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ECONOMIC ANALYSIS AGRICULTURAL RESEARCH AND FOOD CRISIS

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E C O N O M I C A N A L Y S I S A G R I C U L T U R A L R E S E A R C H A N D F O O D C R I S I S *

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FOREWARD

Previous activities which were organized by United Nations such as World Food and World Population Conferences, have considered in detail various Food & Population problems and have come up with some of the following recommendations: assistance to less developed countries, lowering of barriers to import from low-wage rate nations, internationally coordinated system of nationally held stocks, an improved global "Information and Early Warning System", forward planning of food aid and the formulation of concerted food and nutritional plans and policies and their integration in socio-economic and agricultural planning. All these and related topics have been well covered and the results summarised during a seminar organized by the International Association of Agricultural Economics in collaboration with the Food and Agriculture Organization of the United Nations and the United Nation Fund for Population Activities.That seminar was held in Rome from 1 to 5 December 1975 and the results presented in a Report entitled; Population, Food and Agricultural Development. (21)

As a follow up to the Rome Seminar a plenary session was added to the XVI Conference Program of IAAE to deal with: "Priorities of Decision Making in Achieving a Balance between Population and Food". Among the topics to be discussed in the added plenary session, was: The Role of Economic-Social Science Analysis and the Research Agencies in Seeking Solutions for Policies and Programs in Agricultural Development.

This paper is presented under a general title of: Economic

Analysis, Agricultural Research and the Food Crisis.

After developing a general systems approach methodology, the last part this paper describes the new Brazilian model of a centralized agricultural research system. It is suggested that this system can create new agricultural technology for tropics. If these technologies are adopted by other developing countries this will make an important contribution to the solution of the food crisis by increasing food production in tropics.

This paper offers an optimistic view on the solution of the food crisis as a production problem. It covers a broad scope of relevant topics. However, two very important topics; the rural poverty & role of the sociologist have not been appropriately covered. The rural development strategy designed to improve the economic and social life of the rural poor is only briefly referred to as an unsolved problem.

The role of social scientist other than economist is mentioned in the same section as an unanswered question.

Furthermore, the need for agricultural education, both formal and informal, through very pressing problems were considered outside the scope of this paper.

This paper has been written for agricultural economists of the developed and developing world. The major objective is to outline an efficient planning and organization model, for agricultural research. It can also be rea by agricultural scientists in general and research administrators in particula who could profit by increasing their knowledge about interaction between research, economic analysis, and planning.

This paper is a response to gloomy picture of the food supply situation that prevails among many professional including agricultural economists. The writers believe in great possibilities and infinity of the scientific frontiers facing tropical agriculture and food production. Consequently development of agricultural plants and systems for tropical areas open great opportunities and need attention for long-range improvements. With continuous progress of science, food production systems of totally new dimensions should be developed for presently less favorable agricultural areas. The research efforts that created temperate zone food production system should be duplicated in other climatic zones to create a similar system. It is obvious that current decisions concerning agricultural research particularly in tropics will be instrumental in providing a solution to the food crisis in the future.

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INTRODUCTION

The objective of this paper is to gain a basic understanding of the relationship between economic analysis, agricultural research, and the food crisis

The focus was put on such important areas as research planning, the role of economic analysis and duties of the agricultural economist in an agricultural research center.

One of the major objectives is to understand the planning process as it relates to agricultural research. A brief assessment of the food and population growth is made. Population control and a planned agricultural problem-oriented research program with a long term orientation are proposed as tentative solutions to the food crisis.

A policy for agricultural science and research is discussed in which the idea of a complete agricultural research program is proposed.

Economic and social criteria play an important role in establishing research priorities. Various existing methodologies for selecting research priorities are discussed and some reservation is made about quantitative economic analysis as a tool in setting agricultural research priorities.

A list and a brief discussion of some topics of economic analysis relevant to agricultural research are offered. Examples of economic research topics on both micro and macro levels are indicated. The evaluation of research impact is listed as the third area in which economic analysis has

an opportunity to contribute.

Economic analysis of the food shortage problem in terms of the need to take nutrient content into consideration and various questions are considered. Discussion of research and institutional aspects concludes this section.

A food production oriented agricultural research policy in terms of priorities is proposed.

Before action programs for research are planned, professional considerations have to be taken into account. These are discussed, taking the researcher or the agricultural scientist as a central point of reference. Personality factors as well as the Scientist's conception of agricultural policies are described and potential negative influences on the planning process are singled out.

Two examples of theorical considerations are presented. Hayami and Ruttan's theory of induced innovation is referred to as a launching point to understand the role of research agencies. De Janvry's recently published model of interaction of socio-economic, political and bureaucratic structures in defining the demand for, and supply of technologies is presented in more detail. A few examples are cited in which these theories help to interpret the perfomances of research organizations in various countries.

The formulation of agricultural food research programs is considered in the light of what is seen in the organization of a number of research institutions. General objectives of research programs are proposed and criteria to be met while building "R" and "D" programs

outlined.

The essence of planning is discussed and considered in the light of a new research concept which takes the system approach to agricultural production as a corner stone. A four step planning procedure is then presented.

The case for agricultural research and technology development is made using examples from the U.S. that show the changes made possible by investment in agricultural research.

The historic scarcity of agricultural research activities in the tropical regions of the globe is considered the main reason for the backwardness of the agricultural sectors of those regions.

It is pointed out that more recently the less developed countries of the tropics have realized that to fullfil their food needs they have to invest in research.

The new definitions of research priorities of the developed countries is listed. This lends support to the idea that the potentialities of the tropical zones are very prominent. Illustrations of these potentialities like photosynthesis, biological nitrogen fixation and genetic manipulation beyond those of conventional plant breeding are described briefly.

One of the strong messages of this paper is to emphasize the potentialities of the tropical regions and their likely responses to research investments.

Initial steps have been taken in an attempt to utilize these

potentialities. Brazil, the largest country of the tropics is presently in the process of modernizing and giving high priority to its agricultural sector. Major emphasis has been placed on its new federal agricultural research organization. This country has made some firm commitments to create new agricultural technology adapted to tropical conditions, and with time can contribute to solving the world famine problems through increased food production.

The final part starts with a general description of Brazil's commitment to Agricultural Research and Development. The agricultural research institutions of the country are described briefly in a historical perspective, which culminates with the creation of EMBRAPA.

The case of Brazilian Extension Service is considered, emphasising its interrelationship with research. The connections of agricultural research with University education is defined.

The Brazilian Agricultural Research Model is basically a centrally directed research system. This characteristic is discussed as a key concept applicable to other developing countries.

Brazil's potential contribution to other developing countries is due to its size and diversity of conditions. Brazil is committed to making sizeable investments in agricultural research whose spill over effects will benefit other countries with similar resources, which are located at the tropics and have capacity for transfer of technology.

The last section of this paper states that: eventhough the writers believe that the solution to the food problem as an agricultural production

problem through proper research planning and application of existing and plus future technology is feasible, still, this may not solve world poverty problem. The problem of the poor farmer and rural dweller is a social problem that could not be seen as just a food production problem.

Brazil went to the World Conference in Rome in November 1974, as one of the emerging voices in a growing international effort to provide for the world's burgeoning population. It came out of that conference with a new determination to realize Brazil's full agricultural potential in the future and fulfill its national and international obligation in terms of food production.

FOOD AND POPULATION GROWTH

In 1954 to 1974 period worldwide food production grew at an average annual rate of 2.8 percent while population growth was 2.0 percent per annum.

This means that an additional 25 million tons of grain must be produced each year to feed the current annual increment in world population. (32)

According to high variant of the latest United Nations population projections, the world population would reach about 6.6 billion by the end of the century. According to low variant if fertility begins to decline earlier in the developing countries the world population will not exceed 5.8 billion by that time. (21)

The rapid increase in world population creates the major urgency to increase food production.

Haldore Hanson,Director-General International Maize and Wheat Improvement Center (CIMMYT) stated that without expanding acreage the world can double its food production by the year 2000 to match the expected growth of its population. He hopes to see the reversal of the trend whereby "governments seem to be willing to take action only in the face of hunger, rather than dealing with the long range aspects of the food problem." (33)

World food supplies are and probably will be distributed in

accordance with purchasing power or effective demand and not according to nutritional requirements. (21) As a result, present and future food shortages are not and will not be a problem of particular countries but of the poor, whatever their country may be. In other words, the food shortages are expected to be sporadic and affecting different parts of each country.

Over the long term the problem of providing adequate food for the poor all over the world will require substantial social and political change. If this is not accomplished, civil strife on an unprecedented scale may result.

The writers of this paper believe that fears of world food shortages before the end of the century leading to some major crisis are not justified. The Green Revolution of the sixties has led to more optimism. If weather conditions are favorable over next few years food stocks will grow and food problem will become less severe. Permanent solutions include: population control and a major effort to plan agricultural research oriented to long term solution of agricultural production and food supply problems particularly in those climatic zones where very little research has been historically undertaken.

AGRICULTURAL AND RESEARCH POLICY

The changing nature of today's agriculture and food supply is recognized by everyone who is concerned with the future. These accelerated changes create a set of problems in the economics field, many of which should be the object of future agricultural research. If research is to have the influence of giving some direction to tomorrow's agriculture it must be more opportunity oriented than has been in the past. It should be the purpose of agricultural research to analyse and evaluate alternatives for achieving maximum production of the things people need and want, and to appraise alternative systems that exist or can be developed to supply the ever growing national and international demand, resulting from population growth and increase of income.

The agricultural research policy must be based on the fact that the objectives of agricultural research are not academic or speculative. The objective when possible must be strictly practical and oriented towards the improvements of agricultural production, improving the living standard of the agricultural producer by increasing his income without proportional increase of expenses. In other words, the research should be aimed towards maximising producer benefit and minimising his cost within the context of an over all national development strategy that takes the welfare of the non-agricultural sector, into consideration. What is needed is a "complete agricultural research program" which treats all aspects, social as well as

technological, of agricultural problems.

A complete national research program would be one that will take into consideration the nature of future potential innovations and technology and to evaluate the impact on and the response of the economic, social,and political sectors to these changes before their widespread adoption Such a program will provide data on the expected impact of new developments on employment, on the proportionate amount of labor that will be needed in the various skills and professions, and the kind of activity needed to reduce tha lag between adoption and adjustments.

ECONOMIC AND SOCIAL CRITERIA FOR SETTING RESEARCH PRIORITIES

Schuh proposes to set up research priorities on the bases of the following three propositions. (24)

1. The nature and the objectives of research programs are to be determined in part by the stage of development of the economy.
2. The objective of the research program should be related to the particular development model the government is implementing and specific economic policies used to implement them.
3. An adequate understanding of the development process and the general policy pursued by government.

Each of these three propositions provide an important analytical role for the economist in determining research priorities. His contribution is in part in the identifying of goals and objectives in the light of the general policy matrix. If this is done at an operational level, they should be focused more directly on policy objectives.

Three simple approaches could be suggested TO SELECT RESEARCH PRIORITIES

I. Present and Future Economic Importance of Various Commodities

A simple method to divide available resources in the case of a commodity oriented research program will be to make the ratio of the research expenditure and the relative economic value equal for all commodities. Both present value and projected value at the

time when technology is expected to become available could be used. This method is best applied at early stages of development.(2)

II. Utilization of Income Elasticities of Demand

Income elasticities of demand could well be used as one or the major basis for ordering biological and physical research on farm products aimed at improving consumer and producer welfare in relatively advanced economies. Directors of research might lay out before them, for the purposes focal to this stage the complete array of income elasticities for different agricultural products and for different aspects of products such as quality, quantity, service, convenience, etc. Research resources would then be allocated in terms of, and relative to, magnitude of income elasticities of demand. Products, and services with higher elasticities are those from which consumers will derive greatest satisfaction as their income and total expenditures increase. For this very reason, they are the ones for which consumers will reward farmers most in profit as per capita income continues to grow. (23)

De Castro and Schuh (3) using data from Brazil attempted to demonstrate a model for assessing national research priorities in light of a country's factor endowments and socio-economic goals. They looked at the problem in terms of whether a nation wishes to favor the welfare of consumers or producers. Depending on whether consumers or producers are the group intended to benefit from research results the choices of priorities among commodities was ranked by the size of their price elasticity of demand.

