FOOD AND AGRICULTURAL TECHNOLOGY

BY: JOSEPH H. HULSE
VICE-PRESIDENT, RESEARCH PROGRAMS
INTERNATIONAL DEVELOPMENT RESEARCH CENTRE, OTTAWA, CANADA

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FOOD AND AGRICULTURAL TECHNOLOGY IN COMBATING MALNUTRITION

BY: J.H. Hulse, Vice-President Research Programs
International Development Research Centre
Ottawa, Ontario, Canada

This paper will attempt to address briefly:

(a) progress in agricultural development and food supply in the developing regions;

(b) Some important obstacles to agricultural and nutritional improvement;

(c) Some recommended opportunities for future food and agricultural technological improvement.

To present the subject proposed solely in terms of food and agricultural technology would risk an overly simplistic, even a distorted picture of the difficulties which face the developing countries and the means by which to improve their welfare. First, therefore, it is necessary briefly to set the subject in a broader international economic context.

Food, People and Resources

Though the early English poet John Donne wrote that "No man is an island" and his contemporary George Herbert told us that "Man is one world", to all intents and purposes, the present inhabitants of North America and Northern Europe live in a world and on social and economic islands vastly different in human health, welfare, opportunities and resources from those of their contemporaries in Africa, Asia, and Latin America. The data presented in Table 1 amply illustrate how the privileged minority own most of the world's important resources and control most of its wealth. In addition to the statistics quoted, the developed countries undertake more than 90% of the world's research and publish 89% of all its books. Furthermore, the developed countries enjoy an annual positive balance of more than US $300 billion in their trading transactions with the developing countries.

Table 2 shows how, towards the end of the decade, the population in the developing countries will increase from roughly three-quarters to four-fifths of the world's total. Of particular demographic interest is the increasing proportion of elderly people in the developed countries and of younger people in the developing countries. For example, over the past five years the number of Canadians under the age of 15 has decreased by 7% while those over 65 years of age has increased by 18%. The present median age in Canada is 29 years; it is forecast to reach 36 by the end of the century. In 1950 in the United States there were 16 workers for each pensioner. By 1982 the ratio had fallen to 3 workers for 1 pensioner and by the end of the century there will be only 2 workers for each retired person if the present age of retirement is retained.

Since older people eat less than active young people, major food producers such as Canada, the U.S.A. and Australia, will consume relatively less while the poorer nations with large proportions of young people will demand more. In addition, it is anticipated that the proportion of urban to rural populations in developing countries will significantly increase. The urban population of Latin American countries is expected to exceed 60% by the end of the century.

It requires little diagnostic skill or intuitive imagination to propose that the royal road to nutritional sufficiency lies in first higher food crop production; second, putting more land under cultivation; and third, and perhaps most important, devising and gaining acceptance of more efficient systems of food conservation and distribution. The most primitive of known terrestrial and aquatic species, when left undisturbed, appear to maintain and protect their essential life support systems. Human animals seem almost unique in the willful degradation of their most essential and unrenewable resources: arable fertile land and uncontaminated water.

Land Resources

Table 3 shows the serious loss in arable land per capita the world over during the past 25 years.

Table 4 presents the population pressures on arable land and illustrates the very serious situation which some particular countries will be faced with by the end of the century. Arable land formerly irrigated from the Nile in Egypt has been so over-run by urban spread that the American University and several other Egyptian institutions are investing extensively in research to rehabilitate the surrounding desert for crop, animal and forest production.

Table 5 illustrates the irresponsible depredation of arable land throughout the world, particularly in the developed countries. Only 3% of the total earth's surface is considered arable. Of the 15 million hectares lost annually, nearly half (7 M ha) is attributable to urban spread, 3 M ha of which occurs in the developed countries.

The total loss to urban spread, roughly 15 M ha/yr, could on a conservative estimate produce sufficient cereal calories for about 68 million adults per annum. The average annual increase in world population amounts to about 70 million persons per year. It would seem therefore that our most urgent priority ought to be to protect and conserve the land already available from further destruction. Reclamation of once fertile land that has been destroyed or debased, even where this is possible, costs considerably more than conservation of what is already under the plough. The cost of bringing despoiled, marginal or uncultivated land under the plough varies greatly according to circumstances. Cultivation of savanna pasture costs about $50/ha, whereas cultivation of the tropical rain forest may approach $1,000/ha.

Food Production and Demand

Table 6 indicates the increases in agricultural production necessary to meet forecast demands by the end of the century. Whether achieved by expanding the land under cultivation or by higher yields per unit of land area, FAO estimates that close to a doubling of output will be necessary to meet minimum human demands by 2000 AD.

One's hope must inevitably be conditioned by what is evident in Table 7 where the food production indices in 1979 are compared with a baseline averaged over the period 1961 to 1965. The most encouraging production increases are to be found among the nations of Southeast Asia where for example Burma, the Philippines and Indonesia increased their cereal production by more than 60%. Improved cropping systems practised by these nations, added to those of South Korea and northern India contributed notably to the 37% increase in overall cereal production in the decade of the 70s as illustrated in Figure 1. The prospect for many African nations is considerably more bleak.

Table 8 demonstrates the growing dependence of the developing countries upon cereal exports from North America. The Table does not reveal the grossly disproportionate balance of trade between the developed countries, particularly those of North America, and those of the less privileged regions. Close to 40% of all exports and about one-third of all farm products exported from the United States go to the developing countries. The U.S.A. exports to developing countries at least double what it exports to the European Economic Community (EEC). Exports from the EEC to developing countries are roughly three times what the EEC exports to other developed countries.

Most of us in North America can justifiably complain of the erosion in the purchasing power of our disposable income over the past several years. Table 9 illustrates the enormous burden borne by the developing nations from the increase in world oil prices, the excessive investment in armaments, and the general political destabilization of their former patterns of economic growth and development. This Table clearly indicates that the developing countries, especially those without petroleum resources, have borne a disproportionate cost of the destabilization of the World's economy. The crippling increased cost of food imports illustrated in Table 9 if continued will inevitably seriously reduce the capacity of the developing countries to import fertilizers, machinery and other imports essential to increased food production and improved agricultural technologies.

Though recent estimates forecast sizeable grain crop surpluses in North America and growing butter mountains and milk lakes in Europe, because of their unfavourable balance of trade, most of the food deficient developing countries do not possess the disposable foreign currency with which to buy the food they need. Thus, in spite of its concomitant and unsatisfactory consequences, food aid on concessional terms will be necessary for many years to come.

