ANALYSIS

Ecological Modernization and the "Gene Revolution": The Case Study of Bt Cotton in India* **

Ashok Kumbamu

In recent years ecological modernization has emerged as one of the dominant perspectives in the field of environmental social sciences.[1] A central premise of Ecological Modernization Perspective[2] (EMP) is that while the environmental problems of this century have been caused by modernization and rapid change in the forces of production, these problems can be overcome by technical and procedural innovations.[3] Thus, according to EMP, technology is part of the solution, not the problem.

Critics disagree. Some argue that "capitalist technology is in reality a force of oppression, exploitation, and destruction."[4] Others consider EMP a perspective of "(Northern) Eurocentricity," since its metatheoretical and normative assumptions were formulated on studies conducted in West European political and economic contexts, specifically in the Netherlands and Germany.[5]

In response to such criticisms, proponents of EMP have encouraged scholars around the globe to examine its relevance for the industrial sectors of newly

*I would like to thank Michael Gismondi at Athabasca University, Gordon Laxer at the University of Alberta, Susan A. McDaniel at the University of Windsor, and *Capitalism Nature Socialism* managing editor Karen Charman for their encouragement and useful comments on a previous version of this paper.

**Research for this case study includes analysis of government policy documents, media and non-governmental organization reports as well as qualitative data gathered from farmers during field research in Warangal district between May and August 2004.

[1]Frederick F. Buttel, "Ecological Modernization as Social Theory," *Geoforum,* 31, 2000, p. 57.

[2]I agree with F.H. Buttel who prefers to use the expression "ecological-modernizationist 'thought' or 'perspective,' rather than theory . . .because of the fact that, at least as far as the literature in English is concerned, ecological modernization is not yet a clearly-codified theory." *Ibid*., p. 58.

[3]Maarten A. Hajer, "Ecological Modernization as Cultural Politics," in S. Lash, B. Szerszynski and B. Wynne, (eds.), *Risk, Environment and Modernity, Towards a New Ecology* (Thousand Oaks, CA, London, and New Delhi: Sage Publications, 1996), pp. 249.

[4]James O'Connor, *Natural Causes: Essays in Ecological Marxism* (New York and London: Guilford Press, 1998), p. 200.

[5]Buttel, 2000, *op. cit.,* p. 64.

ISSN 1045-5752 print/ISSN 1548-3290 online/06/040007-25

DOI: 10.1080/10455750601004442

industrializing countries (e.g. Malaysia and Indonesia), countries in "transition" (e.g. Lithuania, Hungary, and China), and the so-called developing countries (e.g. Vietnam, Kenya, and Thailand).[6] The agrarian sector and its environments in the global South remain less studied.[7]

This paper examines the relevance of EMP in assessing the agrarian economic and ecological crisis in the global South in general, and India in particular. It uses the introduction of genetically modified (GM) Bt cotton into India as a case study and considers whether environmental reforms are possible in existing Indian structural and institutional circumstances. The case of Bt cotton offers empirical insight into the relevance of EMP for developing countries, particularly since the proponents of GM crops—the "Gene Revolution"—strongly believe that the advancements of technology in agriculture can solve the economic and environmental problems of developing countries by boosting productivity and reducing dependency on pesticides and insecticides. For example, when Monsanto, the second largest seed company in the world, introduced Bt (*Bacillus thuringiensis*) cotton into India in 2002, it portrayed the new seed as a cure-all for the many challenges farmers face. Bt cotton, Monsanto promised, would cut fertilizer, pesticide and crop management expenses, reduce the environmental problems associated with heavy pesticide use, increase yields, provide high returns, and thus reduce farmer suicide.[8] However, the introduction of Bt cotton into India, especially in the Warangal district of the Andhra Pradesh, reveals a different story.

GM crops provide an important lens through which to assess EMP for two reasons: First, the introduction of GM crops are presented as a solution (if not the only solution) to the economic and environmental problems created by the conventional crops of the Green Revolution—itself a notion of development or progress through technological advancement, which is at the heart of modernization theory from the 1960s through the 1980s. Second, debates about GM crops raise many ethical and political questions about the environmental problems associated with the adoption of new technologies.[9]

[6]See Arthur P.J. Mol, *Globalization and Environmental Reforms: The Ecological Modernization of the Global Economy* (Cambridge, MA and London: MIT Press, 2001); Arthur P.J. Mol and David A. Sonnenfeld, (eds.), *Ecological Modernization Around the World: Perspectives and Critical Debates* (London and Portland: Frank Class, 2000); Gert Spaargaren, Arthur. P.J. Mol and Frederick H. Buttel, (eds.), *Environment and Global Modernity* (Thousand Oaks, CA, London, and New Delhi: Sage Publications, 2000); Lei Zhang, *Ecological Industrialization in Chinese Small Towns*, PhD Dissertation, Environmental Policy Group (Wageningen: Wageningen University, the Netherlands, 2002).

[7]Wendy E. Jepson and Christian Brannstrom, "A Case of Contested Ecological Modernization: the Governance of Genetically Modified Crops in Brazil," *Environment and Planning C: Government and Policy*, 23, 2005, p. 297.

[8]Abdul Qayam and Kiran Sakkhari, "The Bt Gene Fails in India," *Seedling*, July 2003, p. 13.

[9]Dave Toke, "Ecological Modernization and GM Food," *Environmental Politics*, 11, 3, 2002, p. 145.

Core Premises of Ecological Modernization

Ecological Modernization originated in the late 1980s and is considered part of the "third wave" of environmentalism in Western Europe and North America.[10] EMP has evolved from three consecutive phases of development. The first phase, which lasted until the late 1980s, placed more emphasis on technological innovations to drive environmental reforms. In its second phase, from the late 1980s into the mid-1990s, EMP shifted its focus from a technological determinist perspective and, acknowledging its limitations, concentrated more on synergy between the market and the state, the role of human agency, institutions, and culture in environmental reforms. In the third phase, from the mid 1990s up through the present, EMP shifted again and extended its purview to contemporary forms of industrial production and consumption, applied itself to non-European nations, and increased its focus on changing global dynamics.[11]

Metatheoretical Foundations

Ecological Modernization Perspective is said to have modernized modernization theory.[12] One of its leading theorists, Arthur Mol, argues that "the basic, most fundamental, idea of the ecological modernization theory has been formulated as the 'emancipation,' 'differentiation' or growing independence of an ecological sphere and rationality with respect to the economic sphere and rationality, in particular."[13] Whereas modernization theory emphasizes economic rationality and neglects ecological rationality, EMP says that the conflict between economy and ecology can be mitigated within the framework of the capitalist mode of production.[14] To bring harmony between economy and ecology, Joseph Huber, the founding father of ecological modernization,[15] suggests two complementary processes: "ecologization of economy" and "economization of ecology."

---

[10]The first wave of environmental concern originated around the early 1900s. During this phase the focus was on the degradation of natural landscapes caused by rapid industrialization and urbanization rather than raising questions about the foundations of industrialization process itself. Recognizing the limited focus of the first wave, the second wave of environmental concern began in the late 1960s and early 1970s. It focused more on the radical changes that would alter the production process and posited that "the social order was a *conditio sine qua non* [condition without which not—i.e., indispensable] for an ecologically sound society." Mol, 2001, *op. cit.,* pp. 49–50; also see Arthur P.J. Mol, "Ecological Modernization and Industrial Transformations and Environmental Reform," in M. Redclift and G. Woodgate, (eds.), *The International Handbook of Environmental Sociology* (Cheltenham and Northampton MA : Edward Elgar, 1997), pp. 138–149.

[11]Buttel, 2000, *op. cit.*, pp. 59–61; Mol, 2001, *op. cit.,* p. 58; Spaargaren, Mol, and Buttel, 2000, *op. cit.*, p. 5.

[12]Zhang, *op. cit.*, p. 25.

[13]Mol, 2001, *op. cit.,* p. 222.

[14]Buttel, 2000, *op. cit.*, p. 60; Arthur Mol and Gert Spaargaren, "Ecological Modernization and the Environmental State," in A. Mol and F. Buttel, (eds.), *The Environmental State Under Pressure* (Oxford: Elsevier Science Ltd, 2002), p. 36.

[15]Arthur P.J. Mol, "The Environmental Movement in an Era of Ecological Modernization," *Geoforum*, 31, 2000, p. 48.