III. Quantification of Growth Targets Based on Visualized New Technologies

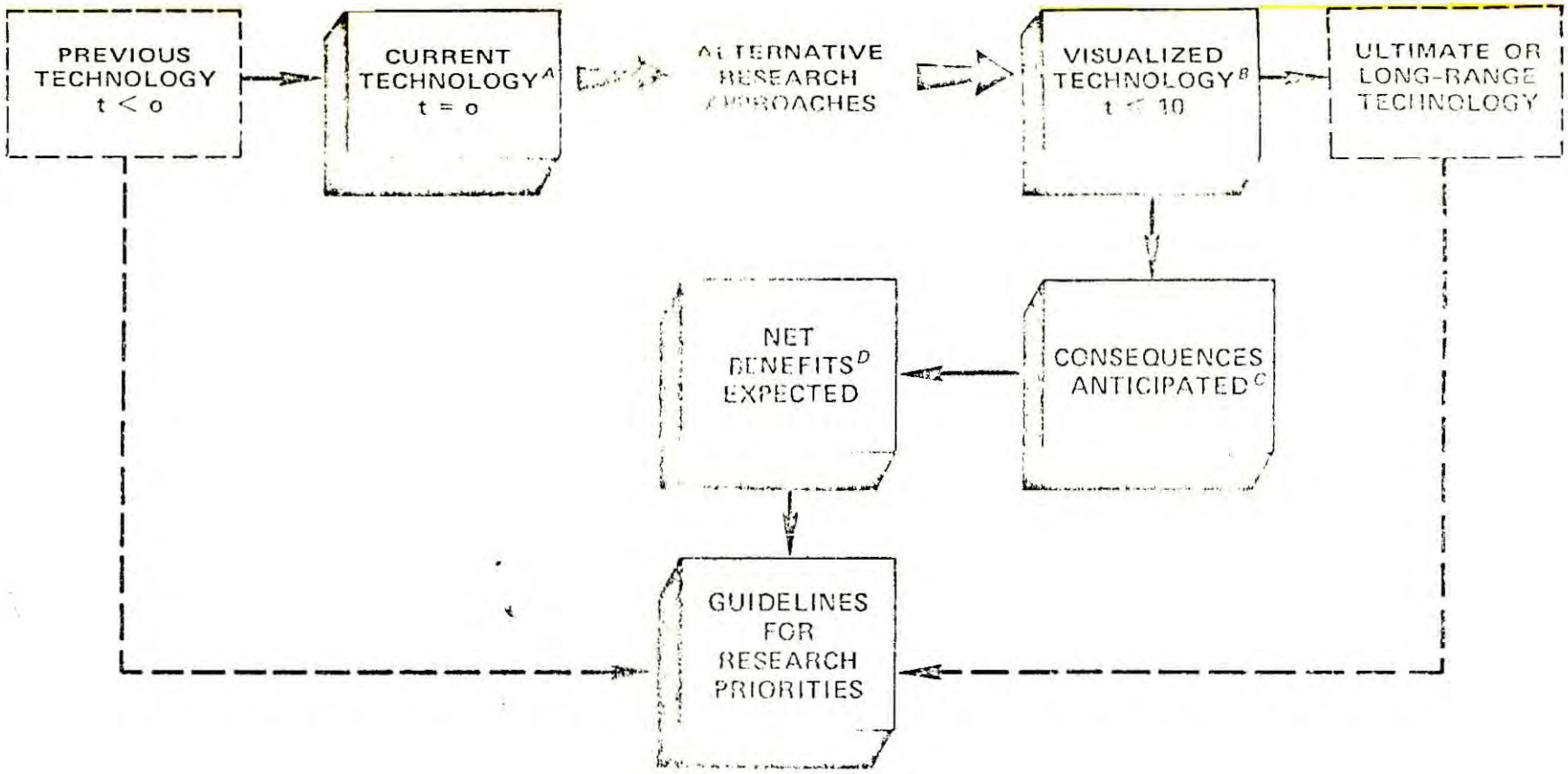
A New Model is being developed in United States by ARS as a part of Management and Planning System (MAPS).

An interdisciplinary group of professionals systematically identify needed technologies for all subject matter areas covered by the agency. It also identifies research approaches that can contribute to these technologies. On the basis of this agency's research objectives, targets for up to a 10 year planning period are set.Estimates of potential benefits, consequences, and cost of new technology, where appropriate, are made. This information is used to obtain technology assessment, cost-benefit analysis and priority setting when needed. Figure 1 shows the procedure. (26)

Best estimates on an industry wide basis are made of the various coefficients that characterize the current level of tecnology. Through the identification of inefficiencies of the process or by characterizing possible ways of getting better contribution of resources, a new level of technology is visualized through an interdisciplinary effort for a targeted year in this case 1985 for which internal - external demand-supply projections have been made.

The change required to go from the current to the visualized technologies are used to characterize the alternative research approaches.

The consequences of the adoption of the visualized technology are assessed. Both the beneficial and the detrimental sides are anticipated. The net benefits generated by the achievement of a technological objective



A The techniques now available to commercial agricultural production, marketing, or consumption.

B A specific technological goal which can be achieved using knowledge produced by one or more research approaches in a period of 10 years or less.

C The beneficial or detrimental aspects of achieving a Technological Objective that would be identified and evaluated in a formal technological assessment.

D The net savings in costs or net value of products generated by achievement of a Technological Objective.

Figure 1.—Schematic Diagram of Research Planning and Evaluation Using a Technological Objective to Focus on Specific Approaches to New Technology and Describe Anticipated Consequences and Benefits of Altering Current Technology (t=time in years).
Source: U. S. D. A., A.R.S., Management and Planning System (31) p. 9

are then computed. The comparisons of the expected benefits of research of several programs beeng proposed will serve as basis for definitions of research priorities. Table 1, taken from a draft of a proposal of beef production research plan serves the purpose of illustrating how estimates of total potential benefits of visualized technology are made. (30)

The estimates as shown in Table 1 are made for all programs and relati size of potential benefit established. These estimates serve as guide and an attempt is made to allocate research resources in proportion to relative benefits by classifying all projects and subprojects in terms of the particula program that are intended to benefit.

Table 1 shows for example that improved feed efficiency through feed additives and improved utilization can produce six times more quantifiable benefit than improved reproduction through early calving.

This approach demands a good information system, knowledge of existing technologies and considerable amount time on the part of researcher. As such not many developing countries can adopt this system in their early development stage..

IV. Some Reservation About Quantitative Economic Analysis as a Tool in Setting Agricultural Research Priorities

The third working conference of Directors of Agricultural Research of Organization for Economic Co-Operation and Development held in Paris between 1 and 5 of December 1975 considered methods to aid decision making related to agricultural research program. During this meeting it was generally agreed that ritualistic cost-benefit analysis was inapplicable to agricultural research and could be dangerously misleading, since

TABLE 1

BEEF PRODUCTION: TOTAL POTENTIAL BENEFITS OF VISUALIZED TECHNOLOGY

Item	Estimated Annual Benefits by 1985
Improved Reproduction	
Increased percent calf crop	$ 588,490,000
Earlier calving	208,750,000
Greater artificial insem. use	see other items
Improved Feed Efficiency	
Feed additives and improved Utilization	1,266,000,000 1/
Replacing protein with Non-protein-nitrogen	2/
Increased use, low-quality Forages and by products	3/
Improved Management	
Reduced labor costs	370,000,000
Reduced feedlot equipment and facility costs	27,000,000
Reduced cow herd equipment and facility costs	108,000,000
Improved Carcass Quality	
Reduced costs, feeding regimes to reduce carcass fat	580,000,000
Reduced costs, genetic improvement for reduced fat production independent of artificial insemination	444,000,000
Reduced costs, genetic improvement for reduced fat production due to artificial insemination	136,000,000
Total	$ 3,728,240,000

Table 1 - continued

1/ To illustrate further how, for example, potential benefits of improved feed efficiency from post weaning gain was made the following paragraph is quoted: Potential Benefits of Improved Feed Efficiency: From improved efficiency of postweaning gain.

To produce the 32 1/4 billion pounds of beef estimated to be needed to fill needs in 1985, live weight production required will total approximately 58.6 billion pounds (assumed dressing percentage of 55 percent). Half of this is assumed to be produced after weaning. At $115 per ton of total digestible nutrients (TDN) (equivalent to corn at $2.50 per bushel) cost of post-weaning gain would be:

At current production rate of 8.5 lb. TDN per lb. of live weight gain:

249 billion lb.	5 3/4c	$14,318 million

At envisioned rate of 7.75 lb. TDN per lb. live weight gain:

227 billion lb.	5 3/4c	$13,052 million
	Potential Saving	1,266 million

...could free enough protein to meet half of annual requirement for 34 million people. Of obvious social value but no known way to express in dollars.

3/ Could add 2.6 million tons of carcass beef to nations annual supply. With increasing food-population pressures, can be of great social value. No known way to express in dollars.

Source: (30)

policy-makers might be unaware of its serious limitations (e.g. inappropriatedness of criteria like internal rate of return or a benefit-cost ratio in which only research costs were taken into consideration; poor quality of input data; importance of unquantifiable factors etc). The importance of economic factors was agreed to by all and it was concluded that economic analysis, in a wide sense, should be one input to aid systematic judgement in reaching decisions on research priorities.

It was agreed that there was no single method or technique on which decision-making could or should be based, that the need for informed judgement must be accepted, and that further exploration of methodologies was necessary. (28)

ECONOMIC AND INSTITUTIONAL ANALYSIS IN AGRICULTURAL RESEARCH

All problem oriented research programs must have an economics component directed specifically at the economic issues associated with the major technological problems to be attacked. Economic studies must be made an integral part of each of the in-depth technological research activities whose priority has already been established. The economic research component associated with each priority research activity will need to be problem-specific.

Two broad categories of economic studies: macro and micro level are associated with technical research programs designed to contribute to agricultural development through technological advance. In addition special topics like research impact, food shortage and its institutional aspects have to be considered.

I. Micro-Economic Analysis

At the lower end of the process, economic analysis should evaluate the economic and social factors at the micro level of generated technologies. The economist in this case should concentrate on the following:

1. Design of physical/biological experiments to permit efficient economic analysis - When appropriate, micro-economic analysis must be based on data obtained through agricultural production experiments. Each field or laboratory experiment must be designed jointly by a physical or biological scientist and an

agricultural economist to assure that data obtained will not only provide the physical and biological information desired but also be amenable to economic analysis.

2. Production function analysis of experimental and related data - This work involves the statistical estimation of empirical production functions and subsequent economic analysis to determine optimum production levels and least-cost combination of production inputs under alternative factor/product and factor/factor price relationship. It seems imperative that all work conducted under the priority research program be subject to this type of valuable economic analysis; if not the research program will fall far short of its potential.

3. Determination of optimal systems of farming - This component would consist of studies designed to determine the most profitable combination of farm enterprises or systems of farming given the new technology developed in the physical/biological research program and the existing state of technology for alternative farm enterprises. Resource constraints and probable ranges of product and input prices would also be taken into account.

4. Product and input price and marketing research - The profitability of adopting new production technology depends importantly upon price and market conditions and

relationship for both products and for factors of production. These economic phenomena must be investigated carefully and understood rather completely if the output of the priority research program is to be utilized effectively by farmers.

5. Analysis of the risk - Recent developments suggest assessing the risk content of the farmers decisions based on research findings. In fact, no recommendation made will have a chance of being adopted, unless its risk is assessed completely.

II. Macro-Economic Analysis

In addition to micro-economic considerations economists in association with other social scientists must consider aggregate macro-economic issues associated with the adoption and utilization of new technology in agriculture. Four of the most significant of these issues are listed below:

1. Internal and external supply and demand studies for food and other agricultural commodities given priority in research programs - These studies must include not only all commodities included in the priority research list but also other commodities that are substitutes for and/or complements to these commodities.

2. Internal and external supply and demand studies for inputs or factors of production - All inputs essential to the utilization

of modern technology developed through the priority research program must be considered.

3. Regional disparities and other potential problems associated with implementation of new technologies - Patterns of food consumption differ by economic level as well as by regional geography and agricultural traditions. These patterns influence crop production.

   As a result the economist will play a role of assessing the impact of the research results, both within a region and interregionally. They must take into consideration existing and needed infrastructure in terms of: roads, storage facilities, population shifts and other factor that can effect adoption of newly created technologies.

   Among agricultural and biological scientists, present and future, market prices, differences in factor endowments among countries or regions, has been treated as largely exogenous to technical changes envisoned by their research objectives. This approach must be changed and research should be undertaken to provide as accurate knowledge as possible on the comparative advantages and disadvantages of the state, area or region for specific crop, livestock, and agribusiness enterprises.

4. Relative price structure of major agricultural input in relation to food and other agricultural products - It is within the

scope of macroeconomic analysis to assess the likely direction of events when market distortion such as distorted input and factor prices due to any changes or policies are present. What would have hapened if distortions such as price subsidies and aid programs were not present? These are cases in which markets were kept from showing their signals to the investments made in technology.