The developing countries that are not oil producers rely on the export of primary products for 60% of their income. In consequence of the depressed industrial growth in North America, Europe and Japan both the prices for and the total volume of raw material exports have fallen, resulting in loss of income and a disturbing rise in the foreign debt load of many third world nations. Developing countries thus have been forced to impose austerity measures and to reduce their imports from the industrialized countries. It was recently stated (Globe and Mail, Toronto, Canada 6 August 1983) that Mexico's cessation of imports from its northern neighbour added more U.S. workers to the ranks of the unemployed than the recession in the automobile industry.

Investment in Development

It would appear self-evident that the greatest need now and for the foreseeable future is to protect the world's limited and fragile productive resources and to invest significantly more in research and development destined to increase food production by conventional and traditional agricultural technologies. What, if any, significant improvement in food resources may be derived from the as yet unfamiliar derivatives of biotechnology and genetic engineering are probably many decades into the future. Notwithstanding what appears to be self-evident, the politicians who guide the destinies of developed, developing and least developed countries seem singularly undisposed to give priority of investment to food and agricultural research and development.

Table 10 shows that in the first two years of the 80s worldwide investment in armaments increased by 44% and is now equivalent to $200 per annum for every man, woman and child in the developing countries. Over the same period multilateral and bilateral investment in food and agricultural development remained static in actual expenditures and therefore significantly declined in constant dollars, the present investment being roughly equivalent to $3 per person per year living in the developing countries.

In dismal contrast to the investment in the proliferation of armaments, Table 11 gives the OECD assessments of overseas development assistance to developing countries as a percentage of the gross national product of the wealthier nations. Shown in the Table is the relatively high contribution of the OPEC countries (roughly 1.46% of their GNP) and the virtually non-existent contribution to economic development, as distinct from the delivery of armaments, by the Soviet bloc.

Are there any contemporary developments that encourage us to believe that those who survive beyond our life span can be adequately fed? If all known existing agricultural technology were supported by a half of what is invested in armaments, we need have little concern for the welfare of generations of humankind beyond us.

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International Agricultural Research

One of the most imaginative collaborative research ventures has resulted in the family of International Agricultural Research Centres (IARCs) supported by the Consultative Group on International Agricultural Research (CGIAR).

Tables 12 and 13 illustrate the immense germplasm base from which new and more productive genotypes, adaptable to a wide range of agroclimatic conditions and possessed of desirable functional and nutritional characters can be derived.

Figures 2 and 3 illustrate advances in plant breeding that have evolved over the life of the International Rice Research Institute (IRRI). One of the earliest high yielding rice types IR8 was the progeny of two parents. The more recent IR36 derived from a more diverse ancestry through genetic selection and gene pyramiding combines a high yield potential with a broad spectrum of disease resistance.

It would appear less difficult to derive food plants possessing superior characters than to persuade farmers, particularly those operating close to a subsistence level, to grow them. Over the last decade agricultural scientists have gradually come to understand that productive research begins not on the experimental station but in the farmer's field. Before seeking to bring about technical, economic and/or social improvement the research scientists must first understand what already exists; what are the technical, social and economic opportunities and constraints by which the rural communities and individual farmers are controlled and conditioned. It is this realization which has given rise to a new methodology in farming systems research.

Figures 4, 5, 6, 7, 8 and 9 present diagramatically the various factors and their interrelations which must be studied and quantified before any useful program of farming systems research can be pursued. Current concepts of cropping systems research recognize the necessity first to understand the nature of the farming systems that exist; to comprehend the farmer's resources, opportunities and constraints before embarking upon research to bring about improvement. In effect this calls for a close working relation between research workers and farmers, since much of the research is carried out in farmers' fields under the farmer's management.

The Value of the Forest

It has been estimated that the area of tropical forest destroyed every year is equal to half the size of the United Kingdom. Furthermore, a high proportion of the trees cut down are not used for human benefit. Trees are immensely useful plants providing, according to species: fuel, food, feed, fodder and fertilizer. Tree plantations stabilize soil conditions and prevent erosion, they can provide shelter for animals and as wind breaks protect cultivated crops from desiccating winds and blowing sand.

In 1982 IDRC began a network of social forestry projects in semi-arid Africa which now includes fifteen countries where trees grown by small-holder farmers and rural village communities provide various combinations of the uses and benefits listed above. In several remote areas of the People's Republic of China IDRC is supporting the production of the indigenous Paulownia, which produces a favorable micro climate when grown in association with various other crops, fuel for rural and urban communities, and an important material of construction for buildings, furniture and, because of its unique physical stability, for musical instruments.

Elsewhere in China, research on bamboo has identified species capable of producing culms 25 metres in height and 18 centimetres in diameter in one year. The program is also selecting bamboo types capable of withstanding frost, thus permitting expansion of bamboo into more northerly regions.

IDRC was largely instrumental in bringing into being the International Council for Research on Agro-forestry with its headquarters in Nairobi.

Post-Production Problems

Though agricultural scientists have made notable progress in recent years in seeking to comprehend the nature, opportunities and constraints of existing farming systems before embarking upon research to improve them, a comparable approach is less evident among scientists and technologists who seek to improve existing or to establish new agroindustrial enterprises. Disproportionate effort seems to be invested in laboratory and pilot plant research: the invention and elaboration of novel products and processes; when often the most urgent need is to begin with a comprehensive quantitative determination and analysis of actual and potential markets in relation to the financial, material, technical and human resources available to the industries that exist.

The linear concept of developmental research: starting in a laboratory, continuing through a pilot plant before considering the market demand, seems often accompanied by an equally unproductive expectation from the transfer of technology. Food and agricultural technologies are conditioned by the physical, social and economic environments in which they are to be applied and by the markets they must serve, all of which need to be thoroughly evaluated before technological research and development is started.

The introduction of new foods derived from familiar plant and animal material resources generally calls for sizeable investments in market research and development. Future derivatives of such embryonic biotechnologies as the genetically manipulated microbial transformation of agricultural wastes and by-products will present a whole new generation of difficulties and hazards. Though some accepted techniques exist by which to determine the chronic or acute toxicities of known chemical additives or contaminants, it is doubtful if any reliable biological methodology is available by which to establish the safety and wholesomeness of "novel" foods derived from unconventional raw materials or by processes of transformation for which no prior long term human experience is recorded.

It would therefore seem sensible to give greatest immediate priority and investment to the conventionally accepted systems of food and agricultural development. Research to produce foods from novel and unfamiliar biotechnologies must be preceded by the elaboration of reliable biological methods by which to evaluate their safety and wholesomeness when consumed regularly and over long periods by human beings.

Under no circumstances should the least privileged people in the developing countries be presented with the products of inadequately evaluated biotechnologies which would not be acceptable to food and drug administrations in the more privileged and economically developed countries.