> The "ecologization of economy" refers to the physical and organizational changes in production and consumption processes. The "economization of ecology" refers to the economic valuation of environment and nature, which are recognized to be the third force of production (apart from labor and capital)."[16]

Thus, EMP proponents mention that a synthesis between the spheres of economy and ecology can be achieved through innovations and advancements in technology, which could in turn enhance economic growth and resolve environmental problems. Some proponents of EMP call this the "scientification of ecology" and consider it the heart of the perspective.[17] For them, in the present day Western industrial mode of production and consumption, ecological rationality can no longer be encompassed in economic rationality. Ecological rationality is emerging as an autonomous and independent sphere from the economic sphere, intertwined rather than mutually exclusive.[18] Proponents of EMP consider:

> Capitalism neither as an essential precondition for, nor as the key obstruction to, stringent or radical environmental reform. They rather focus on redirecting and transforming "free market capitalism" in such a way that it less and less obstructs, and increasingly contributes to, [the] preservation of society's sustenance bases in a fundamental/structural way.[19]

Normative Prescriptions

According to Mol and Sonnenfeld, the central aim of EMP has been to "analyze how contemporary industrialized societies deal with environmental crises."[20] To achieve this aim, EMP, breaks from "demodernization" and "counter-productivity theory" and instead relies on "the proposition that the environmental crisis can and should be overcome by a further modernization of the existing institutions of modern society."[21] EMP policy prescriptions to "safeguard the societies' sustenance bases" place much emphasis on environmental reforms, which EPM advocates believe, not only bring improvements in the physical environment but also in social and institutional environments.[22]

---

[16]Pieter Leroy and Jan Van Tatenhove, "Political Modernization Theory and Environmental Politics," in G. Spaargaren, Arthur. P.J. Mol and Frederick H. Buttel (eds), *Environment and Global Modernity* (Thousand Oaks, CA, London and New Delhi: Sage Publications, 2000), p. 195; Gert Spaargaren, "Ecological Modernization Theory and the Changing Discourse on Environment and Modernity," in G. Spaargaren, A. Mol and F. Buttel (eds.), *ibid*. p. 50.

[17] *Ibid*. p. 51

[18]*Ibid*., p. 53.

[19]Mol and Spaargaren, 2002, *op. cit.*, p. 38.

[20]Arthur P.J. Mol and David A. Sonnenfeld, "Ecological Modernization Around the World: An Introduction," A. Mol and D. Sonnenfeld (eds.), 2000, *op. cit.*, p. 5.

[21]Spaargaren, 2000, *op. cit.*, p. 56; see also Buttel, 2000, *op. cit.*, p. 61.

[22]Arthur P.J. Mol, 2001, *op. cit.*, p. 61.

Mol categorizes these social transformations into five clusters. First, modern science and technology are not viewed as the problem, because they have the potential to solve environmental troubles associated with traditional and conventional technologies.[23]

Second, the process of privatization and the participation of market forces in policy formulations should be seen as conducive rather than obstructive to ecological management. Mol applies capitalist dogma to environmental management and argues that the privatization of public sector resources and services increases the process of environmental reforms, because the market is a more efficient and effective mechanism in resolving environmental problems than the centralized state.[24]

Third, to achieve ecological modernity, the nation-state must undergo "political modernization," which changes relations between the state, the market and civil society, which in turn affect governance and policy-making.[25] Political modernization is seen as the transformation of the structure and function of the nation-state from one that is exclusive, centralized, and bureaucratic to one that is participatory, decentralized, and flexible.[26] Within this model, the state provides institutional support and regulatory mechanisms for the effective functioning of the market, non-governmental organizations (NGOs), and consumer organizations.[27] In order to facilitate reforms on a global scale, EMP advocates the increasing involvement of supranational institutions such as the World Bank, World Trade Organization (WTO), International Monetary Fund (IMF), and United Nations organizations,[28] which further diminish the autonomy of the nation-state. Moreover, the advocates of EMP firmly believe that opting for "a radical alternative outside the (globalizing) institutions of modernity may well mean throwing the baby out with the bath water."[29] Therefore, ecological management initiatives end up supporting the process of neoliberal globalization.

Fourth, social movement actors are asked to increase their involvement in environmental policy decisions but change their ideology and praxis from an anti-systemic stance to a reformist position that harmonizes economy and ecology. This involves a metamorphosis of "critical outsiders" (supposedly "radicals") into "critical insiders" (supposedly "reformists").

Finally, proponents of EMP seek a change in modernist ideology, which treats economy and ecology as a binary opposition, to a "new" ideology that emphasizes

---

[23]Arthur P.J. Mol, *Globalization and Environmental Reform: The Ecological Modernization of the Global Economy* (Cambridge, MA and London: MIT Press, 2001), p. 61.
[24]*Ibid*., p. 61.
[25]Leroy and Tatenhove, 2000, *op. cit.,* p. 188.
[26]Buttel, 2000, *op. cit.*, p. 61.
[27]Mol, 2001, *op. cit.*, pp. 61–62.
[28]Mol, 2000, *op. cit.*, p. 46.
[29]Mol, 2001, *op. cit.*, p. 68.

economic growth and environmental sustainability as compatible and essential for environmental reform.[30]

Empirical Assumptions

In many empirical studies of EMP, case studies were used to trace the historical development of technological innovations, state policies, and regulatory institutions vis-à-vis environmental reforms in specific industries. Most were conducted in northern and northwestern Europe. Based on their structural and institutional circumstances, some analysts conclude that EMP is "applicable primarily for advanced industrial countries, due to prerequisites for green industrial restructuring, e.g. the existence of a welfare state, advanced technological development . . . a state regulated market economy . . . and . . . widespread environmental consciousness."[31] For them, EMP has less relevance to developing countries because it is "a Northern (Western)- oriented discourse rooted in a particular stage of economic development where high material living standards have been achieved among the majority of people."[32]

Other proponents of EMP have aggressively argued that this perspective has relevance to the newly industrializing countries, countries in transition, and developing countries.[33] For them, EMP is not a simple process of transferring ideas from the West to the rest of the world, as was evident in the modernization project. Rather, as Mol argues, "major adaptations would have to be made before these environmental reform ideas, institutional designs and strategies are transferred successfully."[34]

Much of the language of ecological modernization can be found in the current debate over genetic engineering, with some arguing that contemporary strategies promoting agricultural biotechnology in the developing world represent the best chance for human survival. This camp maintains that the successful transfer of ecological modernization prescriptions and technologies will supersede the ecological, social and political problems that resulted from the Green Revolution modernization in the 1960s and 1970s.[35]

---

[30]Buttel, 2000, *op. cit.*, pp. 59–61; Frederick H. Buttel, "Environmental Sociology and the Explanation of Environmental Reform," *Organization & Environment*, 16, 3, 2003, pp. 322–327; Mol, 2000, *op. cit.*, pp. 46–47; Mol and Sonnenfeld, 2000, *op. cit.*, pp. 6–7.

[31]David Sonnenfeld, "Contradictions of Ecological Modernization: Pulp and Paper Manufacturing in South-east Asia," in A. Mol and D. Sonnenfeld (eds.), 2000, *op. cit.*, p. 236.

[32]David Toke, "Ecological Modernization: A Reformist Review," *New Political Economy*, 6, 2001, p. 289.

[33]Mol and Sonnenfeld, 2000, *op. cit.*; Mol, 2001, *op. cit.*

[34]Mol, 2001, *op. cit.*, pp. 68–69.

[35]Gordon Conway, *The Doubly Green Revolution: Food for All in the Twenty-First Century* (Ithaca, NY: Cornell University Press, 1998); Ismail Serageldin, "Biotechnology and Food Security in the 21st Century," *Science*, 285, 5426, 1999, pp. 387–389.

Technological revolutions in agriculture in the 20th century can be categorized into three phases. The first Green Revolution began with the development of hybrid crops using plant breeding techniques that helped increase food production in the developed countries between the 1930s and 1950s. The second Green Revolution disseminated the same technology to the Third World between the 1960s and 1970s. The third Green Revolution—also called the Gene Revolution—advanced the application of genetic engineering techniques in crop development from the 1990s onwards.[36]

The Green Revolution as a Growth Engine?

In the early 1960s, the Green Revolution package[37] combining miracle seeds, controlled irrigation, fertilizers, pesticides, and related farm management skills was introduced into post-colonial societies with the objective of averting the Malthusian specter of famine.[38] Dr. William Gaud, then director of the United States Agency for International Development (USAID), first used the term "Green Revolution" in a speech entitled "The Green Revolution: Accomplishments and Apprehensions" delivered at the meeting of the Society for International Development in 1968.[39] He used the expression "to stress that the changes occurring in the wheat and rice fields of Asia was revolutionary, not just evolutionary, progress."[40]

According to Lester Brown, a one-time adamant proponent of the Green Revolution, the term "revolution" was thoroughly "abused" even though there was "no other term [that] adequately describes the effects of the new seeds on the poor

---

[36]Thomas Bernauer, *Genes, Trade, and Regulation*: *The Seeds of Conflict in Food Biotechnology* (Princeton: Princeton University Press, 2003), pp. 3–4; Govindan Parayil, "The Green Revolution in India: A Case Study of Technological Change," *Technology and Culture*, 33, 4, 1992, pp. 741–744.

