

THE CHALLENGE OF AGRICULTURAL RESEARCH IN BRAZIL

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INTRODUCTION

Historical experience shows distinct agricultural stages in the process of economic development. During the initial stage, production is almost exclusively limited to food and fibers. Industrial production is in its initial phase, and the service sector is not important. Technology is based on the utilization of land and labor; investments in physical and human capital are inexpressive and illiteracy is high. Natural factors determine demographic growth. These are mainly the availability of food and the occurrence of diseases. Birth rates and mortality are high, while family planning is not practiced. The population is predominantly young and rural, at equilibrium as determined by the availability of food, or increasing at a fast rate. Per capita income is relatively low.

The primary function of agriculture is to provide employment and subsistence for the rural population. Its other function, that of producing for the urban population, is of low importance since most of the production is consumed locally. The exception occurs when an export sector exists producing for the external market. Climatic variations largely account for production fluctuations. Land is an independent production factor since investments for the purpose of maintaining or increasing its productivity are insignificant.

After a transitional period, the final phase of agriculture during the process of economic development represents the extreme opposite of the first phase, making it a part of a post-industrial development civilization. Agricultural and industrial production are dominated by the service sector which has become the most important one in terms of creating income and employment.

Technology is based on the intensive use of physical and human capital in all sectors. The predominant investment is in human capital.

During this phase, natural factors like local food supply have lost much of their importance in controlling population as birth control methods are increasingly adopted for this purpose. The decision to have children is now, to a certain extent, determined by the costs of education and training rather than by availability of food. As time passes, the population, now located in urban areas, tends to grow old and even to decline in absolute number.

Agriculture's primary function is to produce surpluses to be sent to the cities or to international markets. Its capacity to offer employment is limited, and it is extremely capital intensive in its use of physical and human resources. Production fluctuations are less dependent on climatic variations. Land loses its characteristic as an independent production factor, becoming part of capital due to large investments aimed at an increase in its productive capacity.

In general terms, the structural evolution passes through the following phases: an essentially agricultural phase, industrialization, and finally the predominance of the service sector. In recent times in developing countries, as a result of high rural-urban migration, the service sector has been growing simultaneously with the industrial sector. However, this only includes that part of the service sector capable of absorbing poorly trained labor that is available in excess of industry's capacity to absorb it. This is in contrast to the growing service sector in developed countries dedicated to highly skilled activities such as the arts and entertainment.

The energy crisis caused a sharp polemic regarding the rationality of the course described above, since countries close to the "final phase" have a very high per capita consumption of fossil energy which would deplete the limited reserves in a relatively short period of time. This kind of argument does not consider the possibility of developing alternative sources of energy as well as of creating technologies which avoid the wastes now observed. It also does not consider the possibility of the reorganization of society so as to modify consumption levels and thereby slow down the depletion of essential energy and the resulting fall in living standards.

The stage of development of a country, in the course of the events described, greatly influences the orientation that its agricultural research should follow. If urban and industrial growth is of such magnitude, that in a time span of 20 to 30 years a significant part of the rural population will have migrated to the urban areas, it will not be worth the effort to dedicate a significant part of researchers'

time to subjects which are mainly pertinent to small-scale and subsistence agriculture, often referred to in relation to the present conditions of certain areas as "appropriate" or "intermediate" technologies. These include intercropping two or more crops that cannot be mechanized, or the use of animal drawn machinery. The justification is that the time needed for the completion and diffusion of these projects can easily vary from 10 to 20 years or more. In this case, a major part of research with long completion and diffusion times, should be directed toward commercial agriculture, already existing or in process of implementation, since small-scale subsistence farmers will probably leave agriculture before special small-scale technology, if any, becomes available to them. Mechanization technologies will acquire importance while those of a biological nature should be directed toward high productivity goals for land. It is important that land be considered as a reproducible capital, created by man. Technologies, which help reduce production fluctuations due to climate and save on increasingly costly modern inputs and research areas such as irrigation, integrated pest control, nitrogen fixation, etc. should be given special attention.

Brazil must learn to live with a mixed system of research priorities that takes into consideration the commercial agriculture of the Center-South and the great pocket of subsistence agriculture in the semi-arid Northeast. Conditions will continue favorable for subsistence agriculture for a long time period, unless a great investment is made in primary education, health facilities and other infrastructure in rural areas. It is believed that the Amazon region will be developed with a technology close to the level of commercial agriculture, although the situation there is still quite uncertain. Commercial agriculture with a sophisticated technology exists side by side with traditional agriculture, which is making headway in the jungle without dominating it.

ECONOMIC DEVELOPMENT POLICY

The description of economic policy will be given in general terms, omitting regional differences, in an attempt to summarize how Brazil followed its path of economic development. This sets the stage for the following section in which the question of the direction in which agricultural research is heading is discussed.

1. Beginning of Industrialization

The industrialization, which took place before World War II, was not brought about by the government. It was much more the result of the relative difference in actual and potential return on investment between industry and agriculture.

Beginning with World War II, government policy was deliberately designed to substitute imports and to transform Brazil into an industrialized country.

Among the factors that brought about this policy, the following should be cited:

- a. **The Great Depression** – the principal source of foreign exchange and of income at the time was coffee. Suddenly its price collapsed causing a general insolvency. It was painful to realize what it means to have a national income so closely dependent on a single crop and sector;
- b. **Necessity to Diversify the Labor Market** – It was necessary to diversify the labor market and national production in order to meet national objectives elaborated during the Revolution of 1930, which called not only for political reforms, but also for economic modernization as well. A necessity was felt to substitute imports so as to alleviate pressures on the balance of payments;
- c. **The Two World Wars** – During the course of the two World Wars, Brazil was left deprived of indispensable industrial products. It was not only the fact that the relationship of prices, between what the country was exporting and what it was importing, had changed, but that it was unable to acquire industrialized products;
- d. **Prebisch's Thesis** – There were two dominant currents of thought in the Third World concerning economic development. Although advocating different routes, both indicated industrialization as the solution to problems of stagnation of the agrarian economies of America, Asia and Africa. They also represented a reaction against the attempt to organize international commerce on the principle that the developing countries should export raw materials and import industrialized products. This was, in fact, the conclusion that could be drawn from the law of comparative advantages applied to international commerce. According to Prebisch's thesis, this exchange arrangement was unfavorable to countries with agrarian economies who were continually obliged to apply more labor in order to import a product unit. The two sector models (Lewis 1954) formalized by Fei & Ranis (1964) assumed the existence of excess manpower in the rural areas (zero marginal productivity for the agricultural labor). Industrialization was the solution for economic use of this surplus labor. When the marginal productivity of

labor became positive, it would be time to introduce technological progress into agriculture, or at that time, expand the cultivatable areas in order to avoid a fall in production. This fall in production would reduce the purchasing power of urban salaried workers. It would be necessary to increase salaries, with a consequent reduction in savings. The strategy was to maintain the latter at the highest possible level. The rate of technological progress in agriculture (or of expansion of the cultivated area) would be equal to population growth. The income elasticity of food was erroneously considered to be zero.