Poverty and Malnutrition

Figure 10 depicts the vicious circle by which the welfare of the world's poorest inhabitants is conditioned. Though science and technology have made, and will continue to make outstanding contributions to social and economic progress, they are not the sole determinants of nutritional adequacy. Nutritional deficiencies are the historical and contemporary companions of poverty. Studies in India demonstrate that the poorest people spend close to 80% of the first increments to their depressingly low incomes on essential foods.

The eradication of chronic poverty requires first, a greater equity in trading relations between the rich and the poor nations; a drastic reduction in the peddling of armaments; and a much greater investment in agricultural development.

Agriculture: the Leading Edge of Development

Historically, from the time of city states of the Tigris and Euphrates, agricultural development has provided the leading edge of national economic growth. Bearing in mind the dominance of the agricultural sector in the economies of most developing countries, it seems axiomatic that future economic progress will be heavily dependent upon agricultural development. It would therefore appear logical that the highest priority be given to strengthening the national agricultural systems of the developing countries. Agriculture and agroindustries provide both food and employment; employment and food surplus to subsistence needs generates the disposable income which is a first essential of economic growth.

The opportunities for imaginative scientific cooperation between food and agricultural scientists in developed and developing countries has encouraged several governments and international agencies to provide the means to support such cooperation. The International Council of Scientific Unions (ICSU) has created an International Commission to identify the opportunities and the means of realizing more productive cooperation in basic research related to agriculture, forestry and aquaculture in the Third World.

Such programs need to be truly cooperative and not a domination of the developing country scientists and technologists by the expatriate agents of bilateral or multilateral assistance. The International Development Research Centre (IDRC) was created to encourage and support the scientific efforts of people and institutions in developing countries. It is the Centre's philosophy that, given adequate resources and encouragement, scientists, technologists, farming and agroindustrial communities of the developing countries will be better able to provide for their own people's long term nutritional needs than will large numbers of imported expatriate experts. More productive agricultural technologies and more efficient post-production systems of preservation and distribution must be developed and put into effect in full cooperation with the communities who are to use and benefit from them. Such cooperation is generally more effectively realized by those who are familiar with these communities, people who speak the same language and inherit similar traditions.

Most urgent and essential however is the need for a dramatic shift in political priorities and political will in all countries: an understanding and acceptance that ploughshares must be given precedence over swords; that bread is more important to human survival than bombs; that "one man's hunger is every man's hunger".

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TABLE 1

RESOURCES 1980

	DEVELOPED	DEVELOPING
WORLD POPULATION (%)	27	73
WORLD AGRIC. PRODUCTION (%)	62	38
WORLD CEREAL PRODUCTION (%)	88	12
WORLD COMMERCIAL ENERGY (%)	62	38
ENERGY IN AGRIC. SYSTEMS (% NATIONAL CONSUMPTION)	17 - 30	60 - 90
AVERAGE DAILY CALORIES/CAP	3300	2200
ARABLE LAND 2000 AD (Ha/CAP)	0.46	0.19

TABLE 2

POPULATION

	1980		2000	
	10^9	%	10^9	%
WORLD	4.4	100	6.2	100
DEVELOPED	1.2	27	1.3	21
DEVELOPING	3.2	73	4.9	79

TABLE 3

ARABLE AREA PER CAPITA, ACTUAL AND PROJECTED (trend)

COUNTRIES	1951-55	1961-65	1971-75	PROJECTED 1985	PROJECTED 2000
INDUSTRIALIZED	.61	.56	.55	.50	.46
CENTRALLY PLANNED	.45	.39	.35	.30	.26
LESS DEVELOPED	.45	.40	.35	.27	.19
WORLD	.48	.44	.39	.32	.25

NOTE: ARABLE AREA INCLUDES LAND UNDER TEMPORARY CROPS (DOUBLE-CROPPED AREAS ARE COUNTED ONLY ONCE), TEMPORARY MEADOWS FOR MOWING OR PASTURE, LAND UNDER MARKET AND KITCHEN GARDENS (INCLUDING CULTIVATION UNDER GLASS), AND LAND TEMPORARILY FALLOW OR LYING IDLE.

SOURCE: THE GLOBAL 2000 REPORT TO THE PRESIDENT, VOL. 2, THE TECHNICAL REPORT. PREPARED BY THE COUNCIL OF ENVIRONMENTAL QUALITY AND THE DEPARTMENT OF STATE.

TABLE 4

POPULATION PER ARABLE HECTARE IN SELECTED COUNTRIES, 1975, 1985 AND 2000 A.D.

ASSUMING NO CHANGE IN POPULATION GROWTH RATE

	Arable hectares (millions)	Population 1975 (millions)	Population per arable hectare 1975 (persons)	Annual Rate of natural increase 1965-75	Population 1985 (millions)	Population per arable hectare 1985 (persons)	Population 2000 A.D. (millions)	Population per arable hectare 2000 A.D. (persons)
Mexico	28	60	2	3.5%	85	3	136	5
Korea	24	34	14	2.0%	41	17	54	22
India	167	608	4	2.0%	741	5	983	6
China	129	823	6	1.7%	974	7.5	1241	10
Kenya	1.8	13	7	3.3%	18	10	28	15
Tanzania	6.1	15	2.5	2.8%	20	3.5	30	5
Egypt	2.9	37	13	2.3%	46	16	63	22
All LDCs	670	1900	3	2.5%	2400	3.5	3343	5

Sources:

Arable hectares from FAO Production Yearbook. Arable hectares includes land used for both annual and permanent crops.

Population levels and rate of natural increase from "Population Growth 1965-75" published by Population Reference Bureau, Washington, D.C.

Ratio of man to land extrapolated.

TABLE 5

ARABLE LAND

ANNUAL WORLD LOSS

		$Ha \times 10^6$
URBAN AND INDUSTRIAL SPREAD		7.0 (DC=3.0)
MINERAL EXPLOITATION		1.0
EROSION		3.0
DESERT SPREAD		2.0
CHEMICAL DAMAGE (SALINITY, ETC.)		2.0
	TOTAL	15.0

POTENTIAL CEREAL PRODUCTION FROM 15.0 M Ha EQUIVALENT TO ENERGY NEEDS OF 68 M ADULTS.

