Green revolution: Indian agricultural experience – a paradigm for Eritrea

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GREEN REVOLUTION: INDIAN AGRICULTURAL EXPERIENCE – A PARADIGM FOR ERITREA

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Abstract

Food problem became more severe after the partition of India and Pakistan in 1947, presenting a series challenges to India's agricultural sector. Even during good harvest years, food imports remain high. A large segment of people were poor. To mitigate these problems, India adopted farming strategies under the "Green Revolution" in the mid 1960s. The application of modern farming technology, introduction of high-yielding varieties of seeds, increased use of fertilizers, development and expansion of irrigation systems, extension of credit and educational services to farmers. These activities resulted in a drastic increase of farm products leading India to achieve self-sufficiency in food within a short period of time. The "Green Revolution" has contributed to Indian agriculture tremendously and transformed India from a starving nation to a food exporter. The activities that comprise the "Green Revolution" are worth emulating in the Eritrean environment. This paper explores the impact of the "Green Revolution" on Indian agricultural production with the aim of drawing lessons for Eritrea to modernize its agriculture and subsequently solve its food insecurity problem. The Indian experience serves as a model for Eritrea to achieve self-sufficiency in food.

Keywords: Green Revolution, Agriculture and Technology, India, Eritrea, Food Security.

I. INTRODUCTION

This paper explores the impact of the "Green Revolution" on Indian agricultural production with the aim of drawing lessons for Eritrea to modernize its agriculture and subsequently solve its food insecurity problem. The "Green Revolution," in the Indian experience, refers to the food production in the 1960s that dramatically increased agricultural yields through development of varieties of grains with greater resistance to disease and pests, together with the use of improved farm management techniques and chemical inputs, such as improved pesticides and fertilizers.

One of the chronic problems India faced following independence was insufficiency of food. With the separation from Burma (now Myanmar) in 1937, India became deficient in food. Food problem became even more acute after the partition of the sub-continent into India and Pakistan in 1947, presenting a series challenges to India's agricultural sector. Although there was a sharp rise in grain production after independence, it was not sufficient enough to meet the food requirements of a growing population. The shortage of grain production in the face of an increasing population resulted in food imports and a rise in the prices of grains. This necessitated the "Green Revolution", which occurred

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primarily as a result of technological breakthroughs, improved water supplies and better agricultural practices. In addition, increased mechanization of agricultural operations and the use of plant protection measures also contributed to the emergence of the "Green Revolution" in India.

Similarly, post-independence Eritrea faces acute shortage of food. The country is not self-sufficient in grain production. The typical food import requirement is between one-quarter and one-half of the demand for food. Even during good harvest years, food imports remain high. A large segment of the population is poor with little purchasing power, and thus vulnerable to food insecurity. Although, food security has been at the top of the agenda of the government since independence, successive years of drought combined with the border conflict with Ethiopia, have created major food shortages. Thus, government policy–makers are keenly aware of the need to increase food production in the country.

In 1998, the Government of Eritrea embarked on the Integrated Farming Scheme (IFS). The aim of IFS is to increase crop production and incomes through the use of modern farming practices. The government supports the IFS by granting land concessions and providing fertilizer and machinery for plowing and harvesting at cost rate. Eritrea can draw valuable lessons from India's experience in the Green Revolution in its effort to increase food production.

The methodology used in this paper is essentially a descriptive analysis of data obtained from secondary sources, mainly government documents, survey reports, research articles, books and other published and unpublished materials on both India and Eritrea. Although the literature available on India is considerable, the one on Eritrea is rather meager.

This study has limitations in that it is confined to agricultural production aspect of India and Eritrea. The broader issues of the cultural, historical and political aspects of both India and Eritrea are beyond the scope of this paper. Nevertheless, the paper provides sufficient material on the experience of India during its Green Revolution that can provide good lessons for Eritrea.

In the remaining part of this article, the background of Indian agriculture and why the Green Revolution was adapted are discussed, followed by the results of the Green Revolution. Then the condition of agriculture in Eritrea and the country's policy strategies are described. That will be followed by drawing lessons for Eritrea from the Indian experience. The article concludes with a summary of the main points.

II. BACKGROUND OF INDIAN AGRICULTURE

India became independent in 1947 after having been under the British colonial rule for over two hundred years. It adopted a parliamentary democratic system, which is considered to be the largest in the world. The relationship between the Center and the individual States is a major facet of the administrative set-up of the country. The individual states have considerable autonomy in decision-making but the Center

exercises basic economic and political control. Each state is responsible for carrying out key policies in its agricultural sector. India's economic policies in 1991 suggested an attempt to liberalize the economy and place greater emphasis on export-led, import-pushed growth, based on market economy. India has been a leader of the "Non-Aligned" movement and has been able to champion many international issues from the Third-World viewpoint, as exemplified by moves to bring about South-to-South cooperation.

The levels of agricultural production in India in the post-colonial period were much higher than the levels achieved in the colonial era. Between 1949-50 and 1973-74, agricultural output grew at the rate of 2.7 percent annum. This was slightly greater than the rate of population growth at the time. In contrast, the rate of agricultural output during the first half of the century was a mere 0.8 percent per annum. (M.L. Dantwaala, 1986: 111; G.S. Bhalla, 1979:133). Rice, which comprised 50 percent of the total grain production, declined in the same period at an average annual rate of 0.09 percent while the population grew at 0.67 percent per annum. The per capita availability food grain has been declined by 26 per cent between 1911 and 1941 (M. L. Dantwala, 1979:4).