Brazil chose expansion of its cultivated area because of its immense agricultural frontier. Agriculture was not supposed to compete with the industrial sector for capital. Many of the problems Brazil faces today resulted from this option, since both the theory of negligible income elasticity for food and the idea that industrialization would eliminate the balance of payments problems were false.

2. Industrialization Policy

Industrialization was based on the following policies:

- a. **Protection Against International Competition** – Various legal devices were employed. Quantitative controls were imposed on importation from 1947 to 1954, while multiple exchange rates were used in the period 1953-57. Tariffs (ad valorem) were introduced in 1967. From 1964 to 1973, a substantial reduction in barriers to international commerce, as well as a change in foreign trade philosophy, took place. While in the early period, the feeling had been against participation in the international market, either as an importer or an exporter; an aggressive export policy was subsequently adopted. With the petroleum crisis of 1973, it became necessary to restrict imports, and controls were once again applied. However, a favorable attitude toward exports continued.

The policies on international commerce succeeded in protecting industry. They were successful in overvaluing the cruzeiro and resulted in the transfer of large quantities of resources from the agricultural to the industrial sector (Bergman & Candal, 1969 and Fishlow (1967).

- b. **Easy Access to Capital** – Besides an overvalued cruzeiro and a reduction in the cost of imported capital, there were lines of credit at special rates

and maturity dates which greatly favored industry.

- c. **Special Conditions to Attract Industries** – These included exemption from taxes and various forms of association between industry and the federal and state governments.
- d. **Heavy Investment in Infrastructure** – Most of the investment was concentrated in the urban infrastructure, in energy and in transportation.
- e. **Stable Salaries for Urban Workers** – These were essential in order to reduce social investment in urban centers and to maintain a high level of profits, and therefore the capacity to invest. Indexing of salaries based on inflation was instituted. This course of action strongly discriminated against agriculture. The internal price policy frequently resulted in price controls and even in threats of confiscation, and in importation of food at times, reducing drastically, for short periods at least, internal prices at the farmer level. The products which suffered most were those intended for supplying food for the internal market such as rice, beans, corn and milk.
- f. **Government Participation in Economic Activities** – The government had at its disposal large sums of resources and entered into sectors which were considered strategic, by means of large state enterprises. In the energy sector, two monopolies, Petrobras and Eletrobras, are the examples. In mining and heavy industry, it competes with private industry, as it does in the financial sector, where its participation is substantial through development banks and even commercial banks. In agriculture its presence is felt through economic policy.

3. Consequences of the Economic Development Policy

The consequences of over-all economic development policy for agriculture were as follows:

- a. **Demographic Growth and Urbanization** – The improvement in living standards, as a consequence of urbanization, resulted in high rates of population growth. In the 1940-80 period, Brazil's population went from 41 million to 123 million inhabitants as the result of an annual growth rate of 2.7%. At the beginning of the period, the population

was 69 percent rural; at the end, 69 percent urban. These changes in population size and location resulted in considerable growth dispersion and diversification in the market for agricultural products.

- b. **Urban Rural Disparities** — In 1940, while the process of industrialization was still in its initial stages, it was normal that the average productivity of labor (based on the concept of per capita income; in fact the true parameter is marginal productivity) was greater in urban areas. During the course of industrialization, as a result of high rural-urban migration, a convergence of average productivities would have been expected. Table 1 shows a greater divergence in 1970; in 1980 the ratio returned to levels of the 1950-60 period. In effect, in 1950 an urban worker produced worth 4.1 times that of the rural worker. In 1970, this relationship increased to seven times, then falling to 3.8 times in 1980. Consequently, the tendency was to maintain the urban-rural disparity in regard to average productivity. Rural-urban migration, although very intense, was not able to bring together the average productivities of the two sectors. Among the causes that increased the disparities in the 70's are the following:
1. In the 1960's, the gross national agricultural product decreased at a rate of 0.1%. This decline resulted from a drastic reduction in the production of coffee at the end of the decade. Between 1969 and 1970, the physical production of coffee decreased nearly 31.7% as a result of the 1969 frost and the spread of coffee rust.
 2. The non-agricultural gross national product grew at the elevated rate of 9.8% per year;
 3. Rural-urban migration intensified in this decade. The growth rate of the rural population in comparison with that of the 1950's decreased substantially, while that of the urban population remained unchanged. However, the greater intensity of migratory movements did not succeed in counterbalancing the difference in the levels of gross national product of the two sectors.
- c. **Rural Urban Migration** — The disparities in per capita income growth between the two sectors in the decade of the 1960's sharpened the rural-urban migratory flux in the 1970's to the point where the rural population decreased and the gross national product of the two groups grew at practically the same annual rate (rural - 10.2%; urban - 10.1%).

The intensity of the migratory movements caused average productivity of the urban worker in 1980 to fall, in relation to that of the rural worker, to a point slightly lower than that of 1960.

The lack of convergence of average productivities indicates that the factors which are behind the rural urban migration phenomenon continue active in the economy, contributing towards the rural exodus which took place earlier in the industrialized countries. Table 1 shows that the cities are growing at very fast rates compared with those of the rural areas and with the population as a whole. In the 1970's, for the first time, the rural population decreased by some 2.4 million inhabitants. The reduction in the growth rate of the urban population in the 1970's, as compared with the preceding decade, is proportional to the decrease of the overall population growth.

TABLE 1. Ratios between average production of the urban and rural worker (GNP per economically active persons) and geometric growth rates of the rural and urban population in percentage.

