Agricultural Engineering Education In Developing Countries

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INTRODUCTION

This Study in Brief

The purpose of this study is to identify the optimum organization of agricultural engineering education in agricultural universities of developing countries with particular emphasis on India. In general, the term "agricultural engineering" in developing countries seems to cover most phases of mechanized agriculture all the way from the farmer to the equipment manufacturer. Men are being called agricultural engineers who have all levels of mechanization training -- from the agricultural graduate with only a few courses in applied engineering in the field of agriculture to the graduate with the most sophisticated agricultural engineering degree. Such a situation has led to an unstable condition for the whole field of agricultural engineering in developing countries. This report clarifies the problem and makes recommendations for improvement.

Many references in this report relate mainly to India since I spent two years in the heart of India as group leader of an Illinois team working with Vice Chancellor L. S. Negi and Dean S. V. Arya, Agricultural Engineering College, J. Nehru Agricultural University, Jabalpur, M. P., India. My experience in other developing countries is limited to traveling through several of them.

This report summarizes my ideas on the need for mechanization of agriculture in developing countries. These ideas have been tempered by my experiences in developing countries and by my discussions with foreign and American agricultural scientists through letters and interviews (Appendix B). Fifteen replies were received from 31 letters sent to foreign agriculturists. Forty-two American agriculturists were interviewed, of whom 24 were agricultural engineers, along with two Indian agricultural engineers in America. Most of these men had considerable experience in and with developing countries.

In essence this report recommends the establishment of a Center for Agricultural Mechanization Technology in each developing agricultural university, but only if there is an existing agricultural engineering department to preserve high standards for the application of practical engineering principles to agriculture. The center and the department should be on the same professional level to prevent domination by either.

These two fields have different but supplemental assignments in developing countries. Agricultural engineering is the profession for sophisticated design work with industries and governments. Agricultural mechanization technology helps fill the area of service in engineering applications to agriculture. This curriculum is introduced to immediately prepare skilled workers who will work with their hands in mechanizing agriculture through the development of short training programs of 3 days, 3 weeks, 3 months, and 6 months and the development of diploma graduates of one and two years. The main objective of the Center for Agricultural Mechanization Technology is to train men <u>now</u> in a particular narrow area and in a skill so they can rapidly be brought to a point of use in connection with irrigation, pumps, drainage, grain processing equipment, shop training applications, and other areas as the needs arise.

The views of the foreign and American agricultural engineers and other agricultural scientists concerning agricultural engineering and agricultural mechanization technology diverge widely (Appendix C) whether they are still working in a foreign country or not. I have attempted to glean all possible ideas from these specialists and to develop a workable program in agricultural mechanization technology for developing countries.

The next portion of this report gives background on the need for mechanizing agriculture in developing countries even though agriculture must absorb a large share of the increase in population for many years to come until industry catches up and absorbs much of the population away from agriculture. Obviously, the first phase of such mechanization in countries with limited land resources must accent such areas as water management and simple tools to increase the output per worker with less land per worker and also find ways to increase production per acre. Later on, larger machinery will undoubtedly enter the picture when a large percentage of the population leaves agriculture for industry. We must plan now for the developments of these two types of forthcoming agricultural mechanization technology which every developing country must consider.

Technological Breakthroughs (Appendix D)

During the last two decades, forecasters of doom have felt that the more than 100 developing countries, which include two-thirds of mankind, could not possibly continue to feed their fast-increasing teeming millions. Today, however, the potential ability to banish famine and hunger from the face of the earth is a reality.

A great reversal has been taking place during the last five years, called the "green revolution." A few nations have become exporters of grain that only a few years ago were importers. Money can now be made in farming, with the advent of new grain varieties, fertilizers, insecticides, fungicides, irrigation, and other new technology. The possibility of tripling production is high. It is evident that the peasant farmer is not hopelessly indoctrinated with custom and tradition and is conscious of profits, although small farmers, who must consider family survival, are more cautious than large farmers in adopting new technology.

Certain problems must be watched, such as scarcity of irrigated land and water control essential for the popular new grain varieties, inadequate markets, poor storage facilities, lack of farm supplies and equipment, and insufficient supplies of fertilizers, insecticides, and pesticides. And governments must be careful not to overtax the farmer during the critical period of radically increasing production, or they will stifle initiative, which is so important.

Population and Labor Applied to Agriculture and Industry (Appendix E)

In developing countries agriculture must not only produce enough food but must also provide the livelihood for a very large portion of the population. For a decade or two possibly a third of the future increase in population must be absorbed by agriculture, even though the ability of agriculture to do so is quite limited. The population in developing countries will remain largely rural until an industrial labor market is developed. Industry and agriculture must stimulate and support each other, but agriculture will be the larger sector in the early stages and so will be the eventual source of manpower for industrial expansion.

Mechanization of agriculture occurs in two steps: first, simple mechanization when agriculture must absorb the bulk of the workers; and second, probably larger machinery used in agriculture after industry overtakes it and leaves a much smaller portion of the workers for farm help.

Where little land is available for settlement it is difficult to say whether the size of farms should be reduced or the number of workers per farm should be increased. In some rapidly developing countries small farms show higher crop yields than large farms. Ways must be found to use tools, machinery, and power to increase output per acre and also output per worker. If developing countries are to feed their populations in the year 2000, they must at least meet the very high crop yields now realized in Japan.

The Farmer, Machines, and Economic Systems (Appendix F)

In general, farmers need basic mechanical equipment and machines regardless of whether they are in developed or developing countries. Prudent use of machinery combined with wise use of human power is essential for providing needed jobs and at the same time for insuring increased food production. Farm labor, even though cheap, can never replace minimum machinery needs for greater precision, speed to take advantage of several seasons, handling seasonal variations of labor, developing land, and accomplishing the heretofore impossible. Small tractors, tractor rental service, and custom service pools should be readily available to farmers along with engines, pumps, and other equipment, especially in irrigation work. Such investments in Japan are among the highest in the world even though human horsepower per hectare is also the highest. The increased need and demands for machinery dictate the furthering of farm electrification in all developing countries.

A strong network of service organizations with well-trained skilled men and with vital services in the mechanization of agriculture is essential, coupled with an intensive agricultural program which includes a tested package of agricultural practices. Private enterprise should be strongly encouraged to develop such services.

Changes in Agriculture in 26 Developing Nations (Appendix G)

Analyzing common problems and elements, as was done in a recent study of 26 developing nations (10), can lend direction to corrective agricultural programs. Techniques used in some of the 26 countries might be adapted to others--for example, the land and other reform techniques used in Japan, Taiwan, and Israel (34). These 26 nations account for one billion of the world's three billion people, and most of them will double their population in about thirty years. Agriculture is the most important industry in these countries.

Recent crop increases have been achieved mainly through the use of fertilizer, new seed varieties, pest control, better use of water resources, and improved planting, tillage, and harvesting methods. Modern implements in general have not been used to save labor but to improve quality of operation and to do things not easily done with traditional equipment--an example is the extensive use of small garden tractors in Japan.

To maintain high rates of increase in agricultural output and productivity, most of these 26 countries need to improve education and research, agricultural credit, and transportation, communication, and marketing. They also need improved sources of fertilizers, seed, pesticides, farm implements, and other production requisites.

The future capacity of agriculture in developing countries to increase agricultural output depends on development of strong programs in applied research and in extension. Farm families often do not appreciate existing education with its seeming inapplicability of knowledge. Application must become the cornerstone for education through sound extension programs like the one in Taiwan.

Taiwan's Agricultural Development (Appendix H)

Taiwan's miraculous gains in agricultural productivity are an important success story (22) for any developing country to study because Taiwan has the characteristics of such countries: rapid population growth, limited land resources, tropical climate, need for irrigation, and a colonial history. The lessons learned from Taiwan's agricultural development experience may be expected to have more application and greater relevance than those learned from the study of more economically developed countries.

In Taiwan, national and local governments played a leading role in accelerating agricultural development. The strategy was a multiphase approach of education, research, and extension--an integrated package including land and water development; experimentation, demonstration, and extension; building of local farmer service organizations; and land reform. Land reform and consolidation of fragmented holdings are vitally needed in most developing countries.

Farm size was cut from about two hectares to one hectare between 1950 and 1960, but output per farm increased. By increasing the number of farms, Taiwan obtained greater intensity of land use. Farms with less than half a hectare produce over twice as much per hectare as farms with over 2½ hectares. The increased productivity has resulted partly from the fact that an organization of small farms may be surrounded by local service organizations. Where such supporting services are not available, large plantation farms that can provide such services may be more efficient.

Taiwan has relied heavily on the introduction of new varieties of plants and animals from abroad and on adaptive research. Researchers are close to farm level problems and conduct research of practical and immediate value to farmers. Vocational agriculture schools, district agricultural stations, and district extension services are Taiwan's method of developing improved technology and getting it quickly to the farmer. Capital was used to increase output per hectare through land and water development for the future growth of agricultural production and not to substitute for labor.

The Role of Agricultural Institutions in Developing Countries (Appendix I)

Economic underdevelopment is largely a consequence of institutional underdevelopment. The present agricultural technology in the United States is a direct result of the development of land-grant institutions. Similar institutions in developing countries and all other educational institutions there must expand and extend leadership to meet the needs of all the people. In all developing countries, programs must be promoted in the areas of research, teaching, extension, and vocational agriculture.

The talents of the scientists must be exploited in every way possible. They should have full-time appointments in the universities, with the responsibility to devote part of their time to practical research. One of the great contributions being made by developed countries is guidance in training men in developing countries on how to obtain maximum experimental data in a short time. The scientists must also be given freedom to teach in the most effective way. They must be allowed and encouraged to use their hands in teaching and research.

The universities must cooperate with foreign agricultural organizations working in their countries to develop package programs of improved agricultural practices.

The image of agriculture must be improved in all developing countries and future leadership must be developed. The image can be improved by teaching vocational agriculture to farm youngsters beginning the last two years of elementary school, before many students begin leaving school. There is no better way to develop the future leadership that agriculture will need. Agricultural universities must lead the way in such leadership training.

RECOMMENDATION FOR CENTERS FOR AN AGRICULTURAL MECHANIZATION TECHNOLOGY PROGRAM

The changes in developing countries described in the preceding section indicate that agricultural production needs to become more sophisticated and needs to make more use of modern technology. Certainly a key development will be the use of mechanical and electrical implements and machinery. These developments will require a thoroughly new approach to an agricultural mechanization technology program in order to be effective.

When speaking of a mechanization program, the problem of service becomes the overriding objective. As a farmer's operations become more mechanized, the farmer becomes more dependent on the machine and its maintenance program. At the critical times of planting, harvesting, and other crucial periods, a machine theoretically should not break down--but it often does. During such critical periods, down-time and lack of capacity determine the extent to which losses will be sustained. The farmer needs service immediately or his crops will fail.

In developed countries farmers can buy machines from agencies that are available for nearly instant service with all necessary parts in stock. As was shown in a recent unpublished study, 1189 tractors in Illinois and Indiana had an average of 4.5 hours of down-time per tractor during corn harvest, with variations ranging from 0 to 32 hours of down-time. Similar data were reported for tillage, planting, and cultivation.

But what is the situation in a developing country? If an irrigation pump or a tubewell breaks down and there is no local service agency, the down-time stretches into weeks and months while a unit must be sent to a large city several hundred miles away. A farmer subject to these conditions cannot afford mechanization.

Servicing problems like these are the reason for developing an agricultural mechanization technology program. The increasing use of irrigation alone can justify the need for mechanization training for tubewells, pumps, engines, and electricity. But when we consider that all phases of mechanization are making strong inroads into developing countries, it is clear that many people must be trained to handle the various kinds of servicing and sales problems ahead. Kline (42) recommends the development of service branches to facilitate the use of mechanized agricultural technology.

The recommendation of this report is to establish centers in developing countries for agricultural mechanization technology to answer the many service needs of the farmer. A vacuum of skilled workers exists in practically all mechanical service areas between the farmer and the equipment manufacturer. This vacuum must be filled by skilled and professional men who can and will work and demonstrate with the use of their hands. All 44 persons interviewed in this study agreed that such a program would benefit developing countries, as did most of the 15 foreign and American agriculturalists corresponding from abroad. The report so far has indicated the need for agricultural mechanization technology based on the influences of population and industry. This section of the report suggests ideas and methods that should be incorporated into the development of these new centers. A summary of these recommendations appears on pages 15 and 16.

