THE ORIGIN AND UNFOLDING OF THE GREEN REVOLUTION REVISITED BY FOUR OF ITS EARLY INSTIGATORS - *AN EXAMPLE OF A SUCCESSFUL, WIDE PARTNERSHIP*

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REDRESSING THE RECORD

Much has been written about the Green Revolution, particularly its science-based technologies and their achievements, that were its foundation. However, much less has been written about the many institutions that participated in the development of complementary technologies and enabling environments for the adaptation, dissemination and adoption of these technologies which brought the Green Revolution to millions of farmers throughout the world.

The credit for these remarkable achievements of the Green Revolution has, understandably, gone to the two main institutes involved, namely, the International Wheat and Maize Institute (CIMMYT) in Mexico and the International Rice Research Institute (IRRI) in the Philippines where the principle research on wheat and rice, respectively, took place. However, other important partners included members of the club of donor foundations, the UN family, particularly the FAO, and the sponsors[2] of the Consultative Group on International Agricultural Research (CGIAR) and governments, as well as bilateral and non-governmental institutions. All these institutions and agencies performed many important roles in bring the Green Revolution to fruition but have never

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been given their rightful credit. The four co-authors of this article, who were amongst the early instigators of the Green Revolution, feel that the record should be set straight and the important and indispensable roles of these institutions brought out.

This article reviews the background and origin of the Green Revolution and how it unfolded, emphasising the role that FAO and other institutions played in this dramatic scene in the history of mankind. FAO played an important role in ushering in the Green Revolution in many countries of North and East Africa, Middle and Near East and South and South East Asia. This article aims to preserve this history, to drawn lessons and to gain some perspectives for the future.

Hunger is still with us as the World Food Summit of November 1996 is a clear reminder. Technological innovation is still, and urgently, needed to further increase food production. And so is the commitment of governments, international institutions and civil society to ensure an enabling political, social and economic environment conducive to achieving sustainable food security for all.

THE ORIGINS

One could say that Malthus was half right. The exponential rate of growth of human population which he predicted has occurred but he underestimated man's ingenuity and the impact of science and technology in raising food production. While his prediction of universal famine has not come true, the situation during and immediately following World War II gave rise to great concern. The Bengal famine of 1943 was one such stark reminder.

Alarmed at the growing gap between the rates of growth of population and food production, India's first Prime Minister, Jawaharlal Nehru, said in 1949, "everything else can wait but not agriculture". Several measure to stimulate food production were initiated in India in the 1950s, and production of wheat and rice did increase. But productivity per unit of land area remained virtually stagnant with enhanced production coming largely from an increase in total cropped and irrigated area. Clearly, something was missing from the agronomic formula, namely, better seed and improved agronomic practices and inputs for that seed to express its potential.

The most crucial factor was, undoubtedly, the identification and innovative use of dwarfing genes to enable plants to utilise applied fertilisers more effectively producing more grain instead of a long weak straw resulting in lodging and crop loss[3]. The original work was done by Orville Vogel at the Washington State ***(university?)*** but it was principally one of the authors (Borlaug), working on wheat at CIMMYT, and Hank Beachell, working on rice at IRRI, together with their co-workers who developed the high-yielding genetic material.

It was in the late 1950s and early 1960s that an effective partnership of international organisations, private foundations and other donors and government institutions began to take shape. A concerted effort to bring together all the inputs needed for a major breakthrough in increasing productivity began. It was the partnership with other institutions that promoted the transfer and adaptation of the technology to local conditions and developed many of the accompanying technologies. In particular, considerable assistance was provided to develop and strengthen the capacity of national institutions for sustained adoption of technologies and formulation of policies for an enabling socio-economic environment.

In a matter of a few years the food deficient countries of Latin America, the Near East, South and East Asia no longer had the need to import large amounts of rice and wheat and, in fact, some eventually became net grain exporters. This transformation happened so short a period of time that the event was aptly named the "Green Revolution". The momentum of this "revolution" in the late sixties and early seventies has been sustained and its extension into Africa is now imminent.