[37]Green Revolution technology has been called "package technology," because high-yielding varieties give substantial yields only under certain conditions where the farmer can apply heavy fertilizers, pesticides and, in fact, supply controlled water. Without these "inputs," high-yielding varieties do not produce more than the traditional varieties and can produce less. For example, one comparative field trial showed that in the absence of the application of synthetic fertilizers, Sonara-64 (a high-yielding variety of wheat) produced 2,232 kilograms per hectare compared to 2,355 kilograms per hectare for the indigenous variety, C-306. However, after 100 kg of fertilizers were applied, the yield of the Sonara-64 rose to 4,600 kg., while C-360 yields increased to only 3,689 kg. Similar differences between local and high-yielding varieties of rice with and without fertilizer applications were observed in India. See Keith Griffin, The *Political Economy of Agrarian Change: An Essay on the Green Revolution* (London and Basingstoke: Macmillan Press, 1979), pp. 209–210.

[38]See Lester R. Brown, *Seeds of Change* (London: Pall Mall Press, 1970), p. 16; Gabrielle J, Persley and Ismail Serageldin, "Alexandria Renaissance: the New Life Sciences and Society," in I. Serageldin and G.J. Persley (eds.), *Biotechnology and Sustainable Development: Voices of the South and North* (Wallingford: CABI Publishing, 2003), p. 7; Eric B. Ross, *The Malthus Factor: Poverty, Politics, and Population in Capitalist Development* (London: Zed Books, 1998).

[39]Parayil, 1992, *op. cit.,* p. 737.

[40]M.S. Swaminathan, "From Green Revolution to Gene Revolution," *Plant Biotechnology Institute Bulletin*, 2, 2004, p. 4.

countries where they are being used."[41] Political critics argue that using the term "Green Revolution" to describe the new technology package was deliberate in order to oppose the politics of "Red Revolution" in the Third World in the late 1960s.[42] In other words, the "Green Revolution" emphasized that rural development could be achieved by intensifying agricultural production using modern technology without resorting to any radical political reforms such as a land redistribution program.[43] Indeed, the discourse of "Green Revolution" suggests that "technical change is an alternative to political change."[44]

For Green Revolution proponents, the new technology became for poor countries, "what the steam engine was to the Industrial Revolution in Europe."[45] They claim that changes in the farm sector resulting from Green Revolution technology spilled over into other sectors of society and human life, increasing not only farm incomes but also off-farm and non-farm employment opportunities for the landless rural households, which raised the purchasing power of rural people.[46] Matin Qaim estimated that through the "income multiplier effect," one dollar of direct benefit in agriculture generated by the Green Revolution resulted in an additional dollar of benefits in other sectors.[47] Both Green Revolution advocates and critics agree that while "the 'success' has eliminated many of the traditional securities for the rural poor and has particularly damaged those at the very bottom of the social structure, . . . it has provided enough economic safety-valves to absorb much of the peasantry."[48]

However, Green Revolution detractors point out that the resulting intensification of the commercialization of agriculture that accompanied the introduction of the new agricultural technology had serious problems. The package character of the technology means that it does not work well with subsistence, non-market farming, because it requires large amounts of money and, in some cases, substantial

---

[41]Brown, 1970, *op. cit.*, p. 6.

[42]John Harriss, "Capitalism and Peasant Production: The Green Revolution in India," in T. Shanin (ed.), *Peasants and Peasant Societies: Selected Readings* (Oxford and New York: Blackwell, 1987), p. 229.

[43]Peter Atkins and Ian Bowler, *Food in Society: Economy, Culture, Geography* (London: Arnold Publishers, 2001); Harriss, 1987, *op. cit.*, p. 229; Ross, 1998, *op. cit.*

[44]Griffin, 1979, *op. cit.*, p. 2.

[45]Brown, 1970, *op. cit.*, p. 10.

[46]*Ibid*.; Bernhard Glaeser (ed.), *The Green Revolution Revisited: Critique and Alternatives* (London and Boston: Allen & Unwin, 1987); Shaila Seshia and Ian Scoones, *Tracing Policy Connections: the Politics of Knowledge in the Green Revolution and Biotechnology Era in India*, Working paper, 188 (Brighton: Institute of Development Studies, 2003); M.S. Swaminathan, "Biotechnology and a Better Common Present: A Synthesis," in I.P. Getubig, et al., *Biotechnology and Asian Agriculture: Public Policy Implications* (Kuala Lumpur: Asian Pacific Development Center, 1991).

[47]Matin Qaim, "Transgenic Crops and Developing Countries," *Economic and Political Weekly*, August 11, 2001, p. 3065.

[48]James C. Scott, *The Moral Economy of the Peasant: Rebellion and Subsistence in Southeast Asia* (New Haven and London: Yale University Press, 1976), p. 208; see also Griffin, 1979, *op. cit.*, pp. 207, 209.

production and marketing facilities.[49] Therefore, while Green Revolution technology was, theoretically, "scale-neutral," it was not "resource-neutral."[50]

Governments that adopted the Green Revolution package often first introduced the new technology in regions where irrigation was relatively well developed, land quality was suitable for new crops, and large commercial farms were dominant. For example, when the new wheat and rice varieties were first introduced in India, the Indian government concentrated more on the irrigated zones of the Indus basin in Punjab and Haryana to demonstrate the success of the new varieties to the farmers in rest of the country.[51] This selective focus led to unequal increases in the production of food grains across the country as resource-rich regions that introduced the new growing system experienced rapid growth compared to other areas.[52] Griffin notes, for example, that from the 1952/53 growing season through 1964/65, agricultural output in the Punjab grew 4.56 percent a year compared to 2.27 percent in Kerala, 1.94 percent in West Bengal and 1.17 percent in Assam. "The Green Revolution in India clearly has accentuated [the] on-going trend towards regional inequality; it has not reversed [it]."[53]

Environmentalists and green activists further argue that the Green Revolution eroded rich biodiversity in the global South and promoted the "monoculturization" of agriculture,[54] which destroyed ecosystems and resulted in unsustainable agricultural practices.[55] Yet despite these negative consequences, biotechnology advocates now insist that these problems can be solved or reduced by embracing the

---

[49]*Ibid*., p. 213.

[50]Theoretically, Green Revolution technology has been considered "scale-neutral," because no economies of scale are involved in it—that is, there is no decline in the cost of production per acre with increased acreage. Therefore, it appears to benefit both small and large farmers alike. But, as critics argue, it was certainly not "resource-neutral," because the farmers who have better access to physical as well as capital resources gained more profit and were in a better position to deal with the risks pertaining to the new technology (Harris, 1987, *op. cit.*, p. 231; also see Terence Byres, "'New Technology, Class Formation and Class Action in Indian Countryside," *The Journal of Peasant Studies*, 8, 4, 1981; Terence Byres, "The Political Economy of Technological Innovation in Indian Agriculture," in R.S. Anderson, et al. (eds.), *Science, Politics, and the Agricultural Revolution in Asia* (Boulder, CO: Westview Press, 1982).

[51]Griffin, 1979, *op. cit.*, p. 211.

[52]See Andrew Pearse, *Seeds of Plenty, Seeds of Want* (Oxford: Clarendon Press, 1980); Biplab Dasgupta, *Agrarian Changes and New Technology in India* (Geneva: UNRISD, United Nations, 1977); Francine Frankel, *India's Green Revolution: Economic Gains and Political Costs* (Princeton: Princeton University Press, 1971); Griffin, 1979, *op. cit.*; Harriss, 1987, *op. cit.*, Terence Byres, "The Dialectic of India's Green Revolution," *South Asian Review*, 5, 2, 1972; Byres, 1981, *op. cit.*

[53]Griffin, 1979, *op. cit.*, p. 212.

[54]For example, as Vandana Shiva argues, in India more than 200,000 varieties of rice were grown, but the monoculture of the Green Revolution destroyed many species. Only 17,000 now remain, and today, most Indian farmers grow just a few dozen varieties. Indian farmers also lost many varieties of wheat and now only grow a few varieties. See Vandana Shiva, *Stolen Harvest: The Hijacking of the Global Food Supply* (Cambridge: South End Press, 2000), pp. 80, 84.