Years	The ratio between Urban and Rural per capita GNP	Population Growth Rates			
		Periods	Rural	Urban	Total
1940	5.7	1940-50	1.6	3.8	2.3
1950	4.1	1950-60	1.6	5.2	3.0
1960	4.0	1960-70	0.6	5.2	2.9
1970	7.0	1970-80	0.6	4.4	2.5
1980	3.8	1940-80	0.8	4.7	2.7

Source: Fundação Getúlio Vargas - FIBGE. Various publications.

The major factors in the urban environment which exercise a strong attraction for the rural population are the following:

1. Larger average salary due to larger average productivity and more diversified employment opportunities;
2. A more impersonal labor market in which the employer is more distant from the worker;
3. Protection of the labor laws and access to subsidized health and housing programs;

4. Existence of primary and secondary schools and universities. The latter two do not exist in the rural community, and an enormous difference in quality of education exists between urban and rural primary schools,
5. Existence of ample entertainment facilities such as soccer and television.

Factors exist in the rural environment which contribute to the expulsion of manpower. Principal among these are:

1. The application of labor laws in rural areas, especially after 1964. The cost of labor increased and the remnants of feudalism in that market were broken. Today the relationships are typically capitalistic. The rural worker migrates each time that he can earn more in the city and have access to the above mentioned advantages.
2. As a consequence of mechanization pressures, which intensified beginning in the 1960's, special credit facilities under very favorable conditions were created, intensifying the penetration of machines and equipment. It should be noted that mechanization came as a consequence of migration which reduced the supply of manpower in rural areas. Once introduced and increased, it became an additional factor in the expulsion of rural manpower (Alves 1981).
3. Economic development policies were successful in creating a powerful urban-industrial complex. This complex contains about 69% of the Brazilian population. In 1980, it was responsible for nearly 90% of the Gross National Product and provided employment for 70% of the economically active population.

For a long period of time, the gross national product grew at much faster rates than the population, resulting in elevated increases in per capita income. In effect, in current dollars, the per capita gross product increased from US\$207.00 in 1960 to US\$1,944 in 1980. In 1977 cruzeiros, the evolution was from Cr\$7,286 in 1960 to Cr\$24,577 in 1980, representing a geometric annual growth rate of 6.3 percent.

It is generally accepted that, as a result of the difficulties which are being encountered due to a reduction in the rate of economic

growth, the migratory movement should be slowing down. It should be pointed out that even if this were to happen, the effect would be felt only gradually in a situation in which the government protects the salaries and employment of low-salaried urban workers. Also, there is no reason for the recession to last long enough for migration rates to be reduced significantly.

In order to equalize conditions in the rural and urban environments in order to keep the population in the rural areas, in addition to raising the pay of the rural worker, a sizable investment in educational facilities, health and housing would be necessary. Obviously there are not sufficient resources for this. A curious fact is that the urbanization process is also intense in the Center-West and in the Amazon frontier regions.

The Northeast is still the region with the greatest percentage of rural population. Of the total rural population of the country, about 45% is found in that region, which contains only 3 percent of the total Brazilian population. It also has the lowest per capita income and greatest population density compared to other parts of the country. Table 2 shows the Northeast is still a major target for policies designed to hold the population in rural areas. The conditions described above advise against the application of this policy in that region exclusively.

TABLE 2. Geographic Distribution of Rural Population in Brazil, 1980.

Regions	Rural population as a percentage of total population	Rural population of the region as a percentage of total rural population of the country	Total population of the region as a percentage of Total population of the country
North	48.31	7.37	4.95
Northeast	49.56	44.73	29.27
Southeast	17.21	23.06	43.45
South	37.59	18.53	15.98
Center-West	52.25	6.31	6.34

Source: FIBGE Demographic Census 1980.

Since it is not easy to prevent the increasing urbanization of the country, the best strategy would be to attempt to channel migratory

fluxes toward the smaller cities whose activities are more closely related to the rural area. This, however, would require harsh measures of industrial decentralization, especially in the food industry, which is closely connected to rural life and which has strong possibilities of creating jobs for less qualified workers. No significant trend in this direction is seen in current development strategy. Decentralization will take place much more as a consequence of the disadvantages already observed in heavily populated urban areas, such as a deterioration in the quality of life, violence, etc.

d. **Changes in Demand** – The following points should also be stressed:

1. With the growth in per capita income and the change in population location, the demand for food showed a tendency toward fruits and products of animal origin, and grew much faster than the population. For these products, the income elasticity of demand is high. Food products which provide mainly energy have a relatively inelastic demand, in terms of income; therefore demand for them grows at a rate equal to population growth. The supply response was also significant for vegetables and products of animal origin but not for carbohydrates. There was upward pressure on the prices of these basic food products and a strong reaction on the part of the urban population at the end of the 1950's. This situation has repeated itself continuously since then (Alves 1979).
2. With the change in distribution of populational and the expansion of agriculture, the necessity grew for transporting food over long distances resulting in increased losses in marketing activities. Marketing costs grew in order to compensate these losses. A great controversy exists on this point. Many blame the growth of marketing costs to oligopsonies and oligopolies, which are believed to dominate the sector, without taking into consideration the technological problems which the rapid urbanization of the country brought to the marketing of agricultural products.
3. There was a marked change in the energy consumption pattern. When the population was relatively small and located in rural areas, the consumption of energy derived from petroleum was insignificant. Forests were the major suppliers of energy. Industrialization altered

TABLE 3. Annual geometric rates of growth of the Gross National Product-agricultural and urban sectors, in percentage.

Periods	Sectors		Total
	Agricultural	Urban	
1940-50	5.2	4.8	4.9
1950-60	3.7	5.9	5.4
1960-70	-0.1	9.8	8.2
1970-80	10.2	10.2	10.1
1966-80	7.8	10.1	9.8

Source: Fundação Getúlio Vargas for Primary Data.
Elaboration by DDM-EMBRAPA.

the demand pattern towards petroleum and electric energy produced by hydroelectric generators. In addition, the per capita consumption increased substantially. In view of the relatively low level of new discoveries of petroleum up until now, the petroleum crisis is causing serious problems for the country. Furthermore, large sums of resources must be diverted to sectors responsible for increasing the alternative energy supply. Above all, this crisis is largely responsible for the change in Brazilian policies with the reintroduction of controls designed to reduce imports.

