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The Green Revolution :  
A Brief Analysis

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The Green Revolution is a catchphrase covering a whole concept of rural development as practiced in many areas of the world. It has been heralded as the answer to the Malthusian apocalypse of population outstripping its food supply. Through the implementation of technology and high yield seed varieties into the agricultural sectors of underdeveloped nations, the Green Revolution would "revolutionize" agricultural practices, dramatically increasing productivity. Combined with "enlightened" economic policies on the part of their governments, the increase in agricultural productivity would be used to induce further social and industrial development to lead underdeveloped nations out of a condition of food scarcity, poverty, and economic dependence to one of independence and relative abundance. The development of underdeveloped nations was to begin with agriculture.

The Green Revolution failed to live up to its expectations. Instead of raising the living standards and promoting the independence of people in the underdeveloped nations, the transfer of technology and the increase in certain agricultural yields, heightened underdeveloped nation's dependence on outside resources, provided them with a higher potential for biological disruption, and intensified internal economic disparities, which has led to greater internal social conflict and unrest.

By examining the inception and the results of the Green Revolution in general, and its development within India in particular,

<sup>we can</sup>  
1 examine this development strategy and ~~to~~ point to shortcomings where they exist. The Green Revolution merits much praise, along with great criticism. The simple transfer of technology and high yielding seeds is not enough. Development should seek to find a strategy that promotes independence, self-reliance, and a technology that is "appropriate" to the socio/economic conditions of the nation concerned. The best that can be done is to help other people implement their own durable solutions.

The Green Revolution, as it came to be called, was the adaptation of the historical development of scientific techniques to the agriculture of developing nations. The direct application of scientific techniques toward this end began in Mexico in 1943, in a cooperative project, sponsored by the Rockefeller Foundation and the government of Mexico. Using an interdisciplinary approach, the goal of the project was to increase the production of the basic food crops in Mexico, and initially much emphasis was placed on the improvement of spring wheat. It was a concerted effort to breed agricultural plants that would bear more edible grain and thus increase yields, without increasing cultivated crop areas. Such was the beginning of what is now known as the International Wheat and Maize Improvement Center.

Success was not too long in the making. In the 1940's, Mexico had been importing half of the wheat it consumed to make up a deficit in production. By 1956, the nation was self-sufficient in wheat in spite of a large population increase. By 1967 wheat production had tripled and corn production had doubled. Both wheat and corn were being exported and the economy was beginning to prosper.

Beginning in 1966, the high yield wheats were exported in quantity, mostly to India, Pakistan, and Turkey. Record harvests, where the seeds were planted under proper conditions, were achieved almost immediately.

Encouraged by this tremendous success, a second major attempt at applying modern science to the agriculture of underdeveloped nations (tropical and subtropical agriculture) was started with the establishment of the International Rice Research Institute (IRRI),

by the Ford and Rockefeller Foundations in the Philippines. The approach taken here was similar to that which had been so successful in Mexico. An interdisciplinary research team had the pragmatic goal of improving the yield of rice that was to be grown on the farm.

Success came early to the IRRI. Crossing a full vigorous variety of rice from Indonesia, called Feta, with a dwarf variety from Taiwan, called Deo-geo-woo-gen, the so-called "miracle rice", IR-8 was produced. The "miracle rice" was more responsive and more efficient in fertilizer use, and matured much faster than traditional varieties, which can mean an extra rice crop in some areas.

The first of these new dwarf varieties of rice was released by IRRI in 1966. They immediately transformed rice cultivation in the Philippines and were soon widely adopted in the lowland regions of Asia.

The success of the high yield varieties, for both wheat and rice, was on their ability to capitalize on the unique natural advantages of tropical-subtropical areas, particularly the wealth of solar energy available only in such climates. The new varieties were widely adaptable to a variety of conditions and could greatly increase yields if, and only if, they were provided with adequate irrigation and fertilization.

High hopes were vested in the high yielding seeds. They were thought to be the impetus for development in the underdeveloped nations. The new seeds were supposed to "revolutionize" not only agriculture, but the entire social structure of the underdeveloped world.