ANNUAL AVERAGE POPULATION INCREASE TO 2000 AD = 70 M

TABLE 6

PRODUCTION INCREASES TO MEET MINIMAL LDC NEEDS IN 2000 AD

		% INCREASE 1971-80
TOTAL CEREALS	X 2	37
COARSE GRAINS	X 2	31
ROOT CROPS	X 2	
VEGETABLES	X 2.5	
VEGETABLE OILS	X 2.5	
FRUIT	X 2.5	
MILK	X 2.25	
MEAT	X 2.5	

TABLE 7

FOOD PRODUCTION INDICES IN
VARIOUS REGIONS OF THE WORLD
(1961/65 - 100)

	Total Production			Per Capita Production		
	1970	1975	1979	1970	1975	1979
World Total	123	135	147	107	108	110
Developing Countries						
Latin America and the Caribbean	129	152	173	107	110	113
Africa 1/	117	120	134	98	96	88
West Asia	122	154	168	102	110	108
South Asia	128	140	146	110	107	103
East Asia 2/	129	155	175	108	116	120

1/ Except for South Africa
2/ Except for Japan

Source: CGIAR Second Review

TABLE 8

NET TRADE IN CEREALS

(M. TONNES)

	1968	1978
NORTH AMERICA	49	113
AFRICA	(2.6)	(10.8)
LATIN AMERICA	1.4	(4.3)
N.EAST/W. ASIA	(4.4)	(14.0)
S.-S.E. ASIA	(11.8)	(11.1)
ALL LDCs	(17.6)	**(40.4)**
USSR GROUP	(0.4)	(28.7)

TABLE 9

COST OF LIVING INCREASES

	1971	1980
AVERAGE INFLATION RATE (%)		
DEVELOPED	5.3	12.7
DEVELOPING	4.5	19.2
AVERAGE INCREASE OF CONSUMER FOOD PRICES		
DEVELOPED	4.6	9.4
DEVELOPING	4.0	22.3

TABLE 10

ARMAMENTS VS. AGRICULTURAL INVESTMENT

($US BILLION)

	1980	1982	% INCREASE	$/CAPITA LDCs '82
INVESTMENT IN ARMAMENTS (WORLD WIDE)	450	650	44	200
AID FOR FOOD AND AGRICULTURE (BILATERAL & MULTILATERAL)	11	11	0	3

TABLE 11

OFFICIAL DEVELOPMENT ASSISTANCE (ODA)

AS PERCENT OF GNP 1981

OPEC COUNTRIES	1.46
UK	0.44
CANADA	0.43
AUSTRALIA	0.41
JAPAN	0.26
USA	0.20

OECD COUNTRIES AVERAGE

1965	0.5
1981	0.32
ACCEPTED TARGET	0.7

TABLE 12

CROP GERMPLASM COLLECTIONS HELD AT GENEBANKS MAINTAINED BY THE IARCs

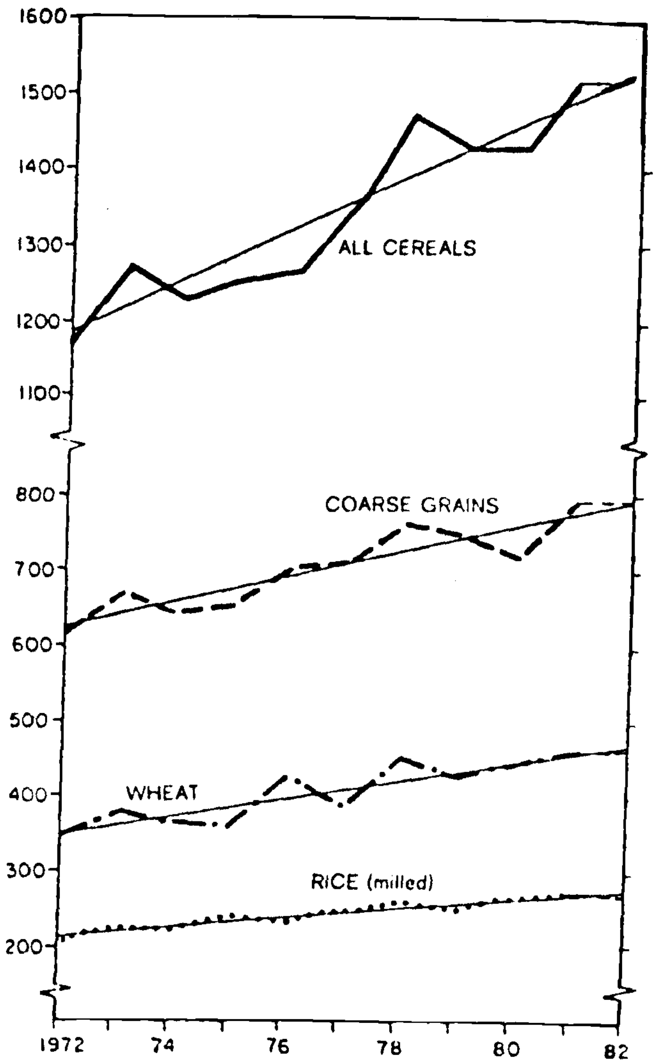
CROP	ACCESSIONS	GENEBANK LOCATION
A. CEREALS		
RICE	60,000	IRRI
	8,226	WARDA
WHEAT	50,000	CIMMYT
	17,000	ICARDA
MAIZE	14,000	CIMMYT
SORGHUM	24,000	ICRISAT
BARLEY	13,000	ICARDA
	10,000	CIMMYT
PEARL MILLET	14,340	ICRISAT
MINOR MILLETS	3,700	ICRISAT

TABLE 13

CROP GERMPLASM COLLECTIONS HELD AT GENEBANKS MAINTAINED BY THE IARCs

CROP	ACCESSIONS	GENEBANK LOCATION
B. GRAIN LEGUMES		
Common Bean	28,750	CIAT
Mungbean	5,000	AVRDC
Lima Bean	2,300	CIAT
Lentil	5,400	ICARDA
Chickpea	13,000	ICRISAT
	5,500	ICARDA
Pigeonpea	8,850	ICRISAT
Groundnut	8,800	ICRISAT
	2,500	IITA
Faba Bean	3,000	ICARDA
Cowpea	12,000	IITA
C. ROOT AND TUBER CROPS		
Cassava	3,000	CIAT
	2,922	IITA
Sweet Potato	1,000	AVRDC
	100	IITA
Yam	695	IITA
Potato	13,000	CIP