- e. **Balance of Payment and Foreign Debt** – When the industrial import substitution policy was formulated, one of its goals was to alleviate or even eliminate the balance of payments problem. This failed to occur for the following reasons:
1. A bias against the exportation of primary products (Prebisch 1949), which continued until about 1964. From then on, except for soybeans, coffee and sugar, agriculture was not encouraged to compete in international markets.
 2. The industrialization cycle has not been completed. Heavy industry still requires large investments, and therefore capital resources to complement domestic savings are sought overseas in the form of loans.
 3. Heavy public investments in the energy sectors, like hydroelectric power, petroleum prospection, atomic energy and alcohol produc-

tion, have been made possible with the aid of foreign loans. The same thing occurs with the major projects of infrastructure, such as construction of the subways of Rio de Janeiro and São Paulo, the special iron ore railway line (Ferrovia de aço) and highways. All of these projects are also designed to economize energy.

4. Industrialization brought a great increase in petroleum consumption in industry and transport. Since domestic petroleum production is still relatively low, importations are high. Thus, the increase in petroleum prices is one of the principal factors aggravating the balance of payments problem.

Import reduction has an enormous impact on industrial growth. Measures of this nature can only be applied over the short run. The long run strategy is to increase exports and reduce imports through internal production. To achieve this objective, agriculture has an important role to play since it is the sector which consumes the least foreign exchange per product unit. Furthermore, it can respond rapidly. For these reasons, an increase in agricultural exports constitutes one of the major objectives of agricultural policy.

5. Agriculture began losing its political power during the Great Depression, although still maintaining a strong influence until the beginning of the 1950's. From then on, this influence decreased rapidly. And today it is relatively small. Political power moved, along with population, to urban areas. This change was more pronounced since it was also associated with the growing economic power of the cities. At present, agriculture accounts for only 11 Percent of the GNP. The importance of agriculture resides in the fact that the national economy depends heavily on it for supplying the internal food markets and external markets where it contributes to the solution of the balance of payment problem.
- f. **Impact on Labor Composition** – The rapid industrialization and growth of the service sectors caused an accelerated growth in demand for specialized labor. The labor supply did not grow in the same proportion as a result of insufficient investments in education, especially in the rural areas. The salaries of this group of workers grew at elevated rates. The problem of income distribution in the cities was aggravated, although everybody benefitted from the economic growth. In reality, a great

mass of workers exists which still does not have access to decent salaries and is cut off from the benefits of progress.

The urban-industrial complex benefitted agricultural labor through expansion of the labor market, which increased and diversified employment opportunities, accelerating rural-urban migration. Increasing of employment opportunities and the resulting rise in labor costs, brought about by modernization of agriculture, increased agricultural wages.

- g. **Pressures for Redistribution of Income** – In this way, the social problem of the country changed from an early, predominantly rural situation of hidden unemployment, substandard housing, high infant mortality rates, etc., to the current urban problems of under employment, slums, marginalization, prostitution and others.

From now on, the country is going to witness strong pressures for a redistribution of income, better salaries and more employment opportunities for the poor. On the other hand, pressure will be exerted to change agriculture policy, to discourage mechanization which has already been blamed with being the main factor in the expulsion of rural manpower. The result of this decision will be to reduce agricultural growth and the increase in average productivity of the worker who chose to remain on the land, and will not diminish migratory movements. On the contrary, these will be intensified when policies of urban income redistribution are successful, while little is being done to improve the access of the rural worker to education, housing and better salaries.

Another subject which continues to be debated is a radical agrarian reform, which may create problems on a national scale. In its early stages, it could cause a decrease in production which the country cannot afford. Furthermore, pressure on the land is much less today because of the decrease in rural population. In fact, there exists a heavy movement of small farmers in the direction of the Center-West frontier, the Amazon region and to areas of low population density in states such as Bahia and Minas Gerais. In these areas, the major conflicts over land are taking place between large landowners who wish to maintain their possession of the land without working it, and small farmers who need land to support their families. An appropriate agrarian policy in these regions, facilitating the possession of land by small landholders,

would resolve the majority of conflicts over land, with the advantage of promoting higher agricultural productivity and social stability.

- h. **Supply Crises** – Urban-industrial complexes are very sensitive to supply crises. Therefore they represent a means of putting pressure on the government to modify agricultural policy in favor of agricultural development.

Often, potential solutions to alleviate these crises were not appropriately selected. One has witnessed, in recent times, the establishment of price controls, the imposition of quotas or export prohibitions, exchange confiscation, all of these aimed at maintaining the prices of agricultural products at a low level in the internal market. The results were frustrating because farmers chose to plant crops less subject to government interference. As a result, the offer of basic food items did not even accompany population growth, resulting in the necessity for occasional food imports.

Food supply crises, however, led to significant changes in agricultural policy. On the product price side, this policy is rapidly heading for a greater liberalization. From the technological side, it is supporting the generation of knowledge and is attempting to facilitate diffusion of technology. A special effort is to be made to facilitate the access of small producers to agricultural credits and to public technical assistance offered by extension service. A great effort is being made to resolve the problem of land conflicts. This includes attempts to improve the access to land for farmers who migrate from older regions to the new lands of the Center-West and to the Amazon region. There is still a great deal to be done in this regard, however.

Impact on Demand – There is accumulated evidence that income elasticity of demand for food by the low income population is high. As these low income classes, who represent the overwhelming majority of urban workers, gain access to better salaries, the demand for food will grow rapidly. If agriculture fails to respond satisfactorily to this growing demand, agricultural products will increase in price thereby cancelling the benefits of income redistribution policies. Agriculture's role in improving the living standard of the urban worker is thus decisive. It is difficult for the urban working class to realize that in part, not only its food but also its jobs depend on the efforts of the rural

worker to produce food and other products for the international market. His efforts help to reduce import restrictions which may reduce employment opportunities by inhibiting economic growth.

The market for agricultural products, initially located mainly in a few urban centers, became more diversified and grew substantially. Agriculture adjacent to these large centers is able to operate at lower costs as a consequence of specialization or of economy of scale. With industrialization, there was an increase in social capital in the form of roads, which reduce transportation costs, and in educational facilities which increased both worker mobility and productivity.