Distinguishing Between Agricultural Mechanization Technology and Agricultural Engineering

Many people in developing countries are confused as to the difference between agricultural mechanization technology and agricultural engineering. Agricultural engineering has been used to mean most phases of mechanized agriculture--from simple skills to sophisticated engineering. It is necessary to clarify the meaning of both professions and to show the importance of developing both curricula side by side at the same professional level but with a strict distinction between them.

Characterization of agricultural engineering. A graduate in agricultural engineering must first be proficient as an engineer. Peikert (21), who studied the existing so-called agricultural engineering programs in Maharashtra, India, said that an agricultural engineering program is based on: (a) advanced mathematics, usually including differential equations; (b) advanced physics; (c) basic engineering subjects in several fields; and (d) courses in biological sciences. These form the background for agricultural engineering courses dealing with the design and application of machines and systems for the production, processing, and storage of food, feed, and fiber. Any student completing such a program can qualify for a wide range of engineering positions and can rightfully be called an agricultural engineer. Present avenues of employment for agricultural engineers in India are summarized in Appendix J.

A panel studying agricultural engineering in Latin America defined the curriculum's academic requirements more generally (28):

1. Basic sciences and mathematics--20 percent.
2. Basic engineering sciences--20 percent.
3. Other courses in agricultural sciences, economics, and humanities; and at least one course in each of the main areas of specialization in agricultural engineering.
4. Total required courses--60 percent of the total undergraduate curriculum, allowing ample program flexibility.

Characterization of agricultural mechanization technology. According to Peikert (21), a program in agricultural mechanization which leads to a B.S. degree granted by a college of agriculture usually combines agricultural sciences, applied engineering, and courses in business. A graduate in this program is usually employed in sales, service, promotion, or management of areas requiring application of mechanical principles.

Such programs are being offered by a number of agricultural engineering departments in the United States, although agricultural engineering students and agricultural mechanization technology students often attend separate sections of the same course because of their differing curricular objectives.

The effectiveness of an agricultural mechanization technology program rests on the emphasis that must be placed on the practice of "working with one's hands." Nearly all 44 of the agricultural scientists interviewed for this study were concerned with the inability of the students, teachers, researchers, and extension workers in developing countries to work with their hands. Many teachers in developing countries are unaware of how silly they look when they cannot demonstrate a machine with their own hands. It is impossible to develop an outstanding agricultural university in a developing country unless the staff can demonstrate with soils, crops, animals, and machines using their own hands and can transmit this ability, which is a demonstration of the dignity of labor, to their students. It is in this spirit that Christensen (22) adds to his list of such ingredients of agricultural development as improved technology, education, and fertilizer a quote from E. O. Heady: "What is less obvious is how to overcome the political, cultural, and intellectual restraints which prevent nations from boosting agricultural productivity."

Developing both curricula. Several American agricultural engineers who have worked in developing countries feel strongly that agricultural mechanization technology should not be developed without agricultural engineering, for it is important that there be a totally integrated engineering approach to the production of food, fiber, and fuel. Though the curricula of the two programs are extremely different, both are vital to the economy of a nation, and each must take its rightful place in the agricultural development of developing countries.

In establishing both an agricultural engineering program and an agricultural mechanization technology program, special consideration must be given to specific conditions in the developing countries. As an approach toward the development of both these curricula, Jacob (44) suggests that the teaching program in agricultural engineering should also include a diploma curriculum to fill the gap between the engineer and practical agriculture.

One American agricultural engineer in India wrote that it can be difficult to get college graduates to work with farmers. Because of the continued emphasis on mathematics and science in the engineering program, many engineers are not interested in applied technology (30). Mechanization majors could be trained to bridge this gap between the skilled worker and the engineer, so that one program is complementary to the other.

The head of an agricultural engineering department at an eastern U.S. university stated that industry in India is at present reluctant to accept agricultural engineers. Variations in graduates qualities have been wide--from general agriculturist to sophisticated engineer; no standard of qualifications has been adopted. As a result, industry has had a tendency to hire a conventional or traditional engineer to be sure of getting a man who can do engineering. Connected with this problem is the concern expressed by most of the individuals who wrote letters and who were interviewed for this report: they urged that graduates of agricultural mechanization technology not refer to themselves as engineers. Both agricultural engineering and agricultural mechanization technology will have to prove themselves as producers of skilled men.

Government Study Committee

The two fields of agricultural engineering and agricultural mechanization technology should be made clearly distinct and each developed according to the needs of the country. As a first step in this process, a high-level government committee should be designated to study the role of agricultural engineering education in agricultural universities and to obtain government approval for changes that should be implemented.

Membership for the study committee would reasonably include a top level agricultural administrator from the government; a person with an appreciation and background in agriculture from the state or national education department; two or more top men from the agricultural equipment industry who appreciate the agricultural mechanization technology problem and who are familiar with the employment situation that graduates will face; two men from such organizations as the Ford or Rockefeller Foundation and USAID, with one perhaps in agricultural engineering and the other in extension; and one or two from the state agricultural universities at each of the levels of agricultural engineers, deans of agriculture, and vice chancellors.

Governmental support is essential. Whatever approach or plan is finally adopted to implement agricultural mechanization technology in developing countries, it must be put into effect forcefully by those in power. The indirect approach will not work soon enough. Training must begin now so that the developing country will be ready when the impact of programs already in progress, such as farm electrification, begins to be felt.

Some of the important questions the governmental study committee should consider are these:

1. Should the two areas of agricultural engineering and agricultural mechanization technology be closely related or divorced completely from each other? (My own opinion is that they should be developed together on the same agricultural campuses. They should be separated enough so that one does not dominate the other, but they must be closely enough coordinated to supply the depth of applied engineering necessary to truly help the farmer with his problems.)

2. Which existing institutions produce which kind of graduates--agricultural engineers or agricultural mechanization experts? How many engineers and mechanization experts are available in agriculture, and how are they distributed within the country?

3. Is the present agricultural engineering program too sophisticated? Too narrow in its various options? Too similar to the traditional engineering programs already offered or to agricultural engineering programs in developed countries? Too oriented to scientific endeavors rather than engineering?

4. On the other hand, are the present programs in agricultural engineering too broad? Do they contain too much general agriculture or agricultural mechanization content to be called agricultural engineering? Or, should the present programs of agricultural engineering be more general with little specialization but still engineering in nature? All these types of mechanization are now available in developing countries under the name of agricultural engineering.

5. Should more agricultural engineering departments or colleges be developed within the developing country? Is there a surplus or deficit of graduates from existing departments? One American agricultural engineer in India writes that there are enough departments, and future growth should be on a regional basis.

Development of Agricultural Mechanization Technology

A five-point priority program is recommended to develop agricultural mechanization technology programs in developing countries:

1. To meet the immediate needs of agriculture, skilled men should be trained in specialized lines of mechanized agriculture.

2. Certificate and diploma specialists in agricultural mechanization technology will be a high priority.

3. A service-oriented center for agricultural mechanization technology should be established that will be responsible for certificate courses, short courses, and diploma courses.

4. A program to provide the best possible training in mechanized agriculture must be developed.

5. Professional teachers and leaders must be provided who will train future agricultural mechanization graduates of 4- or 5-year programs to work as teachers in industry, extension, and government.

Establishing a Center for Agricultural Mechanization Technology

Such a center should be developed as a center within the agricultural colleges in each of the agricultural universities where an agricultural engineering department exists. The center must be on the same level as other departments in the college of agriculture such as agronomy, horticulture, and soil science. The center will handle the service education needs of agriculture in general. If there is reluctance to take this bold step, a vital program in agricultural mechanization technology should be started in at least two or three universities where back-up facilities and supplemental courses are highly rated. Emphasis must be placed on the quality of these centers rather than their quantity. Kline (42) goes so far as to recommend the establishment of regional and international centers for agricultural equipment and mechanization.

The motto and emphasis of the center must be "work with your hands." Every teacher must demonstrate each process himself which the student must repeat; every laboratory must involve every student in a "do-it-yourself" situation. Various mechanization courses should require projects which the student can complete through his own creativity, initiative, imagination, and physical efforts. The student should come to appreciate working with the soil and to obtain the rewards of his own labor in a unique learning experience. Emphasis should also be placed on "earn-while-you-learn" projects.

Certain periods of time, such as the summer, a semester, or possibly a full year, should be set aside for agricultural mechanization technology majors to train with dealers, distributors, and other local agencies to obtain the basic mechanical aptitudes essential for diploma and degree graduates in this curriculum.

The activities of the agricultural mechanization technology center should be coordinated with the extension education program, for both have many similar objectives. Claar (19) outlined in-service education proposals for Indian State government agricultural personnel which should be considered in this program.

Suggested Programs To Be Offered by a Center of Agricultural Mechanization Technology

Of first priority is the development of short-term programs. Conferences, short courses, and diploma programs should be arranged to train skilled workers to do highly specialized tasks, such as pump maintenance, to meet agriculture's most pressing mechanization needs. The length of these programs, depending on needs, could be 3 days, 3 weeks, 3 months, or 6 to 9 months; in addition, specialized programs for one, two, and maybe even three years could be offered. (The university in Bangalore, Mysore, India, has recently introduced a 3-year diploma curriculum in agricultural engineering.) Such training is similar to the training in mechanization to develop skills as recommended by Kline (42).

Subject matter would include training in any of the skills connected with the program content for the degree program listed in the next few paragraphs. The subjects would include work in pumps and power irrigation; drainage; equipment for grain processing, planting, tilling, and harvesting; shopwork; electricity; tractors; and any other important skills needed at the time. To help accomplish this, on-the-job training for students should be arranged with machinery dealers and distributors throughout the state.

Participants should be drawn from all classes of people, but with an emphasis on youth, if possible, rather than on older people connected with agriculture. The educational level of any group in a short course or diploma curriculum should be relatively the same among participants and consistent with good educational development throughout the program. Graduates should be called diploma holders or receivers of certificates; they should not be called agricultural mechanization technology graduates or agricultural engineers.

Of second priority is a degree program in agricultural mechanization technology. This curriculum will be broader in scope than the conferences and short courses that lead to specialized diplomas or certificates. Graduates from the degree program should be called agricultural mechanization technologists, not engineers.

The number entering the degree program should be limited at first to insure adequate instruction and proper motivation for each student. If the graduates are people who cannot get actively involved in their work, who cannot work well with their hands, or who cannot train farm groups, then this program will have limited value. The worth of a graduate of the degree program must be proved from the first if the program is to succeed.

A suggested course of study for the degree program is given below. Courses may vary according to the needs of the particular country involved, but it is essential that the program not evolve into a watered-down agricultural engineering program. A suggested curriculum is as follows:

1. Required basic courses: botany, chemistry, geology, mathematics (at least algebra and trigonometry), physics, rhetoric, speech, zoology, and physical education. The mathematics and physics must be practical and applied; laboratory work should emphasize working with one's hands.

2. Other requirements:

--Approximately one-third of the total college credits should be in agriculture.

--A basic course should be taken in agricultural economics, in animal science, and in dairy science.

--At least 20 to 25 percent of all credits should be in agricultural mechanization technology.

--About one-fifth of all credits should be in commerce or business areas, including accounting, economics, marketing, sales, statistics, and similar subjects relevant to the country involved.

--The remaining courses should include humanities, social science, and other electives.

An example of a curriculum similar to the above can be found in the Agricultural Mechanization Department of the National College of Agricultural Engineering (40). This department in England provides undergraduate training, a certificate course in tropical farm mechanization, and an M.Sc. degree in tropical agricultural mechanization.

Program content. For the next one or two decades, training should be given in approximately the following order of subject matter. After that time tractors and similar machinery might rate much higher in priority.