Development of continious stream of new technology, which alters production opportunities to conform to the long term trends in factor and product prices, is key to the success in achieving relatively rapid rates of agricultural productivity and output growth in any country. Even though major national goal must be production of quality food in sufficient amount for the future through provision of appropriate technology, the priority must be given to the producer.

2.1. Economic Evaluation of Research Impact

The evaluation of the impacts of the research findings can be assessed by their effects on growth, equity and risk bearing potentialities of the new techniques created.

Traditionally, evaluation of the impacts of research have been conducted considering only their growth dimensions. More recently in a few studies equity considerations have been among the elements through which the impact of research is evaluated.

Scobie and Posada (25) examined the distribution of benefits

of rice research in Colombia among upland rice producers, irrigated rice producers and rice consumers. Deriving both the costs and the returns among the three groups and based on price and income elasticities of demand on one side and price elasticity of supply associated with a supply shift introduced by the creation, through research, of the high yelds variety of irrigated rice, they were capable of showing how benefits of the HYV were being distributed.

The models used in these kinds of studies indicate that the contribution of research and technical change to society's goals is dependent on other policies. Distortion of input product prices not only affects farmers decisions regarding use of inputs and choice of commodities to produce it also affects decisions regarding research priority and hence the new techniques that will become available in the future.

When it comes to examining decision alternatives in such a context, economic analysis as well as other social sciences will have contributions to make.

IV. Economic Analysis of Food Shortage Problem

A new approach has to be developed in evaluation of cost and real value of various food crop in terms of nutrients. Then one can talk about cost of producing one million calories from rice or corn as compared to wheat. One can further speculate about the value of one ton of protein from soybeans as opposed to wheat or beef.

Food balance sheets should be constructed for all countries. National food demand at a certain stage must be evaluated in terms million calories

and tons of protein. The supply or expected production can also be estimated in the same units. The balance or food deficit then could be estimated in nutrient terms and alternative sources from either commercial or aid considered.

International trade quotations could also be made in terms of nutrientes so as to provide easy comparison between alternative sources of food. These are just a few of the instances in which economics will have an opportunity to contribute to alleviating the food crisis.

Economics and other social sciences also will have to answer the following questions:

1. When attention is called to the food-population inbalances of a society what will be the behavior of other sectors of the economy?
2. How would a country stricken by a food crisis exploit other comparative advantages it may have, if any?
3. When food commodities are handled without interaction with money markets, which are the roles of other governmental policies?
4. How should the fiscal and monetary policies be handled under food crisis?
5. What would be the possibilities of increasing employment in the other sectors of the economy?
6. How would the international schemes that exist and may be

created to assist different countries with food problems be operated?

7. How should food reserves be built up and released on international level?

8. How would the costs of a stock-holding policies compare with their expected benefits?

9. How could these costs be met, should they be shared among countries, and on what basis?

V. Research on Institutional Aspects of Food Problem

There is another broad field of subject matter in which research is needed. It is in the general area commonly referred to as institutionalism. In this field, one can suggest research to determine causes of the lag between the rapidly advancing technology and its adoption and the economic adjustment to the new advanced technology; between the economic adjustment and social adjustment; and between the social adjustment and political adjustment. These lags are hypothesized to be the cause of apparent misuse of resource. Research of this nature could draw heavily on other research results. However, to do so, presently planned research would have to take into account this need as an objective.

Economists and other social scientists will assess the conditions of profitability and the socio-economic impacts of the adoption of the newly created technologies. They will bring up and analyse the process of adopting technological inovations. In this sense, both the definitions of what to study, as well as the Farmer's decision to adopt the new technique will

be considerably fostered by an integrated systems approach.

This kind of research should provide answer to questions such as:

1. What is the impact of technological developments on employment?
2. What is the projected employment and proportionate amount of labor requirements in the various skills and professions?

Two examples of studies that should be given high priorities are listed below:

1. Economic studies of alternative solutions to the agricultural resource adjustments and agricultural income distribution

   Widespread adoption of modern technology including the effect of the green revolution in some cases have displaced farm people and made them move to cities having little employment opportunity. It also has increased the disparity of income and while providing increased income for larger farmers, did not improve the lot of the small ones. This kind of impact of new technology should be avoided through advance planning and provision of alternative employment opportunities.

2. Economic analysis of the probable consequences of public agricultural policies affecting the priority commodities, their substitutes and their complements - Appropriate economic analyses of the consequences of policies affecting both factors of production (inputs) and agricultural products must be included.

It would be highly desirable to stimulate economic studies of other public policies as they relate to the development of agriculture.

NEW FOOD AND AGRICULTURAL RESEARCH POLICY

l agricultural products in relation to food can be divided into five groups:

1. Direct food crops (staple food and others)

2. Indirect food crops (feeds)

3. Non food crops (fibers other industrial crops)

4. Stimulant and spices (includes cocoa, coffee,tea,etc)

5. Livestock Products

If individual governments and international organization are to commit themselves to a research policy giving top priorities to food crisis the following order of priorities can be suggested.

First priority - Direct food crops, particularly staple foods, including tropical roots,tubers,plantains and fruit trees.

Second priority - Livestock products and indirect food or feed crops.

Third priority - Stimulant and spices.

Forth priority - Non food industrial crops.

Giving stimulant and spices higher priority as compared to non food crops is mainly due to the fact that most of them grow in developing countries and constitute a major foreign exchange earner.

Non food industrial crops can be mostly substituted by synthetics

or industrial products and release land and other resources for growing need of food production.

Direct food plants should be subjected to a major attempt to redesign plant types and induce more protein in general and various essential amino acids when absent in individual crops.

Attempt should be made to create not only varieties that produce most under optimum condition but also develops varieties that produce something under worst conditions.

Indirect food crop research that include pasture should be oriented towards producing varieties for marginal lands and leaving good land for direct food production.

Livestock research should be oriented towards increasing transformation efficiency between feed input and meat and other livestock products. Increased use of waste products as feed should be given high priority.

Agricultural research planner should be the first to start giving high priority to nutrient yields and express various crop production figures in terms of million calories and tons of protein per acre.

PROFESSIONAL CONSIDERATIONS IN AGRICULTURAL RESEARCH

In order to implement a successfull agricultural research planning program; personality factors, professional characteristics, and knowledge of socio-economic, systems and existing policy of the agricultural research community have to be taken into consideration.

I - The Personality Factor in Research Planning

Paul Matussek in discussing "The Personality Factor in Research Planning" states: Man is of central importance in research planning. He is its beginning and its end. He determines the efficiency of planning and application of results (27).

Modern research planning is, therefore, dealing over increasingly with the human factor, a task which has been taken over mainly by psychologists, psychiatrists, and sociologists. One of the major results of their studies is the conclusion that a team's efficiency increases with the amelioration of the interpersonal relationship and declines with its deterioration. These studies are especially important in area where scientists of different disciplines are co-operating on a joint project. If the personal relations of the group members are deficient, then they will fall back upon their professional authority and close their mind to free discussion and possible criticism (27).

II - Agricultural Scientists and Research Planning

In general, agricultural scientists are independent, highly trained people. They seek freedom in their work. They often feel an

allegiance to their profession which transcends their allegiance to the institutions that employ them. For these reasons it is not advisable to supervise their work too closely, to put them under continuous pressure to fill out all sorts of forms and routine reports, and take direction from some one outside their profession. As a result, the research planning system must be based upon close communication between scientists and policy makers attempting to find solution to the basic problems of the society.

The Research Planning System must at least partially rely on individual researchers to utilize a considerable degree of self-directions and self control. It must provide certain opportunity to fulfill professional needs at the ego and self-actualization level. In general the researchers must have potentially creative and rewarding projects and be largely responsible for the achievement of their own results.

Research has intrinsic satisfaction for the research workers in addition to the salaries earned. It also can produce information that contains economic properties for which there is a demand from different parts of economy.

The planning system should take into consideration that in a research environment the work itself is usually a source of satisfaction to the researcher, which explains why he devotes much energy and time to it.

The specialized skill required for successful agricultural research is to take new material from biological research and transform them into inputs that have a tangible economic value at present or

expected value in the future.

The scientists must insure that truly creative research to meet public needs is conducted, and that they are serving a domestic-productivity oriented clientele and not a clientele of domestic and foreign professional journals and conferences desperately trying to fill gaps in the scientific literature.

III - Agricultural Scientists Conception of Agricultural Policy

It is very important that agricultural scientist be properly informed about agricultural policy particularly agricultural prices, existing subsidies, taxes and any other fiscal programs affecting agricultural production.

Some agricultural scientists like many farm leaders, believe that once there is an established optimum relation ship between various inputs yields, in order to stimulate the use of these modern inputs and increase agricultural production the government will have to change the input-output relationship as far as purchasing side is concerned. Agricultural prices would have to be increased faster than prices of inputs, and, at the same time, one would have to stimulate the use of new varieties of improved seed so that farmers, by using new inputs would be able to increase the productivity per unit area. In addition, the increase of cultivated area must come as a result of mechanization resulting from raising the prices of agricultural products faster than the prices of agricultural implements, in particular tractors. This approach does not consider the international economic order and the fact that large part of agricultural crops is

exported and many agricultural inputs like fertilizers are imported. The only way to increas prices in this context is to subsidize them through passing the cost to the non-agricultural sector.

THEORETHICAL CONSIDERATIONS IN AGRICULTURAL RESEARCH

The progress of agricultural research can best be understood with the help of theory and with examination of past experiences.

I - The Theory of Induced Innovation

The theory of induced innovation is a launching point for understanding the nature of the demand for research implicit in the need for technical change. This theory is not new, but was recently revitalized by Hayami an Ruttan (9).

According to this theory, factor endowments provide the motive power for technical change in agriculture. Relative factors scarcities reflected in relative factor prices induce a search for technical developments that tend to conserve the scarce factors.

The effectivenes of the process by which technical progress is generated along with a path induced by relative factor scarcities is conditioned by many circumstances: the state of scientific knowledge, the supply of inputs, the levels of technical and scientific skills embodied in people, market distortions and socio-political circumstances.

II - Social Interest Groups as Determinators of Research Policy

Another model which can be seen as a useful intelectual articulation, rather than a theory has been proprosed recently by De Janvry (4). De Janvry views technical change as a circular, cummulative process in which socioeconomic and Political-Bureaucratic Structures

interact to define the demand for and the supply of new technologies.

The socioeconomic structure defines and is characterized by the land tenure process, product and factor prices, access to institutions, such as credit, technical assistance, information etc. It determines the pay-off matrix that shows the economic gains for particular social groups. From the pay-off matrix the demand for technologies is characterized.

The Political Bureaucratic Structure governs the public research system that will undertake both the basic and the applied research, generating the supply of new technologies.

The key to this model is the pay-off matrix. It is defined by particular interests groups in society: commercial farmers, landed elites subsistance farmers and consumers who derive income gains from public goods such as research.

Each social group pressures the political administrative structure for research goods to be generated depending on the particular pay-off it expects.

The relative social power of different groups determines whether and how their demands get translated into the allocation of resources for particular lines of research.

The resulting supply of research is filtred through the socioeconomic structure and produces specific pay-offs for different social groups.

The extent of basic scientific knowledge determines the area within which technical innovation is possible. The physical characteristics of the innovation in terms of its ability to raise yield or reduce cost,

the extent of difusion of innovation which is conditioned by its suitability to local ecologies and social and institutional arrangements and prices which determine the relative profitability of agricultural research determine the pay-off matrix. The pay-off induce further demand of new research.

III - The Application of Theory for Real Situation

Both, the theory of induced innovation and De Janvry's model can be used to interpret findings of studies dealing with research and its impact in different places in the world. The best example of utilization of the induced innovations theory to interpret the role plaid by research is Hayami and Ruttan's book (9). United States and Japan departing from an entirely different factor endowment situation had their agricultural research induced toward saving the scarce resources, land in Japan and labor in United States.

De Janvry's model also helps to understand the implication of a few studies analising the role of research in several countries. A study in Japan, indicates how agricultural research can prosper where social and economic forces flow together to present a clear demand for technical change (8). When Japan was modernizing there was a unified pull for agricultural research from several groups.

Farmers wanted yield augmenting technologies, consumers were seeking lower food prices, industrial employers wanted low priced food so that cost were kept low to save foreign exchange, government wanted higher land tax revenues.

The social and political structure was uniquely conductive to the generation and difusion of technology in agriculture.

Peterson and Fritzharris (20) on their study of US agricultural research argue that the better and wealthier farmers organized into farmers groups and a political structure which enabled them to press their demands on the body politic and created a productive federal state research system.

In Colombia, the concentration of rice, soy bean, and cotton growers in limited areas or in organized groups had a major impact in inducing research and in adoption of its results.

The land tenure arrangements among wheat growers, on the other hand, had a negative effect on the spread of new wheat technology and subsequent demand for technical change (11).