Why India Adopted Green Revolution

India was among the first developing countries to adopt farming strategies under the "Green Revolution" in the mid 1960s. This has been sustained and expanded throughout the country. Indeed, India became self-sufficient in food production within a relatively short span of time after launching the "Green Revolution."

The decision to adopt the "Green Revolution" was precipitated by the unprecedented drought condition in 1966. As a result, the country had to import large quantities of food grains from foreign countries at an enormous cost or seek food aid from friendly countries. Cereal imports, which averaged about 5.9 million tons per year during the early 1960s, reached a record high of 10.4 million tons in 1966. India found itself in the type of situation in which Eritrea and many other African countries find themselves today. Limited foreign exchange meant that India had no alternative but to seek food aid from friendly countries. For example, the United States supplied 8.4 million of the 10.4 million tons India imports in 1966. The remainder was received in the form of wheat and wheat products from Canada, then USSR, and Australia.

This situation prompted the government to step in and devise a new policy – a new agricultural strategy for increasing the agricultural production within the shortest possible time and for minimizing fluctuations in agricultural production on account of unfavorable weather conditions. Thus, India's Ministry of Agriculture announced the New Strategy of Agricultural Development in August 1965. This new strategy came to be known as the "Green Revolution.**"** The objectives of the "Green Revolution" were to: (1) make available the required inputs in sufficient quantities; (2) encourage investment in fertilizer factories and the manufacturing of agricultural equipment; (3) identify and co-ordinate agricultural research activities to raise productivity; (4) intensify agricultural extension service in selected areas; (5) provide adequate credit to the farmers who are

willing to grow varieties of cereals and adopt the appropriate farm practices; and (6) implement a production-oriented cereal price policy.

The Indian agriculture, which was stagnant and backward for centuries, underwent a vast change due to adoption of the New Agricultural Development Strategy (the Green Revolution). The wider application of systematic and modern technological innovations brought about revolutionary changes in the methods of farming in India. This combined with improved supplies of water and selection of breeds resulted in tremendous increases in yield per acre for many crops. Indeed, the term Green Revolution was appropriate to describe the results in India.

Due to the success of the "Green Revolution," cereal imports in India were generally negligible in the 1970s, except massive crop failures in 1979-80 led to renewed imports of 2.3 million tons of food grains in 1981-82 (De Janvry, A. and K. Subbarao, 1986:10). By the end of the 20th century, India had achieved self-sufficiency by producing enough food, for example, 212 million tons of food grains in the year 2001-2002.

Factors Responsible for the Green Revolution

There were several factors that were responsible for the success of the "Green Revolution" in India. The main ones are briefly described below:

(1) High Yielding Variety of Seeds. This was the main scientific aspect of the "Green Revolution." The Indian Council for Agriculture Research, which was established by the British in 1929 yet was not known to have done any significant research, was re-organized first in 1965 and then in 1973. It developed new strains of high yield value (HYV) seeds, mainly wheat and rice, but also millet and corn. The most noteworthy HYV seed was the K68 variety for wheat. In addition, other high-yielding varieties of seeds were produced by agricultural universities and research centers in India. For example, in the case of wheat, S-308, *Kalyan* and *Sona* 227, etc.; in the case of rice, IR-7, IR-8, *Massuri, Padma, Jaya,* etc., were of high-yield variety of seeds. These seeds ensured a higher yield per acre for the farmer. The discovery and use of standard high-yielding variety of seeds, which considerably raised agricultural productivity, is primarily responsible for the success of the "Green Revolution."

(2) Double-Cropping Existing Farmland. Double cropping was a primary feature of the "Green Revolution." Due to the early maturity of new seeds, it became possible to grow two or three crops in a year from a plot of land, instead of just one crop. The one-season-per-year practice was based on the fact that there is only one natural monsoon per year that brings in rainfall. So, there had to be two "monsoons" per year. One would be the natural monsoon and the other an artificial monsoon. The artificial monsoon came in the form of huge irrigation facilities. Dams were built to arrest large volumes of natural monsoon water, which until then were being wasted, and simple irrigation techniques were used to water the fields. This practice contributed to increased agricultural production in India.

(3) Use of Fertilizers. Increased use of fertilizers also contributed to significant increases in agricultural output. Use of chemical fertilizers in India increased from 1.8 milllion tons in 1968-69 to about 12.7 million tons in 1991-92.

(4) Use of Modern Machinery. India's farming practice was dominated by traditional tools and methods. The increasing use of machinery and other modern equipment such as tractors, pump sets, power tillers, tube wells, harvesters etc., during the "Green Revolution" enabled multiple cropping and the growing of high-yield varieties of crops in the country.

(5) Extensive Irrigation Facilities. The provision of irrigation facilities constituted yet another important component of the "Green Revolution." An extensive irrigation facility made it possible to extensively provide water to farmers, and ensures better use of land and multiple cropping. The additional land brought under irrigation increased from 1.37 million hectares in 1968-69 to 81.0 million hectares in 1991-92.

(6) Improved Credit Facilities. Many Indian farmers lacked the financial resources needed to acquire the seeds, equipment and fertilizers. Thus, more attention had to be paid to making available adequate credit facilities to ordinary farmers to alleviate the lack of financial resources.

(7) Plant Protection Scheme. Protecting plants by using pesticides and other such devices was another important aspect of the "Green Revolution." The area covered under India's plant protection scheme increased from 17 million hectares in 1965-66 to about 66 million hectares in 1991-92.