[55]See Vandana Shiva, *The Violence of the Green Revolution: Third World Agriculture, Ecology, and Politics* (London: Zed Books, 1991); Vandana Shiva, *Monocultures of The Mind: Perspectives on Biodiversity and Biotechnology* (London: Zed Books Ltd, 1993).

Gene Revolution,[56] which has also been referred to as the "Doubly Green Revolution"[57] and the "Evergreen Revolution."[58]

The Ever Green Revolution?

In conventional plant breeding (including Green Revolution technology), genes can only be transferred within the same or closely related species. It is not possible, for example, to take a pest-resistance gene from a tomato and put it into wheat. In GM seeds, genes for traits thought to be advantageous from any living organism can be spliced into any crop variety.[59] Using genetic engineering, genes from an organism can be mapped, isolated and transferred to: 1) another organism of the same species (e.g. a pest-resistant gene from one tomato variety can be transferred into another tomato variety), 2) an organism of a different species (e.g. a gene from a tomato can be transferred into rice), or 3) an organism belonging to a different kingdom (e.g. a gene from a firefly can be transferred into a tobacco plant; GM cold-tolerant soybeans, which contain a gene from a saltwater fish are an existing example).[60]

In Green Revolution technology, the components of the "package" are physically divisible as seeds, fertilizers, pesticides, etc. In Gene Revolution technology, "the whole technology is packaged into the seed."[61] With this technological innovation, seeds have been engineered as "genetic pesticides" and "genetic insecticides."[62] Genes from the soil bacterium *Bacillus thuringiensis* (Bt), a micro-organism, have been inserted into several crop seeds and act as a pesticide by releasing highly toxic crystals through the leaves and stems of the plant that kill a broad class of insects. Bt, which was isolated from soil in 1911, has been available to

---

[56]The usage of the term "Gene Revolution" has become more frequent since the 1990s, but it is difficult to trace the source of the term itself. See Govindan Payaril, "Mapping Technological Trajectories of the Green Revolution and the Gene Revolution from Modernization to Globalization," *Research Policy,* 32, 2003, pp. 975, 980.

[57]The term "doubly green revolution" was coined by Gordon Conway, president of the Rockefeller Foundation. He used the term to refer to increases in production and productivity while conserving the environment by using Gene Revolution technologies. See Conway, 1998, *op. cit.*; Serageldin, 1999, *op. cit.*, p. 387.

[58]M.S. Swaminathan coined the term "evergreen revolution" referring to "sustainable advances in crop productivity per unit of land, water and time without associated ecological harm." M.S. Swaminathan, "Food Security and Sustainable Development," *Current Science,* 81, 8, 2001, p. 949. Also see M.S. Swaminathan, "An Evergreen Revolution," *Biologist,* 47, 2, 2000, pp. 85–89. M.S. Swaminathan, *Sustainable Agriculture: Towards an Evergreen Revolution* (New Delhi: Konark Publishers, 1996).

[59]Cary Fowler and Pat Mooney, *The Threatened Gene: Food, Politics, and the Loss of Genetic Diversity* (Cambridge: The Lutterworth Press, 1990), p. 140; See Gabrielle J. Persley, *Beyond Mendel's Garden: Biotechnology in the Service of World Agriculture* (Wallingford, UK: CABI publishing, 1990); Qaim, 2001, *op. cit.*, p. 3065.

[60]Fowler and Mooney, 1990, *op. cit.*, p. 141.

[61]Qaim, 2001, *op. cit.*, p. 3065.

[62]Gyorgy Scrinis, "Colonizing the Seed," *Arena Magazine*, 36, 1998, p. 37.

farmers as an organic pesticide since 1930.[63] It is a particularly important pest management tool for organic farmers, who have been using dried mixtures of fermented live Bt formulations for generations, and increasingly since the 1980s. Because Bt sprays are biodegradable and are much less concentrated than when the toxin is expressed in every cell of the plant, they are considered to be safe for humans and non-target organisms.[64]

GM, or transgenic, Bt crops have been commercially cultivated since 1996.[65] The biotech companies emphasize convenience to pitch their product to farmers: "Bt transgenic technology in cotton helps in overcoming certain limitations of Bt sprays such as the need for repeated applications, sensitivity to solar radiations, wash off due to rain, etc."[66] They further argue that not only do GM plants' internal insecticides and pesticides decrease the dependency on chemical sprays, which must be purchased separately, but they also increase yields. Therefore, the biotech companies and GM proponents say these seeds are cost-effective.[67]

Critics, however, point out that the logic behind the introduction of "genetic pesticides" is just as faulty as that behind chemical pesticides; genetic pesticides lead to a shift from "one-chemical-one-pest" resistance, as is now common with chemical pesticides, to a "one-gene-one-pest" resistance mechanism.[68] Since Bt crops continuously release toxins throughout the crop season, they virtually guarantee that the insect population will evolve resistance mechanisms in all stages of its development because of long-term exposure to the toxin throughout the season.[69] Early studies show that Bt resistance has already developed in eight species of insects: the diamond black moth, Indian meal moth, tobacco budworm, Colorado potato beetle, and two species of mosquitoes.[70] There is suggestive data that the continuous release of toxins throughout the season may also affect the soil, since the deposits of Bt toxins exuded through the plant's roots last for a very long time and may damage both the soil and the micro-organisms that live there.[71] There is also some evidence that Bt crops may threaten the survival of other beneficial species such as butterflies, birds, bees, and beetles, which play a vital role in pollination and also control pests through the prey-predator balance.[72] However, a comprehensive ecological study of the impact of Bt crops has not yet been conducted, so there are many unknown factors about its ultimate impact.

---

[63]Shiva, 2000, *op. cit.*, p. 106.
[64]Stephen Nottingham, *Eat Your Genes: How Genetically Modified Food is Entering Our Diet* (London and New York: Zed Books, 2003), p. 47.
[65]Scrinis, 1998, *op. cit.*, p. 37.
[66]R.B. Barwale, "Bt Cotton: The View from MAHYCO," *Current Science,* 80, 3, 2001, p. 326.
[67]*Ibid*., p. 326
[68]Scrinis, 1998, *op. cit.*, p. 37.
[69]*Ibid*., p. 37.
[70]Shiva, 2000, *op. cit.*, p. 107.
[71]Scrinis, 1998, *op. cit.*, p. 37; Shiva, 2000, *op. cit.*, p. 106.
[72]Shiva, 2000, *op. cit.*, p. 107.

Another major issue in the GM debate concerns genetically engineered seed sterilization. Hybrid seed, which was the key to the Green Revolution, does not produce sterile seeds. Although the genetic unpredictability of second generation hybrid seed means that it does not perform as well as parent seed, it can be planted the following season. However, as Jean-Pierre Berlan and Richard Lewontin have noted, the second (F2) generation of hybrid seed, "if not biologically sterile, is economically unusable as seed, producing anywhere from 20 percent to 40 percent less than the first hybrid. For all practical purposes, such a loss of yield amounts to biological sterility."[73] But the agricultural biotech industry wants even greater control over the reproduction capability of crop seeds. Biotech companies have worked to produce sterile seeds, which cannot be planted the next season, and so far have only been stopped by public outcry. Critics have dubbed GM sterile seeds "Terminator Technology."[74]

Terminator technology terminates the capacity of the seed as a means of production (seed) while only retaining its utility as product (grain). Thus it prevents farmers from collecting and saving seeds from their crop harvest for planting the following season. In turn, it forces farmers to buy seeds on the market, which is highly monopolized by fewer and fewer multinational agribusiness corporations, such as Monsanto.

Terminator technology aids the commodification of seeds, which would tighten the grip of these corporations over Third World agriculture and millions of farmers across the globe.[75] Even M. S. Swaminathan—the so-called Father of the Indian Green Revolution—cautions against widespread use of Terminator technology in transgenic crops: "... as crops incorporating the 'terminator technology' [would] most likely be genetically homogenous, genetic homogeneity in crops could become more widespread, enhancing genetic vulnerability to pests and diseases."[76]

---

[73]Jean-Pierre Berlan and Richard Lewontin quoted in David Goodman and Michael Redclift, *Refashioning Nature: Food, Ecology and Culture* (London: Routledge, 1991), p. 104; Robert Ali Brac De La Perriere and Franck Seuret, *Brave New Seeds: The Threat of GM Crops to Farmers* (London and New York: Zed Books, 2000), p. 27; see also ETC Group, 2002, "Terminate Terminator," online at: http://www.etcgroup.org/documents/terminatorbrochure02.pdf.