1. Water management, simple hydrology (rainfall and runoff), drainage, erosion control, tubewells, pumps, and power. Soil and water control is at the top of the list for work to be done now in developing countries.
2. Electricity. Training must be given now to meet the rapidly developing needs of farm electrification.
3. Practical grain storage, processing, threshing, development of low-cost storages, and materials handling. Sprague (32) estimates grain losses of 20 to 50 percent from moths, weevils, and rodents.
4. Shop training, including welding, forging, operating machine tools, etc.
5. Equipment for planting, tilling, and harvesting.
6. Tractor power and accompanying equipment.

Items and priorities will vary with the needs of the country and in some cases with the regions of the country. However, water management tops the list in nearly every case. A panel summary for Latin America (28) also suggests a program: agricultural mechanization and automation; soil and water management, utilization, and conservation; rural planning and construction; preservation, handling, and processing of agricultural products.

A suggested text for the program is Engineering Applications in Agriculture (20). Developed at the University of Illinois for agricultural mechanization technology studies, it has been used successfully throughout the United States for years. A new revision is planned.

Agricultural mechanization technology courses for agricultural students. All agricultural students should be required to take a minimum number of mechanization credits from all available agricultural mechanization technology courses. These courses should be electives from such major areas as irrigation, drainage, mechanization equipment, electricity, and others. Forcing all agricultural students to take a set group of agricultural mechanization courses should definitely be avoided, as such a situation could easily cause course quality to deteriorate.

Agricultural students should attend the same sections of agricultural mechanization courses as the agricultural mechanization technology students. Giving such a series of courses to agricultural students, however, should not be considered a substitute for training agricultural mechanization technology students. There are too many agricultural generalists already in developing countries; more specialists are needed.

Since the agricultural mechanization technology curriculum and center will be in the agricultural college, it should be no problem for an agricultural student to transfer into the program before or after graduation and to make up the mechanization courses.

Additional aspects of the program. All personnel and all facilities should be strongly encouraged to cooperate with existing organizations to develop the best programs possible. Many existing organizations should become involved in the agricultural mechanization technology program, including the district and state implement workshops, the district and state tractor maintenance workshops, and the tractor training and testing stations. Industrial engineering types of training--perhaps difficult to combine with agriculture but effective if accomplished--could involve industrial training institutes for electricians, carpenters, sheet metal mechanics, welders, machinists, engine mechanics, shopworkers, etc.; polytechnics where industrial helpers are trained; and engineering colleges. In addition agricultural machinery companies, distributors, and dealers should try to provide short-term employment for the diploma and degree students; provide up-to-date machinery for use in laboratories at the agricultural university on a small rental or other reasonable basis; cooperate in developing and operating machinery short courses for the area; and cooperate with the agricultural universities in applied research for the development of new machines, most importantly at an early stage of such a project (28). Kline (42) strongly promotes coordination, especially regional coordination, of all facilities of research, agricultural power, and land use.

When there are several branches of a university throughout a state, agricultural mechanization technology courses should also be made available to agricultural students at these outlying institutions. The coursework offered and the teaching must be of good quality. Again, the agricultural students should take a minimum number of courses in agricultural mechanization technology but should have a choice about which group of courses to take. Teaching at the branch institutions might be a good training ground for potential staff for the central agricultural mechanization technology center.

A master's degree program in agricultural mechanization should be encouraged for agricultural students who wish to be connected with this program and for agricultural mechanization technology graduates. However, such a degree must be a good one, developed in an agricultural mechanization technology center after the center is well established.

<u>Teachers for agricultural mechanization technology</u>. These teachers must be the best. They must be mechanically inclined--"doers" who can work with their hands. They should be selected from all regions of the country and from all aspects of agriculture, and they should be able to communicate with all classes of agricultural people. They do not have to be engineers, but they must be technically competent to teach the courses listed for this curriculum.

Members of the agricultural engineering staff could make ideal teachers because they are exceptionally well trained technically in engineering to teach agricultural mechanization technology students, but they must also be able to train students and farmers to be "doers." Agricultural engineers interested in this mechanization work should be given a training program to adapt them to the philosophy of agricultural mechanization technology. They could teach in the agricultural mechanization technology center full time or have joint appointments with the center and the agricultural engineering department.

These teachers will be expected to teach in conferences, in short courses, and in the diploma and degree programs. They should be rewarded for their ability to teach effectively, to demonstrate, and to develop "doers." Work in applied phases of research and in extension should also be rewarded. The M.Sc. degree is definitely recommended, but lack of a Ph.D. should not be penalized.

The upperclassmen working in the degree program in agricultural mechanization technology can also be used to help teach the laboratories of the short course and diploma programs. This will be training in demonstration and extension techniques for their work after graduation.

As in all educational work, emphasis must be placed on encouraging out-of-staters to take teaching positions. Through such migration, better and higher standards of education can be developed; otherwise, inbreeding develops, and progress is stifled. Get the best teachers for this program wherever they may be.

Job opportunities for graduates. Several letters and persons interviewed warned that a new curriculum like agricultural mechanization technology might suffer from a lack of status and prestige among educators, especially since it strongly emphasizes working with one's hands. However, it is hoped that the demand for the services provided by these graduates will give impetus to the program from the bottom up. A discussion of this program with representatives of farm machinery companies operating in developing countries and with American agricultural scientists who have close contacts with such companies indicated that agricultural mechanization technology graduates could be employed by these machinery companies. Many jobs are and will be available as salesmen, demonstrators, mechanics, and possibly dealers. The companies are searching for such men now. They feel that such technicians must be trained through the existing agricultural universities in diploma curricula, short courses, and in the agricultural mechanization technology degree curricula.

However, there are still several problems facing graduates seeking employment. An American agricultural engineer who has been in India for several years stated, "I believe that a well-educated and trained individual in agricultural mechanization could find a job and could fulfill a function in India. However, he would undoubtedly be considered as an agricultural graduate and would have to fit into the particular department of agricultural program as it now exists. Many states have provisions for individuals who assist in the demonstration and popularization of agricultural machinery. This situation is undoubtedly where this individual would first find employment with the Government. He could also find employment with some manufacturers as service representatives. However, it is my sincere belief that an agricultural mechanization program would be of primary benefit to the individual who was hoping to make farming his life's occupation providing he could find the capital to develop an economical and viable agricultural production unit and if allowed to do so under the particular state land-holding requirements."

An Indian agricultural engineering department head observed by letter that when a new type of training is started, it does not fit in any existing employment cadre set by the government, and employment becomes a problem. The agricultural engineers in India faced this problem for some years: they fit into neither the government nor the agricultural cadre. The department head feared that agricultural mechanization graduates would face this problem. He suggested as an alternative that senior agricultural students have the opportunity to specialize in farm mechanization and thus be acceptable in agricultural cadres.

An American agricultural engineer from a Midwest university who completed an assignment in Africa says the problem is that the level of education gets a person the job. Once the person is on the job, the level of education he has or that which he attains in the future dictates his promotions in the job. In English-oriented developing countries, the job description is set up so that only those persons with a certain type of education will be able to occupy that job. He does not think that a person without an agricultural engineering degree will be able to secure a job or will be placed in a job where he will be talking to farmers about the use of equipment.

From the above comments it is obvious that any committee studying the possibilities of establishing a center for agricultural mechanization technology must give much consideration to employment of such graduates. As discussed earlier, industry might guarantee a number of positions at first. Graduates of the agricultural mechanization technology center would have been students in the agricultural college of that university. As such, they are agriculturists and should be hired in many of the agricultural positions listed by government agencies. The agricultural mechanization graduate would be invaluable as an extension worker to coordinate his work with other disciplines in helping the farmer.

Summary

A. Agricultural Needs in Developing Countries:

1. The developing agricultural universities and other educational institutions must expand and extend leadership to meet the needs of all the people, especially the farmers, at this crucial stage of agriculture in developing countries.

2. The image of agriculture must be elevated through agricultural training starting in the elementary grades to develop agricultural leadership so vitally needed. Many vocational agriculture teachers must be trained for this purpose.

3. The mechanization of agriculture in developing countries should expand generally through two stages of development:

--Simple mechanization during the first decade or two, when agriculture must absorb a large portion of the increase in population, to increase output per worker on less land per worker and to increase production per acre.

--More complicated mechanization after industry expands to the point where it absorbs a large portion of workers, leaving a much smaller portion of labor for farm help.

4. A strong network of "service" organizations with well-trained, skilled, and specialized workers should be available to service the mechanized phases of agriculture for the farmers.

B. Establishing Centers in Agricultural Mechanization Technology:

5. The name of agricultural engineering has been used to cover all phases of mechanized agriculture in many developing countries -- from simple skills to sophisticated design engineering. The term "agricultural mechanization technology" should be introduced to designate mechanical skills along with the practical application of engineering principles to agriculture.

6. A high-level government committee should be appointed to study the needs of agricultural mechanization technology with members from the farm equipment industry, the state and national governments, agricultural universities, and organizations like Ford and Rockefeller Foundations and USAID. Industry personnel have top priority on this committee, for industry should consider hiring certificate and diploma holders and degree graduates. The future roles of agricultural mechanization technology and agricultural engineering in any country should be carefully studied and delineated by such a committee.

7. This report recommends the establishment of a vital program in agricultural mechanization technology in developing countries to answer the "service" needs of mechanizing agriculture for the farmer.

8. A curriculum in agricultural mechanization technology should be developed as a center in agricultural colleges preferably where an agricultural engineering department exists to insure adequate depth in applied engineering work. This program must never develop into a watered-down agricultural engineering program.

9. The Agricultural Mechanization Technology Center should be on the same level as departments in agriculture such as agricultural engineering, horticulture, agronomy, and animal science -- to prevent being dominated by any of them and to promote adequate development. It should, however, service all phases of agriculture.

C. Program Goals and Implementation:

10. The two priority programs for an Agricultural Mechanization Technology Center should be: first and most important, the development of conferences, short courses, and diploma courses to train specialized skilled men needed to service mechanized agriculture; and second, the training of at least a limited number of degree holders to be used as teachers and in industry, in extension, and in other areas, who can work with their hands.

11. The areas of training to be developed by the Agricultural Mechanization Technology Center for certificate, diploma, and degree holders should be in this general priority order: soil and water control and use, electricity, simple grain storage and processing, shop training, tillage tools including planting and harvesting, and tractor power and accompanying equipment.

12. The teachers of agricultural mechanization technology must be the best that can be found in the country, preferably agricultural engineers if they are "doers." The teacher should be an agriculturist well trained in mechanization with proven ability in developing students who will work with their hands.

13. Coordination and cooperation of all facilities and personnel should be effected throughout the country in the complete development of agricultural mechanization technology, including district and state workshops, tractor training and testing stations, industrial training institutes, and all other closely allied facilities.

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APPENDIX A - ORIGINAL REQUEST FOR FUNDS FROM THE MIDWEST UNIVERSITIES CONSORTIUM FOR INTERNATIONAL ACTIVITIES FOR THIS REPORT

Category B: The Role of Agricultural Engineering Education in Agricultural Universities of Developing Countries with Particular Emphasis on India

I. *Purpose*

To identify the optimum organization of agricultural engineering education in universities of developing countries with special attention to India.

II. *Background and Progress to Date*

The evolution of agricultural engineering departments in the United States has followed varied paths of development but often has stemmed from agricultural mechanization sections in departments of agronomy. Such sections were established with the advent of field mechanization practices and had their earliest beginnings about mid-point of the last century. The rapid expansion of field mechanization to include both cultural and harvesting techniques coupled with advances in farmstead handling and distribution schemes and soil and water mechanics stimulated growth and the formation of separate departments. Presently in the United States there are some 50 such departments with 36 offering professionally oriented agricultural engineering curriculums accredited by the Engineers' Council for Professional Development.

In many colleges of agriculture over the United States and Canada, and usually associated with departments of agricultural engineering, a curriculum or option exists known as agricultural mechanization, farm mechanics or by some similar title. At the University of Illinois, Urbana-Champaign Campus, the agricultural mechanization program is an option under the general curriculum in agriculture. In this program much greater emphasis is placed on practical operating aspects of agricultural production processes than in the curriculum in agricultural engineering which, in fact, is largely theory-oriented, administered within the College of Engineering, and directed toward qualifying the graduate for professional engineering practice.