(8) Expansion of Farming Areas: The expansion of farming areas was also an important factor for the success of the "Green Revolution" in India. Expansion of areas of land under cultivation had actually started right after the attainment of independence in 1947. The "Green Revolution" continued the trend at an accelerated rate. In 1960, the total area covered under the high-yielding-varieties program was a negligible 1.9 million hectares. By 1970, it reached 15.4 million hectares, by 1980, 43.1 million hectares and by 1990, it reached nearly 65.0 million hectares. Such spectacular increases in the areas of land under cultivation contributed to the success of the "Green revolution."

(9) Miscellaneous Factors: In addition to the above described factors, improvements in storage, food processing and marketing facilities, as well as government support price policies, also contributed to the success of the "Green Revolution" in India.

Results of the Green Revolution

The results of the "Green Revolution" of India can be categorized into economic, social and political aspects. From the economic aspect, the "Green Revolution" resulted in a

record grain output of 131 million tons in 1978-79. This achievement established India as one of the world's biggest agricultural producers. No other country in the world that attempted the "Green Revolution" recorded such a level of success. By the end of the 1970s India transformed itself from a net importer to a net exporter of food. Yield per unit of farmland increased by more than 30 percent between 1947 and 1979, when the "Green Revolution" was considered to have delivered its goods. The crop area under the high-yield varieties (HYV) grew from mere seven percent to 22 percent of the total cultivated area during the 10 years of the "Green Revolution." More than 70 percent of the wheat crop area, 35 percent of the rice crop area and 20 percent of the millet and corn crop areas, used the HYV seeds. Crop areas under HYV needed more water, more fertilizer, more pesticides, fungicides and certain other chemicals. This spurred the growth of the local manufacturing sector. Such industrial growth created new jobs and contributed to the country's gross domestic product (GDP). The increased emphasis on irrigation created the need for new dams to harness monsoon water. The water stored was used to create hydroelectric power. This in turn boosted industrial growth, created jobs and improved the quality of life of the people in villages.

India paid back all loans it had taken from the World Bank and its affiliates for the purpose of the "Green Revolution." Politically, this improved India's creditworthiness in the eyes of the lending agencies. Some developed countries, especially Canada, which were facing a shortage in agricultural labor, were so impressed by the results of India's "Green Revolution" that they asked the Indian government to supply them with farmers experienced in the methods of the Green Revolution. Many farmers from the states of Punjab and Haryana, in northern India, were thus sent to Canada where they settled.[1] These people remitted part of their incomes to their relatives in India. This not only helped the relatives but also added, albeit modestly, to India's foreign exchange earnings.

Socially, the "Green Revolution" created plenty of jobs not only for agricultural workers but also industrial workers by creating lateral facilities such as factories and hydro-electric power stations, as previously stated. In short, because of the "Green Revolution," India transformed itself from a starving nation to an exporter of food. This earned admiration for India, especially in the Third World.

With respect to the success of the "Green Revolution" in India, it is usually the increased production in rice and wheat, particularly in the northern and northwestern parts of the country, which is often cited. However, it should also be mentioned here that it has been argued that during the period of the "Green Revolution," sorghum yields outperformed rice and wheat in India. In fact, all the three key African cereals - maize, millet, and sorghum - did very well in some Indian states during the same period. This clearly demonstrates that impressive increases in yields is possible the use of fertilizers and HYVs even under conditions of low irrigation (M.L. Lipton, 1985:87-88).

The conditions that existed in India prior to the advent of the Green Revolution, as previously described, have some similarities to Eritrea's current conditions. Eritrea

[1] That is why Canada today has many Punjab-speaking citizens of Indian origin.

emerged in the last decade from many years of colonial rule under several colonial occupiers. The main economic stay of the Eritrean people is agriculture in which crop production, followed by livestock herding, is the core economic activity. The agricultural sector employs about seventy percent of the working population, yet its production is not sufficient enough to meet internal food demand. The country has experienced droughts that severely limited cereal production. As a result, the country faces food insecurity, much as India faced in the early 1960s. The similarities will become clear in the following section dealing with background to Eritrea's agriculture.

III. BACKGROUND OF ERITREAN AGRICULTURE

Eritrea is located in the Horn of Africa, bordered in the north and west by Sudan, in the south by Ethiopia and Djibouti, and in the east by the Red Sea. It has an estimated population of about 3.9 million and a total land area of some 12.2 million hectares. Its annual population growth is estimated at 2.9 percent. Eritrea has nine ethnic groups and six administrative *zobas* (provinces/regions). The country has six agricultural zones defined by climate, altitude, soils, and population density. They are: (1) The Central High Land Zone; (2) The Western Escarpment Zone; (3) The South Western Lowland Zone; (4) The Green Belt of the Eastern Escarpment of the Highland Zone; (5) The Coastal Plains Zone and, (6) The North-western Lowland zone.

Agriculture is the backbone of the Eritrean economy, playing a vital role in the country's economic development. Agriculture is the livelihood of the vast majority of the Eritrean people. More than 70 percent of the population depends on agriculture and its allied fields (crop production, live stock, forestry, traditional fishing etc.,). Although agriculture is the most important sector in terms of employment and livelihood, its contribution to the country's GDP is relatively moderate, estimated to be between 21 to 30 per cent (The World Bank, 1994: 5-6). This is comparable to the average of about 30 percent for Sub-Saharan African countries. Agriculture production levels in Eritrea are generally low, with average yields per hectare perhaps among the lowest in Africa. The contribution of agriculture to exports is also modest with most of the exports coming from the livestock sector. The current situation of low performance of the agricultural sector can be attributed primarily to the more than four decades of armed struggle for independence.

