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Green Revolution

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Synonyms

Agricultural development; International development; Modernization

Introduction

The period after the Second World War witnessed major changes in the primarily agrarian peasant economies of Asia. Fueled in part by new agricultural technologies, systems of state support, and strategic alignments with capitalist or communist nations, governments in unaligned nations undertook massive projects in internationally supported agricultural development collectively referred to as the green revolution. This complicated process fundamentally changed agrarian economies by: (1) introducing input- and capital-intensive farming methods; (2) replacing agricultural labor with technology, thus moving people out of agricultural sectors while simultaneously creating markets in the industrial economy; (3) institutionalizing various elements of the development apparatus through international aid, research collaborations, and trade; and (4) expanding the role of the state in everyday life. This move was perhaps strongest in India, where the state collaborated with both Soviet and American organizations to bring agricultural infrastructure and high-yielding varieties of wheat and rice to farmers. As a result, gross production of commodity grains rose in tandem with increases in state-funded agricultural infrastructure, industrially produced agricultural inputs, interactions between peasant farmers and state bodies, and the urban population. This article discusses: the early technological and institutional history of the green revolution, the cold war geopolitics of green revolution development, state and peasant responses in South Asia, and the lasting impact of the green revolution on international development.

High-Yielding Varieties and Other Green Revolution Technology

This section discusses the historical, institutional, and technological context of green revolution agriculture. By the 1930s, American and European agriculture was incorporating a suite of new technologies and inputs made possible by scientific discoveries in chemistry, genetics, and engineering, along with public and private institutions capable of bringing them to farmers. Where most farmers globally continued to produce their own agricultural inputs, manage a subsistence and market economy, and controlled

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agricultural labor and knowledge to an extent, the changes in Euro-American farming systems allowed for a new externalized and commodified form of agriculture. Following the industrial trends seen in factories, farmers began to resemble workers who purchased tools and produced commodities in an attempt to achieve agricultural efficiency. This synergy benefitted industry, states, and commodity markets, although its effects on farmers were more mixed.

At the heart of this new relationship to agriculture was the hybrid seed (Kloppenburg 2004). Designed using the newest understandings of Mendelian and Darwinian genetics, seed breeders developed hybrid seeds through cross pollination, allowing breeders to select for particular traits, and later backcrossing, in which parent lines are bred with descendent lines to increase the uniform performance of those traits. When farmers purposively saved such hybrid seeds from their fields, the following harvest often suffered losses in yields and increased disease susceptibility because of inbreeding. Thus, the hybrid seed came to resemble a commodity. Rather than use open pollinated varieties that could be saved and gradually improved or save hybrid seeds that would produce inferior products in subsequent years, farmers began to adopt hybrid seeds that were purchased new each year.

Increases in yield were achieved in three ways. First, breeders identified naturally occurring resistance to plant pathogens and bred those traits into plant lines. This required no new technological changes in plant breeding but was built on the early twentieth century rediscovery of Mendelian genetics. This agriculturally beneficial response was termed "hybrid vigor" or "heterosis." Second, breeders recognized new industrial processes by which nitrogen could be industrially fixed from the air. Many plants used nitrogen fertilizer to grow taller and thus became susceptible to lodging and other weather damage. By breeding dwarf varieties with hybrid lines, plant breeders created crops that could use an excess of fertilizer to grower larger and heavier grains. Because chemical fertilizers decreased soil moisture content and increased crop water demands, farmers began to rely more heavily on irrigation and infrastructure provided by states and private builders. Finally, disease-resistant plants were used in conjunction with newly available chemical pesticides, allowing farmers to plant hybrid crops bred to overproduce when given extra nitrogen in monocultures with less fear of pest predation. Because of their increased production, given the right combination of nitrogen, water, monoculture farming, and pesticides, such seeds came to be called high-yielding varieties or HYVs.