FIGURE 1



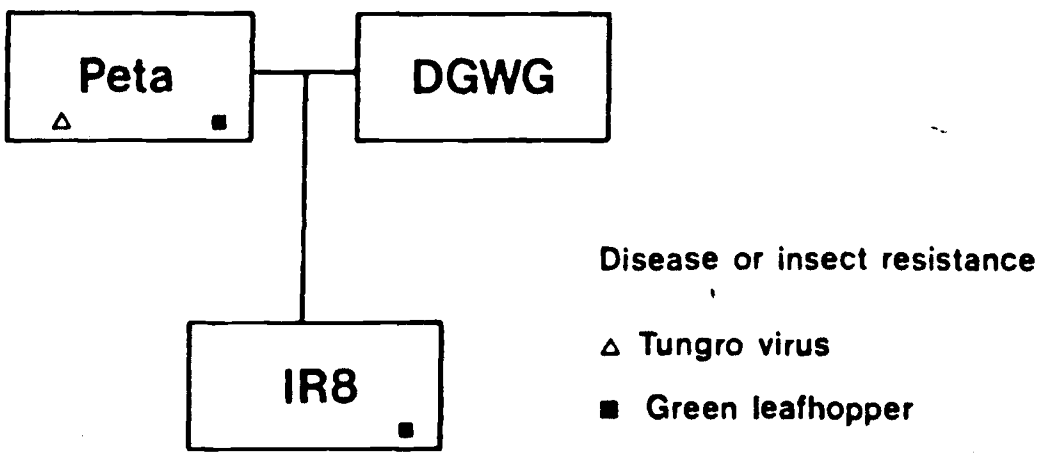
WORLD CEREAL PRODUCTION

ACTUAL AND 1970 - 1981 TREND

(MILLIONS OF TONS)

SOURCE FAO

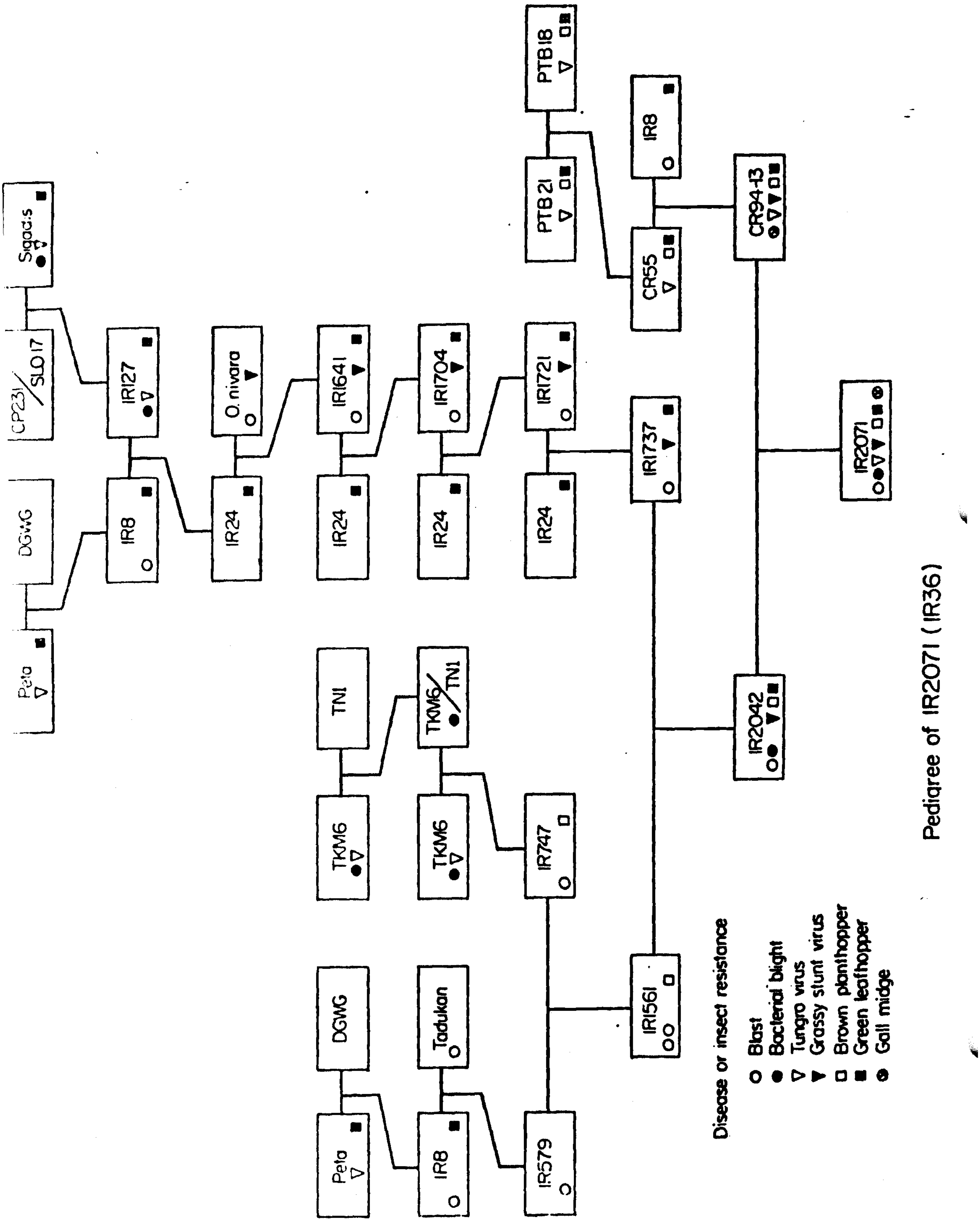
FIGURE 2



PEDIGREE OF IR8

SOURCE: IRRI

FIGURE 3



Pedigree of IR2071 (IR36)