One of the primary goals of the agricultural sector is to guarantee food security by introducing modern technology, irrigation, terracing, soil and water conservation, with less dependence on rainwater. To date, major dam project like the Tokar dam, have been built and an additional 20 dams are on the pipeline. Once food security is attained, the goal foresees the export of agricultural products as foreign currency earner.

Land Types and Uses in Eritrea

Table 1 shows land types and current and potential land uses in Eritrea. Currently, only about 3.6 percent of the total area of the country is under cultivation. On the other hand, 57.2 percent of the country's land is devoted to browsing and grazing. About 5.5 percent of the country's land is considered to be woodland and shrub land. A mere 0.4 percent of the country's land is composed of scattered patches of forests and another 0.1 percent

under forest plantation activities. It should be noted that 33.2 percent of the country is considered to be barren land.

Table - 1 Current and Potential Land Use Categories in Eritrea (1994)

	Current		Potential	
Types of Land Use	**Hectares**	**Percentage of Total**	**Hectares**	**Percentage of Total**
Rainfed Cultivated land	417,000	3.4	1,500,000	12.3
Irrigated land	22,000	0.2	600,000	4.9
Disturbed Forest	53,000	0.4	53,000	0.4
Forest plantations	10,000	0.1	10,000	0.1
Woodland and scrub land	673,000	5.5	5,979,000	49.1
Browsing and Grazing land	6,967,000	57. 2		
Barren land	4,047,000	33.2	4,047,000	33.2
Total	**12,189,000**	**100.0**	**12,189,000**	**100.0**

Source : FAO (1994) Agriculture Sector Review and Project Identification Mission, p.21.
Note: *Depending on the sources, the statistics cited above may not match figures in other reports.*

Potentially, the consensus estimate of potential arable land is 2.1 million hectares (or 17.2 percent of the country's total land). Of the 2.1 million hectares of potential arable land, it is thought that 1.5 million hectares are suitable for rain-fed agriculture and 600,000 hectares for irrigation. The Government of Eritrea, and particularly the Ministry of Agriculture, should take the necessary steps to bring more amount of land under cultivation and realize the potential arable land.

Land and Population

As population increases, per capita cultivable land diminishes simply because arable land remains at best constant. Land can become alienated from agriculture to urbanization and road network, and some land becomes so degraded that it will be only marginally usable for cultivation. At present, with total population of about 4 million, per capita cultivable land in Eritrea is 0.11 hectare. By 2010, when the population can be expected to reach over 5 million, the per capita cultivable land may diminish to well below 0.1 hectare unless the area of cultivable land is substantially expanded.

Population density and land use density in Eritrea vary by region. Table 2 shows population size, amount of cultivated land and cultivated land per rural person by *zoba* (the term used to refer to administrative regions in Eritrea). The *zoba* of Debub, with a slightly more than a million people, accounts for about one-fourth of the country's total population. *Zoba* Gash-Barka has the largest cultivated land, 217,600 hectares, and also the largest cultivated land per rural person, 0.28 hectare. Overall, the cultivated land per rural person for the country is 0.15 hectare.

The average farm size in the most intensively cultivated *zoba* Debub is about 0.2 hactare. Farm sizes in Gash-Barka are larger with the average reaching close to 2 hectares. However, this figure includes some of the concessions. The average number of Topical

Livestock Units (TLUs) in the agro-pastoral sector of the country is known to be between 0.1 and 1 per hectare of cultivated land. While there is no reliable survey data on the distribution of livestock ownership across rural households, evidence from other semi-arid African countries shows that ownership is skewed, with most of the animals owned by a small fraction of the total households.

The greatest potential for the expansion of cultivable land in Eritrea lies in the lowland regions, particularly Gash-Barka and Anseba, where the growing season tends to be short and most variable without irrigation. Expansion in the highland regions implies intensification on sloping land where the costs and risks of erosion are most severe (Ministry of Agriculture, 2002:16).

Table – 2 Cultivated Land and Population Distribution, 1999

S.No.	Zoba	No. of Sub Zobas	Population (000's)	Rural Population (000's)	Cultivated Land(000's) Hactares	Cultivated Land per Rural Person
1	Anseba	10	570.2	562,7	58.1	0.10
2	Debub	11	1014.8	976.3	128.1	0.13
3	Gash-Barka	14	754.8	790.8	217.6	0.28
4	Maekel	4	726.6	188.5	27.8	0.15
5	N.Red Sea	9	558.5	567.2	40.8	0.07
6	S.Red Sea	4	273.9	223.9	0	0.00
	Total	**52**	**3,900**	**3,198**	**471.9**	**0.15**

Source: Ministry of Agriculture, Government of Eritrea, Agricultural Sector Policy and Strategy Framework: Background and Context Development and Management (November 2002), Asmara, p.16.
Note: The cities of DekemHare, Assab, Tesseney, Massawa, and Keren, have been excluded from their respective *zoba*s. However, the capital, Asmara, is included in the figures shown for *zoba* Maekel..

Food Production in Eritrea

In Eritrea, increasing food production is a central policy issue in the country's agricultural development. There are no reliable data on agricultural production in Eritrea. The information available from different sources – for example, the National Statistical Office (NSO), the Ministry of Agriculture, the Food and Agricultural Organization (FAO) – varies substantially. But the main indication of agricultural production that emerges is that one of either stagnation or very slow growth, especially during the period between 1998 and 2002.