Plant breeder and pathologist Norman Borlaug is perhaps the most influential individual of the green revolution. Trained as a plant pathologist, Borlaug worked with the DuPont Company before representatives from the Rockefeller Foundation and US government asked him to lead an agricultural modernization project in Mexico (Hesser 2006). In an analogous push to that seen in agrarian economies in Europe and the USA through the 1920s and 1930s, the Mexican government of the 1940s sought to increase commodity production, replace farmer knowledge and labor with off-farm inputs, and move rural populations into urban and industrial sectors. Under the mantle of development or agricultural modernization, this pattern, which further integrated rural farmers into industrial capitalism, would be repeated throughout Latin America, Africa, and Asia.

Borlaug worked with the Mexican government to breed wheat that would flourish in the new agricultural normal: monoculture, dense planting, fertilizer intensive, machine-harvestable, and water intensive. Taking advantage of longer tropical-growing seasons that allowed him to breed two generations of wheat in a variety of climactic conditions in northern and southern Mexico, a faster breeding method termed shuttle breeding, Borlaug identified wheat varieties that would produce large seed heads, would produce under a variety of light and temperature conditions, and could survive in close proximity without succumbing to disease or rust fungus. However, Borlaug's hybrids suffered from lodging, in which they would become top-heavy and fall over during strong winds or rains. To solve this problem, Borlaug crossbred his varieties with dwarf wheat strains originally developed in Japan,

particularly a cultivar known as semidwarf Norin 10. The resulting hybrid wheat strain used nitrogen fertilizer to create a larger seed head rather than a taller stem, thus preventing lodging. When incorporated into the system of fertilizers, pesticides, irrigation, monoculture, and machinery, Borlaug's wheat seeds became the first HYVs.

The 1950s witnessed an explosion of state infrastructure, private sector growth in factories repurposed to build tractors and construct fertilizers rather than tanks and bombs, and increasingly interconnected global trade networks. By increasing plant yields and reorganizing agriculture to fit within industrial capitalist conditions, Borlaug was catapulted to international fame and new responsibility. Under the mantle of international development, Borlaug worked with national governments, philanthropic organizations particularly including the Rockefeller and Ford foundations, and arms of the United Nations to spread HYVs, along with the state infrastructure and agribusiness that accompanied them, to the Middle East and South Asia. His shuttle-breeding approach would later be repeated with dwarf rice varieties in the Philippines, and Borlaug received the 1970 Nobel Peace Prize in recognition of his contribution to increased food production.

Just as important as Borlaug's scientific efforts was the creation of an international network of scientific experts who could share technology and plant resources across scientific institutions. Previously, this role had been filled by state agencies, particularly the American navy and its imperative to send potentially lucrative germplasm back to American scientists, and philanthropic organizations with vast international networks, such as the Ford and Rockefeller foundations. Founded in 1971, the Consultative Group for International Agricultural Research (CGIAR) system established 15 institutions in 14 countries with specific crop foci and a mission to improve food security and yields. CGIAR centers, which linked the Philippines' International Rice Research (IRRI) Center and Mexico's International Maize and Wheat Improvement Center (CIMMYT) where Borlaug first developed HYVs, allowed green revolution scientists to share germplasm and train new agricultural experts in developing countries. The CGIAR system initially received major funding and support through the American philanthropic Ford and Rockefeller institutes in coordination with the World Bank. These organizations worked with states to oversee agricultural research and development, helping to design national agricultural policies, promoting input-intensive farming models, and aligning national production with the goal of exporting cash-crops to international commodity markets. IRRI in particular worked to distribute both the package of HYV technology and the American-style consumer capitalist mindset that accompanied it through public education programs and the institution's high modernist design. Although their influence in international development has diminished as private agribusiness and new philanthropic groups have assumed a growing importance compared to the state since the neoliberalist policies beginning in the 1980s, CGIAR centers were crucial to the initial spread of green revolution technology and agricultural logic (Kloppenburg 2004).