[74]"Terminator Technology" (also called "Suicide Technology") refers to biotechnology tools that alter the seed and prevent it from giving rise to new life in the next generation. In other words, it takes away one of the primary use-values of the seeds—the ability to produce. The ETC Group (formerly RAFI, the Rural Advancement Foundation International) labeled this technological method "Terminator Technology" when a patent right (U.S. Patent Number 5,723,765: Control of Plant Gene Expression) was awarded in March 1998 to Delta and Pine Land Co. in collaboration with the United States Department of Agriculture. Delta and Pine Land was later purchased by Monsanto. See Ricarda A. Steinbrecher and Pat Mooney, "Terminator Technology: The Threat to World Food Security," *The Ecologist*, 28, 5, 1998, pp. 276–279.

[75]De La Perrier and Seuret, 2000, *op. cit.*; Erosion, Technology, and Concentration Group, "Terminator Technology – Five Years Later," *ETC Group Communiqué*, 79, May/June 2003, pp. 1–10.

[76]M.S. Swaminathan, "Farmers' Rights and Plant Genetic Resources," *Biotechnology and Development Monitor*, 36, 1988, p. 8.

Institutional Reforms in the Agricultural Sector in India

In India, national seed policies have reformed according to changing global political and economic dynamics. Table 1 chronologically presents the gradual policy reforms in the Indian seed sector from 1966 to the present day.

The stated objective of all these reforms was to provide better quality seed to farmers to increase production at the national level. These policy reforms removed hurdles that had prevented multinational agribusiness corporations from entering the Indian seed sector and facilitated the growth of the private sector in research, development and distribution. These reforms also made seed-saving and exchange by farmers illegal and replaced indigenous seed varieties with corporate seeds.

After the seed policy changes, the private sector share of the seed industry jumped from 20 percent in 1981 to 76 percent in 2001. In just four years the value of the seed market more than doubled from Rs. 10 billion in 1994–95 to Rs. 22 billion in 1998–99. While the share of the organized seed supply by private firms increased from 35 percent to 60 percent, the share of the public sector seed supply fell from 40 percent to 25 percent. During that same time, the share of the unorganized/informal seed sector dropped from 25 percent to 15 percent.[77]

Since biotechnology boosted the already lucrative agricultural input industry, mergers, acquisitions and other strategic alliances have been increasing. In fact, almost all of the major Indian seed companies have collaborated with foreign partners to get access to the new patented technologies.[78] As the private companies pump money into research and development of "high quality" seeds, it is expected that they will sell their seeds at a higher price in a monopolistic market situation. And already there are glimpses of this future. In India, Mahyco-Monsanto sold Bt cotton for Rs. 1,600–1,800 per packet compared to Rs. 300–400 for non-GM hybrid cotton.[79]

Besides increasing the presence of private firms in the seed sector, the new seed policies also resulted in the development of new commercial non-food crops in place of traditional food crops, which along with an emphasis on high-yielding varieties,

---

[77]Sachin Chaturvedi, *Status and Development of Biotechnology in India: An Analytical Overview* (New Delhi: Research and Information System for the Non-Aligned and Other Developing Countries, Discussion Paper, 28, 2002), pp. 16–17.

[78]Carl E. Pray, Bharat Ramaswami and Timothy Kelley, "The Impact of Economic Reforms on R&D by the Indian Seed Industry," *Food Policy*, 26, 6, 2001, p. 596.

[79]Ian Scoones, *Regulatory Maneuvers: The Bt Cotton Controversy in India*, Working Paper, 197 (Brighton: Institute of Development Studies, 2003), p. 10.

Table 1. Seed Policy Reforms in India: An Outline

SEED POLICY	OBJECTIVE
The Seed Act (1966)	Provided a statutory body that regulates the release of new varieties, seed certification, and seed testing.
Seed Control Order (1983)	Placed seeds of all food crops, fruits, vegetables, cattle fodder and jute on the essential commodities list and regulated the quality of seed production and distribution.
New Policy on Seed Development (1988)	Liberalized the seed sector and facilitated the entry of local and foreign private sector companies into seed research, development and marketing. Also, relaxed constraints on seed imports.
Plants, Fruits and Seeds Order (1989)	Permitted unlicensed imports of seeds and planting material, including vegetables, flowers and ornamental plants.
Protection of Plant Varieties and Farmer's Rights Bill (2001)	Provided a right to farmers to sell, use, and exchange their farm produce, including seeds from varieties protected under this act in the same manner as they were entitled to before its enactment. However, it prohibited farmers from selling branded seed of a variety protected under this act.
National Seed Policy (2002)	Allowed imports and exports of seeds from all crops. Opened the seed supply to agribusiness giants.
The Seed Bill (2004)	Made seed registration mandatory for farmers wanting to exchange or sell their saved seed for agricultural purposes. Thus, this bill made the historical practice of seed-saving and exchange by farmers illegal. This bill also enlarged the scope of agriculture by including horticulture, forestry and the cultivation of plantation, medicinal and aromatic plants. Under the 1966 Seed Act, "agriculture" included only horticulture.

Source: Compiled by the author

meant greater use of fertilizers and pesticides.[80] Against this background, Bt cotton was introduced into India with claims that it would not only reduce consumption of

[80]C.H. Hanumantha Rao, "WTO and Viability of Indian Agriculture," *Economic and Political Weekly*, Vol. 36, No. 36, Sept. 8, 2001, p. 3455–3458; see Bharat Ramaswami, "Understanding the Seed Industry: Contemporary Trends and Analytical Issues," *Indian Journal of Agricultural Economics*, 57, 3, 2002, pp. 417–429; Bhagirath Choudhary and Gaurav Laroia, "Technological Developments and Cotton Production in India and China," *Current Science*, 80, 9, 2001, pp. 925–927.

pesticides and insecticides, it would reduce the environmental problems associated with these biocides, because the Bt cotton plant itself acts against the "bollworm complex." Bt cotton was also championed as one solution to the growing number of cotton farmer suicides in India.

Ecological Modernization and Bt Cotton In India

Myth of Decentralized State as a Guardian of Environmental Sustainability

Efforts to introduce Bt cotton into India began when Monsanto approached the Indian government through the Department of Biotechnology for permission to test the new variety in 1990. But the Indian government rejected Monsanto's proposal in 1993 on two grounds: a) the technology transfer fee was very high, and b) Bt cotton seeds containing the *Cry1Ac* gene were not yet approved in the U.S. when Monsanto was negotiating with the Indian government; therefore, agricultural officials did not feel that there was enough field experience with the new genetically engineered American variety to anticipate the results of backcrossing it into a local variety.[81]

Two years later, however, the government of India decided to allow Bt cotton seeds into the country by permitting a business deal between Mahyco (Maharastra Hybrid Seed Company) and Monsanto, an arrangement that avoided enormous public expenditures for the technology transfer fee.[82] In 1996, Mahyco imported 100 grams of transgenic Cocker-312 cottonseed, which contains the *Cry1Ac* gene from Bt. Between 1996 and 1998, Mahyco developed three Bt cotton seed varieties from the imported transgenic seeds: MECH-12, MECH-162, and MECH-184.

Monsanto considered Mahyco a "good vehicle" to enter the Indian seed market.[83] In May 1998, Monsanto bought a 26 percent share of Mahyco, one of the oldest and largest seed companies in India. Monsanto paid 24 times the market rate, and later the two companies formed a 50:50 joint venture establishing Mahyco-Monsanto Biotech Limited to produce and market genetically modified Bt cotton in India.[84] That same year Mahyco-Monsanto got permission from the Review Committee on Genetic Manipulations (RCGM) in the Department of Biotechnology to conduct field trials in 40 plots covering 5.164 hectares in nine states.[85] After

---

[81]Scoones, 2003, *op. cit.*, p. 7; Bharathan, 2000, *op. cit.*, p. 1068; P.K. Ghose, "Bt Cotton: Government Procedures," *Current Science,* 80, 3, 2001, p. 323.

[82]C.R. Bhatia, "Bt Cotton in India," *Current Science,* 80, 3, 2001, pp. 321–322; Ghose, 2001*, op. cit.*, p. 323.

[83]Commenting on the partnership with Mahyco, Jack Kennedy (Monsanto's director of Product Development and Applied Genetics) said: "We propose to penetrate the Indian agriculture sector in a big way. Mahyco is a good vehicle." Quoted in Vandana Shiva, "Globalization and the Threat to Seed Security: Case of Transgenic Cotton Trial in India," *Economic and Political Weekly*, 34, 10, 1999, p. 601.