The annual average output of the major food crops during the period between 1994 and 1997 suggests that there was a marginal increase in the output of the main food crops, namely sorghum, barley, wheat, maize, millet, and *taff*. This small increase was due to the expansion of the cultivable land rather than increase in productivity.

It is often suggested that food production at the farm level can be increased through one or more of the following methods: (1) changing the crop mix within the confines of currently produced in the farms and given techniques; (2) changing the crop mix by

introducing new crops; (3) changing factor proportions in crop production by changing the levels of existing inputs to the optimum levels; and (4) changing the technology by incorporating a new production function (G.R. Saini, 1979:90.).

Although the priority attached to the agricultural sector is obvious in Eritrea, the emphasis placed on food versus or cash crops is not clear. Historically, colonial policies in Eritrea placed emphasis on cash crop cultivation, primarily for export while the food aspect was neglected. Industrialization was encouraged primarily in areas related to the processing of cash crops for exports.

Patterns of Crop Production

The majority of Eritreas are engaged in peasant farming, growing sorghum, barley, *taff* (fine grain used for making Eritrean bread), maize, wheat, fruits and vegetables as food crops, and producing cotton, coffee, and oil seeds as industrial crops. Livestock products such as dairy, meat, and sea fisheries also play significant roles in the economy. The highly developed commercial agricultural sector exports cotton, coffee, sisal, fruits and vegetables, and fish to the neighboring countries, including Djibouti, Sudan, etc. The agriculture sector is thus a prime mover of the country's economy (Ravinder Rena, 2002: 5-6).

The weak agricultural research base in Eritrea has meant a lack of suitable high yielding varieties for the main staple crops (sorghum, *taff*, wheat, millet, etc.). Imports of crops, such as rice, have discouraged the production of cheaper, less elegant, home-grown crops. Cash crops are not very significant in most part of the country. Farmers usually plant the traditional food crops on their larger fields. If they plant any cash crops, it is usually carried out on the smaller fields.

Traditional rain-fed agriculture accounts for at least 90 percent of the estimated 400,000 hectares of cropped land in Eritrea. The most important determining factor of the traditional agricultural system is availability of rainfall, and thus, soil moisture. Modern agricultural inputs are near absent. Farmers produce mainly cereals, pulses and oilseeds on farms whose average size is less than one hectare in the highland areas and close to two hectares in the lowland areas.

Commercial farmers use surface and drip irrigation for high value crops, mainly horticultural. Such farms are located in the southwest part of the country along the river basins of Gash, Barka and Anseba. The principal products of these farms are bananas, onions, papayas, tomatoes, peppers, eggplants, okra, mangoes and citrus fruits. Double cropping is routine. Due to the practice of irrigation, farmers can meet domestic needs for most vegetables and fruits as well as generate some exports.

Agriculture and the Crisis of Food Security in Eritrea

Over the past hundred years, backwardness and uneven development have characterized Eritrean agriculture (Gebremedhin, 1996). The agricultural sector of the country has been

facing many problems including: near absent investment in agricultural research, lack of irrigation facilitates and land conservation measures, poor rural roads and related infrastructure. As a result, agricultural productivity has been low.

In the context of current national policy, "food security" refers to an "existence of the capacity and ability to make readily accessible to all Eritreans food of sufficient quantity and acceptable quality at an affordable price at any time and place within the country" (GSE, 1994). Based on this definition, there is currently a crisis of food security in Eritrea.

The 2002 harvest in Eritrea was the lowest level recorded in the past 20 years. According to studies conducted by the Ministry of Agriculture, a mere 54,000 metric tons of cereals was harvested in the country, which was about 11 percent of the normal annual grain production, and about 9 percent of the total food consumption in Eritrea. This means at least 90 percent of the demand for food had to be covered either from food aid donations or be purchased from international markets.

The food production outlook remains bleak as a large number of the war-displaced farmers are unable to return to their farms and large tracts of land are still inaccessible due to land mines, a reminder of the large-scale border war between Eritrea and Ethiopia between 1998 and 2002. The spring rains of March through May, which are needed for early land preparation and regeneration of pastures, have failed in many areas in recent years. Prices of cereals have increased significantly, reflecting the shortage of supplies. Indeed, the drought experienced over the past few years has resulted in severe losses of both human and livestock populations of the country. The failure of the rains, and the resulting drought condition, has affected Eritrea so adversely that the country is facing a crisis of food security.

Agricultural Research and Integrated Farming Scheme

Agricultural research in Eritrea is in its infancy, lacking in resources and skilled manpower. The agricultural research institute has nevertheless released some improved crops selected through adaptive research. They include staple crops such as sorghum vulgaris. It has also established a germplasm bank on plants, three research stations, and contacts with the international research institutions. Applied research on plant pests, livestock, forestry and horticulture are in progress. The laboratories are also under preparation. The main constraints are shortage of research scientists and skilled technicians, and lack of proper facilities and equipment (FAO, 2000:18).

There have been attempts, with some success, to apply modern technology in specific areas in the country such as *Elaberit, Halhale, Aligidher, Hagaz, and Amalmalo.* Three agricultural sites in Eritrea in particular -- Golluj in the Gash Barka, Shi'ib in the Northern Red Sea, and Hazomo in z*oba* Debub -- are considered to be "breadbasket" areas of the country.[2]

[2] These areas are chosen as work sites where deep agricultural research is proposed in due course.