"Thus the new seeds promise to improve the well being of more people in a shorter time than any other technological advance in history. They are replacing disappointment and despair with hope. For literally hundreds of millions, they can be the key to the door opening to the twentieth century. But that door

will open only if a sustained effort is mounted by both the rich and the poor countries together." (1)

Previous to the creation of high yield varieties, development in underdeveloped nations focused on industry to the neglect of agriculture. Some underdeveloped nations assumed that they could more or less permanently depend on food aid from abroad. With continued food aid governments postponed any meaningful decisions to improve agriculture. In 1965, the United States government policy shifted from direct food aid to helping poor nations increase their own food production. The creation of high yielding variety seeds was a great incentive to continue with this development approach.

The emphasis on crop production campaigns combined with realistic economic policies and efficient management were the impetus to this mode of development.

The introduction of the new seeds were to provide for far reaching changes in every segment of society. The new seeds demanded entirely different agricultural practices. As the mold of tradition was initially broken by the demand for new agricultural techniques, on the part of farmers whose incomes were rapidly increasing from their improved yields, the farmers would be more susceptible to change in other areas. They were to become interested in family planning. New sources of savings and investment were to be created, which could help finance industrial development through investment in the nonfarm sector. A potentially higher tax take would be available from the rural population. Food prices would be lower for the urban population. The people of the poor nations were to be drawn into the mainstream of modern economic life.

The development of agriculture in the poor nations was dependent upon the transfer of fertilizer and other agricultural technologies

from industrialized nations. The institutionalization of the transfer of technology was to take place through multi-national corporations involved with agribusiness. Such a transfer would have great returns to the investment. They provided a new potential source of profit for these corporations. As more farmers adopted the new agricultural techniques, the demand for farm inputs was to rapidly increase. Farm production would become more dependent upon purchased inputs, and a steady rise in expenditures would result. Multinational corporations would have a vested interest in the development of the poorer nations. Together, with the poor nations themselves, they were to provide the initiative to improve the quality of life for the majority of mankind.

The Green Revolution did not meet the expectations that it had originally maintained. Criticism can be justifiably levied against the Green Revolution. Criticism can come in the form of biological and ecological objections, incongruent social consequences, shortcomings in results, and the ways and means by which it was implemented.

The growing of the high yield varieties involves a totally different agricultural technique than those used by subsistence farmers in the underdeveloped nations. Native varieties of plants, given the conditions under which they are grown, may represent the optimum choice among among the native varieties. The farmers who have grown them for years are not backwards. Their practices represent a sound agricultural and economic technique.

Native varieties have been bred by traditional methods for



thousands of years. They have acquired a precise adaptation to local conditions. They are therefore very diverse. The diversity of plant populations tends to limit the number of pests and diseases, and thereby, to prevent disastrous crop failures. The net effect of this agricultural technique is to give the farmer a measure of security. The strategy of the subsistence farmer is not to obtain the greatest yields in the best years, but to ensure some yield even in the worst years. The main shortcoming of the traditional agricultural system is that yields cannot be significantly increased.

The development of the high yielding varieties was done through the crossbreeding of thousands of diverse genetic strains of wheat and rice to achieve the desired characteristics. As a result, much genetic diversity was reduced. With greater genetic uniformity, the high yield varieties are more susceptible to destruction through disease and pests. Much of the diversity of native varieties is being lost. According to Ingrid Palmer, author of a United Nations Research Institute for Social Development study of the Green Revolution, "many local varieties of food crops are in danger of becoming extinct, so that certain genetic characteristics are in danger of becoming extinct. Parts of the Near East are being described as genetic disaster areas." (2)

A plant crop exists in constant co-evolution with organisms that compete and prey on it. New genetic varieties must continually be created to stay one step ahead of its competition.

Green Revolution technology and research was based on what was known of temperate agriculture. This is then transferred to tropical and subtropical regions, which have very complex biological systems; much more complex than those in temperate regions. The technique of the Green Revolution is based on monoculture.

Monoculture is not suitable to tropical and subtropical regions due to their different genetic and ecological systems. Major ecological problems could result.

In several Asian nations, there has been a major decline in the per capita availability of protein rich pulses (peas and beans). Some observers feel that improvements in the quantity of food available have been accompanied by a worsening in the nutritional quality of food supplies in many areas. The availability of high yielding grain varieties may have accelerated this process by making grains more profitable to grow than pulses. The protein content of pulses is double that of wheat and triple that of milled rice.