The role of prices to induce research can also be illustrated in the case of Colombia. Rice prices made a jump in three years of import controls. This stimulated research on that cereal.

The international aid programs bringing wheat into the country at low prices diverted research effort from that cereal for a number of years.

In both theories a few elements play key roles. The first emphasizes the natural supply and demand forces showing through the factor, and product prices the signals of scarcities. De J nvry's places emphases on the socio-economic political structure. Both of them recognize the role of the available scientific knowledge and of the body of trained personal to sense the market orientation or to follow the

commandments of the governing structure. The power struture of the society plays an important role in De Janvry's model.

FORMULATING AGRICULTURAL & FOOD RESEARCH PROGRAMS: MISSION-ORIENTED SYSTEM APPROACH

A review of past and current research activities of a number of research organizations indicates that:(a) Each organization tends to have its own method of formulating its R&D program. This method is generally dependent on the nature of the organization, its policies, the internally and externall imposed constraints, and the size and nature of available and future resource (b) There has been a great deal of fragmentation, duplication, and lack correlation and direction in the overall research program and some waste of research effort.

It is evident that there must be better organized and systemized procedures and structures through which the entire effort of agricultural research can be guided, coordinated, and promoted toward positively defined goals. This paper includes the development of concepts and methods of agricultural research program formulation. These concepts and methods are especially important from the viewpoint of subsequent detailed development of R&D programs.

A new organization structure is proposed based on the concept of "mission-oriented systems approach". A hierarchal structure is developed designing strategic, tactical, and action models for the purpose of programming.These structures are used to generate concepts and methods for developing dynamic programs based on national needs and resources. These

program techniques are helpful in providing systemized procedures that will ultimately guide, coordinate and promote positively defined goals.

I. Objectives

The problem of Agricultural Research and Development Program formulation should be examined within the framework of the following objectives:

1. To develop conceptual definitions and methods for structuring agricultural research efforts toward improvement of Food supply systems.

2. To develop concepts and frameworks for establishing short and long range dynamic R&D programs, guiding future R&D efforts in a systematic and well coordinated manner, and maximizing the tangible benefits resulting from R&D.

While these objectives can be spelled out only in the broadest terms, the criteria that must be met by the resulting R&D programs can be identified more specifically as follows:

1. Provision for both theoretical (new concepts) and applied research (new methods and development);

2. Provision for the translation of theoretical research results into practical use;

3. Use of systems concepts to permit a better understanding of the relationship among many research areas;

4. Capability of development and expansion within the framework of overall programs already established by Federal and State governments.

5. Realism in terms of available physical, fiscal, and manpower resources;

6. Realism in terms of priority and scheduling; and

7. Compliance with the research institution's policies.

The overall significance of a framework within which R&D programs can develope the end product, namely, a sound base and structure for the orderly expansion and development of both existing and future research and development programs; is of particular importance when viewed against the complexity and magnitude inherent in future research efforts required to meet the challenges of tomorrow's food requirements.

The following section first defines the basic concept and then outlines the procedure for design, management and operation of a dynamic agricultural research program.

II. Agricultural Research Planning

In order to get a complete agricultural action research program with problem solving capacity, the planning process in terms of capabilities and limitations should be fully understood; and a new concept of research defined and a complete procedure established.

1. The Essence of Planning - Planning is identified with the future consequences of present decisions; or, conversely, to produce a given set of consequence in the future, decisions have to be made accordingly in the present.

   Planning tends to involve itself with the change from the

present state to the future desired state or situation. This concept has inherent in it the necessity for seeing the entire flow of events between the present and the future states. Planning is not forecasting. The important distinction rests between what is going to happen (forecasting) and what can be made to happen (planning).

The purpose of the plan is to pave the way for rational action. The tragedy in the use of anything other than realistic planning is that the entire planning process quickly becomes discredited and useless for what it was intended to be.

Planning deals with the future, and thus is vitally concerned with the problem of uncertainty. Uncertainty has a profound bearing both on what will happen and what, through planning, can be caused to happen. One has to be sure that the distinction is known in his own situation. It is important to have at least a "feel" for the uncertainty involved in any forecast. This is because the risk of wide variation from the assumed future conditions dictates the required flexibility which must be built into any long term plan.

To summarize,planning must answer three question:

1. What is feasible to do?
2. What is relevant to do?
3. How to do it in terms of resource allocation?

The development of goals, the establishment of priorities for

them and the development and selection of programs and projects are all part of planning.

The most difficult job for the formal-planning discipline is to obtain and maintain management commitment to it.

2. A New Concept of Research - Research is the study of systems for the purpose of producing information about those systems. The particular concern is the study of agricultural production systems existing, and new technology subsystems and socio-economic systems closely related to the production of agricultural commodities.

The main product of agricultural research is information that is useful for improved operation, management and further study of such systems. This information constitutes the technological innovation process that is the major objective of all research.

III. Agricultural Research Planning Procedure

Research planning may be subject to pressure because of conflicts of interest that may arise between certain short-term aims of farmer groups and the overall requirements of the national economy. Conflicts of interests may also arise between the national objectives and wishes of the research workers themselves who may give preference to subjects of general scientific interests.

To increase the likelihood that useful information will, in fact, result from research activities, the research must be planned and a complete set of methodology has to be developed. For this reason the following planning

stages have been identified.

1. Systems Analysis - Research planning should begin with suitable identification and analysis of the system or systems of existing and potential production technology.

   The purpose is the pursuit of integrated interdisciplinary research toward the development of new farming systems.

   According to Heady: Cooperative or team research is becoming increasingly important because of the growing scientific complexity of the production process. He further states that: with the growing trend toward a view of the farm as an overall business, the farmer must consider the entire bundle of farm practices as a unit.

   The result according to him is that: Practices now have to be considered in a system approach and research has to be conducted accordingly. (10)

   A system is comprised of activities, inputs,outputs and utilities for conducting the activities and processes,the environments within which the activities occur, and characteristics of activities, inputs, outputs, utilities, environments, the system at large, and the related systems. A systems analysis will generally include both the identification of all these system aspects and their interrelatedness.

   The system analysis must name variables and attributes that may be used to describe the system. It may suppose that the

system's independent variables are those that describe system concepts and elements and that system characteristics may be identified with dependent variables. System studies seek to determine the most effective ways of utilizing the resource of a community for its own development.

A minimal result of systems analysis is an explicit or implied list of the types of information that are necessary and sufficient for understanding and improving the system under study. This information should help in determination of the sort of technical advances that are needed and can be used to improve the system.

Although the systems analysis should indicate information needs, it does not necessarily bring out the extent to which the needs have already been met.

2. Information Analysis - The second stage in planning research should be an information analysis that reveals the existance and adequacy of available information on the system under study. The acquired information can them be evaluated and analyzed with respect to information needs. The analysis should reveal information gaps and inadequacies, particularly from the statistical point of view. The net result is a clear picture, perhaps in terms of problem statements, of information needs that might be satisfied through research activities. Thus one can consider research needs to be equivalent to needed

information on the system under study.

National goals and priorities as basis for research and development planning is a phrase heard frequently these days. The most important problem seems to be some means to resolve the conflicting priorities and methodologies involved in this process. Recognition of very real limits on total resources compared to the conflicting claims against these resources is the essential first step. The hard choices which must be made depend on the availability of comprehensive objective information and methodology to use empirical analysis as a guide when possible to establish national or/and regional priorities.

3. Economic Analysis

Once all information available and needed has been established, the research strategy should take into consideration the interrelationship between technical and economic change. According to Robert E. Evenson: (6)

The economic value of research output is determined by the extent to which it is, as a final product, an improvement over existing production inputs, techniques, and products. The value of the intermediate research product is determined by the extent to which it is incorporated as an input into other research products and eventually yields a final research product.

4. Program Formulation - The fourth step in agricultural research planning is to formulate research program whose goals cover the information needs of economically justified research. The program formulation is the structuring of research activities into programs and projects within programs. It includes the statement of program goals, project objectives, levels of effort and priorities for program and projects.

RESULTS OF AGRICULTURAL RESEARCH IN THE UNITED STATES

The Compelling need to provide adequate food and related products for the growing population of the world greatly increased the importance of agricultural research during last few years.

The value of agricultural research and technology development has been demonstrated in the United States and other developed countries.

Until the begining of World War I the added need for agricultural products in U.S. was met largely by cropping new lands. Acre yields remained nearly constant through the 1930's when the U.S. still benefited from the millions of added acres that were available for food production as mechanization released the lands previously used.

During the period begining in the 1920's however, the added emphasis on research at federal and state level laid the groundwork for the super abundance of today. (17)

According to U.S.D.A. published indices of agricultural productivity the ratio of outputs to inputs per acre in 1972 as compared to mid thirties has risen by 45 percent. The production per man hour has more than doubled. The number of people supplied by each farmer has risen from 15 to 52. The acreage harvested per consumer has been reduced by nearly one half. In 1976, 5 percent of American population was considered as farmers. In 1776, when U.S. became an independent country, 85 percent of new nations population were farmers.

Agricultural research and extension funded by the United States Department of Agriculture and state governments totalled about $ 1 billion in 1975 with $ 450 million committed for research related to agricultural productivity.

The rate of return on additional investment in agricultural research and extension has been 45 to 50 percent per year over past 40 years. This has kept food prices low. Americans spend about 16 percent of their income on food.(19) In addition,U.S. agricultural exports are expected to total U.S. $ 21.9 billion in fiscal 1976. With agricultural imports estimated at U.S. $ 10 billion, the positive trade balance will reach about U.S. $ 11.9 billion. (32)

HISTORIC SCARCITY AND NEW INTEREST IN AGRICULTURAL RESEARCH IN TROPICAL REGIONS

I. Past Experience

Eventhough the United States does possess large amount of natural resources like land, water, proper climate and human resources including some of the best farmers in the world, it could be argued that a considerable amount of the success was due to a continuous and large amount of effort directed to agricultural and related research that created the largest and most efficient agricultural production machine in the world. This effort was supplemented in other developed countries with more or less similar temperate climatic conditions. The relatively small amount of agricultural research effort undertaken and performed in tropical conditions till now did not show great food and other agricultural production possibilities. This has resulted in gloomy conclusions and consensus of low food production potential in these areas as shown by the following quotation from "The second report to the Club of Rome".

> Few crops have been grown satisfactorily on a commercial basis in the humid tropics, and these tend to be low-protein or non-food cash crops such as palm oil, sugar cane, bananas, coffee, cocoa, and latex. Even the native crops tend to be low-protein varieties such as cassava, yams, and plantains. Here the invention of a completely new agriculture will be necessary, either to develop

> tree-like plants that yield ordinary nourishing foods and can withstand the hot and humid climate,or to generate a series of plants that grow under the cover of tropical trees, which protect them and their soil against the pounding of the heavy tropical rains that otherwise cause distruction by horizontal erosion or vertical washouts. For decades to come only minimal contributions to the solution of the world's food problem can be expected from the humid tropical zones.(15)

It is suggested that agricultural scientists and policy makers strongly question the above statement and dedicate large amount of time and other resources in an attempt to create a large food production system and some new concepts of technology for tropical zones that are capable of making a major contribution to the solution of World Food Crisis.

The low level of real research investment in the major developing-country climate zones, especially in the tropical and desert zones, partly explains the relatively poor agricultural performance of these regions. The sub-tropical zone on the other hand, has enjoyed more attention from researchers and has enjoyed a better record in terms of productivity growth. (2)

In 1965 the developing countries spent 11 percent of the world agr research budget, 20 percent of the extension budget, and had 17 percent of the research and 47 percent of the world extension personnel. Among the various regions, the two less developed ones, Latin America and South Asia, were ranked lowest in terms of research expenditure while the two highest

income regions North America and Nothern Europe rank highest. (7)

The situation was somewhat changed in 1974. In this year the three countries investing most in agricultural research were United States, U.S.S.R. and Japan. They accounted for almost 45 percent of the world's total agricultural research expenditure. Based on available statistics one could also conclude that, in general, low-income countries have expanded their research systems at a faster rate than have the high-income countries during last few years. (2)

II. New Developments

Research Institutes, national as well as international are seen and recognised as promising contributors to boosting food production.

The best proof of the recognition of the role that research can play into solving the problem of agricultural production is on the increased financial support that society has given to this activity. On a global basis it is estimated that expenditures on agricultural research, in constant 1971 U.S. dollars, rose from approximately $ 1.3 billion in 1959 to $ 3.8 billion in 1974. In the less developed countries of Latin America, Africa and Asia, the increase was proportionally greater. Research expenditures in these countries went from an estimated U.S. $ 141.0 to U.S. $ 957.0 million (7

The effect of this surge on research investment was dramatized by t Green Revolution Development effects, based on the extension of existing or imported technology. This revealed the need to develop a more broadly based agricultural research capacity in the developing countries, where the deficit

in food energy is more concentrated.