[3] /. Perhaps the most significant event was the almost unnoticed discovery by the Austrian monk, Gregor Mendel, 1822-1884, botanist and plant experimenter, that the flower characteristics of the garden pea tended to be transmitted from parent to offspring following a predictable pattern. The resulting science of genetics allowed man not only to speed up evolution but to direct it according to his needs. The science and art of plant breeding started to raise yields and quality in the first half of the century but, nevertheless, the spectre of Malthus created real fears in the immediate Post World War II era.

THE UNFOLDING PROCESS - SOME GLIMPSES OF SUCCESSFUL PARTNERSHIPS

Although much research work had been done on wheat and rice, the varieties developed before the Green Revolution had a low-yield potential because they were tall with soft hollow stems and prone to lodging even with small doses of fertilisers and blowing of strong winds. It had been shown experimentally that the yields of these cultivars could be doubled if the varieties were artificially prevented from lodging which, of course, was impractical in the field.

The problem of lodging was addressed at CIMMYT by introducing genes of a semi-dwarf Japanese variety (Norin 10B), obtained from Orville Vogel ***in 19??,*** through crosses with more traditional varieties. The resulting new varieties proved to be lodging resistant. In 1960, the Rockefeller Foundation and FAO sponsored a three-man mission, headed by one of us (Borlaug), to find out if the highly successful plant breeding and agronomic technologies being developed for wheat at CIMMYT could be transferred to Africa and Asia. The principal recommendation was the establishment of uniform testing scheme in countries of North Africa and the Middle East.

In 1962, similar breakthroughs in plant breeding and agronomic technologies developed by IRRI led to HYVs of rice. By the mid-1960s, the technologies were being adopted in India and Pakistan and other countries in Asia. The bountiful wheat harvests in 1967-68 in India and Pakistan lead the then Administrator of USAID to write in his Annual Report, "Something has happened; there is a dramatic change in wheat production and now beginning in rice. It appears that a Green Revolution is taking place." And so this new phrase came into being, signifying one of the great events of the 20th century. Four years later, in 1971, India became self sufficient in wheat and in a further three years in all cereals. India and Pakistan have essentially maintained near self sufficiency in basic cereal production despite the rapid population increase.

FAO played a key role in the implementation of the Green Revolution through a variety of programmes including training local scientists, conducting regional trials leading to the identification and extensive use of HYVs, as well as in helping to develop new breeding techniques. In fact, FAO's active involvement in efforts to increase food production dates back to the early years of the

development of high-yielding varieties (HYVs). For example, the first organised attempt to introduce hybrid maize in Europe from the USA took place at a meeting held in Bergamo, Italy, in 1947. Subsequently, the FAO Hybrid Maize Project and Maize Seed Certification Scheme were launched which contributed to a very significant increase in maize production in Europe.

Wheat

Middle East: The 1960 mission, led by Borlaug, recommended that FAO establish a Regional Programme in the Near East and North Africa for the improvement of wheat and barley. The Programme, funded by UNDP's predecessor bodies, was based at the FAO office in Cairo and headed by another of the co-authors (Hafiz) and consisted of training young plant breeders and agronomists from 24 countries in three continents.

A uniform field testing scheme was established in North Africa and the Near and Middle East for bread wheat and barley, and a parallel testing programme for durum wheat was established by FAO and IAEA through their joint division in Vienna and headed by another of the co-authors of this paper (Sigurbjornsson). This programme quickly led to the identification of high yielding varieties. When tested in the FAO uniform trials in 24 countries stretching from Morocco to Nepal and Turkey to Ethiopia in the 1960s, they broke all previous yield performance records and became the precursors of the Green Revolution.