Little research was done on indigenous fruits and vegetables, which constitute a considerable portion of the food intake within underdeveloped nations. Food, within the framework of the Green Revolution, has been used synonymously with "grains". Much of the high yield varieties which were produced, especially in earlier phases of the Green Revolution, was not socially accepted.

The growth of high yielding varieties is dependent upon proper irrigation, fertilization, and protection to provide the expanded yields that they promise. "If a single one of these elements is lacking, High Yield Varieties can sometimes produce less grain than could of been obtained with traditional varieties." (3)

The availability of water for irrigation is a major limiting factor in the spread of the Green Revolution. However, the distribution of irrigated land is very uneven and the total irrigated acreage is inadequate. Irrigation projects may take two forms; major centralized projects which are very capital intense, expensive, use up very much land, and take many years to complete; or those that are done on a localized scale, using small pumps and tubewells. India had a massive increase in small scale irrigation.

Still, after this intensive effort to increase irrigated lands, only one third of India's rice crops were irrigated. The rest captured water in the traditional method by flooding or by trapping monsoon rainfall. The lack of irrigated land and its unevenness in distribution, is both an impediment to the advancement of the Green Revolution and increases regional disparities in the sharing of its benefits.

The necessity for fertilizer and other production inputs is another factor that has hindered the advancement of high yield varieties and in several ways, has actually weakened the relative economic positions of the nations that have accepted them.

Most of the necessary productive inputs must be purchased by the poor nations outside of their borders. They generally lack the necessary capital to build the facilities to manufacture the inputs themselves. The poor nations have had to import the necessary inputs, mainly from the United States. Farm production became more dependent on outside purchased inputs. The importation of these supplies meant a weakening in their balance of trade. Billions of dollars were drained from the foreign exchange of the poor nations.

Not only did the relative economic position of the underdeveloped nations decline, but their dependence on imported inputs, to a very large degree, dictated the form in which agricultural development was to be taken. It was thought that the American multinational corporation involved with agribusiness, was to be the means by which the transfer of technology to the underdeveloped was to take place. Multinational corporations themselves had a vested interest in agricultural development along with the

poor nations themselves. This meant that if poor nations wish to develop their agriculture, they must follow a path taken by the United States. Because of this dependence on imported agricultural inputs, corporations had a degree of control, to the detriment of the poor nations, over the development process itself.

"Simultaneously with the Green Revolution, international companies have created a monopoly structure for the selling of seed, fertilizers, and chemicals. These extensive and highly profitable transactions hamper the industrial development of the poor nations" (4)

Independence and self-sufficiency were not encouraged by the institutionalization of the Green Revolution. Dependency has remained.

The nations into which the new varieties were introduced were not prepared for the infrastructure changes which the new varieties required or for the social consequences which the new varieties produced.

The marketing system of the underdeveloped nations was geared to subsistence agriculture and the reception of food aid. It could not rapidly adjust to an agricultural economy based on the production of cash crops. There was a lack of adequate storage, transportation, and marketing systems, that allowed the increased yields to be distributed throughout the country. Much food was wasted through inadequate storage or pests. When surpluses cannot be sold, prices drop along with farmer's incomes. This causes anger and increases the possibility of social unrest.

Landownership patterns, credit systems, and policy makers within underdeveloped nations tend to favor the large landowners and farmers above the masses. Small landowners have difficulty obtaining farm credit. It was the large landowners and farmers who benefited from the Green Revolution, for only they could obtain the necessary

capital to finance the purchase of inputs, mandated by the high yielding seeds. Mechanization displaced labor. Economic disparities increased between large and small farmers, landlords and tenants, and between landowners and laborers. Large landowners obtained the benefits of the Green Revolution and the poorer masses began to question the institutional structures that prevented them from sharing in its benefits. Increased rural unemployment, rural to urban migration, and social discontent and violence were the results.

In the original design of the Green Revolution, nations using the high yield varieties were supposed to dramatically increase their agricultural productivity to change their position from one of food importation, to one of self-sufficiency and eventual food exportation, through cash sales on the international market. Several factors have prevented nations from achieving these goals.