Furthermore, the realization that the unused available resources of land are not where the imbalance in the rates of growth of population and food is more intense, places additional burden on the need to increase yield of the available and already utilized resources. The need for adequate performance of the reseach organization is thus enhanced from both sides, the increased support society has given to them, (the supply side), and the required impact of the results of their work on the level of productivity of agricultural resources, (the demand side).

ILLUSTRATION OF POTENTIAL IMPORTANCE OF AGRICULTURAL RESEARCH IN TROPICAL ZONES

The Board of Agricultural and Renewable Resources (BARR) of the U.S. National Researc Council, on direct order from the President of the United States, had to develop specific recommendation on how the U.S. research and development capabilities can best be applied to meet the challenge of future chronic shortages of food.

The following are the first three of a list of ten recommendations made by the group: (34)

1. Expand research on photosynthesis so as to increase crop productivity.
2. Strengthen research on biological nitrogen fixation to establish coordinated programs for developing field demonstrations.
3. Develop technique for genetic manipulation beyond those of conventional plant breeding, including in vitro technique for assexual approaches, and broad-crosses between crop species.

Photosynthesis and nitrogen fixation are inter-dependent processes, and research on one is complementary to the other. Morever, since new techniques for genetic manipulation have worldwide application in the development of new and improved plants, research in all three areas should be coordinated.

The Third Working Conference of Directors of Agricultural Research of Organization for Economic Co-Operation and Development held in Paris between 1 and 5 of December, 1975 considered the topic of international co-operation in agricultural research through O.E.C.D.

The conference chose as first stage four research areas of which the first two areas coincided with BARR's and were as follows: (28)

1. The improvement of nitrogen fixation for plant production.
2. The improvement of the efficiency of photosynthesis particularly in order to better use solar energy.

It seems that there is a general consensus that new emphasis of agricultural research should be oriented away from extensive use of scarse resources that constitute the basis for inputs like fertilizers, pesticides, insecticides and others towards design, selection and development of plants that can use non-scarce resources like atmosphere and solar energy to produce foods and other agricultural products.

Without going into detailed discussion it can be stated that tropical areas with abundant intensive solar radiation and continuous growing seasons with large amount of water supply, present much higher potential for this new technology than temperate zones with limited growing season, often deficient solar radiation, resulting in the fact that plant growth & activities of soil bacteria are practically stopped for nearly half or larger part of the year.

In addition, large number of tropical plants, till now very little exploited in terms of possible food production, present the greatest challenge

for genetic architects to introduce desirable characteristics like increasing protein content of some tree crops.

BRAZIL AND ITS COMMITMENT TO AGRICULTURAL RESEARCH AND DEVELOPMENT

I. Economic Growth and Agricultural Potential

Brazil covers one of the few, large areas of the world where rapid increased production through area expansion is possible. Land, climate and water are available; but the necessary human and physical infrastructures will have to be provided.

Generally Brazil has been quite successful in meeting its economic objectives. The high growth rates since 1968 have caused people to speak of the "economic miracle" and make comparison with countries like Japan. This analogy, in spite of the fact that Brazil at present has one of the ten largest economies of the world, may be a bit premature, particularly in view of current energy problems. Still, performance has been exceptional in the past few years; in large part due to expert decision-making by technocrats.

The research and the rapidly growing literature on economic and agricultural growth and development in Brazil show that it holds untapped and underutilized agricultural resources that in due time could become one of the important breadbaskets to help feed the hungry world. By achieving high growth rates for several years, it has demonstrated a capability to effectively draw some of these resources into production.

As an example, the increase in agricultural production in 1974 is estimated to have been between 10 to 13 percent.

Brazil has a great agricultural future. In 1974 only 41 million hectares of Brazil's total territory was under cultivation. This already enabled it to export more than US$ 4.0 billion in agricultural products in that year. It is estimated that or 281 million hectares could be cultivated. The office of the U.S. Agricultural Attache in Brasilia visualizes agricultural exports of at least $ 25.0 billion in current dollars around the turn of the century.

Although one must recognize Brazil's potential as a future important supplier of agricultural products, at the same time one should take into consideration the fact that Brazil as yet has a weak infrastructure to further expand its agriculture. It also has a short supply of qualified farme and managers to undertake the tremendous task of opening the vast interior to agricultural production.

In terms of per capita income (in 1974) it still was only 2/3 of world average. Seventy percent of Brazilian families in that year earned less than twice the minimum wage; that at official exchange rate of that year equaled US$ 57. In the Northeast and North this percentage was 90%. Considering this statistics one can be well aware of the enormous social problems a country like Brazil is confronted with. If only because of its annual rate of birth of 2.8% it should have a population of more than 200 million at the turn of this century.

Many important changes have occured in Brazil's agriculture in recent years. The most significant have been diversification of agricultural export, rapid growth of wheat and soybean production,and rapid modernization

of the agricultural sector. Between 1960 and 1970, the number of tractores in use in Brazil increased by 147 percent and fertilizer use increased 223 percent.

II. Brazilian Agricultural Research Services: Background Information

The development of agricultural research services in Brazil has gone through four periods.

1. Pre-Industrial Period - The first period ran from the late 19th Century up to the mid-1940s , when plantation agriculture was at its peak, but there was no defined farm policy to provide clear research objectives at the federal level. Efforts were largely confined to the major export crops such as coffee, cacao and sugar and emphasis was clearly on expanding the agricultural frontiers rather than increasing production per unit area. This period ended as industrialization began to play a more important role in economic policy.
2. Period of Industrial Development Priority - The second period went from the mid-1950s to the mid-1960s when economic expansion of the industrial base was a clear prerrogative and allocation of resources away from agriculture, resulted in less support for this sector, particularly its research institutions. With the gradual withdrawal of support from institutuions, at both the federal and state levels, several went out of existence entirely and research activity was

severely curtailed in others.

3. Pre-EMBRAPA*Period - The third period, which began in the early 1960s and continued until creation of EMBRAPA, is characterized by a broader understanding of the role of agriculture in the economic development process. It has been recognized that expansion of the agricultural frontier alone cannot continue to meet demands from both domestic and foreign markets and that higher productivity per unit area must be part of agricultural policy in the future.

4. Creation of EMBRAPA - Since early nineteen seventies the expansion of agricultural productivity was the main objective of the Brazilian economic policy. The emphasis that till then has been largely on growth,has been shifted towards growth with equity.

   In 1972, a Task Force was formed to study agricultural policy and propose institutional reforms. As a result of its recommendations, the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) was organized late that same year.

   The statutes of EMBRAPA are contained in Law Nº 5.851 of December 7, 1972, which outlines the agency's main functions as follows: (a) direct, control and execute agricultural research activities for the purpose of producing new technology for the development of national agricultural production; (b) assist the Federal executive branch, and its entities, in

* Portuguese acronym for Brazilian Agricultural Research Corporation

technical and administrative matters related to the agricultural sector; (c) stimulate and promote the descentralization of research activities to the benefit of state and local interests; (d) provide technical coordination of research projects, the execution of which involves the technical-administrative services of other Federal agencies; (e) maintain close contact and coordination with the Brazilian Technical Assistance and Rural Extension Corporation (EMBRATER) to effectively execute diffusion of research results and technology, and (f) plan, program and budget research activities to reflect the guidelines and policies established by the National Commission for Agricultural Research, Technical Assistance and Rural Extension (COMPATER).

Since creation of EMBRAPA, the Brazilian Federal Government has decided to invest heavily in agricultural sciences and research, thus fully acknowledging the vital role played by the new technology in boosting agricultural productivity. As a result of this policy, EMBRAPA was allocated 65 million dollars in 1975. This was twice the investment made in agricultural research at Federal Government level in 1973. The budget for 1976 exceeds 100 million dollars. This does not take into consideration the research investment made by State Governments, Universities and Private Sector.

III. Brazilian Agricultural Extension Services (EMBRATER)

1. Background - Technical assistance and rural extension activities in Brazil have long been fragmented, with responsibilities spread among several institutions which, in most cases, provide commodity services in only selected geographic areas.

Till the 1970's the ability to transfer technology to farmers was impaired by the weak financial and institutional structure of the extension system, 1/ plus the fact that Brazilian research operations provided virtually no results that were relevant to the needs of large segments of the farming sector, especially the small farmers in the Northeast. In any case, extension activities were generally limited only to those farmers who were actually receiving credit, the main objective being to assess the credit-worthiness of the client and to ensure that he undertook the technical recommendations necessary to make his enterprise a success.

Since the early seventies the Government started taking positive steps to strengthen the extension system in an effort to overcome institutional and inter-institutional impediments.

1/ Past investigations have indicated that only 20% of available scientific information was transferred to farmers. Moreover, a high proportion of technical assistance flowed only to the larger and more creditworthy farmers.

In mid-1974, the Brazilian Enterprise for Technical Assistance and Rural Extension (EMBRATER) was created as an autonomous entity within the Ministery of Agriculture. It is headquartered in Brasilia and has 24 state extension institutions (formely ACARs), which are now being legally reestablished as State Extension Companies (EMATER) under EMBRATER guidelines. The primary functions of EMBRATER are to collaborate with other agencies of Ministery of Agriculture to formulate and implement policies pertaining to technical assistance and rural extension; and to promote, stimulate, and coordinate technical assistance programs. Centralization of all federal budgetary allocations for technical assistance and extension gives EMBRATER control over the state level agencies, which now will have to comply with EMBRATER regulations if they wish to receive federal monetary support.

2. Interinstitutional Relationships of EMBRATER - EMBRATER regards itself as a catalyst for bringing about technical, economic and social change in the agricultural sector by mobilizing the respective institutions which must contribute to these efforts. At the national level, EMBRATER will coordinate its work with agencies handling research, rural credit, commercialization, rural cooperatives, the supply industry, education, nutrition, health, and vocational training.

3. Relationship between EMBRATER and EMBRAPA - The National Commission of Agricultural Research and Technical Assistance (COMPATER) has been set up as the coordinating link between Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) and EMBRATER and will be responsible at the federal level for synchronizing, reviewing and coordinating programs of both agencies. Members of COMPATER will be one representative of the Ministry of Agriculture, as Chairman; the presidents of EMBRAPA and EMBRATER; one representative each from the Central Bank, the National Farmers Confederation, and the National Agriculture Workers Confederation; and two representatives from groups outside the Government. COMPATER will be jointly financed by EMBRAPA and EMBRATER. Within the two institutions, the Department of Diffusion of Technology (DDT) of EMBRAPA and the Department of Technical Support (DTS) of EMBRATER will act as liaison units. At state level, the representative departments responsible for diffusion of technology in the each institution will work together. The main point of interaction between research and extension is entended to be at the farm level,using extension bulletins. Technological packages are to be prepared as a result of discussions between researchers, farmers,and extension staff.

EMBRATER considers their new focus on projects, as the main innovation in the Brazilian extension system.

Three kinds of projects can be recognized:

(a) projects to increase productivity and improve living conditions;

(b) indirect production support projects; and

(c) projects to strengthen the extension system.

The way resources are allocated to crops, areas,and types of beneficiaries will follow national priorities.

IV. Organizations of Brazilian Agricultural Research in Relation to Universities

In many developed countries, in particular the English speaking group including: the United States, Canada, Australia and New Zeland, much publicly supported research is organized around graduate education program so that the investment in the research process simultaneously generates new knowledge and trains additional research personnel.

According to Ruttan and Hayami : An agricultural research institute or experiment station whose staff does not engage in training as well as research activities looses its capacity for self regeneration.(22)

The tendency to dissociate the research from teaching and advisory services may have an indirect benefit of making the research program mission oriented and responsive to the needs of farmers and consumers rather than scientific interest of academic community.

Eventhough research could be made independent from universities the influence is through graduate work where a student is greatly influenced by the work and interest of his major professor.This prevails over his selection of a topic for thesis as well as his choice of a research

project at the begining of his career with a research institution. Still, the academic community could be influenced to orient its interest and research work toward the solution of specific national problems as estabilished by official guidelines.

According to McDermott, U.S. Land Grant system which has served homeland well, has not been of great use in technical assistance efforts in agricultural development. This may have been due to the fact that the land grant system is characterized by giving considerable freedom to the research worker. (14)

In 1962, the Brazilian Ministry of Agriculture was reorganized and rural universities became autonomous. As a result, agricultural education and research were no longer subordinate to a single administration. This situation still exists.