The progress in plant breeding made during 1962-80 in North Africa and the Middle East showed that average wheat yields in all the developing countries rose from 870 kg/ha. to 1,630 kg/ha, the area under wheat rose from 76 million to 96 million hectares, and production increased 140% from 65 million tons[4] to 157 million tonnes. Turkey recorded a breakthrough under dryland conditions, increasing the yield level by more than 100 per cent between 1961 to 1979) and became exporter of wheat. Saudi Arabia increased its production from 120 000 tonnes in 1961/63 to 1.4 million in 1984 and over 4 million in 1991. Egypt achieved five tonnes per hectare and many

[4] /. Source of data quoted in this paper are principally from Hanson, H., N.E. Borlaug, and R.G. Anderson, Wheat in the Third World, (1982). Other data sources include ... ***(authors to expand as appropriate).***

countries up to four tonnes per hectare. The varieties spread both in irrigated and rainfed areas, necessitating the introduction of field machinery (tractors, reapers, threshers) and fertilisers. The myth about farmers not being responsive to technological change broke down as it became abundantly clear that they were ready and able to adopt convincing improved technology provided expected returns were sufficient. Progress continued from mid-1980 through the 1990s in those countries where inputs were made available to the farmers on time and at a reasonable price along with provision of favourable prices for the output.

India and Pakistan: The examples of India and Pakistan, which concentrated on enhanced wheat production programmes in 1962 and 1964, respectively, are informative. Together, India and Pakistan doubled their wheat production between 1966 and 1971 and trebled their wheat production by 1976.

In Pakistan the first half of the 1960s was characterised by an annual growth rate of wheat and rice production of 1.5 and 4.8 percent respectively, while the second half of the decade heralded the advent of a new era in recording a phenomenal annual growth rate of wheat and rice production of 12.5 and 11.6 percent respectively. The elusive goal of self-sufficiency in food for the first time was within sight. The rural scene in Pakistan was alive with activity and enterprise, leading to an unprecedented upsurge in prosperity. The period of 1972-77 showed a standstill a slowdown in the growth of wheat production with a resurgence from 1978 onwards, increasing to 17 million tons in 1995 (starting from about 6 million tons in 1971).

India likewise achieved spectacular results in increasing wheat production. In 1947 production was six million tons rising to 12.3 million tons (1965), 16.5 million tons (1968), 57.2 million tons (1993) and 65.8 million tons (1995). Planned production 2000 is 87.5 million tonnes. All this was due to earnest implementation of packages of technology (including varieties, agronomy and post harvest handling), services (timely supply of inputs and credit) and public policies (input and output pricing, assured remunerative marketing, building of grain reserves and strengthening of rural techno-infrastructure). If 1965 is taken as the base year of Green Revolution in India, production has increased four times to 1995 (or six times between 1961 and 1997).

Rice

The International Rice Commission (IRC) was established under the auspices of FAO in January 1949. In 1956, the IRC appointed N. Parthasarathy as the FAO Regional Rice Breeding Specialist. Parthasanathy recommendation that FAO "... give due consideration to the proposal of establishing an international rice research institute ..." in Asia which was adopted by IRC in 1958. Due to his vision, drive and energy, IRRI was eventually established in 1960 with financial support from the Rockefeller and Ford Foundations, and IR-8 (miracle rice) ultimately came into being. IRRI was established in 1960. FAO's Regional Representative in Asia and the Pacific has been a member of the Board of Trustees of IRRI since 1964.

Parthasanathy was affectionately referred to as "Papa Rice" (the father of rice) by the farmers of the region. Under his leadership, the IRC organised meetings on all aspects of rice breeding and production. Parthasarathy worked closely with IRRI in the early years and helped organise the regional testing of the new HYVs which had been developed by Hank Beachell at IRRI. Together with FAO, in view of its inter-governmental status, agreements with regional governments were concluded for the introduction and release of the varieties.

As with wheat, the development of miracle rice varieties was based on crossing Thaichung native nr. 1, a semi dwarf indica rice, with traditional varieties, leading to the release of IR-8 and many other varieties with added resistance against some pests and diseases. These varieties became popular with the farmers in many countries of South and South-East Asia increasing the yield per unit area and total production manifold.

Since 1960, there has been a large increase in world rice production to 535 million tons in 1994 from 145 million tons in 1948, i.e., nearly four times while the yield level doubled (from 1.68 to 3.6 t/ha). Today, countries are obtaining impressive yields: Egypt - 8.3 tonnes per hectare; Japan - 6.3; China - 5.9; Indonesia - 4.3; while others 3-4.