Shortly after gaining independence, the Government of India provided for five national institutes of technology to provide trained engineering manpower. At one of these institutes (Kharagpur) an agricultural engineering department was established with assistance from the Colleges of Engineering and Agriculture of the University of Illinois, Urbana-Champaign Campus. It has been, and continues to be, effective in providing highly qualified agricultural engineers. Graduates from the curriculum enrolled in various graduate colleges including the one at Urbana-Champaign have, in general, performed satisfactorily.

III. *Justification*

In establishing colleges of agriculture in India it has been almost uniformly felt that a department of agricultural engineering should be provided. Furthermore, it has been the feeling that the department should provide a curriculum leading to a baccalaureate degree in agricultural engineering essentially equivalent to that offered by the counterpart university in the United States. One observation often heard is that Indian graduates in the upper quartile of their classes should possess training so as to permit them to adequately perform in a graduate level program in agricultural engineering in a first rate graduate college in the United States.

Unfortunately, however, because of the difference in agricultural development of the two countries -- India and the United States -- these highly trained Indian engineers, be they trained in India and/or the United States, are not finding the professional challenge which they demand in the agricultural industries of their country. Many are accepting assignments in the United States; those who return to India often work in areas unrelated to agriculture.

It is believed that the above and related questions should be considered by a senior professor of agricultural engineering who has had extensive experience in India. Perhaps the results of the study would suggest that agricultural engineering programs in some agricultural universities should give way to a less sophisticated educational program more attune with the present degree of mechanization in Indian agriculture. Such programs might be administered through a Department of Agronomy or perhaps a Department of Agricultural Mechanization. Instruction would be more practical and descriptive, less based on mathematics and the physical sciences than that found in departments and colleges of engineering.

The researcher would possess the desired overseas background and would use this to an advantage in contacts with such organizations as the American Society of Agricultural Engineers, the American Society for Engineering Education, and the Engineers' Council for Professional Development. Consultation with the Committee on Engineering Technology of the latter organization should be particularly helpful. He would also make extensive contacts with leading agricultural engineering educators in other American universities having educational interests and commitments in India.

This study will also draw on and add to the CIC-AID Rural Development Research Project. This project was in part conducted at Urbana-Champaign and much data is available on campus which will be useful in the proposed study.

IV. *Qualifications of Investigators*

Professor Elwood F. Olver will have served as leader of the University of Illinois Group stationed at the J. Nehru Agricultural University, Madhya Pradesh, India, for a two year period beginning about July 1, 1967. In addition, he has served as Chairman of the Group Leader organization made up of a number of representatives of American land grant universities having educational projects in that country. He has outstanding educational qualifications holding the bachelor and master of science degrees from Pennsylvania State University and the doctor of philosophy degree from Iowa State University. He has not only demonstrated on a number of occasions his technical competence but also his administrative finesse and effectiveness.

APPENDIX B - SOURCES OF INFORMATION AND SOME OF THE IDEAS IN THIS REPORT

This report was developed during the winter of 1969-1970. Basic ideas were obtained from the following:

1. 31 letters of requests for information sent overseas to:

		sent	received
a.	Indian agricultural scientists and	8	2
	agricultural engineering department heads	7	2
b.	American agricultural scientists and	5	2
	agricultural engineers	8	6
c.	German agricultural engineers	2	2
d.	South American agricultural engineers	1	1
		31	15

2. Personal visits made in the United States to:

a.	American agricultural scientists	18
b.	American agricultural engineers	24
c.	Indian agricultural engineers	2

Discussions with all scientists and engineers visited centered on the proper context of agricultural engineering and agricultural mechanization technology curricula and professions in developing countries. The following foreign and American agricultural engineers and other agricultural scientists, tabulated above, who have had considerable experience in developing countries furnished many of the ideas in this report by letter or interview:

Foreign Engineers and Scientists

A. Alam, at University of Illinois from Agricultural Engineering College, JNAU, Jabalpur, India

A. P. Cobra, Instituto Interamericano De Ciencias Agricolas De La Oea, Lima, Peru

A. C. Pandya, Head, Agricultural Engineering Department, I.I.T., Kharagpur, India

B. S. Pathak, Head, Agricultural Engineering Department, Punjab Agricultural University, Ludhiana, India

G. Preuschen, Director, Max-Planck-Institute, Germany

G. Rangaswami, Dean, The University of Agricultural Scientists, Bangalore, India

N. K. A. Rao, Dean, College of Agriculture, UPAU, Pant Nagar, India

U. Riemann, Institute of Agricultural Engineering, University of Kiel, Germany

H. R. Tyagi, at University of Illinois from Agricultural Engineering College, JNAU, Jabalpur, India

American Agricultural Engineers in India

J. S. Balis, USAID

B. L. Bondurant, from The Ohio State University with the Punjab Agricultural University, Ludhiana, India

R. E. Harrington, from Deere & Company with the Ford Foundation

E. D. Rodda, from the University of Illinois with the Uttar Pradesh Agricultural University, Pant Nagar, India

M. D. Shaw, from The Pennsylvania State University with the Maharashtra Department of Agriculture, Poona, India

H. V. Walton, Chief of Party, from University of Missouri with the Orissa University of Agriculture and Technology, Bhubaneswar, India

American Agricultural Educators

T. R. Stitt, from Southern Illinois University at Kathmandu, Nepal

R. R. Renne, from the University of Illinois at UPAU, Pant Nagar, U. P., India

American Agricultural Engineers Interviewed:

Cornell University:

O. C. French, Head, Agricultural Engineering Department

P. R. Hoff

G. Levine

University of Illinois:

R. C. Hay

F. B. Lanham, Head, Agricultural Engineering Department

Iowa State University:

W. F. Buchele

University of Maryland:

R. L. Greene, Head, Agricultural Engineering Department

Michigan State University:

C. W. Hall, Head, Agricultural Engineering Department

C. K. Kline

C. J. Mackson

University of Missouri:

D. B. Brooker

C. L. Day, Head, Agricultural Engineering Department

M. M. Jones

R. L. Ricketts

The Ohio State University:

H. J. Barre

D. M. Byg

F. L. Herum

S. G. Huber

G. L. Nelson, Head, Agricultural Engineering Department

G. O. Schwab

E. P. Taiganides

The Pennsylvania State University:

D. C. Beppler

W. L. Kjelgaard

F. W. Peikert, Head, Agricultural Engineering Department

Other American Agricultural Scientists and Educators Interviewed:

Cornell University:

F. K. T. Tom, Agricultural Education

K. L. Turk, International Programs

L. W. Zuidema, International Programs

University of Illinois:

W. D. Buddemeier, International Programs

R. J. Martin, Director, Engineering Experiment Station

G. W. Salisbury, Director, Agricultural Experiment Station

University of Missouri:

W. E. McKinsey, Agricultural Economics

Parker Rogers, International Programs

W. J. Upchurch, Agronomy

E. Kiehl, Dean, College of Agriculture

The Ohio State University:

C. E. Johnson, Agricultural Mechanization Technology

The Pennsylvania State University:

Frank Anthony, Agricultural Education

R. McAlexander, International Programs

F. J. McArdle, Division of Food Science

Southern Illinois University:

W. E. Keepper, Dean, College of Agriculture

H. L. Portz, Agronomy

U. S. Government:

R. P. Christensen, Director, Foreign Development and Trade Division, ERS, USDA

F. W. Parker, Consultant, USAID

APPENDIX C - VIEWS ON AGRICULTURAL MECHANIZATION TECHNOLOGY AND AGRICULTURAL ENGINEERING

The viewpoints of foreign and American agriculturists recorded in Appendix C are widely divergent. The variation in American viewpoints was wider than the variation between foreigners and many of the Americans. These viewpoints are taken from both letters and interviews. Most of the Americans have had considerable experience abroad.

The letters from Indians, Germans, and Americans working in developing countries show that agricultural engineering means something different to almost everyone. Both agricultural engineering and agricultural mechanization technology are practiced in most developing countries under the title of agricultural engineering. These opinions expressed in Appendix C have helped to develop this report and to place both curricula in their proper context. They are divided into four groups: (1) Indian views comparing agricultural engineering and agricultural mechanization technology; (2) German views comparing agricultural engineering and agricultural mechanization technology; (3) American views that compare agricultural engineering and agricultural mechanization technology; and (4) American views that mainly discuss agricultural mechanization technology.

These men feel that agricultural mechanization must be flexible and must respond rapidly to the needs of the country. Government support must be found for whatever program is developed. If farm boys are to be brought into the program, money is needed and the government must sanction the program fully. Students should be allowed to obtain various specialized programs, but the program should not be worked into a Ph.D. program. To meet the needs of the developing country the program must be service conscious, not degree conscious.

Indian Agriculturists' Views on Agricultural Engineering and Agricultural Mechanization Technology

1. A high-level Indian administrator in an agricultural university said that in India "agricultural engineering" is taught at the following levels:

   B.Sc. Agricultural Engineering, five-year program after pre-University in which all aspects of agricultural engineering are dealt with. In one or two centers graduate education leading to a master's degree in some branches of the subject has also been instituted.

   B.Sc. Agriculture, four-year program in which agricultural engineering (farm machinery, and soil and water management) is taught as a part of the program. In general, students carry 12 to 15 credit hours of work under the trimester system.

   Some universities have recently introduced a major field of specialization in agricultural engineering. Over and above the general coverage of the subject in the final year of the B.Sc. Agriculture class, agricultural engineering is covered at a somewhat advanced level with a total of 12 to 18 credit hours.

   In a university at Bangalore a diploma course in agricultural engineering has been introduced. The minimum admission requirement is a pass in the high school examination, for which the candidate should have studied mathematics, physics, and chemistry. The duration of the course is three years, and subjects include some branches of basic sciences and humanities, soil and water management, and farm machinery.

In his opinion each of the above four programs has a role to play in the development of farm mechanization in India. At present the B.Sc. Agricultural Engineering degree holders are not readily employed in India. The B.Sc. Agriculture degree holders do not have enough training in the subject to extend it to the farmer's field. The persons who are to specialize in agricultural engineering in their B.Sc. Agriculture degree program are yet to prove themselves in the field. The diploma holders are expected to go back to the land and practice mechanized farming. They are expected to be employed by the progressive middle-class farmers who are looking for opportunities to mechanize their farms.

2. Another agricultural university Indian administrator made these points: There is a need to produce graduates in agricultural mechanization. There is also a feeling current among educators that just now there is a limited scope for agricultural engineering graduates and that the existing institutions are enough to meet the needs and that more agricultural engineering colleges should not be started.

   The agricultural universities which have not started the agricultural engineering degree program are anxious to start such a program.

   While the agricultural engineering graduates produced at the agricultural universities and the Indian Institute of Technology (IIT), Kharagpur, with proper orientation to practical agriculture can serve in the areas of service, sales, and management where mechanical principles are applied, this need might be better met by an agricultural mechanizatinn program. For such a need, it may not be necessary to include as much of basic engineering as is being done at present in agricultural engineering but far more practical agriculture is needed than is being given in agricultural engineering. It may therefore be desirable for some of the agricultural universities which have not started the degree program in agricultural engineering to have a four-year program of agricultural mechanization closely tied with agriculture. Many of these institutions will not be able to develop a strong program in basic engineering, like civil, electrical, and mechanical, but may be in a position to develop an agricultural mechanization program. Before such a program is initiated, the industry dealing with farm machinery and equipment and the agro-industrial corporations that are coming up in each state must be consulted and a program developed which will suit their needs.

3. An Indian who is head of a professional agricultural engineering department said that a large number of engineers in India have not obtained suitable employment. The number generally quoted is about 50,000 engineering graduates, mostly civil, electrical, and mechanical. Besides the Indian Institute of Technology (IIT) and Allahabad Institute, some other agricultural universities such as UPAU, PAU, Udaipur, J. Nehru Agricultural University, Orissa, and Poona are admitting students for bachelors' degrees in agricultural engineering. The students from IIT, Allahabad Institute, Punjab Agricultural University (PAU), Uttar Pradesh Agricultural University, and Udaipur are already in the market for employment. PAU and Udaipur had prolonged strikes by agricultural engineering graduates because they did not get suitable employment. So the immediate problem is to absorb the agricultural engineering graduates who are already produced in the country.