Counterfactual models show that the green revolution led to increased yields in the developing world (Evenson and Gollin 2003), but it is difficult to attribute yield or income gains to any individual element of the green revolution package. The added cost of the total green revolution package, including seeds, fertilizers, mechanization, pesticides, and interest rates, led farmers to earn less per unit with green revolution crops while the crops themselves underperformed when not provided with the optimal combination of irrigation and fertilizer. Overall, the green revolution allowed farmers to put more calories into the global market at a lower price, but this success is tempered by changes in agriculture as a mode of production (Cullather 2013). The push for monoculture and industrial inputs in agriculture throughout the developing world replaced and actively sought to displace biodiverse subsistence farming with cereal export agriculture integrated with industrial inputs produced in urban centers by displaced labor.

Second, the green revolution's impacts were not evenly distributed across all farmers. Like

other models of technological change, green revolution innovation often began with particularly well-connected, affluent, engaged, or interested farmers (Griffin 1974; Gupta 1998; Shiva 1993). In some instances, this meant that the benefits of new farm inputs went mostly to those farmers who could afford them or who had special relationships with agricultural officers. In other situations, the farmers who provided early success narratives for the green revolution added extra labor or capital investments, in effect trying harder, with the new varieties. Effectively, much of the green revolution benefits went to those farmers who one would expect to do best regardless, while farmers with poor access to resources were forced out of agriculture. The land tenure reforms that accompanied agricultural changes also reformed social life by reorganizing rural means of production. In Bali, new methods of rice management disrupted efficient systems overseen by water temple priests and led to immense increases in chemical use (Lansing 2006). In the Philippines, green revolution policies turned the Philippines into an exporting, cash crop economy. Ironically, Filipinos moved abroad or into other sectors and the Philippines on grain from Thailand, Japan, and China. Similarly, Guatemalan Maya farmers lost land to larger farmers backed by the state, who used the newly landless peasantry as a reserve labor force for coffee, banana, and cattle (Ross 1998).

Third, the HYVs planted during the green revolution were destined for international markets rather than local consumption, meaning that the food security benefits of the green revolution came more from increased incomes rather than from increased food production. In fact, several countries became net importers of food products as a result of large-scale HYV planting. India, the Philippines, and Mexico, all home to international crop breeding centers and all major agricultural producers, became net importers of wheat or rice because the state moved rural producers to urban centers and used cheap international food aid programs to supply urban workers (Cullather 2013; Griffin 1974). Green revolution farms often produced greater harvests, but only of some crops, only under certain conditions, and only to the benefit of some farmers.

Cold War Geopolitics and the Green Revolution

This section discusses the ways in which the green revolution fit goals of international development and global geopolitics between 1950 and 1970. Because of their close association with international development, the goals of the green revolution were never separate from Cold War geopolitics or the changing relationship between the peasant smallholder farmer and the state. Following a Malthusian logic, agricultural development in the 1950s–1970s assumed a mismatch between population and food resources (Perkins 1997; Ross 1998). America's philosophical and financial commitment to this ideology began with the postwar Truman administration, which saw agribusiness as a key front in the Cold War: win hearts and minds by winning stomachs. Green revolution developers saw postwar land grabs by peasants, especially Maoist insurgencies throughout Asia, as evidence that the Earth had run out of food or land to produce it. In combating imbalance with HYVs, state and private agricultural changes ultimately privileged landlords producing grain for export and national imports of Western food commodities over seemingly inefficient smallholders. For the Rockefeller and Ford foundations, this push to modernize and capitalize agriculture in the form of larger export-oriented farms would serve also vested commercial interests in oil and agribusiness. Thus, the green revolution as forwarded by American philanthropic organization, the US government, and multinational corporations (MNCs) had a special interest in subordinating peasant agriculture, seen as backward, unproductive, and politically dangerous, to a commercial and capital-intensive international agribusiness. This, they hoped, would not only improve rural livelihoods and increase global grain production but also foster the spread of liberal, capitalist, Western democracy averse to communism or fascism.