Other Crops

Apart from these two success stories of wheat and rice, FAO through its Near East Regional Project also achieved some visible breakthroughs in summer cereals (maize, sorghum and pearl millet), food legumes (gram) and oilseeds (soybean, sunflower and winter rape) as well as in wheat/sheep husbandry particularly in North Africa. This was also due to the international co-operative efforts of FAO/UNDP, donor agencies, universities of advanced countries and the national governments. The superiority of the co-operative approach has been of paramount importance for which much of the credit goes to FAO.

The Green Revolution was thus an unfolding process of wide partnership between international, government and private organisations particularly FAO, UNDP, IAEA and the Rockefeller and Ford Foundations and many national and international universities and national research institutes and extension services This was a good example of FAO performing a catalytic role of attracting partners[5] from all over the globe for financial and technical support to a common cause of, what is now referred to as, Food For All.

THE ELEMENTS OF SUCCESS: FACILITATING TECHNOLOGIES AND ENABLING ENVIRONMENTS

The wheat and rice success stories would not have been possible without the close interrelationships between multiple institutions which gave rise to the development of facilitating technologies and conducive socio-economic environments. ***(More introduction on facilitating technologies/enabling environments would be appropriate here?)*** A brief description of these essential elements is narrated below.

Research and Training in Plant Breeding: In order to build up the national research and development capabilities, different types of training programmes were organised by FAO with

support from the Rockefeller Foundation for the young, energetic and dedicated plant scientists. The requirements of each member country were identified along with a selection of the most suitable candidates by carefully watching their performance and aptitude for learning and good work..

In all, 58 training courses (apart from individual fellowships) were conducted from 1960 to 1980 imparting training to 305 scientists. Out of those eight, 8-month FAO/Rockefeller Foundation Training Courses on wheat improvement at CIMMYT played a pivotal role in introducing and popularising the CIMMYT breeding technology and varieties in the Region. The other important training courses were FAO/SIDA course on plant breeding and genetics; FAO/SIDA courses on maize, sorghum and millet; FAO/DANIDA training courses on Food Legumes; FAO/Italian courses on durum wheat and sunflower; FAO/SIDA/SAREC courses on grain quality improvement FAO/NECP Saudi Arabia/Australia courses on dryland systems of farming and individual PhD fellowships.

This trained manpower constituted the backbone of the national programmes. Later on, the Tropical Asian Maize Network (TAMNET) was established during the First South-East Asian Workshop by FAO in 1993 in order to develop hybrids for increasing maize production through a co-operative programme. Parallel to this FAO, jointly with IAEA, conducted a series of training courses and a fellowship programme on novel technology for plant breeding, including induced mutations and biotechnology.

Three key institutional elements were incorporated by FAO and its partners into the Regional Programme to enhance the involvement of the national scientists and administrators of the member countries in the planning and execution of project activities at national and regional levels, namely: the development of national inter-disciplinary research task forces for planning, conducting and monitoring all research and production programmes; the establishment of an Advisory Committee consisting of senior national scientists and project advisors; and, the creation of inter-

[5] /. The technical and financial support from bilateral development assistance agencies, particularly, SIDA, DANIDA, NORAD, ADAB, USAID, and other donor governments is also acknowledged., and many

regional links for conducting co-ordinated research programmes between the Middle East, Asia and Latin America.

In 1965, a programme on rice breeding using induced mutations was launched to complement those of IRRI. The IRRI ran the regional tests of the new varieties which gradually became the leading varieties in the region. Training and research support was provided for biotechnology and molecular genetic applications to rice breeding, particularly *in vitro* culture technologies often in co-operation with IRRI, which are contributing to the sustainability of the Green Revolution and hopefully to further breakthrough in rice breeding. The extensive networks of co-ordinated research in Asia on rice breeding, run by FAO in co-operation with IAEA, inspired the foundation of the Society for Advanced Breeding Research in Asia and Oceania (SABRAO) in 1968, which proved to be a great stimulus for rice and plant breeders in countries of the region.