   The department head believed that instead of a separate farm mechanization course, the present graduates of agricultural engineering who are not employed could be given suitable additional training to work for the farm mechanization program. Advocating a farm mechanization program at the present stage will cause confusion in the professional field, It is also possible to reorient the curricula in some of the state agricultural universities to allow some work in farm mechanization as applicable to the Indian situation. This may be done at the universities that do not have the excellent engineering facilities needed for a modern engineering education. The University of Agricultural Sciences, Bangalore, has organized an Institute of Agricultural Engineering at Raichur, where it proposes to train diploma holders in agricultural engineering. Such diploma training is available in civil, mechanical, and electrical engineering in India.

4. Another Indian agricultural engineering department head reported that in India some employment cadres have been established at the government level as well as with the industries. When a new type of training is started, it does not fit in any of the existing cadres, and employment becomes a problem. The agricultural engineers in India faced this difficulty until some years back because they were not always acceptable in the engineering cadres nor did they fit in the agricultural cadres. Agricultural mechanization graduates might face the same problem. Providing opportunity for specialization in farm mechanization to the senior students of a college of agriculture might be an alternative. These people will be acceptable in the agricultural cadres. The recent trends in India have shown a very close relationship between assured water supply and mechanization. It might be advisable to consider emphasis on water management as an integral part of the specialized training in agricultural mechanization.

5. Randhawa (36) said that mechanization of agriculture in India is essential for increased food production. He recommended that the operations be mechanized in this order: irrigation, tillage and soil conservation, sowing, seeding, fertilization and plant protection, reaping, harvesting and threshing, and transportation. He also stressed new electrical uses. He recommended that repair and servicing centers be located near marketing places in each farming block within easy access of the farmer. He shows how essential is the training of team leaders, skilled personnel, and leadership through short courses.

6. An Indian administrator, Jacob (44), suggests a compromise for India that comes somewhat closer to the recommendation of agricultural mechanization technology centers of this report. He feels that the teaching program in agricultural engineering should also include a diploma curriculum. This diploma program would be for the purpose of filling the gap between the engineer and the technician. Engineers are now trained by the degree program in agricultural engineering colleges while the technicians through Industrial Training Institutes (ITI's). The diploma program should be so designed, states Jacob, as to develop technologists who will carry out the actual application of agricultural science and technology on the farm.

German Agriculturists Views Comparing Agricultural Engineering and Agricultural Mechanization Technology

The following comments are from two German agricultural engineers:

Very often, after technical specialists have studied engineering in German colleges, these able engineers do not go back home. Or if they go back, they do not take much interest in the necessary but low stage of mechanization probably needed in their countries.

In Germany agricultural engineers are trained with agricultural facilities which teach all agricultural subjects. This training parallels the engineering training at technical colleges. These agricultural engineers are all-round farmers with additional knowledge in the application of mechanization, but without knowledge in designing machinery. They give much advisory service in Germany.

Agriculturally trained engineers should be trained also in labor study, including knowledge in sociology essential in evaluating human work and in ergonomics (biotechnics), for work in various climates is performed differently than in the temperate zone. This (applied) agricultural engineer should be acquainted with the proper use of hand tools that will remain in use.

Developing countries need more mechanization people than engineers, especially since the production of agricultural machinery is very low, making the demand for engineers in the same ratio.

Every agricultural college should have a department of farm mechanization and buildings. Special courses should be offered leading to a degree in farm mechanization, other courses in farm mechanization for agricultural students in other departments. The farm mechanization curriculum should offer:

Fundamentals in physics, mathematics, and engineering

Methods of farm mechanization and selection of the best mechanization system

Methods of machinery testing

Industrial instrumentation

A survey of the whole field of agricultural machinery of that area

Critical evaluations of machines to help designers develop better tools

Plans for the mechanization of agriculture

Precedence in developing countries should be given to expansion of water supply systems and to introduction of modern fertilizer.

American Agriculturists' Views on Agricultural Engineering and Agricultural Mechanization Technology

1. An American agricultural engineer working in India for approximately seven years made the following analysis:

   Discussions with Indian farm equipment manufacturers, many of them with only small businesses, suggest that they need engineers. These engineers should be able to do production design, field testing, trial, and demonstration as well as material purchasing, labor management, and business management. The requirement is for creative personnel who are able to handle a broad range of industrial and management problems encountered in the development, production, and sales service of agricultural machines.

   The common use of agricultural mechanization implies skills in application and use, rather than production of hardware. There is also a need for a large number of professionals in agricultural machinery application to advise and guide farmers, as a significant trend toward mechanization gets under way. Agricultural mechanization seems to be a distinct vocation that should not be substituted for engineering even though the two vocations are closely related.

   The problem appears to be to develop appropriate criteria for an engineering and a mechanization curriculum that trains men for the local job market. It is recognized that India does have a certain number of sophisticated industrial, research, and administrative positions which require all of the advanced and specialized training that can be crammed into a curriculum.

Engineering curriculum planning should start with a sound basic group of courses in the engineering fundamentals and science prerequisites. The advanced mathematics and physics required for advanced engineering courses could be deleted. The engineering courses should cover a broad range of subjects in moderate depth, that is, increase the subject matter areas but decrease the number of courses in a subject matter sequence.

A major objective in planning mechanization programs is to reduce basic science and engineering courses and increase practical and laboratory work with typical machines in field operations for the purpose of developing skills. It would seem to be impossible to develop an effective academic program in mechanization that would become an equally effective engineering program through a series of transitional modifications.

2. An agricultural engineer finishing his second year in India sent these observations:

The number of agricultural engineering schools in existence, being developed, or being planned is adequate to meet the needs for at least the next ten years. Agricultural engineering educational facilities should be set up on a regional basis. Unfortunately, each state will undoubtedly insist upon a professional agricultural engineering program when an agricultural university comes into existence in each of the 17 states. We still have the problem that some states will employ only their own people.

Although "agricultural mechanization" has not been defined in India, quite a few men are doing this kind of work.

One difficulty with an agricultural mechanization program, particularly at the B.Sc. level, is that these men would surely say they had majored in agricultural engineering and many would claim to be engineers. If agricultural mechanization is offered as a degree curriculum, it should be offered by only one or two of the colleges of agriculture in the new agricultural universities having qualified agricultural engineering staff on a trial basis for a limited number of students and should be offered only after consultation with the government and other educational institutions. The program would have to be very clearly defined to avoid confusion with agricultural engineering.

The difference between agricultural mechanization and agricultural engineering should be even greater in India than in the United States. Preparation would be needed to get acceptance by industry, extension, government departments, and others who might employ graduates. The fact that agricultural mechanization graduates are needed is not enough; probably prospective employers should help set up the curriculum, thus preparing the way for employment of the graduates. Agreements to hire the first group on a trial basis might be worked out.

Teaching agricultural mechanization as a two-year diploma curriculum may be considered in the beginning so that more students can be accommodated if the demand is there. If the program is well accepted, it could be upgraded to a B.Sc. agricultural degree curriculum. Even if the graduates are well accepted, any thought of an M.Sc. degree should be held off for several years.

3. An American agricultural engineer working in India for several years had the following comments:

There is a market for the present agricultural engineering student, but the supply is beginning to exceed the demand. The two major markets are government and universities. The government market is likely to grow through additional jobs in agro-industrial corporations and in the field of irrigation. The percentage needed by universities is likely to decrease as education becomes more stabilized. In India one company which has made 20,000 of the 50,000 tractors employs only two product engineers.

At present most engineering knowhow for sophisticated farm equipment is being imported, but there is a considerable long-range market for agricultural engineering students in the farm equipment industry. Currently, there is a greater need by industry in adapting equipment to India's specific needs than is generally recognized. The agricultural engineering graduate is probably more useful as a product than a graduate in agricultural mechanization.

Indian agricultural engineering education should emphasize the role the engineer has in seeing that projects are completed in spite of varied obstructions to progress. Manual skills must be developed for job functions he is most likely to supervise later. Emphasis must be placed on thinking in preference to memorization. Courses must be strong in both indoor and field laboratory work. Relating courses directly to future job opportunities is extremely important.

A frequent complaint by the foreign consultant is that educated people in his specialty are not practical enough and avoid direct contact with problems that may dirty their hands. This attitudinal problem has deep roots and will not be changed by a simple downgrading of educational standards. It is generally difficult in India to get persons with any college training to work directly with the farmers.

Thousands of three-year diploma holders in mechanical engineering are being turned out from Industrial Training Institutes (ITI's) in India. These can be useful in serving agriculture, especially if they have a farm background. There would still be room for diploma holders in agricultural mechanization.

4. One American agricultural engineer who has been in India for several years believes that an agricultural mechanization program in a particular state without an agricultural engineering program will have the disadvantage of stressing that mechanization of agriculture is the solution to that state's particular problems. The total integrated engineering approach to the production of food, fiber, and fuel is needed throughout India. Many of the same mistakes that were made in the United States on mechanization can be easily made in India if agricultural mechanization is stressed as a program or discipline. The United States and other countries which had high material and natural resources as opposed to human resources were able to survive these mistakes, while most of the heavily populated developing nations in the world today cannot afford to commit the same mistakes. Highly trained engineers, whether Indian or otherwise, do not often respond to making a contribution at the levels which are needed during the early stages of the application of engineering to agriculture. This is not a result of the rigor of their training but is development of an attitude in basic philosophy. It is not the difference of requiring a strong foundation versus a vocational education but is an attitude being developed that an engineer should in fact become a scientist rather than an engineer. Engineers in the United States are rapidly losing their identity as engineers but are instead becoming bio-scientists.

India cannot at this time afford to have both agricultural mechanization and agricultural engineering programs. It should either revert to agricultural mechanization programs throughout India, or it should develop agricultural engineering programs for Indian conditions and not for American conditions. Agricultural engineering in India is going through some very difficult and trying times.

It will take at least 10 years to evolve a program which will be Indian-oriented rather than copied from developed nations.

5. Agricultural engineers from one midwest U.S. university made these comments:

   Agricultural engineering and agricultural mechanization are entirely separate but of the same professional standing. They must not be confused.

   Both professions are needed in developing countries. Now that agricultural engineers have been developed, programs need to be developed for jobs to put them to work. Agricultural mechanization graduates are needed and programs to put them to work. Pressure should be used for developing programs to fill this vacuum.

   A critical question is whether an agricultural mechanization graduate will work with his hands. If he will not, the mechanization program will fail in developing countries. People in developing countries who have the opportunity for an education have not worked with their hands for generations. If the graduate will not work with his hands, there is no choice but to limit the mechanization curriculum to a diploma holder--not a degree holder.

   There is a great need for people trained at the sub-professional level. Local agricultural maintenance men are very scarce.

   Agricultural mechanization graduates should not be tied to agricultural engineering. Technical schools might be developed along with diploma courses.

   It might be best to divorce agricultural mechanization from the academic program. Since its objectives are closer to those of extension, it might be wise to place mechanization in the extension area because the man must be a "doer" and know "how to do it." (Others disagreed strongly with having mechanization in extension.)

   A program of six months or more of practical work and demonstrations might be developed to train interested and potentially unemployed agricultural engineering graduates for work in extension and other phases of the agricultural mechanization program.

   Technical 2-year programs beyond high school along with development of the teaching of vocational agriculture in early grades would be highly desirable.

   On-the-job-training with dealerships should be started in connection with diploma curricula developed at the agricultural universities.

   We have various levels of engineering in several developing countries, and now various levels of applied engineering are needed. Agricultural engineers have priced themselves out of the market, and "working with their hands" is too often beneath their dignity. Agricultural mechanization graduates are needed and must be: (1) agriculturally interested, (2) engineeringly oriented, and (3) economically motivated or aware.

   However, engineers can do agricultural mechanization if they are vitally interested and if they will take an apprentice program to really understand the farmers' mechanization needs.

   Proof that a sophisticated engineer is not essential for applied engineering work is shown throughout Europe where the more applied type of agricultural engineer has handled the agricultural mechanization work for years. Such men are doing well for they are mechanically minded and mechanically talented.

