinction between society and environment is by no means a universal one. The cultures (or "cosmologies") of many of the world's people today still involve seeing humanity as an integral and inseparable part of nature. For them, the notion that society or technology has "impacts" on "the environment" is unfamiliar or even nonsensical. Even so, the symbolic salience of the environment is still important in the Western world and in much of the remainder of the world that is undergoing Westernization and modernization. Widespread public concern about the environment is one of the defining features of social life in the late twentieth century.

Some sociologists believe that the essence of environmental concern is basically a response to the growing knowledge that the ecological/environmental sciences have been generating about how the expansion of human societies and modern technological practices are prejudicing the quality of the biophysical environment. Without denying that this process plays an important role, I believe that the significance of environmental concern is more social and symbolic (Hannigan, 1995). Matters such as personal security (particularly health), aesthetics, community livability, and the future quality of life for one's children tend to be the most enduring types of environmental concerns. Some movement leaders, however, have had a tendency to want to stress global environmental concerns that cannot be directly experienced by individuals and communities. One of the ways that environmental issues become socially salient is through the formation of public perceptions that there exist environmental risks that are unwarranted or unreasonable. This can occur when there is an environmental event that can be attributable to or blamed on an institution or organization in which there is a lack of trust. We, of course, live in a world where there is fairly widespread cynicism about major institutions, including both government and industry, creating fertile ground for cycles of concern about environmental and technological risks (Beck, 1992; Macnaghten and Jacobs, 1997).

Whether or not we define a particular social issue as an environmental one or not is therefore as much a process of social "framing" (Hannigan, 1995) and culture as it is a deduction from scientific research. I noted earlier that agricultural biotechnology has been contested increasingly on the grounds of whether this type of technology will or will not have adverse environmental implications. Thus, groups that for one reason or another have concerns about agricultural biotechnology are increasingly couching these concerns in environmental terms. Similarly, proponents of agricultural biotechnology, including many of the large private biotechnology firms, devote considerable effort to justifying these technologies on environmental grounds.

These debates about the environmental advantages and disadvantages of biotechnology occur not only in the media as direct or indirect attempts of various groups — including those of us at this conference — to influence the views of the public. They also occur in a variety of political, regulatory, and scholarly arenas. It is increasingly the case today that groups on opposite sides of a social policy issue will both actively use scientific arguments to bolster their case. In particular, it has increasingly been the case that social movements — including but not limited to environmental movements — will couch their arguments in science. This process, which I call the "scientization of social movements," is having significant impact on the work and practices of scientists (Yearley, 1991). This is particularly the case in the sciences whose processes or outcomes have potential environmental impacts. Agricultural biotechnology is a prime example of the "scientization" of public policy discourse. A parallel process that I find particularly significant as well is that professional and interest groups are increasingly conducting themselves more or less like social movements, in the sense that they actively hone ideological positions and claims in order to influence policymakers and the public. And in this process of the "social movementization" of professional and interest groups it is commonly the case that these groups rely on scientific arguments, and also make appeals to environmental concern or greenness.

The typical configuration of these policy debates and conflicts today is that environmental-type groups employ scientific reasoning about how technologies, policies, or other interventions will lead to environmental and other risks. Their opponents will typically respond with claims that in the reputable (or "sound") scientific literature there is no evidence that an adverse environmental impact necessarily will occur. And increasingly the response is complemented with uncertainty arguments. It is typically argued that the risks discussed by environmentalists are only hypothetical, that there is doubt in the scientific predictions and conjectures used to forecast risk, and that it would be imprudent to make costly responses to risks that are only hypothetical. Typically, both sides sincerely believe that "sound science" is on their side. It should be stressed, though, that risk and uncertainty, while they are common words in our language that have several meanings (Thompson, 1997), are perfectly legitimate scientific concepts. But they are employed so often as rhetorical weapons that there is now a growing cynicism in policy circles about whether they are more-so political slogans or methods of scientific analysis.