In the 1960-80 period, per capita income grew at an annual rate of 5.3% and population at a rate of 2.7%. With a medium income elasticity of 0.5%, the annual growth of internal demand for food would have been on the order of 5.4%. Since the agricultural frontier did not grow at this rate, but rather at its historic 3 percent figure, the difference of 2.4% was covered by an increase in productivity or by imports, or prices were raised in order to bring supply and demand into balance. In the Center-South, there is evidence of increased productivity for many cultures (Alves, 1979). On the other hand, evidence exists of price increases for basic food products in São Paulo, with a perceptible deterioration in the nutritional standards of the low income classes (Barros & Graham, 1978). Furthermore, much of the subsidy for national wheat producers (a high portion of which is imported), is justified since this product guarantees a source of calories at lower prices for the working class. Abolishing these subsidies without a corresponding increase in the national production of wheat and of substitute products is not advisable. Fortunately, the possibility of increased agricultural production exists, as seen in the planting of wheat in "cerrado" areas and in the increase in the production of corn and sorghum. Corn can be mixed with wheat flour in a proportion up to 20% while sorghum can be used in a proportion up to 10% for this purpose.

With data collected on income-elasticity of demand and with the official data on production increase, Table 4 was elaborated. An annual population growth of 2.5% for the 1975-80 period was used as a basis. Products were divided into four groups: group 1 – fruits and vegetables; group 2 – basic products in human nutrition (calories and vegetable

protein); group 3 – basic products in animal nutrition; group 4 – meats.

TABLE 4. Medium annual rates of growth of production and internal demand for selected products. Period 1975-80.

Products	Growth rates in percentage	
	Production	Demand
Group 1: banana	2.95	4.43
oranges	8.37	5.48
English potato	2.52	4.78
onion	11.61	4.57
tomato	5.58	4.92
Group 2: rice	1.20	2.69
bean	0.62	2.48
cassava	-0.75	3.87
wheat	-0.13	–
Group 3: corn	2.71	4.85 ⁺
soybeans	5.93	4.85 ⁺
Group 4: poultry	13.97	4.85
beef	3.30	6.87
pork	4.46	5.82

Source: Alves (1981).

+ For corn and soybeans the income elasticity of meat and poultry was used. The population growth rate is 2.5% and refers to the 1970-80 period. It probably decreased in the 1976-80 period, but not sufficiently to affect the results.

Based on data presented in Table 4, the following observations could be made:

1. The increase in the demand for vegetables, meat and animal feeds was high, greater than population increase.
2. In a general way, supply accompanied increased demand, except for group 2, basic food for workers. In the case of meat, with substitution of beef and pork by poultry, an equilibrium between supply and demand should have occurred.
3. The products in group 2 were the most prejudiced by price policies.

Therefore farmers ceased to plant them in favor of exportable products and commodities consumed by the higher income groups, such as fruits, vegetables and meat.

- j. **Impact of Future Growth** – If population continues to increase on the order of 2.2% and per capita income grows by 5%, (given income elasticity of demand for food of 0.5) there will be an annual increase in demand of 4.7%, a rate exceeding the historic growth rate of the agricultural frontier by nearly 2%.

Brazil still has a vast agricultural frontier: the Amazon region, which is, however, far from markets. Heavy investments will be required in physical infrastructure and social services in an area where the land is generally poor. In this region, agriculture can obviously expand in the direction of Rondonia, Mato Grosso, Goias, Maranhão and in the vicinities of Manaus and Belem to supply these cities. In these areas, the conditions are particularly favorable for rubber tree and African oil palm culture and for forest exploitation.

Because of the increase in transport and modern inputs costs and the high rates of rural-urban migration, it will be difficult to maintain the historic 3 percent growth rate of the frontier, equivalent to incorporating 1.5 millions hectares per year.

The 4.7 percent growth rate in demand does not consider the necessity of increased exports, the bio-energy program or the implications of income redistribution policies.

A policy designed to increase agricultural productivity, so as to reduce the pressure on expansion of the agricultural frontier, would be much more logical. Since productivity levels of most Brazilian crops are low, this strategy should be successful. Moreover, if the increased productivity is not at least 2 percent a year, supply and demand will be brought together only through imports or price increases, assuming the agricultural frontier can still be expanded at the historic rate of 3 percent a year.

The newly industrializing Brazilian economy long ago passed the point at which it could return to its agrarian origins, ceasing to be essentially agricultural to become essentially industrial. It is true that the country is living in a transition phase which may be prolonged due to

the implications of the two petroleum crises and the resulting foreign debt.

With an annual growth rate of 3.9% for the urban population and of 2.2% for the population as a whole prevailing until the end of the century, the total population of the country will be 148 million inhabitants, of which only 30 million, or 20% of the total, will still live in rural areas.

The transition period will have largely passed by the end of the century and agriculture will become less important in its function of providing employment. In fact, it has already lost much of this capacity during the past decade. It will continue to increase its function of producing surpluses for the cities and for international markets.

Since occupation of vast areas of the country, using a labor intensive technology, as occurred in the past, can not continue indefinitely, the necessity of applying technology to agriculture, in order to increase the productivity of land and labor, will increase. Chemical-biological, mechanical and processing technologies will have a decisive role in efforts to reduce marketing losses. Requirements of trained labor will be greater as agriculture becomes more intensive in physical and human capital.

Agricultural policy must thus be adapted to the spirit of a modern agriculture, intensive in the use of physical and human capital. If this does not happen, supply problems will become unbearable by the end of the decade. Agriculture will lose its capacity to participate heavily in the international markets, since everything that is produced will be consumed at home.

Agricultural research will meet serious challenges during the course of the decade. An option will have to be made for commercial agriculture, increasing investments in more promising regions as well as becoming better acquainted with the Amazon region. Studying traditional agriculture, which is disappearing, even though running the risk of creating technologies already outdated when ready for dissemination, is also necessary.

THE CHALLENGE OF AGRICULTURAL RESEARCH

An attempt was made to show that the Brazilian economy is on a course

which will require agriculture to significantly increase its production to supply the cities and international markets. At the same time, its capacity to provide jobs may be further reduced. The solution adopted in the past, the expansion of the agricultural frontier, will eventually lose much of its importance.

Regions which still have an agricultural frontier and are being brought under cultivation, such as the north of Goiás, the south of Pará, Rondonia, Mato Grosso and areas adjacent to cities in the Amazon region, will no longer have the abundance of manpower such as existed at the time of the agricultural conquest of the north and west of Paraná. Agriculture will be compelled to resort to a capital intensive technology requiring a trained labor force. To do this it must appeal to science.

Since agricultural technology is site specific and the possibilities of importing it are restricted, research and creation of new technology become decisive instruments of agricultural policy. The Agricultural Research System must face the following challenges:

1. Relationship with other Institutions

In order to optimize its contributions to economic and social development, EMBRAPA must establish correct relationships with other institutions.