The key, for both developing states and American foreign policy, was to change peasant mentalities and align rural people with the goals of the state. Food aid through the American Public Law 480 (PL-480) program made possible central planning goals to move rural labor into urban sectors by providing cheap grain and by pricing grain below the point at which farmers were willing to sell. Simultaneously, green revolution inputs, machinery, and public works projects like irrigation and electrification could be produced by new industrial labor and put to use by the largest farmers who were able to capitalize on the new combination of inputs and prices. American political scientists used the green revolution as a means to increase consumption and dissuade peasants from Maoism through consumer capitalism. Meanwhile, developing state governments used this new mode of production as a way to make their citizens more legible, connecting them to credit and infrastructure programs while increasing industrial production and thus growing GDP. For both interests, commodity producers connected to agribusiness would present less of a risk to state stability.

Given the Malthusian underpinnings of this Cold-War development, it is important to note the political economy of the relationship between rural hunger and green revolution. First, the wartime food crisis that led the Mexican state to modernize wheat production stemmed in part from American purchasing shifts toward rubber and other nonfood crops, which peasants planted instead of maize. Neo-Malthusian theories about population/food imbalances gave plant breeders and developers a convenient frame for the necessity of their work. Furthermore, the massive shift in South Asian grain production was facilitated in large part by an overproduction of wheat in the United States. PL-480 food aid program sent high-yield grain to India, checking communist threats while relieving excess US grain stock. PL-480 provided the millions of cereal food grain tons needed to move rural labor to urban centers while lowering grain prices below a profitable margin for small farmers.

Borlaug's success in Mexico laid the foundation for a Cold War mentality that linked hunger and overpopulation to communism and national security. Hunger and population were thus serious national security threats linked to inefficient agriculture and rural political instability. Following this logic, Western states could save capitalism and democracy in the third world by providing superior plants and espousing the material benefits of consumer capitalism. Demographic surveyors reinforced the image of the Asian countryside as primitive and crowded, especially in need of development. Ironically, anthropological case studies of the time showed that rural peasants were using their resources efficiently and desired better pay for their wages rather than increased yields (Cullather 2013). Yet in the aftermath of the green revolution, American and Asian leaders were able to celebrate the new seeds and the new state programs that enabled their harvest as state building tools. By supporting landlords, promoting agribusiness, moving rural labor to urban centers, and increasing the role of the state in peasant life, the green revolution sought to curb the spread of communism in Asia.

India: A Case Study in the Green Revolution

This section considers India as a case study for the local, geopolitical, and technological changes that occurred during the green revolution. New wheat and rice varieties, their associated agricultural inputs, and the spread of agricultural experts would have profound impacts on how farmers organized village life. Additionally, India's political negotiations during the 1960s defined the "third world" as a balanced approach of developing states to Cold War geopolitics. Given national successes in raising grain production and bringing peasants into greater connectivity with the Indian state, India's experience with agricultural development would come to provide a model for development generally after 1970.

Following independence in 1947, the Indian state undertook a series of 5-year plans modeled after Soviet and American central planning initiatives (Guha 2008). In general, these plans sought to move peasant labor from rural agriculture to

urban industrial sectors. This, the state hoped, would increase GDP, raise standards of living, increase exports, and bring citizens into more regular contact with the state. Agriculture was a necessary component of the industrial plan, which required rural labor and food to be produced for urban industrial centers. However, the state could not simultaneously seek to move farmers to cities as it raised agricultural production without international food aid to fill the production gap (Perkins 1997). Independent India at first relied on Pakistani wheat to feed urban citizens at low prices, but this proved to be both expensive and geopolitically embarrassing. Indian politicians furthermore recognized their large and impoverished peasant population as a potential threat to the stability of a modern, industrialized state. The United States began to have more direct interaction with India during the Kennedy administration, as the Cold War escalated. To gain the support of politicians sympathetic to socialism and suspicious of Western soft power, the American government, the Ford Foundation, and the Rockefeller Foundation offered aid through both PL-480 and international scientific cooperation. By the late 1960s, Indian politicians largely abandoned a model of small-scale village improvement in favor of agribusiness and increased cereal production through HYVs. In this way, they could meet basic urban needs while industrializing the nation. Crop failure during the 1966–1967 harvest provided the perfect reason to introduce HYVs on a large scale.