V. The New Brazilian Agricultural Research System; a Centrally Directed Public Corporation Model

The Reform of Brazilian Agricultural Research Establishment was based on the assertion that relatively autonomous,multi-purpose, locally responsible institutions such as U.S. land grant colleges do not represent a valuable model for developing countries because the social and economic environment,which ensured that these institutes responded to needs of farmers and consumers, is not present in most developing countries.

The social economic and political structure of the poor countries may be such that the price signals of the market get distorted and do not communicate the right indications to research investment.

The subsistance farmers which will be the demanders for technical changes in less developed countries will not be organized in groups capable of ensuring that the research institutions respond to their needs.

Such distortions have been made responsible for reduced efficiency in the performance of earlier Brazilian research organizations. (18)

1. Organization - After the creation of EMBRAPA in 1972, the first two years were spent on the basic studies for the new institutional and operative model through the National Research Centers and State Research Systems. Till now,EMBRAPA was able to create the organizational structure of 16 national centers and organized 24 state representative office with individual research programs. Five States already reorganized their research system into corporation type agencies according to the federal model and, as a result, their program are partially supported by EMBRAPA.

   Eight other states have passed a law creating such systems. EMBRAPA's research is organized mainly on commodity basis. One of primary organizational features that is claimed as superior by the international agricultural research institutes, is the focus on one or at most a limited number of commodities (2) . Priority commodity oriented interdisciplinary programs provide opportunity for a comprehensive system approach, through which National centers deal with specific climates like Cerrado, Humid, and Semi-arid tropics. These centers work on a variety of crop best suited for specific climatic condition A network

of federally supported state experiment stations (UEPAE) can integrate both "commodity" and climatic zone resource programs either directly or through satelite activities of the centers.

The public corporation concept means that EMBRAPA operates like a private corporation. It can use all types of financial and human resources and can sell its service to all kinds of clients. The EMBRAPA's principal product is technology and its primary client, the federal government.

2. Selection of Priorities - Priorities are established by federal and state governments in terms of various products for export and domestic consumption. In this framework, there are two levels of research priorities guiding EMBRAPA's program. The first refers to the projects performed by individual state with EMBRAPA's support and based on a regional priority.The second are projects performed directly by EMBRAPA through national centers or jointly with the State Units when it is necessary. This system combines national priority with region specialization in order to assure transferability of research results. (18)
3. Planning System - The major tool of execution of the whole program is a centralised system of research planning that establishes a methodology that permits the setting of objectives and goals, the selection of the most appropriate measures for their attainment, the choice of ways and means to carry out the

selected measures, the assessment of results and the proposal of adjustments. EMBRAPA has a central planning unit which coordinates the activities of various other units. This unit systematically seeks information about the farm sector through social research or other means.

The EMBRAPA Research Planning System at present is not fully implemented and its implementation is done gradually so as not to disrupt established practices.

4. Transfer of Technology to Farmers - Brazil has accumulated a stock of knowledge that is useful to her agriculture. Farmers are drawing from this stock of knowledge to organize their production systems with the help of the Extension Service. The stock of knowledge is however, insufficient to attend to Brazil's needs. It was generated according to the analytical tradition without paying attention to the idea of production systems. However experience has demonstrated that it is possible to generate some technological packages out of this stock of knowledge. EMBRAPA started organizing meetings for this purpose in 1974. The meetings covered the most important products and regions. Extension people, farmers and researchers met together, on an informal basis, with the objective of organizing available knowledge into technological packages for different classes of farmers (classified according to size of land holding,type of land ownership, etc). Each meeting covers

Table 2

)F EMBRAPA's NATIONAL CENTERS

IN OPERATION - 1976

. National Research Center for Wheat - Passo Fundo, State of Rio Grande do Sul
. National Research Center for Rice and Beans - Goiânia, State of Goiás
. National Research Center for Corn and Sorghum - Sete Lagoas, State of Minas Gerais
. National Research Center for Soybeans - Londrina, State of Paraná
. National Research Center for Rubber - Manaus, State of Amazonas
. National Research Center for Cotton - Campina Grande, State of Paraíba
. National Research Center for Fruit Crops and Cassava - Cruz das Almas, State of Bahia
. National Research Center for Dairy Cattle - Coronel Pacheco, State of Minas Gerais
. National Research Center for Beef Cattle - Campo Grande, State of Mato Grosso
. National Research Center for Hogs - Concórdia, State of Santa Catarina
. National Research Center for Goats - State of Ceará
. National Center for Genetic Resources - Brasília, Federal District
. Agriculture Research Center for Humid Tropics - Belém, State of Pará
. Agriculture Research Center for Semi-Árid Tropics - Petrolina, State of Pernanbuco, and Juazeiro, State of Bahia

. Agriculture Research Center for "Cerrado" Region - Brasília, Federal District

. National Service for Soil Survey and Conservation - Rio de Janeiro, State of Rio de Janeiro.

FIGURE 2

LOCATION OF EMBRAPA's NATIONAL RESEARCH CENTERS

just one product and generates technological packages for a region where the available knowledge is known to be applicable (18).

5. Transfer of Foreign Technology - EMBRAPA makes all possible efforts to bring in technology in terms of materials and certain packages. This seems to be of limited potential in many instances. Among the types of technological transfer, training abroad and hiring foreign professionals are considered as being most aplicable to the Brazilian situation. (18)
6. The Training of Personnel - This program at present could be considered the most important. In Latin America countries the standard degree at research institutes is the "Ingenero Agronomo" which is not basically a research degree. (2) Before EMBRAPA was created only 10 percent of researchers had graduate degrees. The aim of the corporation now is to have at least 80 percent of EMBRAPA's researchers obtain Master's or Doctor'r degrees. (18) Out of some 1200 professional research workers, more than 550 are doing full time graduate work. During the whole study period they are paid full salary and educational allowance.

VI - Role of Economist at EMBRAPA's Agricultural Research Center

EMBRAPA is supposed to have one or more economists in each of the centers in addition to the central office staff located in Brasília. Following is the list of major activities that are supposed to be undertaken

1. Establishing Good Working Relationship With Other Research - Scientists: Agricultural Economist first gets himself, integrated with the other technicians at the Center. He shows interest, asks research questions, listen to answers. The relationship with other agricultural scientists is very important because:
   1) Most economists can learn a great deal from the other scientists at the center.
   2) At times, the needs of the research team may require that the economist be willing to perform functions that are not directly releted to his duties .
   3) By integrating with the research team, the economist can get a better picture of the way in which he can make his greatest contribution.
2. Defining Existing Production System - A major activity of agricultural economists is to help develop knowledge of systems of production in use by farmers. This is a team effort with the economist often playing a coordinator's role. Possible sources of information are:
   1) Surveys - These are prepared in cooperation with rest of the team. Questionnaires are administered with participation of planning team in around 20 % of the sample. Information obtained are: dates of planting, harvest, degree of mechanization, use of fertilizer.

2) Census data - Using agricultural census data comparisons are made of productivity of farms of different sizes and regions, relative importance of different regions and farm size groups in the production of commodities of interest, percentage of rural population dependent on cultivation of the commodity of interest, percentage of commodity produced by intercropping or rotation with other crops, other products produced on same farm, etc.

3) Interviews with farmers, extentionists, bankers, suppliers of inputs. Information which can be obtained from these sources includes: plans and motivations of farmers (income maximizing or some sort of "satisficing"), and institutional distortions or constraints (credit availability and terms of credit for different purpose and for farms of different sizes, problems in timely delivery of inputs, etc).

3. Participating in Development of Technological Packages - The economist when possible acts as one of leaders in the interdisciplinary effort to provide farmers with new technological production packages that have complete economic social science input as a part of the total system approach.

4. Economic Analysis of Experimental Data - This includes:

1) Conventional analysis of profitability.

a) Budgeting - direct calculation of costs and returns of various treatments.

b) Estimation of production functions

2) Alternative analysis with different price assumptions to measure the sensitivity of profitability to price changes, such as to subsidized input and output prices.

3) Risk analysis - the effect of experimental treatments on variability of yields. In many areas of Brazil, both farmers and the Government as a whole are at least as interested in reducing variability, as in increasing yields or profitability

4) Analysis of the adaptability detailed study of any technological innovation situations of farmers of different regions and different scales of operation (does adaption require investment, special skill, etc?).

5) Secondary and tertiary effects of new technology e.g. erosion problems due to changes in management practices, etc.

5. Analysis of Distributional Effects of Potential Innovation - This function is limited to:

1) Combination of information obtained from (4) " economic analysis of experimental data" and (3) "defining existing production system" to project which groups of farmers would be able to adapt potential new technology.

2) Given assumptions regarding demand for a commodity, determination of what will be division of benefits between consumer and producer (analysis of producer's and consumer's surplus).

3) New technology's potential effect on demand for agricultural labor on regional and national basis.

6. Estimation of Labor Requirement of New Technology - Individual experiments can often produce more economic data with slight modifications in the physical researcher's plans (e.g. in cases where plots are sufficiently large, labor requirements for certain operations can be measured, and will not vary much from labor requirements for the same operation on farms).
7. Quantification of future technology - The economist can also contribute through transition from volume - oriented, to value oriented planning; and with the general endeavour to determine the development and research needs of the agricultural & food sector on the basis of economic efficiency.
8. Assistance in Planning of New Research - As a result of information obtained (items 2 through 8), the economist may be able to suggest research which will result in the development of new agricultural technol[illegible] ore appropriate to Brazil's needs.

RELEVANCE OF BRAZILIAN MODEL TO OTHER DEVELOPING COUNTRIES

A model of research systems based on autonomous, multipurpose, locally responsible institutes may not be applicable to coping with the problems developing countries face, and will continue to face as the mal-nutrition situation prevails.

The socio-economic structures of the rural areas of the developing countries will favor a centrally guided research system that will have to be agressive in visualizing the directions its resource uses should go.

Research agencies will have to be aware of social circumstances and by themselves should do the job of discovering the poor farmers needs for technical advances, interpret them and use them as orientation for their own resource allocations.

The reduced resources available to these countries, both human and material, also sugest that a centrally directed system may bettor perform the function of allocation of such resources.

The idea of centrally planned research organizations and program has helped in Brazil to combine the scarce, highly trained scientists into strong and solid interdisciplinary research teams. In Brazil, these teams have been geared toward the solution of the problems on specific products (crop, or livestock); an orientation probably inspired by the structure of the international research centers.

When farmers do not communicate their needs to the Research organization, the central coordination should induce the research agencies to go after them to seek the information required for efficient performance of the knowledge producing process. Efficiency concepts here will be related to time elapsed between the investment in research and the adoption of new technologies by the farm sector. It will be a function of how agressively the research organizations do their job of finding out what to study, how to study, how to communicate their discoveries to the producers. At this point, research and extension get mixed together in a continuum of activities.

Once directed toward the poor farmers needs, it will not be likely that research actions continue to be done on the traditionally compartmentalized academic disciplines. The interdisciplinary approach will prove more fruitfull. Again, in Brazil, the association of the interdisciplinary teams with a systems approach to the farmers problems has been adopted and the hopes are that the time span from the understanding of the problem by researcher to the adoption of new tecnologies by farmers will be curtailed.

The idea of centrally planned research seems to gain more appeal every day, even in countries where decentralized institutions have proven their efficiency in research.. In the United States, for example, both houses of the congress have introduced (and at this time approved) bills aimed at encouraging some centralization in Research Planning.

The local research institutions of developing countries will tend

to concentrate their efforts on applied, adaptative research. Applied adaptative research may be understood as a search for new technology within boundaries of existing scientific knowledge.

POTENTIAL CONTRIBUTION OF BRAZILIAN AGRICULTURAL RESEARCH TO OTHER DEVELOPING COUNTRIES

The capacity for innovating in agricultural technology is essential for agricultural development. McDermott refers to research as the "technological innovation process" (4). Materials and technologies developed for temperate zone agriculture are usually not suited to tropical environments. As a result transfer and diffusion of agricultural technology from temperate to tropical ecosystems through problem-oriented adaptive research becomes important. Capacity to transfer depends heavily on indigenous research capability The strategy of waiting for the neighbor's technology to spill in just does not work. Countries without an indigenous research capacity, benefit very little from their neighbor's (5).

Since technology transfer in agriculture has shown to be limited by geo-climatic factors, it is also important to specific countries that they know where potentially transferrable discoveries of technology and technical knowledge are being made (2).

The low level of real research investment in the major developing country climatic zones, particularly in tropical zones, partly explains the relatively poor agricultural performance in these regions (2). In addition, since most of research was performed by colonial powers and was on major export crops, their research often neglected basic food commodities.

This is why the major commitment and investment in agricultural

research by Brazil with heavy emphasis on major food crops like wheat and soybeans, may play a significant role in contributing to the solution of the Food problem in developing countries.