- a. **Strengthening State Research Institutions** – Brazil is too big for the Federal Government to assume responsibility for all research. This makes direct support of research and cooperation with the states, in creating and developing their research institutions, very important. State agricultural research corporations have been in the process of development since 1973. Still much has to be done, especially in the case of some state governments, before they realize the essential role of agricultural research at the local level at the particular stage of economic development of each state, and provide more resources for this activity.

Although the Ministry of Agriculture multiplied its research budget by almost forty times in the 1973-81 period (from US\$ 6 million in 1973 to nearly US\$ 220 million in 1982), an effort that no other country has made in such a short space of time; a similar effort failed to be made on the state level. Several key states in national research failed to increase or even reduce investments destined for

research, particularly in 1982. They are still strongly influenced by the thesis which prevailed in the 1950's and 1960's according to which there already existed a body of knowledge, in the desk drawers of researchers and in the hands of the more advanced producers, which was sufficient to duplicate agricultural productivity. The only thing that was lacking was a rural extension service. They developed the credit, extension and related activities, in part at the expense of resources destined for research, which decreased or failed to grow, an erroneous decision which, in the 1970's, proved to have been based on a false thesis.

- b. **Participation of the Private Sector** – Private enterprise has an undeniable and important role in the development of research, chiefly in the areas of genetic improvement and agricultural chemicals. Brazil is just now taking its first steps in these areas. The lack of patent and cultivar registration laws is the chief obstacle to producers benefiting from the potential scientific progress to be generated by research undertaken by the private sector. It should be pointed out that public research is indispensable in the case of agriculture. This is true in all developed countries. Still, agricultural research should be done by private enterprise in fields in which it has a comparative advantage.
- c. **Collaboration with the University System** – Research carried out by the public agricultural sector is of an applied nature and as such does not attempt to develop or test scientific theories. Its function is not to systematize knowledge, but to create technologies which lead to an increase in the productivity of land and labor, with low input costs when possible.

Basic research, without which applied research would be destined to failure, is more appropriately done in the universities and specialized institutions created for this purpose. The division of responsibilities in a climate of mutual collaboration is an important problem to be reconciled.

- d. **Relationship with Commercial Agricultural Institutions** – Commercial agriculture requires appropriate institutions; not only public ones such as research facilities, rural extension, rural credit, minimum prices, storage, environmental protection, etc.; but above all, those of a private nature such as cooperatives, service firms (for example, those that rent machines and equipment), food processing companies and others. Many

of the accusations which claim that modern technology does not serve the needs of the small farmer result from the failure to observe that the problem lies in the nonexistence of firms specialized in farm machinery and equipment rental.

When available, the small producer can utilize large-scale mechanical technology through rental services for machines and equipment. Sometimes it can be simpler and faster to stimulate the development of these services through cooperatives and other types of enterprises, than to attempt to create intermediate technology which gives small farmers access to low-cost machines and equipment, but whose effect could be to deprive them of a more sophisticated technology with its resulting greater net income.

At a time when the prices of the services of production factors are continually growing, a better organization of farm activities could mean enormous gains in economic efficiency. Hence, a growing pressure can be foreseen on the part of farmers for information in the area of rural administration. In terms of research, this is an area where agricultural economists, rural sociologists and other social scientists are supposed to play the key role.

Relationship with Policy Making Institutions — Agricultural policy will be dominated by the necessity for increasing agricultural production to supply the cities and the international markets. Increasing productivity will emerge as the principal line of action. For this to happen, research must establish a closer relationship with agricultural policy makers, not only in order to receive information on priorities, but also to indicate the shortest path to increased productivity.

Pressure for new knowledge will be enormous and researchers will not always dispose of the time they normally require to formulate new technologies. Traditionally, research has liberated new knowledge in the form of isolated practices. Government programs will require synthesis in which various practices are integrated, and researchers will need to gain experience in this synthesizing effort, which in advanced countries, is done by the farmers themselves with the aid of rural extension or through specialized firms.

Discussion of social justice will reappear prominently in the political arena and agrarian reform will certainly once again be debated.

Pressure on research will be to create technology for small traditional farmers. These simple technologies, representing a small advance over what is currently being done, will not be physical and human capital intensive. Some old ideas, which prevailed during the early industrialization period, may return. Allocating a minimum of capital for agriculture, in order that savings might be absorbed by the industrial sector without significant competition, is an example of these ideas. One of the main arguments in favor of simple technologies will be the necessity of conserving energy, although even in advanced countries, agriculture is a sector with a reduced energy consumption up to the farm gate.

Again, it is up to social scientists involved in agricultural research to show that times have changed and that Brazil is already an urbanized country with a rural-urban migratory movement which shows no signs of diminishing, and therefore the continuation of traditional agriculture might eventually lead to hunger in the cities and to the need for agricultural imports.

Finally, research will be called upon to evaluate and reformulate agricultural policy, at the same time being evaluated itself as to the benefits it affords to the economy. It must be prepared to defend these contributions through a professional use of the communications media.

f. Relationship with Extension Activities – The flow of new technology from research institutions must overcome physical, economic, and social constraints before that improved technology is adopted by farmers. The research scientists and administrator should take the following into consideration:

1. To be adopted, the new technology must result in greater production per unit of inputs used, than that from the previously existing technology.
2. Given the costs, prices, and possible markets that exist for particular individuals or locations, the technology must result in higher returns to family-owned resources than existing technology produces.
3. Variability in yields and net returns of new technology must not be greater than when using the old technology.

4. The social and personal changes as well as the output increases that result from accepting the new technology must be positively valued by both society and the individual.

Research and extension workers must work closely with each other. The research workers must go into fields together with extension personnel to learn the problems of farmers. These will help the researchers in the definition of research problems and priorities in conducting experimental trials at the farm level, and even in the interpretation of the results.

2. Formation of Modern Technology

The following types of technology could be recognized:

- a. **Modern Input-Saving Technology** – The green or seed-fertilizer revolution resulted from applying genetics to the creation of plants with an elevated response capacity to modern inputs. But this elevated capacity can only be realized with the use of high levels of modern inputs.

The discoveries in the fertilizer and pesticide industries, which have drastically reduced the costs of these products relative to the costs of agricultural products, led to the creation of improved varieties of elevated productivity, but also stimulated heavy dependence on modern inputs.