6. These comments came from an eastern U.S. university:

Too many trained personnel in developing countries cannot use their hands and do not even try.

There is a large gap between the agricultural engineer in industry and the farmer, which must be filled by skilled technicians, three-month to two-year diploma holders, and some professional degree holders--all in the area of agricultural mechanization.

In any training program developed in agricultural mechanization, it is important that existing facilities and trained personnel in the state or area be used and coordinated immediately--laboratories, public and private workshops, and training centers; agricultural engineering, agricultural mechanization, and agricultural talent existing and available.

An agricultural engineering department is needed in a developing country to design machines and parts. The service and sales must be handled by a professional person such as an agricultural mechanization graduate. There is a definite question as to whether a sophisticated agricultural engineering staff should be used to teach agricultural mechanization students for fear of inadequate manual training. Regardless, agricultural mechanization students when graduated will be of no value unless they can demonstrate equipment and work with their hands.

Agricultural mechanization students must have the best application of engineering to agriculture, with emphasis on application.

The teachers must be the best, who can apply engineering to agriculture to develop "doers" out of agricultural mechanization graduates. If such teachers can be found, or developed, in the ranks of agricultural engineers, so much the better.

Agricultural mechanization must be developed along with, but not in competition with, agricultural engineering. Both must be on the same professional level.

American Agriculturists' Views on Agricultural Mechanization Technology

1. One agricultural engineer working in India stated it was obvious that no one had the exact answer to this important matter. The area is as abstract as the areas in which economists and sociologists work, without even the benefit of some basic data. There is no question but that agricultural mechanization training should be more important to India than agricultural engineering education. However, the cultural setting in India motivates students for training in agricultural engineering or some equally sophisticated degree program. Students who trained in agricultural mechanization in India will find that they have no place to go to study for advanced degrees.

He visualizes some difficulty with the matter of terminology. There has been difficulty in this regard in the United States, and now we find ourselves giving encouragement to a developing educational program which will lead people to think of non-engineers as agricultural engineers. The stature of agricultural engineering will suffer. The fact still remains, however, that India needs the agricultural mechanization graduate rather than the agricultural engineering graduate.

He believes that the best plan would be to introduce agricultural mechanization courses into a curriculum such as agricultural economics. This would avoid the confusion which exists even now in agricultural mechanization programs in the United States. A good agricultural education graduate can compete very nicely with an agricultural mechanization graduate. He feels that we would never have started agricultural mechanization programs in the United States if agricultural economics departments had encouraged their students to elect applied agricultural engineering courses in sufficient numbers.

2. An agricultural engineering department head and an agricultural scientist from a northern U.S. university agree that mechanization training has a high priority for developing countries.

   Agricultural mechanization must develop a better image, for in general it is second rate in foreign countries. A definite distinction must be kept between agricultural engineering and agricultural mechanization. It would be desirable to develop a center of agricultural mechanization which should maintain a good image to encourage students to enroll in it. Members of the staff could and probably should be agricultural engineers. The best instructors must be found to teach agricultural mechanization students--men who will train students to work with their hands.

   Agricultural mechanization specialists should teach and should also be extension specialists. All phases of agricultural mechanization and agricultural education programs should be coordinated at all levels. Agricultural mechanization should be equal and parallel to other agricultural curricula. If a two-year program is developed, it should be called a diploma curriculum, not an agricultural mechanization curriculum. Agricultural mechanization must fit the conditions of the country. It will start slowly but will finally take off.

3. Two engineers from an eastern U.S. university state that something is definitely needed in the educational system between the agricultural engineer and the farmer. The need is for "doers," skilled people who will and can work with their hands and can understand what programs are needed by the farmer in order to provide reasonable mechanization in the future to supplement labor for increasing crop production.

   An educational structure must be built to place skilled labor on the market. Diploma courses of one, two, or three years might be needed. Competent skilled labor is needed, such as agricultural mechanics, electricians, and others. Electricity must be high in priority because it should be extended rapidly in developing countries.

   If planned mechanization programs do not seem to take hold, possibly incentives should be developed to encourage men to participate--such as setting aside a block of positions for graduates of such courses with guaranteed incomes. Industry support should be strongly solicited for all short courses and diploma courses. The quality of such courses is more important than the quantity. Some schools in developing countries are now teaching tractor driving, driving heavy equipment, and industrial skills applicable to agriculture. These schools should be part of, connected with, or coordinated with the developing agricultural mechanization curricula in agricultural universities.

4. An agricultural engineering department head from an eastern U.S. university said that the development of an agricultural mechanization department parallel with the agricultural engineering department would be logical. Agricultural mechanization graduates can probably find jobs in developing countries in industry and extension. The agricultural mechanization students should come from any or all classes who will develop into "doers."

   Contacts with Indian industry and distributors proved they needed agriculturally trained degree men who could and were willing to go into rural areas to teach the use of implements and chemical application along with the use of other items to be demonstrated and sold. Two-year diploma holders might work in repair and adjustment of machinery and in maintenance work.

5. Another agricultural engineering department head from an eastern U.S. university proposed a three-step program of development. First, give immediate training in agricultural mechanization of a few weeks to a few months in pressing areas of obvious need, such as how to install water pumps, how to maintain an engine, tractor driving, field drainage, and surveying an area. Second, work out a 10- to 15-year plan, to include some "whys" along with "how to do it." Specialists with only two to three years of college training--possibly diploma holders--might be used during this period. Third, work out a longer plan, extending over at least 25 years. The leaders in this plan must be given the best education possible.

6. Two agricultural engineers from a northeastern U.S. university stressed the importance of "status" for those working in the agricultural mechanization field. Every effort should be made to show the importance of this field during its development; otherwise, a prestige factor may prevent a healthy development. Agricultural mechanization must have a special status in the minds of agricultural students entering it. This program must be different from regular education programs now in developing countries. Students should be shown what makes agricultural mechanization important and different from other curricula.

7. An American agricultural educator working in Nepal stated that there is a great need (as opposed to demand) for training in the agricultural mechanization area. Making the people aware of the need and respectability of such training and employment is a tremendous task. The training programs must be geared to a "how to" approach. Agricultural engineers often return from training with complete knowledge of the technical mathematics and science. Knowledge (memorized) of the theoretical physical principles of a tractor and its relationship to equipment is at a very high level, but there is no practical application.

   He said that he works with teachers who have been trained in schools at A.U.B., India, or elsewhere who have had courses in agricultural mechanics, farm power, and farm shop. Often it is taught by the Agricultural Engineering Department. He has worked with five new staff members (graduating within the past two years) from the previously mentioned institutions who had some courses in the area of agriculture mechanics. None of them could successfully operate the power equipment available. Lawnmower, rotor spader, and garden and farm tractors are among the equipment available. They could not gas, check oil and water, start, hitch, or operate them. Mathematical formulas for drawbar horsepower they knew, but you cannot do anything with just that knowledge. Nepal needs a trained cadre of people to get the agricultural equipment operational and in the field.

8. One American agricultural engineer in India for three years said that one of the biggest handicaps of the people who are there now and have some training is that they have been trained to read the book and not to think things out. He sees a need for specialization. If a man can survey, is it necessary that he know how to overhaul a tractor? It would give him more flexibility of job hunting, but the short courses could be tailored to immediate needs. If a big program is seen coming up a few months ahead, then the emphasis could be put on the specific training needed by the men doing that job. This is a short-cut way to get men trained fast.

APPENDIX D - TECHNOLOGICAL BREAKTHROUGHS

The developing countries number more than one hundred with a total population of about two-thirds of mankind (14). The so-called developed world, with 34 percent of the world's population, has 87.5 percent of the total gross national products, compared with 12.5 percent of the total gross national product produced by the less developed countries. In 1961 almost $8 billion, or nearly one percent of the gross national products of the high-income non-communist nations, was flowing into the low-income nations. By 1968 this figure had reached nearly $14 billion.

Some of the changes engendered by this flow of incomes are noted by Swaminathan (26): "In many respects the year of 1967 represents a significant milestone in the history of Indian agriculture. We are now on the threshold of a major agricultural transformation shifting from what I would like to term natural into 'exploitive' agriculture. With the growing awareness of the possibilities for high yields and with the entry of the educated classes in agriculture, we are at the beginning of exploitive agriculture."

Moreover, as Gaud (23) says, today for the first time, a number of the so-called developing countries are able to change and modernize at a pace faster than the advanced nations are willing to support.

A good part of the developing world is now experiencing a major breakthrough in food production, widely characterized as the "green revolution" (14). In 1968-69, India's food output was about eight million tons greater than the previous record of 89 million tons in 1964-65. Pakistan increased its wheat production by 50 percent in two years. Ceylon's rice production has gone up by 34 percent between 1966 and 1968.

How did such dramatic increases take place? In India, agriculture employs 70 percent of the population and contributes 46 percent of the national product. Yet before the mid-1960's agriculture received only about 15 percent of the Indian public development expenditures and was not regarded as a potential growth sector. Then, in 1965, the droughts struck. The government was forced to allocate more funds to agriculture.

Almost simultaneously, new high-yield varieties of wheat and rice, which had been developed in Mexico and the Philippines under the sponsorship of the Ford and Rockefeller Foundations, became available. In 1965, India began a program (1) of high yield varieties which set a goal of 32.5 million acres to be planted by 1970-71. In 1968 nearly a million acres of the new rice (IR-8) and 2.3 million acres of the new wheat were planted. The 1968 crop season saw 18 million acres already planted, which contributed to the most successful year in recent Indian agricultural history--100 million tons of food grains. Self-sufficiency in food grains is predicted in three or four years. Such an achievement is a demonstration that the peasant farmer, contrary to many expectations, is not hopelessly fettered by custom and tradition.

It is now generally believed (1) that major technological breakthroughs in food production have lifted the spectre of famine in the immediate future and to have posponed the prospect of a Malthusian population disaster. The possibilities for doubling or even tripling production are based upon new high-yield varieties coupled with adequate supplies of water, fertilizer, pesticides, and modern equipment. The estimated world acreage planted with new high-yield varieties rose from 200 acres in 1964-65 to 20 million in 1967-68. Traditional food-importing nations like the Philippines and Pakistan are becoming self-sufficient and have the prospect of becoming net food exporters.

Perhaps the greatest accomplishment of all has been the development of the ability to banish famine and hunger from the face of the earth (13). Since time unrecorded, man has been obsessed with the fear of famine. Modern agriculture has freed man from this fear.

Certain problems in connection with the developments must be watched. Wharton (1) warns that the new technology in developing countries may not spread as rapidly as predicted because of shortage of irrigated land at least at first. The new high-yield varieties of grains need careful water control throughout the growing cycle. Existing markets may not be able to handle the increased production. Storage and transport facilities are inadequate, and crop grading often deficient. There is also an increased need for farm supplies and equipment. Fertilizers, pesticides, and insecticides must be available in the right quantities, at the right times, and in the right places. Smaller farmers, who must consider family survival, are more reluctant than commercial farmers to accept the new technology. Unless appropriate extension measures are taken to educate farmers with respect to these new farming complexities, the higher yields will not be obtained.

Southworth and Johnston (3) feel the central barrier to innovation is a person's fear that in attempting new practices he may fail to produce as much as he knows he can with his old methods, a failure that endangers his very survival. This environment of fear encourages local loyalties and distrust of outsiders and operates as a formidable barrier to progress. On the other hand, Abercrombie (4) feels he can report that use of high-yielding varieties and other crop improvement exercises is so far being taken up equally by farmers with large and small holdings.

Much more attention must be given to marketing increased output, according to Wharton (1). A doubling in yields in a semi-subsistence agriculture usually leads to much more than a doubling of the amount sold. During the 1968 crop year, India experienced a marvelous increase in food-grain production, but the marketing network and storage facilities were not prepared to cope with it. Thus, if the full potential offered by the new technology is to be realized, every effort must be made to insure that there is in fact a significant return to the producer and that the rapid rise in output does not lead to a counter-productive slump in prices.