Several international organization, some bilateral others non-governmental organizations (NGOs), are operating in Eritrea as partners in agricultural development. The partners are involved either directly in agriculture and fisheries, or indirectly in the development of rural infrastructure or institutional capacity. Within the UN system, they include the Food and Agricultural Organization (FAO), United Nations Development Program (UNDP), United Nations International Children's Emergency Fund (UNICEF), World Health Organization (WHO), World Food Program (WFP), United Nations High Commissioner for Refugees (UNHCR). Among the multi-laterals and financing institutions, the European Union (EU), the World Bank, International Fund for Agricultural Development (IFAD) and African Development Bank (ADB) are actively supporting a wide range of programs to create an enabling environment to achieve food security and rural development. Among bi-laterals, the Danish Development Agency (DANIDA), Norway, the United States Agency for International Development (USAID), the Netherlands and Italy are the major partners. Among the NGOs, Africare, the Lutheran World Federation and local churches are the main participants in the Eritrean agriculture development.

Impact of Integrated Farming Scheme on Food Grains

Currently, two farming systems, the Impact Farming Scheme (IFS) and the traditional farming practice, exist side by side. The IFS was started by the Government of Eritrea in 1998 to develop semi-and commercial rain-fed agriculture, mainly in southern Gash-Barka, considered to have the highest potential for the project. The aim of IFS is to increase crop production and incomes through the use of modern farming practices and larger land holdings. The government supports the IFS by granting land concessions and providing machinery and fertilizer at cost. Reliable data are not yet available on the performance of the IFS. But, it is known that the area of land on rain-fed crops has increased by about 27 percent between 1996 and 1998. The area under IFS has been doubled from about 44,000 hectares in 1998 to about 90,000 hectares in 1999 (FAO, 2000:13).

According to a Ministry of Agriculture report, fertilizer, quality seeds, and better land preparation can raise cereal yields by about 85 percent; the maximum would be for pearl millet (127 percent) and the minimum for barley (32 percent). Potential increases for sorghum and wheat can reach 100 percent. (MoA., 2000).

The main source of water for irrigation is underground water explored from shallow, open hand-dug wells. In the Gash and Barka river basins, the wells are dug either on the river sand bed or on its outer edges in order to maximize the water content of the deep fine silt of alluvial soils. The capacity of wells is higher along these river basins because the water catchment areas are vast and annual rainfalls are high enough to induce adequate recharge (MOA, 2002, 16-17). The Government of Eritrea has been constructing new and rehabilitating old micro-dams in many areas.

Spate irrigation is considered to be the best option or strategy to increase crop production in Eritrea. This is true particularly if resource management, effective water control,

improved seed variety, good quality extension service, such as pest control, are introduced. Adoptive research is also important for the continuous improvement of crop yield. At present, about 20, 000 hectares of land are under spate irrigation, but potentially this can be increased to about 600,000 hectares (FAO, 2000:13). Under this system, the spate flows of rivers are diverted by temporary structures into bunded fields. The bunds are low and are allowed to overflow to irrigate nearby fields. Although, spate irrigation is cheap, it permits only minimal water control and often necessitates repairs owing to flood damage. Absence of water management can results in flood damages

Full implementation of spate irrigation, coupled with use of high-yield crop varieties, fertilizers and improved animal husbandry, will conceivably enable Eritrea to attain food sufficiency by the year 2010 (FAO, 2000:29). This can be achieved only if normal, evenly distributed and reliable rainfall conditions prevail in the country.

IV. INDIAN AGRICULTURAL EXPERIENCE – A PARADIGM FOR ERITREA

We have seen from the background to the Indian agriculture that post-independence India in the 1950s faced chronic insufficiencies of food and had to rely on food imports and food aid to feed its growing population. India also faced an unprecedented drought condition in 1966 that exacerbated the food crisis. The 1966 drought condition prompted the launching of a successful "Green Revolution" which in a period of ten years enabled India to transform itself from a starving nation to an exporter of food.

Similarly, post-independence Eritrea currently faces acute shortage of food, relying on donations and food imports to feed its population. Intermittent drought conditions and wars in the past decade have exacerbated the food insecurity situation. The Indian experience through the implementation of a "Green Revolution" should serve as a paradigm for Eritrea to transform its agricultural sector so that crop yields are increased to make the country self-sufficient in food. The specific strategies are detailed in this section.

One of the main problems in India's agriculture sector was that traditional tools and methods dominated farming practices. India introduced the use of modern farm tools such as tractors, power tillers; pump sets, etc. during the "Green Revolution." Eritrean farming practice is also dominated by traditional tools and methods, which have been in place for many generations. Appropriate modern farm tools should be introduced to farmers if agricultural production is to increase.

Another important factor responsible for the high crop yield and general success of the "Green Revolution" was the use of high yield variety (HYV) seeds. Agricultural research efforts by universities and research institutions in the country produced high-yield varieties of the common Indian cereals such as rice, wheat, corn and millet. Use of such seeds by farmers resulted in higher yields per acre. Similar research activities should be undertaken in Eritrea by the agricultural programs of the national university as well as by the research units of the Ministry of Agriculture to produce high yield varieties in wheat,

sorghum, *taff*, corn, cotton and other crops prevalent in Eritrea, so that farmers can use such seeds to increase the yield on their farms.