The Green Revolution did not address itself to the "population problem". Most underdeveloped nations have a rapid population growth and an age structure which is characterized by a large percentage of young people. This requires that a large number of employment opportunities must be made available for the increased number of people. The Green Revolution not only displaced labor through increased mechanization, but gains in agricultural productivity that were made were lost through rapid population increase. A net reduction in food per capita has resulted. "The futility of relying solely on the new agricultural technologies to 'solve' the population problem is evident in Mexico, where the Green Revolution began. Fifteen years of dramatic advances in wheat production made Mexico a net exporter of cereals in the late 1960's, but a population growth rate that ranks among the highest in the world has again converted that country into an importer of food." (5)

Selfsufficiency cannot be spoken of in a situation as this.

Had self-sufficiency been achieved and a surplus developed, the underdeveloped nations would of had great difficulty selling on the international market. The international market is dominated by countries that have sophisticated worldwide shipping, docking, and marketing systems needed to sell their own products and surpluses. Their interests are protected by trade restrictions and tariff barriers that prevent smaller countries from competing with them.

The Green Revolution was not what it was suppose to be.

The Green Revolution was not what it was suppose to be.

India has served as a test case for experiments in various modes of development, family planning, and in the reception of food aid. India can also serve as a model by which to study the consequences of the Green Revolution.

Development in India via the introduction of the high yield variety of seeds took the form of the standard western economic model. It is rooted in the principle of economic rationality and assumes, as in the United States, that the average size of the functioning farm will gradually expand to coincide with the power units made available. With the replacement of animal labor by tractors and other farm machinery, Indian farmers will benefit from economies of scale as farmers in the industrialized nations. The inefficient farmers (small farmers), who cannot afford the new technology, will leave agriculture when the returns become greater in the nonfarm sector of the economy. Similarly, the tenant class will begin to disappear as he finds large farmers unwilling to rent land that can be cultivated directly at a higher profit.

It was thought that mechanization may displace some agricultural

labor, but mechanization on a whole will increase employment by increasing multiple cropping and the intensity of farm practices per crop ; ie. greater weeding, plowing, etc. .Mechanization of agriculture will push up the demand for skilled farm labor and the production of machines and farm implēments, which will in turn, create more employment in the industrial sector of the economy. The overall impact of farm mechanization will thus be greater employment and an improvement of the economy as a whole.

The actual implēmentation of the high yielding seeds in India came as part of the Food Ministry's "New Strategy", which called for the initiation of the High Yielding Varieties Program in November, 1965.

Almost from the point of its inception, the High Yielding Varieties Program began to raise agricultural productivity. (1965 - 1972)  
 "Over a period of only seven years, India has expanded its wheat production from eleven to twenty-six million tons - an increase in production of a food staple unmatched by any other country in history." (6)

The production of rice, however, India's principa† food staple, has not risen so dramatically. The reasons are that rice breeders have been less successful in developing high yielding varieties well adopted to Indian conditions and because the necessary control of water supply and drainage often has not been available in rice growing regions.

An accūlation of unprecedented cereal reserves and the attainment of economic self-sufficiency in cereals was obtained in 1972. This atleast temporarily eliminated the need for imports, for a nation, that only a few years earlier, had been the principa† recipient of food aid from the United States. This is not to be

confused however, with nutritional selfsufficiency, which requires much higher levels of productivity and purchasing power. Because of a poor monsoon in 1972, India was forced back into the world market as an importer of food.

Much of the increase in wheat production was not due to the new seed varieties. Around forty percent of the Indian gains in wheat are due to added acreage. Wheat is only eight percent of the tilled acreage and less than two fifths of the rice acreage. Rice remains the most important grain crop in India ( twenty-two percent), followed by millet and sorghum (twelve percent each), which were effected little by the high yield varieties. Wheat ranks forth among the staple crops.

The increased acreage taken over by the new varieties of grains has been at the expense of other nutritionally more important crops, such as beans. Forty percent of the wheat acreage is irrigated and merely eight percent of the bean acreage. The reason for this phenomena, is that beans are not as profitable for the farmers to grow as grains. India would need over a million tons of beans a year merely to provide for its population increase. According to 1970 data, the newly born in India recieve eight percent less bean protein than in 1960.