[84]Vandana Shiva, *Protect or Plunder?: Understanding Intellectual Property Rights* (London and New York: Zed Books, 2001), p. 81.

[85]Barwale, 2001, *op. cit.*, p. 325.

reviewing the results of the first trials, the RCGM suggested another eleven field trials in 1999.

During the field trials, biosafety assessments were done. These included studies on pollen escape, also known as gene flow or "outcrossing," the effects on non-target organisms, toxicity, allerginicity, aggressiveness and wildness, and confirmation of the absence of Terminator genes. In response to the growing opposition to GM crops, in 1998 the Indian government banned Terminator technology.[86] Both the Indian government and the company repeatedly asserted that Bt cotton did not contain Terminator genes.[87] However, farmers' organizations alleged that the seed tested in field trials did contain Terminator technology.[88]

During the field trials, the farmers and civil society organizations protested against the introduction of Bt cotton into the country. In the state of Karnataka, the *Karnataka Rajya Raitha Sangha* (Karnataka State Farmers' Association) attacked and destroyed the field trial stations as part of a campaign called "Cremate Monsanto!" The protestors warned biotech investors and shareholders: "You should rather take your money out before we reduce it to ashes."[89] In 1999 the Research Foundation for Science, Technology and Ecology, headed by Vandana Shiva, filed a public interest lawsuit in the Supreme Court challenging the legality of the field trials on the grounds that no data were made public.[90]

Based on "totally confidential" data from the field trials, in July 2000, the Genetic Engineering Approval Committee (GEAC), which is constituted and chaired by the Ministry of Environment and Forests, permitted Mahyco-Monsanto to conduct seed production on 150 hectares and large-scale field trials on 82 hectares at 395 locations in seven central and southern states.[91] After reviewing the results of these field trials, on March 26, 2002 GEAC announced that the performance of Mahyco-Monsanto's Bt cotton was "satisfactory" and formally approved commercial release and cultivation for three years in six states: Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, and Tamil Nadu.[92] After the commercial release of Bt cotton, in May 2003 the Indian Government set up the Task Force on the Application of Biotechnology in Agriculture, headed by M.S. Swaminathan, to

[86] *Ibid.*, p. 325; Joel I. Cohen, "Unlocking Crop Biotechnology in Developing Countries – A Report from the Field," *World Development*, 32, 9, 2004, p. 1567.
[87] Bharathan, 2000, *op. cit.*, p. 1070.
[88] De la Perriere and Seuret, 2000, *op. cit.*, p. 63.
[89] See http://home.ica.net/ ~fresch/ndp/monsant3.htm. Accessed on April 19, 2005.
[90] Bharathan, 2000, *op. cit.*, p. 1073.
[91] Barwale, 2001, *op. cit.*, p. 325; Matin Qaim, "Bt Cotton in India: Field Trial Results and Economic Projections," *World Development,* 31, 12, 2003, p. 2117.
[92] See Barwale, 2001, *op. cit.*; Biswajit Dhar, "Regulations, Negotiations and Campaigns: Introducing Biotechnology into India," *Biotechnology and Development Monitor*, 47, 2001, pp. 19–21; Peter Newell, *Biotech Firms, Biotech Politics: Negotiating GMOs in India*, Working Paper 201 (Brighton: Institute of Development Studies, 2003); Liz Orton, *GM Crops: Going Against the Grain* (London: Action Aid, 2003); Scoones, 2003, *op. cit.*

formulate a draft policy framework governing the use of agro-biotechnology. In its May 2004 report to the Ministry of Agriculture, the taskforce recommended replacing the existing three-tier approval process for GM crops[93] with a one-step approval process to speed the commercial release of subsequent GM crops. The report recommended the establishment of an autonomous regulatory body, the Agricultural Biotechnology Regulatory Authority, to separately handle biosafety issues pertaining to GM crops.[94]

How does the story of Bt cotton in India help us critically assess the claims and assumptions of the Ecological Modernization Perspective in the global South? EMP advocates argue that ecological restructuring should be possible by using environmentally friendly production technologies. However, they acknowledge that the new technologies themselves do not solve ecological problems[95] and maintain that such technologies should operate in a political and economic system where the state provides both institutional support and ensures that competing interests do not impede the market. This process of "political modernization" also entails attempts to steer the ideologies, programs, and actions of the radical environmental movements towards "pragmatic" and reformist environmental management.

But, as discussed above, these assumptions have little relevance to understanding the experiences with Bt cotton in India. Agricultural policies and institutions in general, and seed policies in particular, have been gradually restructured according to changing global dynamics. And the *undemocratic* and *unscientific* approval process that Bt cotton underwent in India demonstrates that the nation-state operates within the logic of global capital, which restructures its institutions and reforms its policies to facilitate the expansion of markets. The Bt cotton story also tells us that the state is "flexible" and "democratic" when it deals with corporate firms but not with its citizens and civil society organizations.

For example, at a meeting in June 2001 to discuss the implications of Bt cotton with representatives from Monsanto, the Ministry of Environment, independent scientists, and farmers that was organized by Greenpeace, a New Delhi-based NGO and affiliate of Greenpeace International, neither Monsanto nor the government provided any scientific evidence to answer the questions raised by Greenpeace. Similarly, in November 2002, Gene Campaign, another New Delhi-based NGO

---

[93]In the first tier, the Institutional Biosafety Committee assesses the research proposals and decides whether to approve or reject them. In the second tier, the Review Committee on Genetic Manipulation (RCGM) permits limited field trials and assesses them for farm health and environmental safety. In the third tier, the Genetic Engineering Approval Committee (GEAC) conducts a more detailed environmental impact assessment, recommends multi-location field trials, and then decides whether the variety will be approved for commercial release.

[94]Pallava Bagla, "Report Says India Needs Stronger, Independent Regulatory Body," *Science*, 304, 11, June 2004, p. 1579.

[95]Robyn Eckersley, *The Green State: Rethinking Democracy and Sovereignty* (Cambridge, MA and London: MIT Press, 2004), p. 77.

headed by Suman Sahai, filed a lawsuit in the Delhi High Court charging that the field trials conducted by Monsanto were "unscientific," since the company did not follow appropriate monitoring, evaluation and precautionary procedures. The government insisted that Bt cotton was safe, but its conclusions were based on inferences drawn from confidential data.[96] The state ignored civil society organizations' demands that the state and Monsanto be democratic and transparent in conducting the field trials. Contrary to the assumptions of the Ecological Modernization Perspective, rather than strengthening the voices of civil society, the synergy between the state and market suppressed them.

Myth of Advanced Technology as a Panacea

In recent years one cannot talk about cotton in India without mentioning Warangal district in the State of Andhra Pradesh. More than 1000 cotton farmers have committed suicide in the district in the last five years.[97] In the midst of this rash of suicides, Mahyco-Monsanto introduced Bt cotton seeds into Warangal district in 2002. The company even used the cotton farmers' suicides as a rationale to promote Bt cotton, arguing that the farmers committed suicide because they used the conventional/hybrid seeds which not only demand more fertilizers and pesticides but are not able to fend off the cotton bollworm that destroyed cotton crops in the district. The Mahyco-Monsanto campaign maintains that Bt cotton will cut farmers' expenses on fertilizers, pesticides and wage labor, while boosting their crop yields and economic returns.[98] But despite the company's promises, there were massive *failures* of the Bt cotton crop in Warangal district.