The petroleum crisis resulted in an unprecedented increase in the price of modern energy-based inputs. With agricultural product prices increasing proportionately, the consumer was the big loser, after having been the chief beneficiary of the technological revolution in agriculture for a long time. It was now his turn to pay for benefits received. In the case of Brazil, the purchasing power of the population is limited, principally in the low income groups. The increase in prices of agricultural products represents a heavy burden for the mass of workers. For this reason, research is confronting the problem of reducing the use of modern inputs in order to decrease the cost of production, while at the same time assuring elevated growth in productivity. Much effort is needed in areas such as genetic improvement, nitrogen fixation, pest and disease control, soil biology, cultural

practices, irrigation, harvest losses and marketing activities. The modern input industry, especially that of fertilizers, will have to redouble its efforts to create more efficient products.

- b. **Labor-Saving Technology** – It was pointed out that the rural population will continue to migrate to the cities in large numbers, thereby substantially reducing the supply of labor for agriculture. Existing manpower will have to be substituted by farm machinery and by new, poorly trained workers.

Agricultural engineering research is at present insignificant, at both the private and public levels. Most machines and equipment were designed during the cheap fuel period and are consequently inefficient in terms of energy consumption, in addition to being poorly adapted to Brazilian conditions.

A strong alliance between public and private research will be necessary to make up the delay. Furthermore, developments in the area of agricultural engineering are indispensable today both on the agricultural frontier and in older production areas. The new machinery is needed for conservation of natural resources, minimum cultivation, irrigation, food processing, land clearance, soil preparation, cultural practices, harvest, storage and transport.

- c. **Loss-Diminishing Technology** – A population located in urban areas, while production is dispersed over a vast territory, increases energy consumption and potential wastes and losses in marketing activities. These losses are proportional to the amount of manpower, modern inputs and fuel which were used in their production.

The change in location and the affluency of the population tends to modify the food chain. What was formerly predominantly a plant-man system, is now a plant-animal-man system in which energy consumption is very high.

In a predominantly urban country like Brazil, product-saving or waste-decreasing technologies diminishing the losses which occur between the harvest and consumption, assume great importance. In fact, they save energy consumed at the farm level in transportation, processing and storage. The elimination of these losses is extremely important as a way of increasing the food supply and reducing energy consumption,

when the technologies utilized for this purpose show an adequate energy balance.

These technologies involve plant breeding aimed at diminishing storage and harvesting losses, improved transport facilities, processing of food, and conservation in bulk and at the home level.

- d. **Bio-Energy Technology** — Unless great success is obtained in petroleum prospection, agriculture will be called on to produce a greater supply of energy from forests, vegetable oils and biogas than it is presently doing. Part of the production is for on-farm consumption, while a part is for the cities. There will be competition for land for both energy and food cultures. In a situation which offers little promise of expansion of the tillable area, pressure will grow for an increase in productivity, so that the energy cultures will not cause serious problems to internal food supply. Irrigation is undoubtedly the technology with the greatest capacity for raising productivity, but is a high energy consumer. Neglected in the past, irrigation should become one of the first priorities of agricultural policy and of research in areas where cheap energy is available or could be produced.

3. Spatial Considerations

Regional differences in agro-climatic conditions require that agricultural research be given a spatial dimension.

- a. **Optimum Zoning of Agricultural Production** — Land is a production factor. In the expression "land", light, heat and precipitation are also included. And there is a difference between land as a natural resource and arable land. The former is transformed into the latter through operations which vary from place to place. In the desert, irrigation is required; in the Amazon region, clearing the forest, road construction and providing other infrastructural improvements are required, whereas in the "cerrados", improvement of soil fertility is essential.

Production can be increased either by expansion of the agricultural frontier or by productivity increase. In one case, the number of hectares cultivated is increased, while in the other, the increase is in the productivity per hectare. If technology doubles the productivity of the land, each hectare is now worth two.

In the case of Brazil, an agriculture policy decision might have been made to concentrate exclusively on increasing productivity, or to expand the agricultural frontier, or a combination of the two options. The latter combined option is currently being implemented.

The petroleum crisis, however, caused new restrictions. It should be noted that the agricultural frontier, which Brazil still has, is located mainly in the Amazon region, far from markets and lacking in infrastructural improvements. There are some areas of fertile land, but low fertility is the rule. Due to increasing urbanization and labor shortage in rural areas, expansion of production will require conquering the land with machines and equipment, and high labor cost. These conditions will exert pressure for a higher productivity of land. It will, however, be necessary to transport modern inputs such as fertilizers, pesticides, machines and equipment and fuel, as well as resulting production over long distances before it reaches the principal markets. With present transportation costs, it is possible to foresee elevated production costs compared with those of the Center-South. The solution would be for the region to concentrate on livestock, forest production and on products of high economic value, such as rubber and African oil palm. But these are precisely the products which require sophisticated technology for their production. Consequently, the manner of conquering the Amazon region will be different from that of the rest of the country where modern technology is a very recent phenomenon. Dominating the land in that region will be done with a much greater contribution from science, including minimizing the negative effects on the environment. If this does not happen, the result will be a subsistence-type of agriculture, which ranges through the forest without dominating it. Cutting forest is followed by planting for three or four years. Later the area is abandoned and regrowth of the forest follows. Obviously, in regions of more fertile land, the cycle will take more time, passing through a pasture stage which will also come to an end as has already happened with thousands of hectares.

- b. **Occupation of New Land** — A question should be raised at this point: why not increase the productivity of regions already under cultivation and limit the advance of agriculture in the Amazon and other regions to smaller proportions and mainly to areas adjoining already developed areas?

The explanation may be divided into two parts. The first is based

on the importance of maintaining the population already in the interior of the region, as a way of assuring its hard-earned possession, bearing in mind future problems which will surely arise if the rate of urbanization is not drastically reduced. Statistics from the 1980 census, however, indicate a growing urbanization in the region, especially in a few cities, which shows that the objective of increasing the rural population in the region has failed.

The second part is a consequence of the region having conditions to absorb the small, trained and experienced farmers from the Center-South. These farmers sell their lands at high prices in order to acquire larger areas in the Amazon region. In this way, the pressure on land in the Center-South and in the Northeast (in smaller proportions) is reduced, and experience from the older regions is transferred to the Amazon region.