Increased yields have done little to increase per capita food consumption. Continued population growth exceeds increases in output. " Despite record harvests since 1967, the amount of food available dropped eight percent last year (1969) ". (7)

The Green Revolution did not address itself to the "population problem" in India. An increase in grain prices and a deterioration in nutritional standards have been the results.

The intensive agriculture of the Green Revolution requires ample energy and fertilizer supplies. The critical need for fossil



fuels, to operate tubewells and irrigation pumps needed for irrigation, was illustrated when the "energy crisis" hit India in 1973. Farmers in some areas reportedly had to wait in line for days to obtain diesel fuel for their pumps. Because of the "energy shortage", and lacking sufficient capital to build their own fertilizer plants, it is becoming increasingly difficult for India to obtain needed fertilizer. In a report published by the United States Department of Agriculture, it is said that the combined shortages of energy and fertilizer played a principal role in reducing India's 1974 wheat crop from the original projections of thirty million metric tons to the estimated twenty-three million tons finally harvested.

Implementation of the high yield varieties also provides the potential for biological degradation. New varieties of wheat have been bred primarily against rust, but may well be susceptible to other pests and wheat diseases that are common in Asian nations and even to new rust strains. In India, one fungal disease and one insect, a stem borer, have found new rice varieties especially attractive and have reduced acre yields. Because of intense irrigation, swamping, and salination have occurred in the Punjab area. And increased fertilization has had harmful side-effects in the promotion of weeds and certain fungi.

Gains from the introduction of technology and high yield varieties have been unevenly distributed among the Indian population. This has resulted in increased disparities among the rural economy and growing discontent and tension among the people. The new technologies and seeds has led to an actual deterioration in position of the small owner class on a whole.

Almost all people have experienced some improvement in income and yields from the introduction of modern methods of agriculture. However, the large farmers, those with holdings of

ten acres or more, have increased their gains by using increased profits to buy more land, improving land already under cultivation, to purchase modern farm equipment, and diversification to more profitable crops. According to India's National Sample Survey, conducted in 1961 and 1962, over ninety-five percent of all rural households owned holdings of less than twenty acres and accounted for sixty-four percent of the total cultivated area. Less than five percent of the rural householdshad holdings of twenty acres or more.and controlled thirty-five percent of the land. Thus, the benefits of the high yield varieties tended to pass the majority of Indian farmers and benefitted the minority of farmers instead.

Given the cost of financing the High Yielding Varieties Program, the economic disparities between the minority of farmers who could finance land improvements and the majority who could not, were bound to increase.

"The majority of farmers, probably as many as seventy-five to eighty percent in the rice belt, have experienced a relative decline in their economic positions. Some proportion, representing unprotected tenants cultivating under oral lease, have suffered an absolute deterioration in living standards." (8)

Growth in economic disparity has contributed to increasing antagonism between landlords and tenants, large and small farmers, and between landowners and laborers. The transformation of the rural economy from a subsistence way of life to a profitable set of business activities has been accelerated. " Landowners are now more likely to be influenced by rough calculations of opportunity costs in determining whether or not to lease out part of their land or to cultivate directly, than by traditional sentiments of personal obligation to customary tenants. they do not hesitate to raise rentals in line with appreciating land values and/or to even

evict tenants having long standing cultivating possession of the land." (9)

Social polarization and conflict have increased. The poor can see the increased yields from the new varieties. They increasingly come to question the social institutions that prevent them from sharing in the <sup>benefits.</sup> The new technology itself inadvertently challenges the underlying rationale of the traditional religious ethic of sacrifice and its general "other worldly" attitude.

In a 1969 Home Ministry report titled, "The Causes and Nature of the Current Agrarian Tension", an increase from nineteen to forty-three cases of rural conflict were reported in one year, (1967 -1968). Over eighty percent of these conflicts were led by the landless against the landowners and concerned demands for increased agricultural wages, larger crop shares, security of tenure, and most importantly, the redistribution of land. The causes of increased conflict in rural areas have been identified as failure of land reforms to provide tenants with security of tenure, or fair rents, or to correct inequalities in landownership through redistribution of surplus land (ie. land held by individual farmers in excess of legally established limits).