When a successful 1968 harvest followed the 1967 famine in Bihar, the controversial and complicated set of policy changes came to be known as the green revolution, a triumph of science and planning over environmental limits. Technology intensified existing rural class tensions, profit margins shrank for 80 % of the farming population, and the state had few means to store grain long term (Cullather 2013). Still, overall production rose and urban populations, fed by green revolution crops, fueled the growth of an industrial sector. Indian and American officials declared that famine had been conquered, reducing the conflicts and contradictions of 20 years of agricultural development to a single event: the green revolution. Future food crises in Africa and Latin America would be solved using the green revolution model: a political package of seeds, pricing, financing, chemical inputs, and population management. Just as agriculture had conquered overpopulation and communism in India, so too would it be deployed under the guise of philanthropy and later neoliberal development to conquer poverty and terrorism in other postcolonial nations.

Conclusion

The green revolution relied on both technological and social changes to create a new mode of agricultural production. Technologically, the green revolution introduced an agricultural mode that followed industrial logic: expert knowledge and management through CGIAR centers and local extension; off-farm inputs produced on an industrial scale including pesticides, fertilizers, and machinery; an economy of scale that took the form of grain monocultures destined for export; a shift from household labor to capital and chemical inputs on the farm; and the use of the state as a mechanism for providing infrastructure and incentives for increased production. From the perspective of social organization, the green revolution effectively moved millions of peasant farmers out of rural economies and into urban or industrial centers by providing new economic incentives and replacing rural labor with off-farm inputs. This both raised national gross domestic products and allowed states to have more direct influence in the lives of national citizens.

The agronomic consequences of the green revolution are more mixed. Wheat and rice yields rose in some parts of Asia but fell in others, while the HYVs themselves only overproduced for some farmers given the right combination of technology. Similarly, overall caloric intake increased in Asia as a whole, while biodiverse subsistence agriculture and local food security likely decreased as peasant subsistence agriculture turned into export-based cereal production. In Latin America and Asia, farmers planting HYVs have seen yields continue to rise but only in tandem with increased costs, especially those of

pesticides and fertilizers. Increasing pesticide use encouraged an evolutionary treadmill in which pests adapt to new biocides and farmers buy even more powerful sprays. With the spread of chemical fertilizers and export-driven monoculture farming, some areas have seen depletions of trace minerals, increased erosion, and a decrease in soil moisture content. Both pesticides and fertilizers seeped into groundwater and river systems. Finally, the irrigation required for optimal performance of green revolution seeds led to soil salinization in some areas while the water diversions themselves heightened existing tensions between those with access to water and those without (Evenson and Gollin 2003; Griffin 1974; Gupta 1998).

The green revolution was made possible by the ascension of scientific plant breeding, was encouraged by a liberal democratic capitalist global society for humanitarian and national security reasons, and was then seized upon by MNC agribusiness. Grain exports and political alignment helped developing states on the international stage, but their effect on hunger and the environment are more clouded by varying degrees and definitions of success. Although marketed as a seed that would inherently provide a miraculous harvest, the green revolution HYVs were so successful because of the agricultural, social, and economic changes that necessitated them. The seeds required chemicals and machines that had to be made by urban industry; farmers needed systems of reliable, state-sponsored credit to buy these green revolution tools; farmers were moved into urban spaces in part because of low grain prices and cheaper food options in the city made possible by American food aid; and the resulting national distribution was easier to monitor, tax, and contributed more to gross domestic production.

Ironically, the same green revolution processes lauded as miracles between 1950 and 1970, including political methods like subsidies and the ecological damage of input intensive agriculture, have led growers to be heavily criticized for their overproduction. From a state of famine, government interventions in agriculture have come to be criticized as a waste of taxpayer and state resources while the surpluses that they created are blamed for depressing commodity prices in the developing world.

Cross-References

- Economy of Food and Agriculture
- Food Assistance and International Trade
- Food Sovereignty and the Global South
- South Asia and Food
- US Agricultural Policy

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