THE ENVIRONMENTAL IMPACTS AND IMPLICATIONS OF BIOTECHNOLOGY: SOME OBSERVATIONS

Why is there so much debate and concern about the environmental implications of agricultural biotechnology? My analysis thus far is that one dimension of this concern is socially constructed. One implication of this point is that scientific evidence and argument alone can play only a partial role in resolving policy conflicts whose origins have deep roots in society and social structure. But it is important to recognize that these conflicts are not merely symbolic — or, some might say, nonempirical or irrational — ones. The fact that agricultural biotechnology remains controversial nearly 20 years after the onset of large-scale public and private R&D suggests that concern about the technology is much more than an irrational obstacle or public resistance to change. Agricultural applications of biotechnology account for less than 15 percent of private biotechnology R&D investment, but perhaps 80 percent or more of the conflicts and controversies over the technology have been agriculturally related (Krimsky and Wrubel, 1995). In part, this is because many of the first generation of crop biotechnology products — particularly herbicide-tolerant and Bt (*Bacillus thuringiensis*) engineered crop varieties — have had environmental liabilities or vulnerabilities.

Second, agriculture in the US and elsewhere faces some considerable environmental and resource management challenges, and the nature of ongoing trends suggests that the path we are on is problematic for dealing with these challenges. Agricultural chemical use has increased, and since the late 1980s there has been a decisive reversal of the farm-crisis-induced decline of agrochemical usage (Goodman and Redclift, 1989). Nitrogen usage has never been higher. Despite much touting of integrated pest management (IPM) technology, agricultural pesticide usage (as measured by pounds of active ingredients) remains virtually unchanged from the levels of 15 years ago (GAO, 1995). Cultivation of highly erodible land is still widespread (ERS, 1995a, 1995b). Agriculture remains the most significant contributor to impairment of the quality of the nation's water resources. About 38 percent of the miles in lakes and streams, and 44 percent of the nation's lake acres, were estimated to be not fully supporting their intended uses, according to US Environmental Protection Agency (EPA) data for 1992 (GAO, 1995). Agriculture was the leading source of impairment of the quality of water in rivers, streams, and lakes. At some point over the next decade or two the national and world agricultural communities will need to address the interrelated problems of the excess of fixed nitrogen compounds in the global environment (Vitousek et al., 1997; Hellemans, 1998), and the impact of agricultural production on the quantity and quality of water resources. Add to these macro-level environmental constraints the more highly salient public concerns about food quality and safety, the odors and water quality impacts of animal wastes, and so on, and it becomes clear how important the environmental dimensions of agricultural technology will be in the future.

There have traditionally been two major ways in which the environmental implications of agricultural biotechnology have been analyzed and dealt with in policymaking. The first approach to assessing the environmental implications of biotechnology has been to undertake experimental field or laboratory assessment of whether a particular biotechnology, such as Bt-engineered corn or herbicide-tolerant soybean varieties, has definite, empirically verifiable adverse environmental consequences. Experimental assessment of a specific biotechnology product generates data that can be useful in regulatory arenas. There is, to be sure, more than a small amount of grumbling about the EPA, the US Food and Drug Administration (FDA), and the United States Department of Agriculture (USDA) regulation of agricultural biotechnology. But it has been very seldom that regulatory roadblocks have derailed an attractive agricultural technology. And a strong regulatory process serves a useful long-term purpose in building public trust and in discouraging scientists from bringing highly risky technologies to the market. Nonetheless, these experimental data, while they are of clear use in addressing what might be termed the population-ecological and ecotoxicological effects of agricultural biotechnology, do not exhaust the broader environmental issues that relate to agriculture.