As Boyce and Evenson have shown, one reason some countries do not invest heavily in agricultural research is due to the fact that "the majority of the gains may flow to other countries depending on the capability of other countries to utilize them" (2). The fact that Brazil is the largest country located in the tropical zone justifies its major investment in agricultural research. However the resulting new technology could easily be shared by other countries enjoying the same climatic condition. Since, as already indicated, only direct investment in research will increase the capability of a country to benefit from the research of its ecological neighbor's (2), Brazilian experience could only benefit those who at an early stage of their development make substantial investment in the field of agricultural and related research.

Agricultural research based activities taking into consideration geo-climate diversity and furnshing the location-specific evidence must be the bases of innovation and new technological packages for all developing countries.

One can finish this section with a reference to a general development policy statement made in the preface of the/Second Report to the Club of Rome According to which:

> Paths of development, region-specific rather than based on narrow national interests, must be, designed to lead to a

sustainable balance between the interdependent world regions and to global harmony ... (15)

UNANSWERED QUESTIONS AND UNSOLVED PROBLEMS

A United Nations study of the socio-economic impact of the introduction of high-yield food grains noted in 1974 that where serious inequalities already existed and resources are not abundant; the technological advances for increased agricultural production may be limited to "those who have superior endowments of land and social status, to the exclusion of the poorer majority".(16) In other words, since high-yielding varieties require relatively high levels of fertilizer and water for maximum yield; the many small, poor farmers of the developing world are being left behind.

In terms of equity consideration it became increasingly apparent that in many cases, the application of advances in agricultural technology, such as those associated with the Green Revolution, were increasing in both absolute and relative terms the income disparities between poor and rich farmers in developing countries. (16)

In other words the new high yield agricultural technology resulting from the successes of Green Revolution was not "scale neutral". There is growing evidence to suggest that without a considerable amount of adjustment to local circumstances the technological packages, now available or being developed , will not help small farmers. (16)

The traditional system developed during centuries by small scale farmers provided for stability of yield, at least at subsistance level, and served the basic need of the rural community. This systems was established

so as to guarantee the subsistance of farm families in good and bad years.

The explanation is that agricultural research institutions are producing a modern agricultural technology with high-yield hydrid plant varieties that can produce when and if their specialized needs for water and agrochemicals are met on time. As a result taking advantage of the new seeds and new methods of cultivation, requires increased expenditure on seeds fertilizer and other inputs, plus the availability of sufficent water at a particular time: "Stated differently, the new technology plans the needs of plant ahead of those of the producer" (16).

This century saw development of capital intensive labor saving agricultural technology in the United States. It also saw development of land use intensive technology in Japan . The new challenge is to create labour - intensive, land and capital saving technology for small scale farmers in developing area. Whether the modern technique of plant design through genetic architecture based on somatic or body cell reproduction can or can not create this technology is an open question. Till now very little progress has been made in this line. The problems of application, on the farm by farmers, have not yet been touched.

Other policies like: more equal distribution of land, mass migration to new sparcely populated areas, sea farming, industrialization resulting in employment possibilities in urban areas, all can contribute to the solution of the problem of the small farmer.

The major thesis of this paper is that existing and potential agricultural technology resulting from appropriate planning can solve the

food crisis as an agricultural production problem. This does not necessarally mean that the poverty can be eliminated among urban poor and subsistance farmers in developing countries.

A possible approach to the problem of the small farmer is instead of considering him as potential full time agricultural producer, take him as an under employed rural dweller who at best could be made into a successful part time farmer and has to be provided with supplementary employment.

If new technology is developed for this group it could also be applied as a way to help poor urban dwellers to grow part of their food by providing them with small plots of land on a rental bases close to urban zones.

The paper while covering a large number of topics has not taken separately the role of social and behavioral scientists in relation to agricultural research of the food crisis.

It seems that the major contribution of this group will come in providing insights on solution of small farmer's agricultural and food production problem.

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

Food and Rapid Population Growth

The rapid increase in world population creates the major urgency to increase food production.

1. Government Food Policy - The governments of developed and developing countries must be willing to take action not only in the face of hunger, but concentrate on long range aspects of the food problem.

2. Worldwide Distribution of Food - World food supplies are, and probably will be, distributed in accordance with purchasing power or effective demand and not according to nutritional requirements.

3. Permanent Solution of Food Crisis - Permanent solution includes: population control and major efforts to plan agricultural research directed toward a long term solution of the agricultural production and food supply problem, particularly in those climatic zones where very little research has been historically undertaken.

Agricultural and Research Policy

1. Practical Agricultural Research Policy - The agricultural research policy must be based on the fact that the objectives of agricultural research are not academic or speculative. The objective when possible must be strictly practical and oriented

towards the improvements of agricultural production, and the living standard of the agricultural producer.

2. National Research Program Based on Innovations - A complete national research program should take into consideration the nature of future innovations and technology; and proceed to evaluate the impact on, and the response of the economic, social, and political sectors to these potential changes.

Economic and Social Criteria for Setting Research Priorities

The nature and the objectives of research programs are to be determined by the stage of development of the economy.

1. Initial Development Stage - Estimate present and future economic importance of various commodities and then divide research in proportion to the increase of economic importance of each one of th

2. Intermidiate Development Stage - Allocate research resources according to income elasticities for different agricultural products and various other aspects of products such as quality, quantity, services convenience, etc.

3. Advanced Countries - Quantify potential growth targets of various crops based on visualized new technologies and divide research resources according to estimated marginal value of the new technolog in relation to the existing level.

4. Some Reservations - In general one can say the there is no single method or technique on which decision making could or should be based. The need for informed judgement

must be accepted, and that further exploration of methodologies is necessary.

Economic and Institutional Analysis in Agriculture Research

1. Need of Economic Analysis - All problem oriented research programs must have an economics component directed specifically at the economic issues associated with the major technological problems to be attacked.
2. Micro-Economic Analysis - First economic analysis should evaluate the economic and social factors at the micro level of generated technologies. These include:
   a. Design of physical/biological experiment to permit efficient economic analysis.
   b. Production function analysis of experimental and related data.
   c. Determination of optimal systems of farming.
   d. Product and input price and marketing research.
3. Macro-Economic Analysis - In addition to micro-economic considerations economists in association with other social scientists must consider aggregate macro-economic issues. Four of the most significant of these issues are:
   a. Internal and external supply and demand studies for food and other agricultural commodities given priority in research programs.
   b. Internal and external supply and demand studies for inputs

or factors of production.

c. Regional disparities and other potential problems associated with implementation of new technologies.

d. Relative price structure of major agricultural input in relation to food and other agricultural products.

Economic Evaluation of Research Impact

These studies should evaluate the impacts of the research findings in terms of their effects on growth, equity and risk bearing potentialities of the new techniques created or to be created.

Economic Analysis of Food Shortage Problem

A new approach has to be developed in evaluation of cost and real value of various food crops in terms of nutrients. (e.g. Billion Calories)

Theorethical Considerations in Agricultural Research

The progress of agricultural research can best be understood with the help of theory and with examination of past experiences.

1. The Theory of Induced Innovation-According to this theory, factor endowments provide the motivating power for technical change in agriculture.
2. Social Interest Groups as Determinators of Research Policy - According to this theory, technical change is a cummulative process in which socioeconomic and political-bureaucratic structures interact to define the demand for and the supply of new technologies.
3. The Application of Theory to Real Situation - United States and Japan departing from an entirely different factor

endowment situation had their agricultural research induced toward saving the scarce resources, land in Japan and labor in United States.

In both theories a few elements play key roles. The first emphasizes the natural supply and demand forces showing through the factor, and product prices the signals of scarcities. The second places emphases on the socio-economic political structure. Both of them recognize the role of the available scientific knowledge and of the body of trained personal to sense the market orientation or to follow the commandments of the governing structure, The power of the society plays an important role in the second model.

Formulating Agricultural and Food Research Programs

A new organization structure is proposed based on the concept of "mission-oriented systems approach".

1. Objectives
   a. To develop conceptual definitions and methods for structuring agricultural research efforts toward improvement of Food supply systems.
   b. To develop concepts and frameworks for establishing short and long range dynamic R and D programs, maximizing the tangible benefits resulting form R and D.
2. Agricultural Research Planning
   a. The essence of planning - planning is identified with the

future consequences of present decisions.

3. Agricultural research planning procedure - To increase the likelihood that useful information will, in fact, result from research activities, the research must be planned and a complete set of methodology has to be developed.
   a. Systems analysis - Research planning should begin with suitable identification and analysis of the system or systems of existing and potential production technology.
   b. Information analysis - The second starge in planning research should be an information analysis that reveals the existance and adequacy of available information on the system under study.
   c. Economic analysis - Once all information available and needed have been established the research strategy should take into consideration the interrelationship between technical and economic change.
   d. Program formulation - The fourth step in agricultural research planning is to formulate a research program whose goals cover the information needs of economically justified research.

Results of Agricultural Research in the United States

The value of agricultural research and technology development has been demonstrated in the United States and other developed countries.

According to U.S.D.A. published indices of agricultural productivity, the ratio of outputs to inputs per acre in 1972 as compared

to the mid thirties has risen by 45 percent. The production per man hour has more than doubled. The number of people supplied by each farmer has risen from 15 to 52. During this same time, the acreage harvested per consumer has been reduced by nearly one half.

The rate of return on additional investment in agricultural research and extension has been 45 to 50 percent per year over past 40 years. This has kept food prices low. Americans spend about 16 percent of their income on food.

A considerable amount of the success was due to a continuous and large amount of effort directed to agricultural and related research that created the largest and most efficient agricultural production machine in the world.

Historic Scarcity and New Interest in Agricultural Research in Tropical Regions

1. Past experience - The low level of real research investment in the major developing country climate zones, especially in the tropical and desert zones, partly explains the relatively poor agricultural performance of these regions.
   The relatively small amount of agricultural research effort undertaken and performed in tropical conditions till now did not show great food and other agricultural production possibilities.
2. New developments - Lately many research Institutes, national as well as international, are seen and recognised as promising contributors to boosting food production.

The effect of increase in research investment was dramatized by the Green Revolution Development effects.

It was realized that the unused available resources of land are not located where the imbalance in the rates of growth of population and food is more intense. This, places additional burden on the need to increase yield of the available and already utilized resources.

Illustration of Potential Importance of Agricultural Research in Tropical Zones

The following are the first three of a list of ten recommendations of agricultural research priorities made by the Board of Agricultural & Renewable Resources of U.S.

1. Expand research on photosynthesis so as to increase crop productivity.
2. Strengthen research on biological nitrogen fixation to establish coordinated programs for developing field demonstrations.
3. Develop techniques for genetic manipulation beyond those of conventional plant breeding, including in vitro technique for asexual approaches, and broad-crosses between crop species.

Tropical areas with abundant intensive solar radiation and continuous growing seasons with large amount of water supply, present much higher potential for these kinds of experiments and the resulting technology than do temperate zones with limited growing seasons. Temperate zones are often deficient in solar radiation,

growth and activities of soil bacteria are practically stopped for nearly half or larger part of the year.

In addition, a large number of tropical plants till now very little exploited in terms of possible food production, present the greatest challenge for genetic architects to introduce desirable characteristics like increasing protein content of some tree crops.

Brazil and its Commitment to Agricultural Research and Development

I. Economic Growth and Agricultural Potential

The research and the rapidly growing literature on economic and agricultural development in Brazil shows that it holds untapped and underutilized agricultural resources that in due time could become one of the important breadbaskets to help feed the hungry world.

II. Brazilian Agricultural Research Services: Background Information

The development of agricultural research services in Brazil has gone through four periods.

1. Pre-Industrial Period - The first period ran from the late 19th Century up ot the mid-1940s, when plantation agriculture was at its peak.
2. Period of Industrial Development Priority - The second period went from the mid-1950s to the mid-1960s economic expansion of the industrial base was a clear prerrogative in the allocation of resources.

3. Pre-EMBRAPA Period - The third period, began in the early 1960s and continued until creation of EMBRAPA, in 1972.

4. Creation of EMBRAPA - The Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA (portuguese acronym for Brazilian Agricultural Research Corporation), was organized in 1972. Since creation of EMBRAPA, the Brazilian Federal Government has decided to invest heavily in research on agricultural sciences The budget for 1976 exceeds 100 million dollars.

III. Brazilian Agricultural Extension Services (EMBRATER)

1. Background - Technical assistance and rural extension activities in Brazil have long been fragmented. Since the early seventies the Government started taking positive steps to strengthen the extension system. In mid-1974, the Brazilian Enterprise for Technical Assistance and Rural Extension (EMBRATER) was created as an autonomous corporation within the Ministery of Agriculture.