Application of fertilizers was also an important element in the Indian experience. Not only did the government of India enhance use of traditional natural methods of fertilizing farms but also introduced chemical fertilizers which resulted in significant increases in crop production. We have seen that the soil of the farm lands in Eritrea has deteriorated due to years of traditional farming practices with little attention paid to fertilize it. There are some traditional practices, such as use of manure and crop rotation, which farmers use to fertilize their fields, but not extensively enough. The government should take measures to enhance the traditional practices of naturally fertilizing the soil. At the same time, chemical fertilizers appropriate for the types of soils and terrain in the country should be introduced to increase crop production.

We have seen from the background information on Eritrean agriculture that currently less than four percent of the total area of the country is under cultivation. Potentially though over 17 percent is estimated to be cultivable. Efforts should be made to realize the potential. The Indian experience indicates that the area of land devoted to high-yielding varieties of crops was relatively small, about 2 million hectares, in the early 1960s. By 1990, such area was expanded to 65 million hectares. Such an expansion greatly contributed to the success of the "Green Revolution" in India.

Inequality in land holdings and the existence of feudal and absentee landlords in India necessitated land reforms. Series of measures to reform the agrarian structure in the mid 1960s resulted in changes to the status and privileges of semi-feudal landlords (the *zamindar*s and the *jagridars*) and the absentee landlords. The reforms enabled the rise a small group having the potential for becoming capitalist farmers. The status of the landowners who were residents of and cultivating the *ryotwari* (farming) areas was not affected by the reform (T. Byres, 1981:423). Without such a reform, the impact of the introduction of modern farming methods and the other activities introduced during the "Green Revolution" would not have been as successful as they were. In Eritrea, it has been recognized that traditional land holding systems were a hindrance to the agricultural development in the country. The Government of Eritrea introduced a Land Proclamation in 1994. However, implementation of the proclamation has been stalled. The uncertainty in the country's land policy is a factor severely constraining Eritrean agricultural development (MoA, 2002:9). The government should decide either to implement the Land Proclamations or amend it to address any concerns.

Traditional Indian agriculture relied primarily on one natural monsoon per year that brings in rainfall. Extensive use irrigation facilities made it possible for Indian farmers to have two "monsoons" per year, one natural and the other artificial. The artificial monsoon came in the form of huge irrigation facilities. Dams were built to arrest large volumes of natural monsoon water, which until then were being wasted, and simple irrigation techniques were used to water the fields. Use of irrigation facilities enabled farmers to practice multiple cropping in a year, which in turn contributed to increased agricultural production in India. In Eritrea, farmers rely on rain, which is not only usually

insufficient but also unreliable. Drought conditions are very common. It is therefore critical that alternate sources of water be explored. As previously mentioned, the main source of water for irrigation in Eritrea is underground water. The Gash, Barka and Anseba river basins hold the best promises. The Government of Eritrea has been constructing new and rehabilitating old micro-dams in many areas for better control and management of water resources. Such efforts should continue to ease the problems presented by shortages of rainfall and drought conditions.

The introduction of modern farming equipment and methods, high-yield variety seeds, irrigation schemes will not amount to anything if farmers cannot afford them. The overwhelming majority of Indian farmers were too poor to afford them in the 1960s. The government made available credit facilities for the ordinary farmers to overcome the lack of financial resources. In addition, educational services through extension programs were provided to farmers. Similarly, Eritrean farmers, the overwhelming majority of whom are subsistence farmers, are too poor to afford modern farm equipment, new seeds or irrigation facilities. The government should develop credit facilities to go hand-in-hand with the introduction of modern faming equipment and related activities. Further, the need to educate Eritrean farmers through extension programs is evident as they know very little beyond their traditional methods of farming.

In sum, Eritrea can learn from the Indian experience of the "Green Revolution" by: introducing modern farming equipment and methods, developing high-yield varieties of its staple cereals, applying both natural and chemical fertilizers, expanding cultivable lands, developing irrigation systems, reforming land holding systems, and extending credit facilities and educational services to farmers, By dong so, it is conceivable that Eritrea can attain food sufficiency within the next decade. Efforts towards initiating programs similar to those practiced in the Indian appear to be already underway. The embarking of the Integrated Farming Scheme (IFS), as previously discussed, incorporates elements of modern farming practices similar to those found in the Indian experience.

V. CONCLUSION

The term "Green Revolution" is a general one used to describe successful agricultural experiments in many Third World countries that resulted in increased crop production. For example, high-yielding varieties of wheat, rice and other staple grains have been developed in countries like Mexico, Philippines, etc. However, India is the country often cited as the one with the most successful experience in the advent of "Green Revolution." The Indian post-colonial experience of agricultural and food production through the "Green Revolution" provides valuable lessons on how to achieve self-sufficiency in food.

"Green Revolution" in the Indian experience refers to the sum of the following activities: application of modern farming technology, introduction of high-yielding varieties of seeds, increased use of fertilizers, development and expansion of irrigation systems, extension of credit and educational services to farmers. These activities resulted in drastic increases of farm products leading India to achieve self-sufficiency in food in a short period of time.

We have seen in the descriptions of the backgrounds to Indian and Eritrean agriculture that Eritrea now faces the problem of food insecurity and dependency on food imports, much the same situation post-independence India faced in the 1950s and 1960s. Initiating the "Green Revolution" enabled India to achieve self-sufficiency in food within a span of ten years. The Indian experience should serve as a model for Eritrea to achieve self-sufficiency in food. The activities that comprise the "Green Revolution" are worth emulating in the Eritrean environment. However, the condition in Eritrea is also different from that of India in many resects. For example, drought is currently the number one problem in Eritrea. In addition, wars, famine, constant environmental degradation resulting in disappearance of forests and erosion of fertile soils, and shrinking water resources, have crippled agricultural and general economic developments. Thus, research should be an integral part of adopting any element of the Indian "Green Revolution" so that any application is appropriate to the specific agro-ecological and socio-economic conditions of the country.