The Andhra Pradesh Coalition in Defense of Diversity (APCDD), an umbrella organization of more than 140 NGOs, commissioned a study on the economic and environmental impacts of Bt cotton in Warangal district. The study was carried out in 69 villages in 2002–2003 among 225 randomly selected farmers.[99] The APCDD study found that Bt cotton seed accounted for 15 percent of the total cost of production, whereas non-Bt cotton was just 5 percent. Despite the higher costs of the Bt seeds, farmers accepted Mahyco-Monsanto's claims and expected the Bt cotton to

[96]See http://www.makingindiagreen.org/btcotton.htm, accessed on April 2, 2005.
[97]For a detailed account of the farmer suicides in India in general, and in Warangal district in particular, see Sunitha Anmangandla, "Rice or Cotton?: Socio-economic Causes and Consequences of the Agricultural Land Use Change in Warangal District, Andhra Pradesh, India," MSc thesis, (Enschede, The Netherlands: International Institute for Aerospace Survey and Earth Sciences, 2001); Center for Environmental Studies, *Citizens' Report: Gathering Agrarian Crisis – Farmers' Suicides in Warangal District (A.P.)* (Warangal: Center for Environmental Studies, 1998); Glenn Davis Stone, "Biotechnology and Suicide in India," *Anthropology News*, 43, 5, 2002; P. Parthasarathy and Shameem, "Suicides of Cotton Farmers in Andhra Pradesh: An Exploratory Study," *Economic and Political Weekly*, 33, 13, 1998, pp. 720–726; E. Revathi, "Farmers' Suicide: Missing Issues," *Economic and Political Weekly*, 1998, 33, p. 1207; Usta Patnaik, *Global Capitalism, Deflation and Agrarian Crisis in Developing Countries*, Social Policy and Development, Program Paper Number, 15 (United Nations Research Institute for Social Development, 2003); Vandana Shiva, 1999, *op. cit.*, pp. 601–613.
[98]Abdul Qayam and Kiran Sakkhari, "The Bt Gene Fails in India," *Seedling*, July 2003, p. 13.
[99]*Ibid*., p. 13–17.

reduce their fertilizer and pesticide expenditures and increase their yields. But plant protection costs for Bt cotton was only $3/ha less than non-Bt cotton. The total cost of cultivation for Bt cotton was $61/ha more than non-Bt cotton. The average yield of Bt cotton (1,125 kg/ha) was also substantially less than non-Bt cotton (1,725 kg/ha). So while Bt cotton reduced total expenditure on fertilizers and pesticides by 4 percent, average yield plummeted 35 percent. And, the majority of Bt cotton farmers—about 71 percent—experienced losses compared with about 18 percent of non-Bt cotton farmers. (See Table 2 below).

Similar results were found in the 2003–2004 season.[100] The three-year average yield of Bt cotton (from 2002 to 2004) was 649 kg/acre compared with 708 kg/acre for non-Bt cotton. The average cost of pesticides for Bt cotton was 7 percent less than their non-Bt counterparts. But the average total cultivation cost of Bt cotton increased by 12 percent due to the high cost of the seed and greater expenses on crop

Table 2. The Economics of Bt and non-Bt Cotton Cultivation in Warangal District (2002–2003)

	Characteristics	Bt Cotton	Non-Bt Cotton
1	**Cost of seed/ha**	Rs 4,000 ($89)	Rs 1,125–1,250 ($25–28)
2	**Expenditure on pesticides/ha**	Rs. 7,273 ($162)	Rs 7,428 ($165)
3	**Percentage of total expenditure spent on plant protection**	27%	31%
4	**Total cost of cultivation/ha**	Rs 26,638 ($592)	Rs 23,908 ($531)
5	**Average yield/ha**	1,125 kg	1,725 kg
6	**Market price/100kg seed cotton**	Rs 2,080 ($45)	Rs 2,164 ($47)
7	**Net returns/ha at the end of cropping season**	−Rs 3,238 (−$72)	Rs 2,164 ($46)
8	**No of farmers who incurred loss**	160 (71%)	40 (18%)
	■ > Rs 10,000	3 (1.3%)	1 (0.4%)
	■ Rs 7,501–10,000	15 (6.7%)	2 (1%)
	■ Rs 5,001–7,500	33 (14.6%)	0 (–)
	■ Rs <5,000	109 (48.4%)	37 (16.6%)
9	**No of farmers who profited**	65 (29%)	185 (82%)
	■ Up to Rs 12,500 ($278)/ha	39 (17%)	67 (30%)
	■ Rs 12,500–18,750 ($278–417)/ha	4 (2%)	28 (12%)
	■ Rs 18,750–25,000 ($417–555)/ha	9 (4%)	20 (9%)
	■ Rs >25,000 (>$555)/ha	13 (6%)	70 (31%)

Source: Adapted from Qayam and Sakkhari, 2003, *op cit*., p. 16. (see *Seedling*, October 2003.)

[100]See Abdul Qayam and Kiran Sakkhari, *Did Bt Cotton Fail Again in Andhra Pradesh*? (Hyderabad: Deccan Development Society, 2004).

management. Average net returns for those growing Bt cotton were 57 percent lower (See Table 3 below). The findings of these studies clearly refute the biotech industry's hype that GM crops decrease production costs and increase productivity and farmers' net returns.

To mitigate the growing opposition to Bt cotton and counter the findings of the APCDD study, Mahyco-Monsanto commissioned its own study of the agronomic value of their cotton variety. The study commissioned by Mahyco-Monsanto was not carried out by scientists nor agronomists but by a marketing agency, AC Neilson ORG MARG. The Monsanto-Neilson study reported opposite results to the APCDD study and declared Bt cotton a success (See Table 4).

But the Monsanto-Neilson study does not reflect what farmers experienced with Bt cotton, which is evident from a number of recent developments in the district:

- Bt cotton farmers also committed suicide in recent years due to heavy losses.
- The anger of farmers who incurred heavy losses turned to violent street protests; they burned down Monsanto's seed outlets in the town of Warangal, imprisoned Mahyco-Monsanto representatives in the villages, and demanded the company compensate them for the crop failure.[101]

Table 3. Three-year Averages of Mahyco-Monsanto Bt and Non-Bt cotton (2002 to 2005)

	Parameter	**A Three-Year Average**		
		Bt Cotton	**Non Bt Cotton**	**Gain with Bt**
1	**Seed cost (Rs/acre)**	1,557 ($35) (13.4%)*	466 ($11) (4.5%)	−1,090 (−$25) (−234%)
2	**Pest management cost (Rs/acre)**	2,571 (22%) **	2,766 (27%)	195 (+7%)
3	**Total cost of cultivation (Rs/acre)**	11,594	10,336	−1,259 (−$4) (−12%)
4	**Yield (kg/acre)**	649	708	−59 (−8.3)
5	**Net returns (Rs/acre)**	20,324	4,787	−2,755 ($63) (−57%)

*Percentage of the cost of seed of the total cost of cultivation.

** Percentage of the cost of pest management of the total cost of cultivation.

Source: Abdul Qayum and Kiran Sakkhari, *Bt Cotton in Andhra Pradesh: A Three-Year Assessment* (Hyderabad: Deccan Development Society, 2005), p. 10.

[101] See "Bt Cotton Fails Yet Again in India – Farmers Go On Rampage," http://www.gmwatch.org/archive2.asp?arcid=4557, accessed on April 28, 2004.

Table 4. Differential Findings of the Andhra Pradesh Coalition in Defense of Diversity (APCDD) and Monsanto-Mahyco Biotech (MMB) in Andhra Pradesh

	MMB		APCDD	
	Bt Cotton	**Non-Bt Cotton**	**Bt Cotton**	**Non-Bt Cotton**
Average number of sprays for bollworms	3.6	5.2	4.36	5.19
Average spending on pesticides Rs (US$)	1,369 ($31)	3,225 ($73)	1,616 ($37)	2,072 ($47)
Average yields (quintals)	10.14	8.16	8.27	8.1
Average net profits Rs (US$)	7,276 ($165)	—	7,650 ($174)	8,401 ($200)

Source: Qayam and Sakkhari, 2004, *op cit*., p. 29.

- Considering the growing wrath of the farmers and pressure from civil society organizations, the state government of Andhra Pradesh recommended the central government not renew Mahyco-Monsanto's license to sell its three varieties of Bt cotton.

In response, on May 3, 2005 the Genetic Engineering Approval Committee banned Mahyco-Monsanto's Bt cotton in Andhra Pradesh. However, this was seen as a "tokenistic" response to the farmers' agitation against Bt cotton, because the committee continued to allow it to be sold and grown in the five other Indian states where it was already approved. The committee also approved five new Bt cotton varieties: RCH-144 Bt and RCH-188 Bt developed by Rasi Seed company, MRC-6301 Bt developed by Mahyco, and Ankur-681 and Ankur-09 developed by Ankur Seeds. The approval of these new Bt cotton varieties clearly demonstrates the strong commitment of the Indian state to the Gene Revolution, whatever the results.

The Myth of "Internalization of Externalities"

GM seeds entail a specific kind of cropping pattern that is entirely new to Indian farmers. For example, in the case of Bt cotton, farmers are supposed to follow resistance management plans, which include a "refuge strategy," i.e., planting non-Bt cotton in at least five rows surrounding Bt cotton, or in 20 percent of the total sown area, whichever is more. To help farmers implement the refuge strategy, Mahyco-Monsanto sold seed packages with two packets: a 450-gram packet of Bt cotton and a 120-gram packet of non-Bt cotton for the refuge. The logic behind this is that when non-Bt cotton is planted within or around a Bt cotton field, the non-Bt cotton acts as a "refuge" for Bt-sensitive insects that will breed with Bt-resistant insects, thereby minimizing or delaying the development of Bt-resistant insects. The refuge of non-Bt cotton is also supposed to act as a "pollen-sink," or border, to prevent outcrossing of transgenic Bt cotton pollen. There is, however, no consensus among the scientists on the function, size, or best method to implement the refuge strategy.[102] Furthermore, the refuge strategy is alien to farmers' age-old agricultural practices.