2. Interinstitutional Relationships of EMBRATER - EMBRATER regards itself as a catalyst for bringing about technical, economic and social change in the agricultural sector. At the national level it, coordinates its work with agencies handling research, rural credit, commercialization, etc.

3. Relationship between EMBRATER and EMBRAPA - The National Commission of Agricultural Research and Technical Assistance

(COMPATER) has been set up as the coordinating link between (EMBRAPA) and EMBRATER and will be responsible at the federal level for synchronizing, reviewing and coordinating programs of both agencies. The main point of interaction between research and extension is intended to be at the farm level, where technological packages are to be prepared as a result of discussions between researchers, farmers, and extension staff.

IV. Organizations of Brazilian Agricultural Research in Relation to Universitie

The tendency is to dissociate the research from teaching and advisory services tends to make the research program mission oriented and responsive to the needs of farmers and consumers rather than scientific interest of the academic community.

V. The New Brazilian Agricultural Research System; a Centrally Directed Public Corporation Model

The social economic and political structure of the poor countries may be such that the price signals of the market get distorted and do not communicate the right indications to research investment. Their social and economic environment often ensures that research institutes do not respond to need of farmers and consumer.

1. Organization - EMBRAPA's is a public corporation, which means that operates like a private corporation. Thus it can use all types of financial and human resources and can sell its servies to all

kinds of clients. The EMBRAPA's principal product is technology and its primary client, the federal government.

2. Selection of Priorities - National priorities are established by the federal, and regional priorities by the state governments in terms of products for export and domestic consumption.

3. Planning System - The major tool of execution for the whole program is a centralised system of research planning that establishes a methodology which permits the setting of objectives and goals, the selection of the most appropriate measures for their attainment, and the choice of ways and means to carry out th selected measures.

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5. Transfer of Foreign Technology - Training abroad and hiring foreign professionals are considered as being most aplicable to the Brazilian situation.

6. The Training of Personnel - Out of some 1200 professional research workers, more than 550 are doing full time graduate work. During the whole study period they are paid full salary and educational allowance.

VI. Role of economist at EMBRAPA's Agricultural Research Center

Following list of activities are recommended to agricultural economists.

1. Establishing Good Working Relationship With other Research Scientists
2. Defining the Existing Production System
3. Participating in Development of Technological Packages
4. Performing Economic Analysis of Experimental Data
5. Making Analysis of Distributional Effects of Potential Innovation
6. Estimating of Labor Requirement of New Technology
7. Quantifying of Future Technology
8. Assisting in Planning of New Research

elevance of Brazilian Model to Other Developing Countries

The socio-economic structures in the rural areas of the developing countries will favor a centrally guided research system that is agressive in visualizing the directions its resource should be used.

The idea of a centrally planned research organization and program has helped in Brazil to combine the scarce, highly trained scientists into strong and solid interdisciplinary research teams.

When farmers do not communicate their needs to the Research organization, the central coordination should lead the research agencies in their performance of the knowledge producing process.

In Brazil, the association of the interdisciplinary teams with a systems approach to the farmers problems has been adopted,and

hopefully the time span from the understanding of the problem by researcher to the adoption of new tecnologies by farmers will be shortened

Potential Contribution of Brazilian Agricultural Research to Other Developing Countries

The capacity for innovating in agricultural technology is essential for agricultural development. McDermott refers to research as a technological innovation process. The key is in the transfer and diffusion of agricultural technology from temperate to tropical ecosystems through problem-oriented adaptive research. Capacity to transfer depends heavily on indigenous research capability.

It is also important to specific countries that they know where potentially transferrable discoveries of technology and technical knowledge are being made.

Brazilian model of centralized agricultural research system is a potential partial solution to food crisis through increased food production in Tropics using the new technology which it hopes to produce.

Agricultural research-based activities taking into consideration geo-climate diversity and furnshing the location-specific evidence must be the bases of innovation and new technological packages for all developing countries.

Unanswered Questions and Unsolved Problems

The application of advances in agricultural technology,

such as those associated with the Green Revolution seem to increase in both absolute and relative terms,the income disparities between poor and rich farmers in developing countries.

The new challenge is to create labour-intensive, land and capital saving technology for small scale farmers in developing areas. Whether the modern technique of plant design through genetic architecture based on somatic or body cell reproduction can or can not create this technology is an open question.

The papers offers an optimistic view on the solution food crisis as a production problem. However, clearly states that:

1. Rural development strategy designed to improve the economic and social life of the rural poor is still an unsolved problem.

2. The role of social scientist has not been clearly defined within the context of the food crisis and also constitutes an unanswered question.

FINAL REMARKS: GENERAL POLICY RECOMMENDATION

Importance of Agricultural Research

Despite great difficulty inherent in trying to predict the future, the authors of this paper believe that current decisions concerning agricultural research, particularly in developing countries will be instrumental in producing food in the future.

Categories of Agricultural Research

Two broad groups can be recognised:

1. Research that serves the scientific community
2. Research that serves the public - This kind of research must be mission-oriented or problem solving research. Over the years the agricultural research program, which was strongly production has made significant contribution to farming efficiency in the United States and thereby, directly & indirectly to the whole world. This also helped in concentrating Food Production in temperate zone on a worldwide bases.

Scientific Frontier

In the long run, increased understanding of the biological principles underlying agricultural productivity will provide the major contribution. In the short run, however, problem oriented adoptive research can considerably increase agricultural & food production.

Biological Research Orientation

Research should focus on ways of decreasing dependence upon chemically synthesized nitrogen fertilizer, and on increasing the supply of biologically fixed nitrogen by forage and grain legumes and nitrogen-fixing associations of microorganisms with grasses, shrubs trees, lichens, and marine organisms, and the design of new cropping systems.

Socio-economic Aspects Agricultural Research

As far as social science policy is concerned the action oriented research must shift the focus from the character and personality of the farmer to the socio-economic conditions that lead him to accept or reject changes.

Certainly we need to know far more than we do about the economic social and political relations in agriculture and we know even less about the relations between the rural farm and urban group. These, for most part, are untouched territory. Research on resource development and public policy can also stand expansion.

Chief Objective of Research

Chief objective of agricultural research and development must be to increase welfare where human misery is the greatest. Some parts of tropics constitute such areas.

Need for Sound Agricultural Policy

A sound agricultural policy, correctly articulated with the national development policy as a whole, is essential if the national goals are to: increase food output, improve nutrition and cope with the interaction between food supply and growth of population .

Limitation of Effective Demand

Eventually the place where additional food can be produced and the place where food is needed will not be the same.

The commercial demand for agricultural and food products will continue to be closely tied to world economic conditions.

A food crisis in the world poverty belt will not create effective demand. This is because impoverished and malnourished people can not get their foodstuffs in the market. Since market can not indicate actual need, the situation may require a new way of sensing how research will react in response to food scarcity. 'Centralized planning of food production research by each country and the coordination of their efforts on an international level may be the best solution to this world crisis. It is hoped that the Brazilian Model described in this paper is a correct step in this direction.

Today's World Food Production system was build mainly by and for the people of temporate climate. The people who live in the tropical climates can use this experience to build one for themselves.

REFERENCES

(1) ARNON I, Organization and Administration of Agricultural Research, New York: Elsevier Publishing Company Ltd. 1968.

(2) BOYCE, JANES K. and EVENSON, R.E. National and International Agricultural Research and Extension Programs. New York: Agricultural Development Council Inc., 1975.

(3) CASTRO JOSÉ P.R. and SCHUH G.E. Um Modelo Econômico Para Determinar Prioridades em la Investigacion Agrícola y una Prueba para la Economia Brasileira (original in english) in Metodos para la Investigacion Agrícola aplicad en America Latina - CIAT, CALI, 1975.

(4) DE JANVRY, Alan. The Organization and Productivity of National Research Systems ADCRTN, Conference on Resource Allocation in National and International Agricultural Research, New York, 1975.

(5) EVENSON, Robert E. Comparative Evidence on Return on Investiment in National and International Research Institutions, Conference on Productivity in International Agricultural Research, Airlie House, Virginia, January 1975.

(6) _____ Economic Aspects of the Organization of Agricultural Research (in) Walter L. Fishel's. Resource Allocation in Agricultural Research, Minneapolis: University of Minesota Press, 1971.

(7) _____ and KISLEV, Yoav. Agricultural Research and Productivity, New Maven: Yale University Press, 1975.

(8) HAYAMI, Y, and MASAKATSU A. Efficiency and Equity in Public Research: Rice Breeding in Japan's Economic Development, American Journal of Agricultural Economics, Vol. 57 nº 1, February, 1975.

(9) HAYAMI J. and RUTTAN V. Agricultural Development, an International Perspectives Baltimore: The Johns Hopkins Press, 1971.

(10) HEADY E.O. Agricultural Problems and Policies of Developed Countries. Oslo: Farmers Publishing Ltd., 1966.

(11) HERTFORD R. ARDILA J. ROCHES A. TRUJILLO C. Productivity of Agricultural Research in Colombia, New York, ADCRTN,1975.

(12) KISLEV Y, and RABNERI URI. Animal Breeding, A Case Study of Applied Research, The Hebrew University, Rehovot, Israel (mimeographed)

(13) LAMBORG M, RIES S.K., TSCHIRLEY. F.H., WITTWER S.H. Crop Productivity Research Imperatives - An International Conference Sponsored by Michigan State University, Agricultural Experimental Station and The Charles F. Kettering Foundation, East Lansing: Michigan - Kettering, 1975.

(14) MACDERMOTT, J.K. The Technology of Technological Innovation, mimeographed Washington, 1975.

(15) MESAROVIC, MIHAJLO and PESTEL, Eduard. Mankind at the Turning Point, The Second Report to the Club of Rome, Bergenfield: New American Library 1974.

16) MORSS Elliott R. et alii. Strategies for Small farmers Development, Boulter Westview Press, 1976.

(17) MOSEMAN A.H. Agricultural Sciences for Developing Nations, Washington American Association for Advancement of Science, 1964.

(18) PASTORE J. and ALVES Eliseu R.A. Reforming the Brazilian Agricultural Research System, Prepared for the Conference on Resource Allocation and Productivity in International Research, Airlie House, Virginia January, 1975 (mimeographed)

(19) PETTERSON, W. Economic Return to Public Investment in Agricultural Research and Extension, mimeographed, St. Paul University of Minesota, Economic Development Center, 1975.

(20) _____ and FRITZHARRIS J.C. Productivity of Agricultural Research in the United States, New York ADC/RTN, 1975.

(21) Population Food and Agricultural Development Report of a Seminar Organized in collaboration with the Food and Agricultural Organization the United Nations and the United Nations Fund for Population Activities, Rome, December, 1975.

(22) RUTTAN V.W. and HAYAMI Y. Strategies for Agricultural Development, Food Research Institutes Studies,Vol. II, nº 2, 1972.

(23) SALMON S.C. and HANSON A.A. The Principles, Practices of Agricultural Research, London, Leondvd Hill, 1964.

(24) SCHUH G.E. Some Economic Consideration for Establishing Priorities in Agricultural Research (mimeographed), 1972.

(25) SCOBIE GRANT M. POSADA RAPEL T. The Impact of High Yielding Rice Varieties in Latin America, with special emphasis on Colombia, A Preliminary Report, Cali Colombia, CIAT, 1976.

(26) SISLER, D.G. The World Food Situation: What is the U.S. Role? Ithaca in, Cornell Agricultural Economics Staff Paper nº 75-7, 1975.

(27) TYBOUT RICHARD A. (ed). Economics of Research and Development, Columbus, Ohio State University Press, 1965.

(28) ULBRICHT, T.L.V. Summarry Report of Meeting for the Study of the Relationships between Agricultural Research and its Socio-economic Environment, Organization for Economic Co-operation and Development, Directorate of Agriculture, PARIS, December, 1975.

(29) U.N. Food and Agricultural Organization, Commodity Review and Outlook, 1974-1975 Rome, 1975.

(30) U.S. Department of Agriculture-Beef Production, ARS, NRP, nº 20360. USDA, Program nº 22678 - Draft, January, 1976.

(31) U.S. Department of Agriculture ARS Management and Planning System, Progra Structure, Concepts Guidelines, For Development ARS-NRP's Implementation, Washington, March, 1976.

(32) U.S. Department of Agriculture E.R.S./F.A.S. Outlook for U.S. Agricultural Exports, Washington, May, 1976.

(33) U.S. Department of Agriculture - The Farm Index, June, 1976.

(34) World Food and Nutrition Study, Enhancement of Food Production for the United States, a Report of the Board on Agriculture and Renewable Resources, Washington D.C. National Academy of Sciences, 1975.

(35) World Food Nutrition Study - Interim Report of the Sterring Committe, Washington D.C. Washington D.C. National Academy of Sciences, 1975.