There is general agreement in India, Pearson (14) states, that agricultural growth must be accelerated through such steps as:

1. Accelerated public investment in agriculture.
2. Attraction of private investment, domestic and foreign, into the fertilizer industry.
3. Rapid increase in the supply of fertilizer.
4. Improvements in fertilizer distribution.
5. Improvements in the system of seed growing, certification, and distribution.
6. Effective support prices.
7. Expansion of minor irrigation, including tubewells.
8. Better storage facilities.

These steps are essential ones for agriculture to improve rapidly in developing countries. The mechanization of many phases of agriculture is seen as a strong element in this procedure.

APPENDIX E - POPULATION AND LABOR APPLIED TO AGRICULTURE AND INDUSTRY

In developing countries agriculture must not only produce the necessary food supplies, but at the present stage of development it must also provide a livelihood for a large part of the population(4). After an industrial market is developed, agriculture will become the source of manpower for industrial expansion.

In most of the developing countries, there is no reason to expect a reduction in the absolute numbers of the agricultural population in the near future (5). This conclusion is even more valid now that population growth has accelerated. Barraclough (6) says that if present trends continue, about one third of the net increase to Latin America's population will have to remain in agriculture during the coming decade or two. Mellor (2) states that the capacity of the agricultural sector to absorb an increased labor force is very limited in most countries. For these reasons, economic development also requires rapid expansion of the nonagricultural sectors of low-income countries. Agriculture must provide major increases in agricultural production, but it must also make significant net contributions to the capital needs of other sectors of the economy. The developing countries have not reached the stage where large-scale substitution of capital for labor would be economical. Labor is abundant while capital and land resources are relatively scarce.

In Taiwan gains in agricultural productivity have made possible the net transfer of large amounts of capital and large numbers of workers from agriculture to other sectors and thereby have contributed to the economic growth in the rest of the economy. Large increases in output per acre and per agricultural worker have been achieved with modest increases in capital inputs from other sectors of the economy.

Mechanization of agriculture will occur in two steps: first, simple mechanization when agriculture must absorb the bulk of the workers; and second, probably larger machines used in agriculture after industry overtakes it and leaves a much smaller portion of the workers for farm help. In the U.S. economy, we tend to equate agricultural progress with mechanization (Sprague, 32). But in certain other countries labor-saving devices have low priority as the population should remain largely rural until an industrial labor market is developed. The peasant farmer's needs for mechanization include only such items as will increase his overall efficiency at costs which are compatible with his economic level.

"I doubt whether any real industrial development can take place in India till we have a firm base for our agriculture." This statement by Jawaharlal Nehru (12) sets the stage for the present aid in agriculture to developing countries. Southworth (3) says that growth in the two sectors of agriculture and industry interact, each supporting and stimulating the other. As the largest sector of the economy, at least in the earlier stages of development, agriculture is the source of manpower for industrial expansion, the source of essential supplies for maintaining a growing industrial population, the source of exports to be traded for industrial goods, and the chief potential source of savings for nonagricultural investment. For these roles to be fulfilled, however, agricultural productivity must be increased.

Industry and agriculture must move together in any economy. Reasonable distribution of labor should then take place. Since seasonal labor shortages have already caused harvesting and planting problems to take advantage of additional growing seasons per year in some areas of developing countries, reasonable supplemental mechanization must be planned to prevent injurious time limitations for crop operations. In most developing countries beginning mechanization could start with building a better hoe. Improved irrigation and drainage and other processes pertinent to farming could be planned to take full advantage of all growing seasons, planting, cultivating and harvesting. Eventually, when labor reserves are reduced, greater emphasis will probably be placed on machinery.

In countries like India, Pakistan, Turkey, the Philippines, Thailand, and Egypt, where little land is available for settlement, farms will need to decrease in size, or the number of workers per farm will need to increase, to provide employment for the expected rise in the farm labor force. Expansion of employment opportunities in urban areas resulting from industrialization can absorb only a small share - probably less than half - of the growing agricultural population. There is no simple answer to the question of whether size of farms should be reduced or number of workers per farm should be increased. Studies conducted in Japan, Iran, and India show that crop yields average higher on small farms than on large farms. Figure 1, Appendix K, shows, for example, that Japan has the highest concentration of 15 human horsepower per 100 hectares of all developing countries even though mechanization is high also.

Wharton (1) warns about the displacement of farm people to the cities if higher yields per acre, multiple cropping, and mechanization force surplus manpower out of agriculture. Employment must be provided for these people, and the current level of industrialization may not be sufficient to do so.

In the vicinity of Calabozo, Venezuela, Barraclough (6) visited an irrigation project on which 119 rice and livestock farms of about 200 hectares each had been established with practically unlimited access to modern capital, technology, management, and organization. No more labor was employed than would be used by similar farms in the United States. These farms were producing almost a third of the rice for the entire country. Modern labor-saving and capital-intensive farm technologies developed in the industrialized countries are imported as a "package." It is quite obvious that this approach will not solve the labor problem of developing countries.

R. P. Christensen says agricultural population may be expected to increase from 935 million in 1962 to 1,388 million in 1985 in the developing countries (letter, November 13, 1969). This means a compound annual growth rate of 1.7 percent a year in the number of people depending upon farming for a livelihood. He thinks it is quite evident that the farm population of most developing countries can be expected to increase for the next 10 to 20 years. Growth of employment opportunities on nonfarm occupations will not be rapid enough to absorb all of the surplus farm population. In countries where land resources are limited it will be necessary to find ways of increasing output per worker with less land per worker. He feels that a major engineering problem in agriculture is one of finding ways to use additional tools, equipment, machinery, and power to increase output per acre and at the same time output per worker. Table 3, Appendix K, shows the relationships between rural and urban populations in developing countries.

Christensen states elsewhere (18) that countries like India, Pakistan, Thailand, and the Philippines appear to have enough land resources to feed the populations expected by the year 2000 if crop yields can be increased to levels now realized in Japan, which averaged increases of 2 percent per year. Developing countries will probably need annual increases in agricultural production of 4 to 5 percent. Crop yields must go up much more rapidly in the developing countries in the next 20 to 30 years than they ever did in the now developed countries.

APPENDIX F - THE FARMER, MACHINES, AND ECONOMIC SYSTEMS

In general, farmers need basic mechanical equipment and machines, whether they live in developed or developing countries. Even cheap farm labor can never replace minimum machinery needs. The increased needs for machinery dictate the furthering of farm electrification in all developing countries. A strong network of service organizations is also needed.

Nearly 95 percent of the world's tractors are in the developed countries (Schertz, 11). According to FAO estimates, developing countries had just under 800,000 tractors in 1965 (Table 2, Appendix K), and the annual increase has been less than 40,000, only 4 to 5 percent a year.

Animal power available to the subsistence farmer, who may have 10 acres or less, is not adequate for land preparation (Sprague, 32). Small, low-cost, trouble-free tractors would be desirable but are not available at a price the small farmer can afford. Tractor rental service, being tried on a limited scale, may provide an economic answer to the power problem. Custom pools are feasible. Randhawa (37) outlined a scheme for custom service in agricultural machinery for India, aiming to achieve a breakthrough from traditional agriculture to scientific agriculture.

The new high-yielding dwarf wheats and rice will sharply affect the resource mix, or inputs, required to make Asia a region without hunger (Schertz, 11). Introducing and developing these varieties bring a need for mechanization--tractors, power tillers, irrigation pumps, and related equipment. The availability of machinery may determine whether individual producers can realize the potential payoff of these new varieties since each day of delay means one day lost to crop production. The greater production will also mean greater requirement for machinery in marketing and grain handling, including storage, drying, and hauling equipment.

Giles (27) estimated that even in developing countries less than two-fifths of available horsepower for agriculture is supplied by humans; the greater proportion is by livestock and tractors. He also pointed out that capital investments in machinery, substantially above those generally in developing countries, are not necessarily inconsistent with large inputs of labor. Human labor in Japan, Taiwan, and Egypt supplies substantially more horsepower per unit of land than in India and Asia as a whole; yet machinery investments in Taiwan and Egypt are substantially above levels in most developing countries, and in Japan are among the highest in the world.

For years it was widely thought that removing labor from agriculture would not lower farm production and that introducing machinery would merely increase unemployment or underemployment of labor. Given these concepts, policy makers did not need to concern themselves with agricultural mechanization and power requirements. Largely ignored was the importance of timing in planting and harvesting, peak labor requirements of some farm tasks, and implications of technological change. Labor requirements vary widely during planting, growing, and harvesting rice and wheat.

Jain (24) has stated that if crop productivity in India is to rise from its present exceedingly low level without loss of time, complete mechanization of agriculture is the only way to achieve this objective.

Human labor, though plentiful in developing countries, is not always the most economical (Schertz, 11). Small but efficient equipment will provide greater and more meaningful results. Upland rice yields in Raipur, India, were increased as much as 40 percent by preparing fields for sowing by mechanization rather than by the human and bullock power commonly used. The fact that demand for tractors in India greatly exceeds the supply indicates the high profitability of mechanization there.

Farm electrification. Less than 1 percent of the farm population in developing countries has the benefit of electric power (War on Hunger Report (11), and Table 1, Appendix K). In 1936 in the United States less than 11 percent of the rural people had electric power, but now more than 98 percent have it. Electric power is considered a key factor in the advancement of agricultural production in the United States.

Several rural electrification studies have been made in developing countries, and some progressive action is being taken. It is obvious that emphasis must be placed on the teaching of electricity to develop many skilled people in the years to come.

The All India Rural Credit Review Committee (15) estimates that by 1973-74, 12.5 lakhs of additional pump sets will have to be energized as part of the rural electrification program for irrigating several million acres. The committee suggests that an autonomous rural electrification corporation be formed with funds for financing rural electrification schemes in priority areas, for subscribing to special rural electrification bonds, and for providing block capital loans to a number of rural electric cooperatives to be organized in various states.

Southworth(3) comments that the high American farm production is possible because large organizations of workers in hundreds of nonfarm industries make the implements and other materials the farmer uses and process and distribute his products; and experiment stations, extension services, and nonfarm businesses provide him with a stream of new production and marketing technologies. He adds that there is no magic mix of improved technologies that can generate steady increases in farm output in all areas and conditions, but that from basic research on the properties of soils, climate, and native plants and animals and from an understanding of why people follow their present practices, we can learn a combination of improved technologies that will be suitable in each particular area.

Whatever the components of the combination may be, they must be generated and brought into rural villages by people from outside. Creation of even the simplest farm gadgets together with the knowledge of how to use them is far beyond the capabilities of such small units of collective action as the extended family, clan, tribe, or village. To achieve progress, these small social units must be linked into much larger organizational units in which people have confidence and to which they feel loyalty.

This concept means that implementing any package of new technologies suitable to any area is impossible except as members of a family and village structures are caught up in a new set of organizations that links them with the outside world in a vast network of service exchanges. Mellor (2) says that in low-income countries peasant agriculture tends to be characterized by low levels of utilization of certain resources, low levels of productivity, and relatively high levels of efficiency in combining resources and enterprises. These three factors are interrelated. Collectively they suggest great scope for increasing total production and resource productivity through technological change. The missing links for these farmers are incentives and productive technological change.

The All India Rural Credit Review Committee felt that it would not be possible for cultivators with small holdings to derive any benefit from the new agricultural techniques and inputs, as they would not be able to pay for the seeds and fertilizers and to command necessary credit (15). If the machinery were set up to turn small holdings to commercial farming, it would be necessary to introduce a countrywide network of pilot projects, in the form of small farmers' development agencies.

Planning strategy in developing countries must emphasize the growth of small and intermediate regional centers to offer market, service, and storage facilities and light labor-intensive industries processing local materials. The construction of such new centers could offer considerable employment for unskilled labor (Pearson, 14).

Christensen (22) described Taiwan's agricultural development strategy as an integrated package approach which included investments for developing land and water resources; agricultural experimentation, demonstration, and extension for introducing technological and organizational innovations; the building of local farmer service organizations; land reform; and local and national planning and program implementation to assure market outlets at incentive prices and to achieve efficient resource use.

Ensminger (38) said that in India the agricultural strategy of the future must be focused on involving all the cultivators in an intensive agricultural and rural development program that will apply a tested package of agricultural practices to the maximum on all of India's cultivable land, and on developing the essential services required for a modern agriculture. The cultivators must continue to be motivated to maximum production through education.