The second approach has been to make assessments about whether biotechnology as a class of technologies is likely to be environmentally friendly or environmentally destructive. For example, many proponents argue that because biotechnology will make possible increased productivity and output, these technologies are environmentally friendly because they will enable food to be produced on smaller acreages than would otherwise be the case. There will, therefore, be less “pressure” on tropical rainforests, wetlands, marginal agricultural environments, and so on. This type of argument, however, has a good many fallacies. It is premised on the notion that biotechnology is the only possible way to increase the productivity and output of the world’s croplands. The nature of technological change in the industrial countries, where biotechnology products will be most extensively used, are not likely to have much effect on land use in the tropics. This argument also ignores the fact that to the degree to which there is rapid technological change in the developing world and this technological change is of the capital-intensive type (as is the case with most biotechnology products), it is likely to exacerbate landlessness. All things being equal, landlessness will result in more rather than less of a tendency for the rural poor in the developing world to seek land for subsistence in rainforests and other ecologically significant zones. Similarly, some observers (including some opponents of biotechnology) argue that due to the nature of the technology it will lead to genetic uniformity and to risk of widespread incidence of pest and pathogen outbreaks. It is not clear, however, that biotechnological methods will lead to genetic uniformity of a magnitude greater than what conventional plant breeding makes possible.

I am not inclined to put very much stock in claims that agricultural biotechnology is environmentally friendly or not due to the methods that are used in research and development. In part, this is because of the fact that biotechnology is not a particularly meaningful term anymore. Granted, there is a certain coherence to biotechnology if we say that it involves cellular or subcellular manipulation of life forms. Recombinant DNA is the most significant — and controversial — technique in the cluster that is generally referred to as biotechnology, but relatively few agricultural scientists actually create transgenic organisms. Gene mapping is a central technique of biotechnology, but again gene mapping is not a common activity among agricultural scientists, and gene mapping can be useful in ways other than creating new organisms. Marker-assisted plant breeding is a tool of general utility. Thus, "biotechnology" is a diverse set of research methods. Further, as with most scientific methods, the implications of the technologies that derive from these methods are shaped more so by the research priorities that these methods are used to achieve than by the methods themselves. Thus, there is no inherent reason to either promote or disparage the technologies that can be developed through use of these methods on environmental or other grounds.

Nonetheless, if forced to make some overall judgment about the environmental implications of biotechnology, my guesses about plant biotechnology products would be as follows. The crop biotechnology products that have been commercialized or are in the pipeline are basically derivative technologies. By this I mean that these technologies are basically being derived from or being grafted onto an established trajectory, rather than defining or crystallizing a new one. This established trajectory in crop agriculture consists of a predominance of farm- and regional-level specialization — basically monoculture, continuous cropping, and spatial homogenization — along with incremental shifts toward labor-saving technology and larger scales of production. New technologies such as the first generation of biotechnology products basically provide some management options for dealing with the problems of large-scale, specialized crop agriculture. Herbicide-tolerant crop varieties, for example, may help to rationalize herbicide usage by expanding the scope of usage of less toxic and/or less persistent herbicides and enabling these crop protection chemicals to be used postemergence. Bt engineered varieties (and other biopesticide products) enable the large commercial producer to control pests without having to resort to crop rotations. Contemporary commercial biotechnology is essentially based on high-value, single-gene traits. We need to recognize that there is an economic-environmental contradiction of single-gene-trait biotechnology. The more valuable the trait the more widespread it will become, and the greater the selection pressures for resistance and other forms of environmental disruption. I would suggest that crop biotechnology products will basically nudge world and US agriculture a little farther along the trajectory of specialization, ecological homogeneity, and incremental increases in chemical use that was initiated earlier in this century. They are not likely to dramatically exacerbate these problems, nor will they do much to solve them.

The technological products derived from biotechnology (and of other combinations of research methods and research priorities) will need to be assessed in meaningful packages that avoid the limits of the two prevailing assessment methods. Meaningful clusters of biotechnology products are much smaller than that of biotechnologies as a whole, but larger than that of a specific biotechnology product. Most importantly, environmental assessment of meaningful clusters of biotechnologies must address the implications of these technologies for the degree to which they will make a significant contribution to addressing the overarching environmental problems of agriculture, such as global nitrogen overload, water quality and quantity, and maintenance of ecosystem services. However, these assessments must not be narrowly environmental or ecological in nature. For instance, the ecological impacts of technology often occur through socioeconomic processes. Hybrid corn, for example, historically led to soil erosion problems, but not because hybrid corn was intrinsically destructive of soil. Rather, the technology involved a high level of genetic uniformity, and was highly consistent with mechanization. The mechanization of tillage, and especially harvesting, led to incentives for monocultural production, and in many areas to soil erosion. Assessments of environmental implications and risks need to take into consideration the context of the use of technology — particularly the structure of the production sectors for which they are being developed (Kunkel et al., 1998).