REFERENCES

Abraham, Kinfe, *Why and How Africa is Underdeveloped* (1995), African World Press Inc., Trenton, New Jersey.

Ahluwalia, I.J., *Industrial Growth in India: Stagnation Since the Mid-Sixties* (1985), Oxford University Press, New Delhi.

Anderson, P.P. and P.B.R. Hazell (1985) *The Impact of the Green Revolution and Prospects for the Future* (1985), Washington, D.C. *(*Reprinted from *Food Reviews International).*

Bardhan, P., *The Political Economy of Development in India* (1984), Basil Blackwell, Oxford.

Beckman, B., "State and Capitalist Development in Nigeria," in *Review of African Political Economy, 23 (January-April, 1982).*

Bhalla, G.S., "Transfer of Technology and Agricultural Development in India", *Economic and Political Weekly,* (1979).

Blyn, G., *Agricultural Trends in India: 1891-1947* (1966), University of Pennsylvania.

Byres, T.(1981) "The New Technology, Class formation and Class Action in the Indian Countryside," in *the Journal of Peasant Studies, 8(2*), (January, 1981).

Dantwala, M.L., "Agriculture Policy in India Since Independence", in C. H. Shah (ed.), *Agriculture Development of India: Poverty and Problems,* (1979), Orient Longman, New Delhi.

_____, "Technology Growth and Equity", in J.W. Meller and G. Desai (sds.) *Agricultural Change and Rural Poverty, (1986),* International Food Policy Research Center, Washington, D.C.

De Janvry, A. and Subbarao, K., Agricultural Price Policy and Income Distribution in India, Studies in Economic Planning (1986), Oxford University Press, New Delhi.

F.A.O., *Strengthening the Agricultural Research and Extension in Eritrea, GCP/ERI/001/ITA* (1988), Asmara.

Government of India, Ministry of Food, Agriculture, *Community Development, and Cooperation* (1967), New Delhi

Lele, U., "Marketing and Pricing of Food Grains", in C. H. Shah (Ed.), *Agriculture Development of India: Poverty and Problems*, (1979), Orient Longman, New Delhi.

Lipton, M. and C. Heald, *The EC and African Food Strategies* (December 1984), Center for European Policy Studies (CEPS), Brussels.

Lipton, M.L., "Research and Design of a Policy Frame in Agriculture", in T. Rose (ed.), *Crisis and Recovery in Sub-Saharan Africa*, (1985), Development Center, OECD, Paris.

Mellor, J.W. and R.H. Adams Jr., *"The New Political Economy of Food and Agriculture Development,"* in *Food Policy*, (1986).

Ministry of Agriculture, Government of Eritrea, *Agricultural Development Program Report*, (2000), Asmara.

_____, *Agricultural Sector Policy and Strategy Framework: Background and Context Development and Management*, (November 2002), Asmara.

_____, *The National Action Programme for Eritrea to Combat Desertification and Mitigate the Effects of Drought*, (January 2002), Asmara.

Mishra, S., "On the Reliability of Pre-independence Agricultural Statistics in Bombay and Punjab," in *The Indian Economic and Social History Review, 20(2)*, (April-June 1983).

Nair, K,.(1983) *Transforming Traditionally: Land and Labour Use in Agriculture in Asia and Africa* (1983), Allied Publishers, New Delhi.

Negash, Amanuel, et al, *Soil Conservation in Eritrea: Some case Studies Technical Report No.23* (2000), Swedish International Development Corporation Agency (SIDA), Nairobi.

Rena, Ravinder, "Eritrean Agriculture: Prospects and Challenges," in *Eritrea Profile* (a Weekly Bulletin of News and Views) (June 15, 2002), Asmara

_____, "Challenges of Research in Eritrea," in *Eritrea Profile* (May 31, 2003); also in *www.shabait.com/articles/publish/article_106.html*

_____, Hand Book on Eritrean Economy (2003, unpublished material), Commercial College, Asmara.

Roy, Sumit, *Agriculture and Technology in Developing Countries: India and Nigeria* (1990), Sage Publications, London.

Sarma, J.S., "Growth and Equity: Policies and Implementation in Indian Agriculture," in *Research Report No.28.* (Novemberr 1981), Washington, D.C.

Tesfa G. Gebremedhin, Beyond Survival: The Economic Challenges of Agriculture and Development in Post-Independent Eritrea (1996), The Red Sea Press, Trenton, New Jersey.

Tesfagiorgis, Gebre Hiwet (ed), *Emergent Eritrea: Challenges of Economic Development* (1993), The Red Sea Press, Trenton, New Jersey.

The Government of India, Ministry of Food and Agriculture, *Review of the Food and Scarcity Situation in India* (July 1967), New Delhi.

_____, *New Strategy for Agriculture Development* (1967), New Delhi.

United Nations, *Food Security in Eritrea: Issues and Recommendations*, (November 1998), Asmara.

Warriner, D., *Land Reform in Principle and Practice* (1969), Butler and Tanner, London.

World Bank Document, Eritrea: Options and Strategies for Growth (1994), Washington, D.C.

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