The National Seed Policy of 2002 in India suggests that packets of transgenic seeds or planting material be labeled to indicate their transgenic nature and their agronomic benefits. But with an average literacy rate of 59 percent in rural areas (as per the 2001 Census)[103], there are real questions as to how many farmers in India can read the instructions provided on the seed packet. Because of the inadequacy of public sector agricultural extension services, the high rates of illiteracy, absence of community awareness programs and campaigns, and insufficient monitoring mechanisms, farmers often depend on middlemen or retail dealers to advise them on what seed variety will give them the greatest financial margin and agronomic benefits. [104]

When asked about the purpose and management of the refuge strategy, farmers in Warangal district expressed widely ranging views. Some farmers thought that the company provided them both Bt and non-Bt cotton seeds just to compare the yields of these two varieties. Many farmers believed that it served as a "wall" to incoming moths and caterpillars. Some rejected the refuge strategy outright, because they believed that mixing Bt cotton with non-Bt cotton would totally damage the crop. Even the agricultural extension service workers—those who are supposedly knowledgeable about the new technology and able to demonstrate farming methods to farmers—were not clear about the purpose of the refuge strategy.[105] This lack of understanding is particularly important in countries like India where there are no effective crop insurance or compensation policies to protect farmers financially in case of crop failure.

Bt cotton also created unanticipated environmental problems in Warangal. According to the APCDD researchers,

> a special kind of root rot was being spread by Bollgard [Bt] cotton. Farmers came out with complaints that they were not able to grow crops like chilli after harvesting [the] Bt crop because it had infected their soil very badly. As against

[102]Alan Dove, "Bt Resistance Plan Appraised," *Nature Biotechnology*, July 17, 1999, pp. 531–532; Glenn Davis Stone, "Biotechnology and the Political Ecology of Information in India," *Human Organization*, 63, 2, 2004, p. 134; Fred Gould, "Testing Bt Refuge Strategies in the Field," *Nature Biotechnology*, March 8, 2000, pp. 266; Shiva, 2000, *op. cit.*, p. 107.

[103]It should be noted that the definition of literacy in India is very liberal. A person who can read and write with understanding in any language is considered literate. He or she need not have received any formal education. In this context, literacy is not a good indicator to analyze the impact of the information gap between the laboratory and the field.

[104]Patnaik, 2003, *op. cit.*, p. 30.

[105]Information gathered during the author's pilot field study between May–August 2004 in Warangal district.

> this, the soil in which the farmers grew non-Bt hybrids was extremely friendly to other crops.[106]

This evidence suggests that rather than solving the economic and environmental problems associated with conventional cotton, Bt cotton exacerbated farmers' financial troubles and introduced new risks and ecological problems.

Free Markets, Regulation and Accountability

In India, seed companies and their agents commonly sell seeds, fertilizers and pesticides that are not what they claim to be. For example, not all Bt cotton seeds are labeled as such; or the seeds might be an unapproved variety. Pesticides and fertilizers are considered "spurious" if their quality is diluted and fake brand names are used. In the Warangal district as well as in the states of Punjab and Haryana, the pesticides cotton farmers were spraying were found to be spurious. A series of studies linked the spraying of substandard pesticides to crop failure and subsequent cotton farmer suicides.[107]

Spurious Bt cotton seeds were sold in Gujarat by an Ahmedebad-based seed company, Navbharat Seed Pvt. Ltd, that surreptitiously introduced unapproved Bt cotton seeds under a pseudo-brand name, Navbharat 151, which had been registered with the Department of Agriculture of Gujarat in 1998. It was discovered that around 500 farmers planted an unapproved variety of Bt cotton on approximately 10,000 acres[108] after several adjoining fields with conventional hybrid cotton were devastated by a major bollworm attack.[109] The same unapproved variety had been planted in Gujarat and other states for two years and is believed to have devastated large tracts of crops. Following the discovery of the Navbharat 151 planting, the GEAC directed the State Biotechnology Coordination Committee of Gujarat to destroy the standing crop. However, a rich farmers' lobby succeeded in stopping the state government of Gujarat from destroying the crop.

Such class pressure to overlook the illegal selling of Bt cotton raises doubts about the effectiveness of regulatory mechanisms and the government's capacity and commitment to control the selling of spurious seeds, fertilizers and pesticides. The Ecological Modernization Perspective does not adequately address what happens when the market is allowed to operate independently in a weak regulatory system, nor who will monitor the malfeasance of private firms that operate to make a profit

---

[106]See "Monsanto's Biggest Lie of the Century," www.ddsindia.com/press_release1.htm, accessed on April 28, 2005.

[107]See note 100.

[108]Cohen, 2004, *op. cit.*, p. 1567; Scoones, 2003, *op. cit.*, p. 9.

[109]Cohen, 2004, *op. cit.*, p. 1567; K.S. Jayaraman, "Illicit GM Cotton Sparks Corporate Fury," *Nature,* 413, 6856, 2001, p. 555.

by any means they deem necessary. There is no straightforward answer to such issues in EMP, because it accepts without question that a capitalist or entrepreneur always strives for "efficiency" in order to compete with his/her potential competitors. This is the reason why "the market is considered to be a more efficient and effective mechanism for coordinating the tackling of the environmental problems than the state."[110] The illegal selling of spurious GM seeds in India is but one demonstration that EMP's assumption that markets are efficient and operate for the benefit of all is a myth.

Conclusion

The case study of Bt cotton in India challenges the normative assumptions of the Ecological Modernization Perspective and empirically demonstrates why EMP is irrelevant to developing countries. The central premise of EMP is that the problems of modernization can be solved by "super-modernization" in a specific political and economic context, where the policies of liberalization and privatization can be implemented and eulogized. Consistent with this, the Indian government embraced the Gene Revolution as a solution to the economic and ecological problems created by the Green Revolution and "traditional" agriculture. But the failure of Bt cotton clearly illustrates that the gathering crisis in agriculture and associated environmental problems cannot be solved simply by embracing yet more advanced technologies or by introducing superficial institutional reforms.

From the Green Revolution to the Gene Revolution, the proponents of the new agricultural technology have claimed that the technology is "need-driven," "sustainable," "humane," and "neutral"—i.e., beneficial for small and big farmers alike. But real world experience tells us otherwise: Neoliberal economic policies eased the entry of multinational agribusiness corporations into Third World agriculture and accelerated the commodification of inputs. This makes perfect sense from the point of corporate agriculture, since the input trade—what farmers buy to produce their crop—is more profitable than the output trade—what farmers sell.[111]

Commodification of inputs makes peasants dependent on the market for capital, information, and inputs. Therefore, the ultimate aim of the developers of the technology in promoting GM seeds on a colossal scale is to replace the small peasant farmer-based farm economy with industrial agriculture. To achieve this aim, transgenic technology has been used as an instrument to control the means of production in modern farming—seed, fertilizers and pesticides. Control over the seed allows the seed industry to decide what the farmer will grow, when and how the

[110]Quoted in Buttel, 2000, *op. cit.*, p. 61.
[111]Parayil, 2003, *op. cit.,* p. 984.

crop will be grown and harvested, where it will be sold, and finally, what people will eat. Therefore, much more than the technology is packaged into the seed—the whole "technocratic formula" is packaged into the seed.

Moreover, various actors, institutions and policy reforms—trade liberalization, structural adjustment programs, supranational institutions, multinational corporations, the state, and so on—are involved in promoting the new technology across the globe. As Brockway puts it, "there is no way to draw the line between science, commerce and imperialism."[112] Therefore, the debate about GM seeds, the environment and the agrarian crisis in developing countries must not be narrowed down to the new technology, *per se.* Rather it must be understood from a political ecology perspective that articulates the wider framework of the "agrarian question" in the context of neoliberal globalization.

[112]Quoted in Shripad D. Deo and Louis E. Swanson, "Structure of Agricultural Research in the Third World," in R.C. Carroll, J.H. Vandermeer and P.M. Rossett (eds.), *Agroecology*, (New York: McGraw-Hill, 1990), p. 586.