SOURCE: IRRI

FIGURE 4

PLANT PRODUCTION SYSTEMS

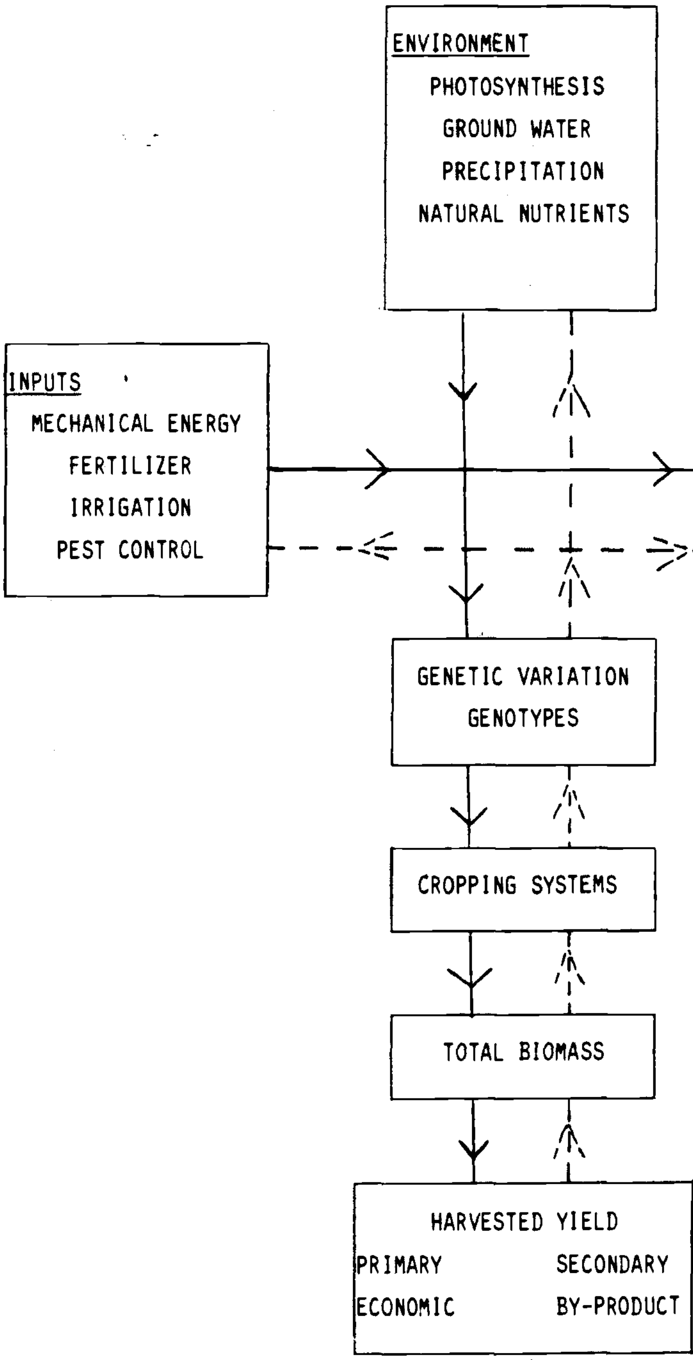
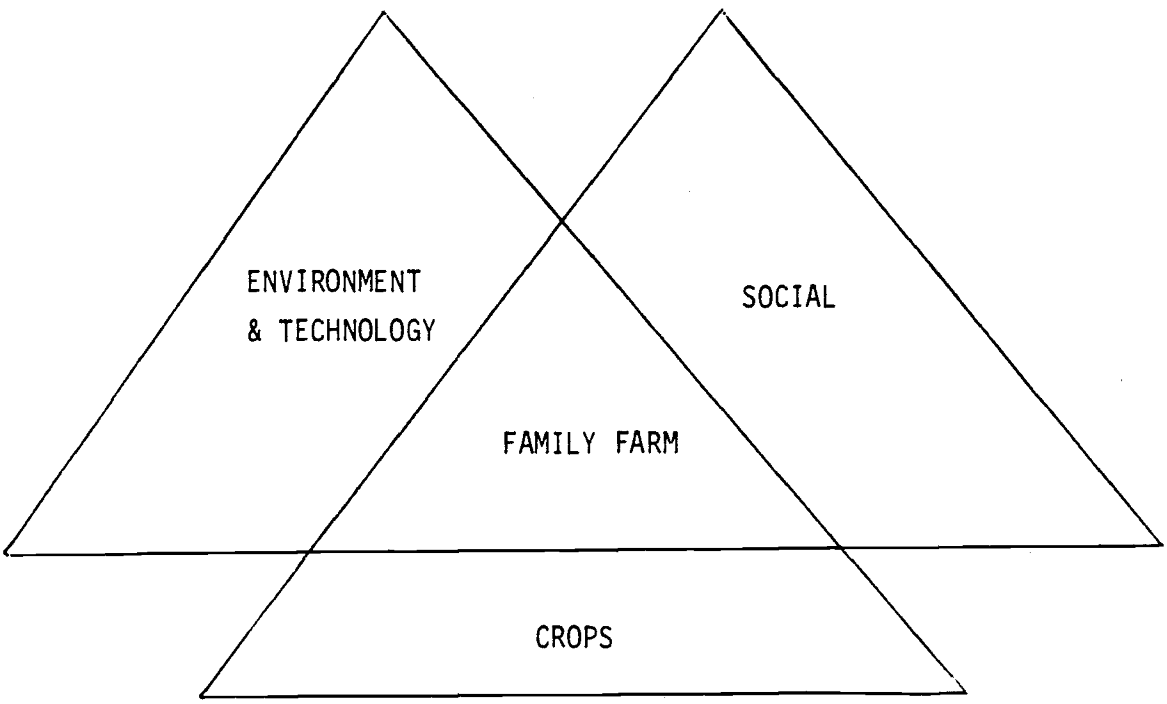
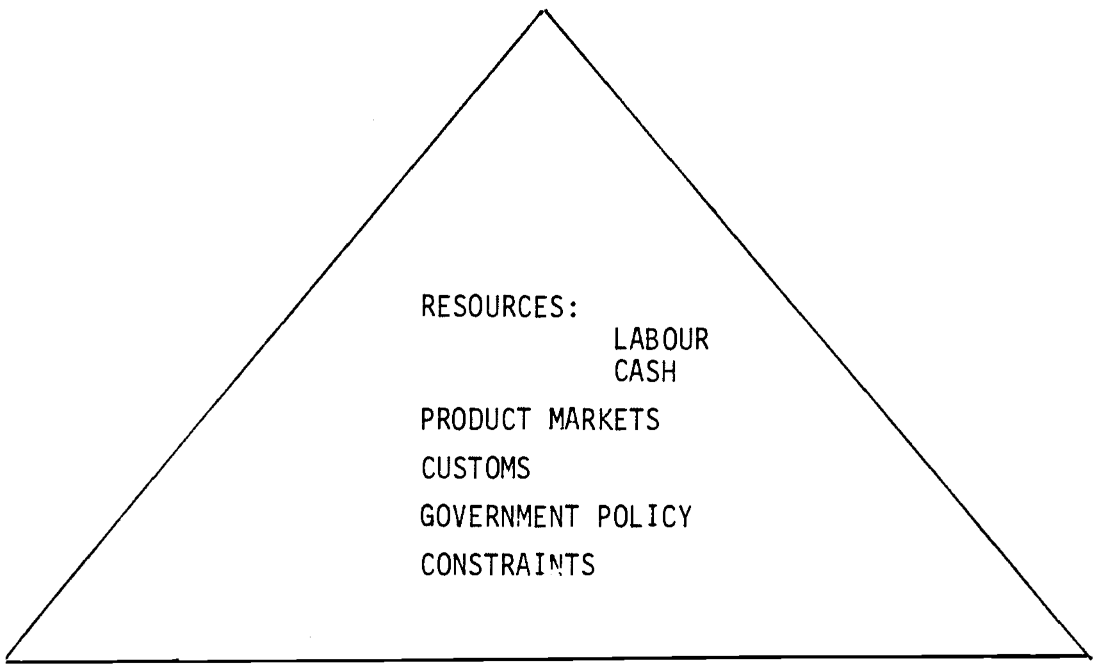