In carrying out this resettlement, obviously the area to be occupied, representing a small percentage of the Amazon region, should be located on fertile lands. Basically, this is happening, but as was to be expected, large interests also intend to use these lands with resulting speculation and an elevated cost to society.

Rondonia, Roraima, the south of Para, areas of Mato Grosso, the north of Goiás and part of Maranhão are the target regions for land acquisition by migrants.

Due to the present need to bring food from far away, agriculture should be expanded in the proximity of Manaus, Belém and other Amazon cities in order to supply them without high transportation costs.

There are still two points to note: first, that a large area of the Amazon, although proportionally small, has already been made arable; in the second place, that the region represents an enormous potential for the future of the country. Therefore, its ecosystems, both lowlands and uplands, must be studied. The same is true of natural resources ranging from forests, soils and climates to native fruits. It is essential to provide scientific support to the farmers residing there. Cultures such as rice, corn, beans, jute, mallow, African oil palm, cacao and rubber will necessitate thorough studies. No less important is cattle raising, both of

buffaloes and beef cattle. Emphasis should also be given to research on pasture improvement.

- c. **Improving Traditional Agriculture** – There are regions in Brazil in which the advent of commercial agriculture will be retarded. The Northeast contains the greatest area of traditional agriculture. The creation of a technology, non-intensive in human and physical capital for these regions, capable of being adopted by the majority of farmers, is inevitable. Intercropping technologies (multiple cultures), using a primitive irrigation, the introduction of plants more resistant to the environment, recycling of organic matter, simple erosion control measures and inexpensive and easily operated machines are a few examples. Obviously, these technologies have little capacity to produce surpluses; the capacity to increase productivity and production is small. But at least they increase the food supply of rural populations who become less vulnerable to climatic hazards. Because these measures are simple, they are always the most complicated from a scientific viewpoint. Research cannot bring about an increase in productivity without profoundly modifying the quality and quantity of inputs used. As pointed out, the danger is in creating technologies which, when ready to be diffused, will already have lost their relevance as a result of the disappearance of traditional agriculture.

CONCLUSIONS

1. The analysis made in this paper showed that Brazil has advanced sharply on the path to development and it is now much more urban than rural. Its agriculture today has a growing responsibility to increase production and to create employment. And all indications are, that with the passage of time, the rural population will become even less significant in number. Subsistence agriculture will mostly disappear while commercial agriculture will increase to the point where it is dominant. Certainly the Northeast which in 1981 held 45% of the rural population of the country will be the last bastion of subsistence agriculture to fall.

2. Agricultural policy will be dominated by need for increasing agricultural production for supplying internal needs and for export. The growth will come from an increase in the productivity of land and labor. Production policies, designed to expand the agriculture frontier, will lose their relative importance. Technologies of

irrigation, improved seeds, mechanization, and food processing will be among the first priorities.

3. The concern with energy conservation and production will be dominant. The country will not only have to conserve energy, but will also have to rely on research to develop technologies, which at the same time increase physical productivity and reduce the consumption of modern inputs per product unit. Along with energy saving production, of alcohol, vegetable oils, biogas and forest products will have an important role.

4. The responsibility of research in the formulation of agricultural policy will increase. A growing number of farmer groups and entrepreneurs will be in search of new knowledge and ready to establish cooperation contracts. On the other hand, the role of private technical assistance will grow while public extension will reduce its function, in relation to large producers, and further turn to small ones.

5. Since modern technology is human capital intensive, pressure on the government will grow to expand rural manpower training programs, which will be an important area of action for rural public and private extension.

6. As a result of the change in structure of the rural labor market, which is much more closely based on capitalist principles, the bargaining power of the rural workers will increase. They will be in a better position to fight for higher salaries and better conditions of life. Many of the difficulties which are currently encountered in rural areas will continue, until rural-urban migration has completed its process.

7. The institutions which develop knowledge — perform research and rural extension — must be strongly supported. The product of their work is the necessary condition for the self-sustained growth of agricultural productivity.

8. National priorities for agricultural research should be continually updated, drawing upon all relevant expertise. At the same time, the agricultural research system must be continually broadened to include all private, public, national and international institutions and individuals conducting science relevant to solving agricultural problems of importance for Brazil.

REFERENCES

- ALVES, E.R. de A. **Adoção de prática:** rea atingida pelo escritório local de Viçosa, EMATER-MG, 1961.
- ALVES, E.R. de A. As atividades sociais do sistema ABCAR como investimento no homem. **Extensão Rural**, 41:7-10, May 1969.
- ALVES, E.R. de A. **Desafios da pesquisa agrícola no Brasil.** Brasília, EMBRAPA-DID, 1981. 32p. (EMBRAPA-DID. Documentos, 14).
- ALVES, E.R. de A. **An economic evaluation of the impact of an extension program.** Purdue University, 1968. Doctoral Thesis.
- ALVES, E.R. de A. Fomento e extensão rural. In: PASTORE, J. **Agricultura e desenvolvimento.** Rio de Janeiro, APEC-ABCAR, 1973.
- ALVES, E.R. de A. As instituições e a modernização da agricultura. **Extensão Rural**, 80:17-21, ago. 1972.
- ALVES, E.R. de A. **A produtividade da agricultura.** Brasília, EMBRAPA, 1979.
- ALVES, E.R. de A.; ALMEIDA; & COLI, P.M. **Técnicas e métodos de avaliação de programa.** ABCAR, 1962. v.2.
- BARROS, J.R.M. de & GRAHAM, D.H. **A agricultura brasileira e o problema da produção de alimentos.** São Paulo, IPE-USP, 1978.
- BERGMAN, J. & CANDAL, A. **Industrialization past success and future problems; the economy of Brazil.** Berkeley, University of California Press, 1969.
- FEI, J.C.H. & RANIS, G. **Development of the labor surplus economy: theory and policy.** Irwing, Homewood, 1964.
- FISHLOW, A. Foreign trade regimes and economic development. In: SPECIAL CONFERENCE SERIES ON FOREIGN TRADE REGIMES AND ECONOMIC DEVELOPMENT. NBER, 1967. v.10.
- LEWIS, W.A. **Economic development with unlimited supplies of labour.** Manchester School of Economic and Social Studies, 1954. v.2. p.139-91.
- PREBISCH, R.O. O Desenvolvimento Econômico da América Latina e seus principais problemas. **RBE**, Rio de Janeiro, 3(3):47-111, set. 1949.