A contribution towards the operation of the rice field testing programme was made by the FAO system for standardising field data recordings. The publication by FAO and IAEA of the Manual on Mutation Breeding and particularly its translation into Chinese greatly contributed to the use of this technology, especially for the development of further semi-dwarf material. Rice varieties of mutation origin are now a significant part of the HYVs in use.

These innovations helped to improve the planning and implementation of programmes on production agronomy, irrigation agronomy and dryland agronomy and also helped through training, technical guidance and provision of seeds and equipment. All these programmes resulted in identification and large-scale diffusion of HYVs, adoption of improved production technology (including use of fertilisers) and helped increasing production and income of farmers, injecting confidence amongst the farmers, scientists, administrators and the Governments as well as providing impetus to overall national research and production programmes.

Seed Multiplication and Distribution: After the successful identification of HYVs for specific countries, the biggest hurdle was the lack of certified seeds of these varieties in sufficient

national and international universities and national research institutes and extension services.

amounts. This lacuna was overcome through a variety of means. Many countries, like Pakistan, India, Turkey, Iraq and Syria, imported large quantities of seeds from Mexico; many countries helped each other in providing, free of cost, substantial quantities of seeds available with them (the Mexico-Pakistan agreement being an outstanding example); scientists from the needy countries were trained and encouraged to produce their own seeds quickly by using low seed rate technology; and, training centres were organised on seed production at national and regional levels.

At later stages, FAO assisted many governments to enact seed laws and establish seed processing plants. Innovative programmes, e.g. those promoted by the fourth co-author of this paper (Swaminathan) in India, encouraged selected farmers to produce their own seed for distribution amongst the neighbouring farmers and proved very important in expanding areas under HYVs. After some years many countries established public and private sector corporations to produce and distribute seeds in large quantities, but the net result was that the existing infrastructures still needed strengthening and improvement, especially in private sectors by encouraging investments from advanced countries.

Fertiliser-Use Efficiency: Apart from determining and demonstrating the fertiliser needs of HYVs of wheat and rice under the Regional Project activities, the FAO began the Fertiliser Programme in 1961 sponsored by the FAO/Freedom from Hunger Campaign and bilateral donors. This FAO Programme carried out trials for 35 years in more than 55 countries in which more than 4.5 million farmers participated, educating them in efficient use of fertilisers. Through the demonstrations and farmers field days, small-scale farmers were trained in efficient fertiliser use and biological nitrogen fixation. The results proved clearly the impact of efficient fertiliser use on agricultural production, giving an average increase in yields of 8 to 12 kg of cereals for each kilogram of plant nutrients. The impact of the FAO Programme was so great that many countries established fertiliser manufacturing factories both in public and private sectors. In some countries, e.g. Pakistan, the Programme assisted with creation and development of Fertiliser Development Centres with objective of defining fertiliser development strategies and policies.

As mentioned above, in 1965, FAO and IAEA initiated a co-ordinated research programme throughout Asia and Latin America. As part of this programme, isotopic tracers were used to determine the most efficient placement and timing of fertiliser applications and water-use efficiency.

Water-Use Efficiency: Investment in irrigation systems and improved irrigation regimes for wheat and rice have greatly helped in enhancing production as determined under experiments on improved production technologies. Since 1951, the Land and Water Development Division and the Investment Centre in FAO have played an important role in the expansion of and investment in irrigation. Emphasis was on water resources development, design of irrigation and drainage schemes, water policies and legislation, construction of dams, groundwater exploitation and modern irrigation techniques. From 1965, field programmes were strengthened through FAO with the financial support of UNDP and various bilateral trust funds as well as, of course, the World Bank and regional investment banks.

Water has become a key issue with effective water use, quality, reclamation and drainage as major topics. Work was also carried out on the development of irrigation techniques and technologies at farm level, including the use of continuos monitoring of soil moisture under the joint FAO/IAEA programme. In 1981, the International Support Programme in Farm Water Management was established. These programmes greatly helped in improving the efficient use of water which is a scarce resource, leading to implementation of better production techniques for enhancing production.