FIGURE 5



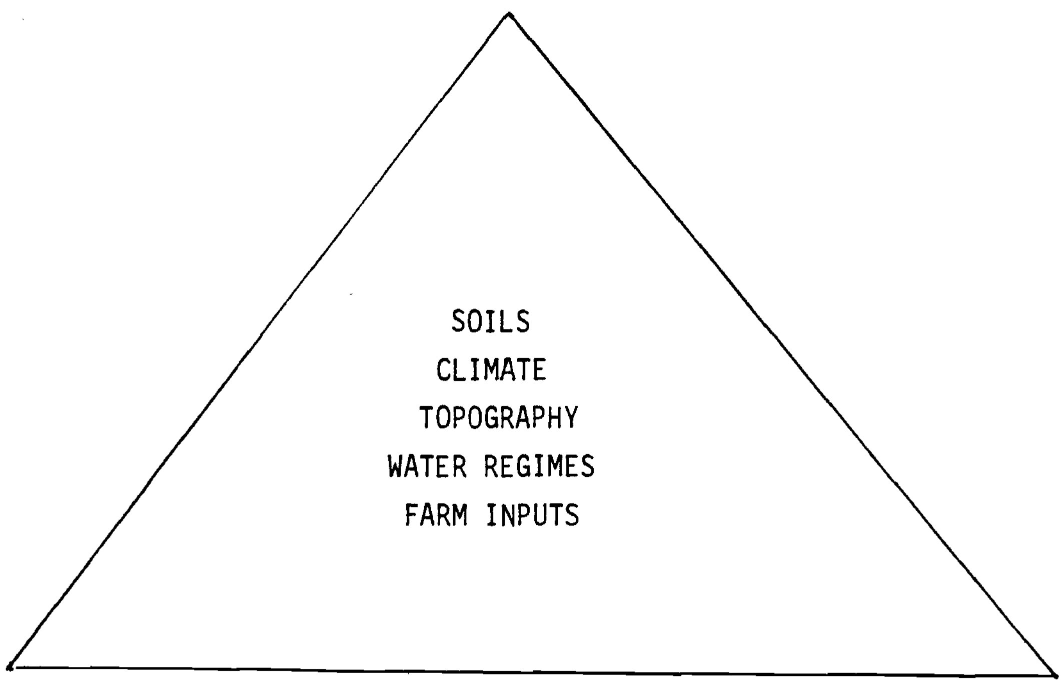
MULTIPLE CROPPING SYSTEMS

FIGURE 6



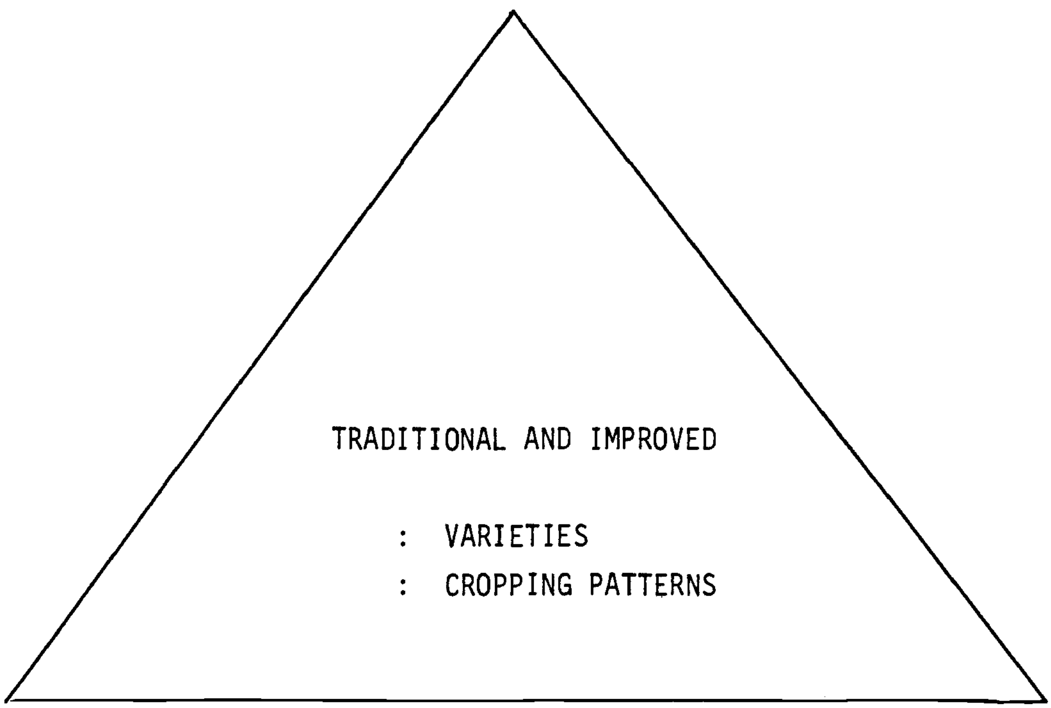
S O C I A L

FIGURE 7



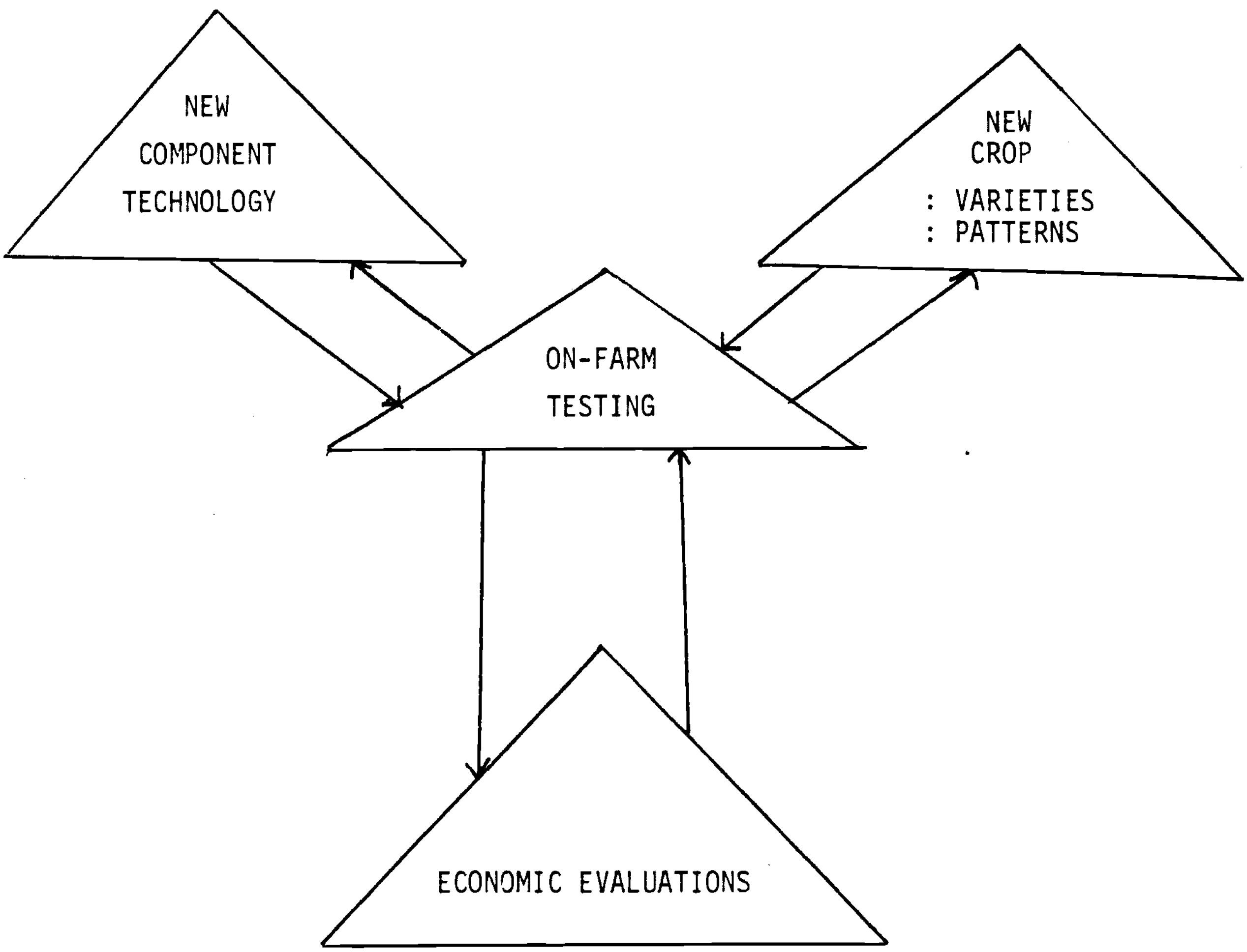