Thus far I have not placed much emphasis on global environmental issues. This might seem to be a serious omission when we consider the fact that the major western environmental organizations have long tended to stress global climate change, stratospheric ozone depletion, loss of biodiversity, and so on. And in my own discussion of the agricultural environment I have stressed the importance of macro-level, if not global, environmental issues. The global surplus of fixed nitrogen is a particularly important example of a large-scale environmental issue in agriculture that we need to take into account as we think about the environmental implication of biotechnology.

Even if we grant that the matter of the global surplus of fixed nitrogen is a relatively new issue (National Research Council, 1997; Burns and Hardy, 1975), it is still worth noting that there is currently no organized movement oriented toward encouraging agricultural researchers and policymakers to address this matter, and there is not likely to be such a movement any time soon. If we think about why this has been the case it can tell us something very important about the often-imperfect alignment between public environmental concerns and global environmental issues. Most people are likely to care more about environmental problems that they can directly experience, that affect their quality of life, their sense of personal safety, or their community integrity. It is usually the case, however, that the typical citizen cannot directly experience global-scale environmental problems such as climate change or the rising level of fixed nitrogen in the environment. This is because these problems will generally not be fully apparent for decades, their impacts may be felt most strongly by others, or any solutions implemented now will mainly benefit future generations. Thus, it is not surprising that while environmental mobilizations around global issues such as atmospheric warming can grab headlines and attention for a while, these issues do not have much public staying power. Global climate change, for example, has now almost entirely disappeared as a major public issue.

Concluding Remarks

Is biotechnology a threat to the environment in some sociological or objective biophysical sense? I do not think this question has a meaningful answer. The technologies that will derive from cellular and subcellular manipulation of organisms will be a function of research priorities or public policy.

Will biotechnology, in and of itself, lead to solutions to the major environmental concerns that I distinguished between earlier? Probably not without some significant institutional changes such as ecological taxes. But if there are some institutional changes, biotechnological methods will have a lot to contribute. I have a strong feeling, however, that we will get the most out of biotechnology if we begin to invest a lot more in agroecological approaches to agricultural systems.

Should agricultural researchers pay attention to the public and the rank-and-file of their clienteles and respond to their environmental concerns? Or should the research system be attentive to the more macro environmental constraints? We need to do both. We always need to listen to our constituents — even the ones we disagree with — and strive to open new lines of communication. This is an integral part of the process of building public trust and being a responsive public institution. And this means more than getting in contact in order to convince them about our data and our views. But we also have an obligation to be forward looking and to anticipate the kinds of technologies that could be possible and desirable in the more environmentally constrained world that we'll meet up with in the next century.

Is the public essentially becoming anti-science or anti-biotechnology? There is no evidence at all that this is the case. There have been no major changes in public trust in science over the past two decades. The only key shifts are that minorities, and to a modest extent women, have declined in their trust in science (when education is controlled), and that today the very well educated are somewhat more polarized between very pro-science and anti-science views than in the 1970s. In general, though, there is no significant public opposition to biotechnology, or science in general, provided that we meet our obligations as scientists and universities of taking the public seriously. But you don't need a sociologist to tell you this. It basically involves doing what the Morrill Act and Hatch Act established the land-grant system to do.

Agriculture has some significant issues to address if it is to build this trust. Farm numbers are again declining rapidly, after a period of relative stability during the 1970s and early 1980s. Livestock industrialization is creating some very problematic public relations for agricultural research institutions, and food and agriculture in general. Many agricultural groups are active politically (in pursuit of "right to farm" and "food disparagement" legislation, in opposition to land use planning) in ways that many in the public find to be narrowly self-interested. Agriculture needs to reestablish itself as a public (rather than primarily a private) goods-generating set of institutions if it is to rebuild this trust.

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