Plant Protection and Integrated Pest Management (IPM): HYVs of wheat promoted in the early days of the Green Revolution were not generally subject to severe disease or pest pressure, but the story was not the same for rice. FAO became aware in the late 1960s of increasing problems of pest management in HYVs of rice. Increased pest outbreaks were being caused by inappropriate use of pesticides which destroyed the natural biological control agents especially spiders that feed on numerous insects in rice fields. In the early 1970s, FAO started to promote IPM for rice and has achieved a major breakthrough in the effort to reduce the need for pesticides. IPM is now considered the most widely accepted approach of combating rice pest and the farmer

participatory approach used for introduction of IPM in Asia is proving to be a very powerful paradigm for technology transfer and farmer empowerment.

National programmes (e.g., China, India, Indonesia, Thailand, Vietnam) with FAO technical assistance and bilateral financial support (Australia, Netherlands and the International Arab Fund) introduced IPM concepts. Besides eliminating serious pest outbreaks, IPM has saved millions of dollars on costs of rice production and reduced contamination of the environment.

Farmer-participatory research and extension methods: Perhaps equally important was the development of farmer-participatory research and extension methods in the concept of IPM field programmes. It was found that small-holder, rice farmers were very responsive to adult education methods which has evolved into the Farmers Field Schools approach. The mode of extension has moved away from promotion of packages of inputs, but toward training farmers to understand the implications of the crop, pests and soil management practices. The Farmers Field School approach, so very effective for introducing IPM in rice in Asia, is showing great promise for working with farmers on crop and soil management practices in Africa. Such participative methods are considered by these authors as fundamental for bringing the new Green Revolution forward, especially in areas where complex management choices need to be made because farmers are, in reality, business managers and need the tools and information to make the best long and short-term choices.

Conservation of Germplasm: A main concern of FAO has been the conservation of wheat and rice germplasm. It published a world catalogue of rice genetic sources, which in 1963 totalled 1 366 entries and provided an early genetic source for the Green Revolution. The rice gene bank, developed by T. T. Chang at IRRI, contained some 100,000 accessions ***(is this in the correct order of magnitude?)*** and has now become the world's central source of rice genetic germplasm. The IRRI rice collection, as are all collections of the CGIAR system, is currently held in trust by the FAO sponsored Commission on Plant Genetic Resources.

Other Factors (enabling environment for the dissemination and adoption of technologies): There are a number of other factors which helped in promoting the Green

Revolution. These involved the pooling of technical and financial resources for the efficient implementation of the Regional Project which helped to develop close co-operation with many universities and donor agencies. The second productive input was organisation of meetings, workshops, seminars and study tours with many advantages in improving research and production programmes and developing working relationships between the national scientists in developing countries and those of the advanced countries, facilitating exchange of information and materials. FAO published on "Wheat Production Potential in Africa" and "Improving Food Crop Production on Small Farms in Africa" in addition to a number of bulletins and special reports. These and many other publications helped to promote the food production activities including the Green Revolution programmes. Last, but not least many countries were provided through FAO with sets of field machinery (seed drills, plot harvesters, head threshers and shellers) to improve the efficiency of experimental work in addition to efficient ways of keeping field notes. At a later stage six countries (Egypt, Ethiopia, India, Iran, Pakistan and Turkey) were supplied laboratory equipment for cereal grain analysis under the financial and technical support of SIDA, besides training at Svalof.

LESSONS LEARNED

(Proposed author - Dr. Swaminathan. Below follow only rough indications of what could go into the text)

Many lessons can be advantageously learnt from the international co-operative efforts of FAO, other UN agencies, CIMMYT, IRRI, many donor agencies, universities and national institutes and governments. These lessons can serve as guidelines in developing enhanced food production programmes to meet the ever increasing demands of a burgeoning population, reducing malnutrition and avoiding famine to save mankind from misery and affliction.