E N V I R O N M E N T   A N D   T E C H N O L O G Y

FIGURE 8



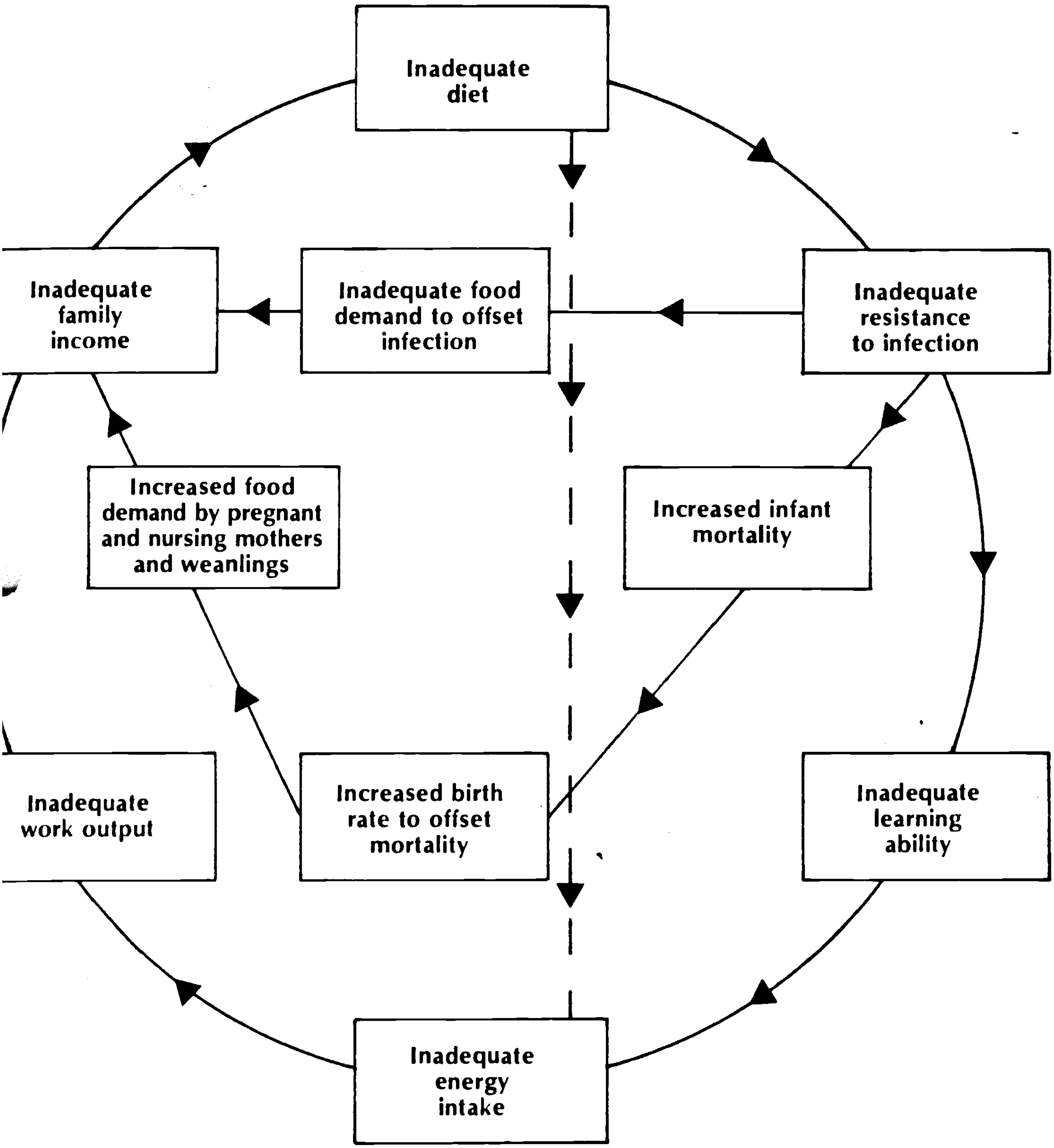
C R O P S

FIGURE 9



RESEARCH METHODOLOGY

FIGURE 10



The Vicious Circle