"However, the 'proximate' causes actually converted latent discontent were located in the new agricultural strategy and the green revolution." (10)

The results of the Green Revolution in India were not what its architects had envisioned. The Green Revolution did not provide the nation with the means to achieve self-sufficiency and abundance. Rather, it increased India's dependence on outside sources for agricultural inputs, provided for the potential of added crop failure and ecological degradation,

heightened regional, social, and economic disparities, overlooked the majority to benefit the few, and intensified conflict among among the people.

India is not alone in these results.

Criticism of the Green Revolution is justified. In spite of such criticism, the Green Revolution has made several positive contributions toward improving the living conditions of many.

Because of the success that the International Wheat and Maize Institute and the International Rice Research Institute have had in breeding high yield plant varieties, other international institutes have been established, which seek to promote improvements in tropical and subtropical agriculture. The International Institute of Tropical Agriculture (IITA) in Nigeria, and the International Center of Tropical Agriculture (ICTA) in Columbia, both founded in 1971, are examples of such institutions. The founding of such institutions provides the potential for investigation into the improvement of noncereal and other indigenous crops. An example is the research directed toward cassava, a root crop which forms the dietary staple in many tropical countries. Cassava was largely neglected until both ~~ICTA~~ and IITA recently undertook to improve it. It has the potential for enormous yields and could serve as a means of increasing many people's indigenous food supply.

Had yields of wheat and rice not been increased in the underdeveloped nations, the disparity between population and food would have been greater than the disparity as it exists today.

It must also be remembered that the Green Revolution did not

create the social disparities and inequalities within the underdeveloped nations. The Green Revolution did however, exaggerate such disparities and inequalities to produce greater social unrest. The potential of the high yield varieties has brought the critical importance of long needed institutional reforms into sharp focus. The new seeds do not provide a technological panacea that alone can eliminate hunger. They do represent a landmark technological achievement, that can, if properly managed, improve the living conditions of many and show what can be done if science and technology are used in a convivial manner.

The Green Revolution came nowhere near to meeting the goals and expectations that it originally promised. Instead of raising the living standards of millions by incorporating them in the modern economic system, the Green Revolution heightened the economic dependency of the underdeveloped nations on the industrial nations, threatened ecological disruption, increased economic disparities, exaggerated social tensions, and actually made the living standards worse for many.

The goal of the Green Revolution to increase agricultural yields and to improve the living conditions for humanity is a cherished ideal. The means by which the Green Revolution sought to do this however, were what led to its demise. "Many of the remedies we are considering derive from a concept of development which is part of the cause of the present problem. There is an urgent need to reconsider the values underlying that concept, and in particular, to reconsider the wisdom of urging it upon us

underdeveloped countries."(11)

A mode of development needs to be sought that promotes independence and self-reliance. It should seek to find technologies that are appropriate to the socio/economic conditions of that particular nation. Development must be sought in a comprehensive framework of social, economic, and ecologically sound strategies that directly attack both rural and urban poverty. The simple transfer of technologies from the developed to the underdeveloped nations has proven itself to be ineffective. Development should begin from the bottom up, seeking to combine the "appropriate" technology with traditional agricultural and industrial techniques, creating employment for the masses and striving toward self-sufficiency.

The best we can do is to help other people implement their own durable solutions.

Footnotes

- 1) Brown, Lester ; Seeds of Change ; Praeger Publishers, New York, 1970  
p. 196
- 2) George, Susan ; How the Other Half Dies ; Allenheld, Osum and Co. ,  
Montclair , 1977  
p.95
- 3) Ibid p.86
- 4) Borgstrom, Georg ; Focal Points: A Global Food Strategy ; Macmillan  
publishing Co. , New York , 1971  
p.195
- 5) Brown , Lester ; By Bread Alone ; Praeger Publishers , New York, 1974  
p.145
- 6) Ibid p.137
- 7) Business Week , "The Green Revolution Yields Bitter Fruit", Nov. 21, 1974  
p.84
- 8) Francine, Frankel ; India's Green Revolution ; Princeton University  
Press, Princeton, N.J. , 1971  
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- 9) Ibid p.197
- 10) Ibid p.10
- 11) Sartaj, Aziz ; Hunger, Politics and Markets ; New York University  
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