Impact Assessment

The Green Revolution introduced land and forest-saving technologies; positive impact on the environment

Elements for Success

Participants in the Green Revolution became aware that the farming systems need to be addressed in a sustainable, holistic manner. The process of developing and disseminating technologies requires a conducive institutional and policy environment. While the plant breeding work was necessary, success was not assured without addressing social-equity considerations.

The Green Revolution was a "process" - as it unfolded, new constraints were identified which were addressed through the development of other facilitating technologies. Proactive approaches to constraints and opportunities identifications were needed

The close involvement of farmers in the research and development activities was essential for the effective transfer and adoption of technology. National scientists had to be suitably trained in different disciplines to update their knowledge and working capability. New approaches emerged such as participatory training methods, farmers' field schools, better understanding of farmers' objectives and decision making processes

National governments had to develop suitable infrastructures for the supply of inputs (seeds, fertilisers, field machinery, electricity, fuel and water) and teams of research and extension workers to diffuse the packages of production technology amongst the farmers through demonstrations, field days and training; giving prizes to those farmers who achieve highest yields in different localities.

National governments also had to frame agricultural policies which provided incentives to farmers to adopt productivity increasing technologies. These included provision of cheaper inputs on time, reduction in electricity and water tariffs, construction of link roads, better marketing facilities and remunerative prices for the output as well as favourable loaning policies besides strengthening field mechanisation.

The Historical Role of FAO

FAO, being an international organisation, performed a leading role in formulating projects which had an immediate effect on food production and induced various donor agencies, universities, international agricultural research centres and national governments to participate in implementing such action programmes. it was quickly realised that such programmes should also take into consideration the environmental issues (so as to remain close to nature to maximise the benefits). It was also found that programmes of a regional nature were more effective as neighbouring countries had similar problems and socio-economic conditions. Programmes assigned to the staff at regional levels, with the full support of the FAO Headquarters, were more flexible in meeting countries' need and more productive.

Partnerships

Role of multiple institutions working in concert.

PERSPECTIVES

(Proposed author - Dr. Swaminathan. Below follow only rough indications of what could go into the text)

As the human fertility has far exceeded the fertility of the land and thus food demand is increasing, FAO will have to take up immediate action in achieving world food security. Besides many other factors it mainly depends on early increasing the food production, building up food reserves and supplying food to all through development of better marketing systems (apart from implementing better family planning programmes). It would, therefore, be advisable to continue with the Green Revolution activities (not only in wheat and rice but also in other staple crops and oilseeds) in countries which have already experienced it, but also in African countries on crops like maize, sorghum, pearl millet, cassava, wheat, barley and potatoes) by preparing and implementing suitable projects on a regional basis, taking into account all those points considered and already discussed in detail.

(Similarly, forestry programmes also need special attention, not only to provide the human needs but also to rectify the bad effects of deforestation, taking place on a large scale worldwide.)

This does not mean that the problem has been solved in food deficit countries, but it clearly shows that the means of increasing productivity do exist. As in the past, FAO can play a prominent role in supporting such action-oriented programmes in collaboration with the partnership of the concerned organisations and the countries. It is rightly said that "to produce harvest is for God, but to increase the harvest is for the man to endeavour because mankind has inherited a vested interest in agricultural production for its survival". Thus it is an on-going process in the countries that were touched by the first cycle of the Green Revolution.

Today, the greatest need for expansion of the Green Revolution is in the African countries south of the Sahara. It holds a great scope almost certainly based on the new evidence merging in part generated by FAO in collaboration with the CGIAR international centres. The new change in production will not be largely in wheat or rice but almost certainly in maize and sorghum at lower elevations and with cassava in more tropical environments (besides wheat and barley and potatoes at higher elevations). It is a challenge for the next decade to change Sub-Saharan agricultural food production, bringing overall revolution in economic and social conditions of these countries. This is not to imply that there should be a neglect of the Asian food production problems - these efforts should continue together.

To overcome food shortages in the future and ensure food for all in an ever more heavily populated world, what is needed is an "Evergreen Revolution". The 1996 World Food Summit emphasised, among other things, the unrelenting need for continuous scientific and technical progress in food productivity and production.