With the technological changes taking place (improved seeds, fertilizer applications, new machines, etc.), it appears that the peasant farmer is ripe for needed changes in agriculture in developing countries. Well-trained men and vital services in agriculture and mechanization are vitally needed at this time to gain the confidence of the farmer for the obvious changes that must and will take place in the near future.

<u>Private enterprise</u>. David Rockefeller (Agronomics, 15) said, "For historic reasons a great many of the developing nations came to independence under leaders heavily influenced by socialist economic thought. The result is that a number of them still cling to the notion that public ownership of the means of production offers the only sure path to economic growth." Pearson (14) says that experience shows that a strong, vigorous private sector serves to attract direct investment from abroad, which can greatly stimulate the development process. Willis (31) says that it is important to the development of India that the private-sector food-processing industry be preserved, strengthened where practical, and trained in anticipation of the time when village economy and agricultural supplies make growth possible.

Wharton (1) says that many agriculturally related industries must develop if the green revolution is to take hold--a seed industry; agricultural chemical plants; factories for hand sprayers, dusters, water pumps, and engines; and many more. Private industry, especially American, has provided a new, more dynamic pattern of distribution. In the Philippines, for example, Esso has become a major distributor of fertilizer and agricultural chemicals. In India the International Minerals and Chemicals Corporation, with the Standard Oil Co. of California, built a fertilizer plant with a yearly capacity of 365,000 tons; the U.S. firms provide the management, but control is held by an Indian firm.

Land reform and consolidation. Pearson states (14) that land reform and consolidation of fragmented holdings will be needed in many developing countries to accelerate technological change, stimulate production, and generate rural employment. Christensen (18) says that land consolidation in Taiwan will do much to increase production even though much hand labor is needed. Land reform will obviously aid any attempts to mechanize agricultural production.

Perhaps governments in developing countries should reclaim available agricultural development land. When the Uttar Pradesh Agricultural University was developed in India, it was carved from the jungle, where plenty of water is available. Such acreages of fertile land could be brought into production and thoroughly mechanized or distributed to farmers in whatever way fits the pattern of the area.

Taxing farmers. India's finance minister Mororji Desai stated (15) in 1969, "If the benefits of the new agricultural technology are to be carried progressively to a growing proportion of our farming population, the resources needed for this purpose should come at least in part from the beneficiaries of the process. Against this background, I propose to levy an excise duty of 10 percent ad valorem on fertilizers and 20 percent on power driven pumps with a revenue yield of Rs. 24."

Agricultural taxation and the general division of the fruits of increased agricultural production among urban consumers, rural producers, and landowners will present thorny policy issues which have grave political implications and which will affect future development. Pearson (14) says some of the increased revenue must come from rural sources because the new technology is raising some rural incomes sharply. In some developing countries, such as India, where agricultural production increases are essential in order to feed the population, farmers can make money, and some educated people are going into farming. The question might be asked whether governments should not be very cautious in increasing taxes to farmers too soon, whether such a move would have a tendency to destroy the incentives of the green revolution. Do governments dare take such a chance? Or, should taxes and subsidies be strongly debated and eventually considered with a cautious approach?

APPENDIX G - CHANGES IN AGRICULTURE IN TWENTY-SIX DEVELOPING NATIONS

This appendix summarizes the Foreign Agriculture Report of the Economic Research Service, USDA (10), as it relates to the mechanized farming problems which must be considered before academic degree, short course, and diploma programs are recommended in developing countries. The 26 countries covered in the report are Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, and Venezuela in Latin America; Nigeria and Tanganyika (as constituted in 1962) in Central Africa; the United Arab Republic (Egypt), Sudan, and Tunisia in North Africa; Jordan, Israel, Greece, Turkey, Iran, Pakistan, and India in the Near East and South Asia; Thailand, the Philippines, Taiwan, and Japan in the Far East; and Yugoslavia, Poland, and Spain in Central and Western Europe. These countries represent approximately 75 percent of the population, 73 percent of the total gross national products, and 73 percent of the AID budget for all AID-assisted countries. The objectives of the report were to show levels of agricultural output and production in these countries and changes in these levels since 1948, and to identify and assess roles of major physical, economic, and social factors associated with differences in the levels and changes.

Agriculture and food demand. Agriculture is the most important industry in all of the study countries and accounts for more than a third of the domestic gross national product in 19 of the 26 countries. Yet food consumption levels, based upon daily per capita intake of calories, are below desirable levels in 11 of the 26 study countries. Since food supplies are unevenly distributed, most of the other 15 countries have large population groups that suffer from both undernutrition and malnutrition.

At present population and income growth rates, the demand for food in 16 of the study countries is increasing at annual compound rates of 4 to 6 percent per year; most of this increase is the result of population growth. If present growth rates continue, most of the study countries will double their populations in about 25 to 35 years. India alone has almost a sixth of the world's population. Pakistan, Japan, and Brazil are in the top eight countries of highest population.

In most of these countries livestock and livestock products account for a relatively small part of total agricultural production. In U.S. dollars the 1960 agricultural output per worker (including both crops and livestock) varied among 19 developing countries from highs of $1,825 and $1,080 in Israel and Argentina respectively to a low of $94 in Thailand. The amount of arable land per agricultural worker also varied in the developing countries from 13.1 hectares down to a low of 0.4 hectare.

Crop increases. At the farm level, increases in crop output have been mainly a function of increases in the number of agricultural workers, the area of land devoted to crops, amounts of both fixed and variable capital, and improvements in the level of applied technology. Recent crop yield increases in the studied countries have been achieved mainly through:

1. Increased use of fertilizers.
2. Improved seed varieties (see Table 7, Appendix K, for the area planted in improved grain varieties in developing countries).
3. More effective pest controls.
4. Improvements in planting, tillage, and harvesting methods.
5. Better use of water resources.

Often, crop improvements have been made as part of a system of improved production practices. In India it appears that the larger part of the recent yield increases has come mainly from better plant spacing, better weed control, and better tillage practices. Some of the improved practices have provided additional employment for labor. The more densely populated countries, including India and Taiwan, have increased the intensity of labor on land that is already in highly labor-intensive uses. Most of these countries have accommodated increases in their agricultural population and labor force, as well as increased their agricultural outnut, largely through technical improvements, land development (such as irrigation and drainage), and increased capital investments.

Mechanization. Improvements in farm machines and implements have contributed to increasing agricultural output and productivity in the new economically advanced nations. In most underdeveloped countries, costly modern implements cannot be used mostly to save labor since the displaced labor cannot be absorbed elsewhere in the economy. However, use of such equipment may be advisable in cases where it makes possible large improvements in the quality of the operations performed or performs tasks that cannot easily be done with traditional implements.

In countries with large land expansion potentials, introduction of more tractors and machinery could facilitate the opening up of many acres of unused or so-called waste land. Land expansion potential, however, must not be mistaken for agricultural output expansion potentials. For example, Japan's agricultural output in 1960 was $961 per hectare of arable land, compared with only $91 for India and $78 for Argentina. These comparisons indicate much more fully than do land expansion potentials the magnitude of the agricultural output expansion potentials in less-developed countries.

In many of the developing countries the shift from wooden to steel-pointed plows, from steel to rubber-tired wheels, or from sickles to scythes may be a major mechanical improvement. Also, the change from broadcasting to row-planting of crops--including in some cases maize and cotton--has yielded favorable results in several areas.

Much progress has been made in recent years in adapting modern farm machinery to the needs of small-scale agriculture. Small garden tractors have been extensively used in Switzerland, France, and West Germany since the late 1940's. Utilization of these tractors has been greatest in Japan: more than 1.4 million were in use there in 1961, and their use has increased rapidly since then.

Aids to technology: research, extension, and education. Progress in increasing yields in developing countries depends on purchased inputs and on the kinds of inputs produced through investments in research and agricultural extension. The productivity of land for agricultural uses is increasingly becoming a function of advances in agricultural technology and of the greater capital and skills technology requires.

In the United States agricultural output and productivity have been increased and expanded through the USDA, the land-grant colleges, and the agricultural experiment stations. Effectiveness of these agencies has been enhanced by agricultural extension and vocational agricultural education working with farm people.

Improving the technological bases of agriculture in underdeveloped countries is fundamentally a research task. Much of the required research needs to be carried on within the underdeveloped countries, but the facilities there are the most inadequate. In 1960 the number of research workers per 100,000 people active in agriculture was only 1.2 for India, 4.5 for Pakistan, and 4.7 for Thailand, compared with 60 for Japan, 79 for Taiwan, and 133 for the Netherlands. In addition, research personnel in developing countries usually have had less training than their counterparts in more advanced nations.

The future capacity of the agricultural sectors of developing countries to increase output will be facilitated by development of improved agricultural research programs. Optimal use of scarce resources for certain problems necessitates the development of regional centers to serve several countries; one example of this is the International Rice Research Institute in the Philippines. While basic research requires our continuing attention, however, we also need to concentrate considerable efforts on applied research within individual countries.

Until recent years, several of the study countries had no agricultural extension programs. Agricultural extension programs are most effective when supported by a large and constantly increasing stock of improved technologies. Because extension programs usually cannot be transferred "as is" from one country to another, the development of effective extension programs in many of the developing countries will have to wait until they build strong agricultural research programs.

A composite index of primary and secondary school enrollment in 1950 has been used for rating and classifying the countries according to the educational levels of their present adult population. For example, only three children in rural areas of Brazil for every 100 in urban areas completed 5 years of schooling. Many families in rural society do not appreciate education because of the seeming inapplicability of knowledge gained through schooling.

The quality of education in many of the study countries is low by Western standards. Often school curricula at all levels of instruction are characterized by excessive work loads and emphasis on detail. Teaching methods are rigid, with emphasis on memorization rather than developing a spirit of inquiry and powers of observation. Class instruction often bears little relationship to everyday experience. Such characteristics have encouraged unqualified acceptance of instruction and have stymied the creativity needed for progress.

Population growth, inadequate transportation and communications, and variations in language and dialect (as in India, the Philippines, and most of Africa) represent significant barriers to educational progress.

Primary and university levels of instruction have generally dominated the educational systems of developing countries. Provisions for vocational and technical training are usually considered inadequate, particularly in view of the great need for technicians in most underdeveloped countries. The United Arab Republic and Israel are exceptions.

There is often little demand for vocational schooling among students just as there is little demand for technical subjects in secondary schools of general instruction or in universities. Prestige is primarily, if not exclusively, associated with highly academic subjects such as humanities and the fine arts; these courses are preparation for law, medicine, and civil service--highly esteemed because of their association with the governing class. Unemployment among professionals, however, is uncommonly high in some countries--notably India and the Philippines--yet such men often refuse to seek employment in fields in which they have not specialized.

Capital resources. More than any other feature, differences in capital resources distinguish the agriculture of underdeveloped countries from that of economically advanced regions. Farmers in economically advanced countries now use modern machines, highly productive kinds of crops and livestock, and other farm inputs that are the marvels of modern scientific and engineering achievement. Yet, millions of tillers of the soil who live less than a day's travel away from modern agriculture still use only a few simple capital items. For many, these include such implements as crude hoes, blunt-edged axes, hand sickles, and wooden pails.

Role of industry. Modern agriculture requires not only large amounts of capital on farms but also large investments in industries, institutions, and facilities. This includes industries engaged in the manufacture of farm machinery, fertilizers, pesticides, pharmaceuticals, and other such items; industries involved in the transport, distribution, and sales of factors and products; irrigation dams and canals; farm credit agencies; agricultural education, extension, and research institutions; and the infrastructure of roads, railroads, harbors, electric power systems, schools, and health and sanitation facilities serving both farm and non-farm sectors.

Growth in non-farm sectors normally requires that agriculture produce an increasing supply of foods and fibers with a decreasing share of the nation's manpower and other resources. Especially in the early stages of their economic growth, most countries must improve the performance of their agricultural sector.

Developing nations cannot expect to quickly achieve agricultural outputs as high as those in economically advanced nations. Even if farmers in countries like Pakistan and India were suddenly to produce as much physical output per farm worker as farmers in the United States, it might still take years to build the transportation, processing, and market facilities; the farm-industry and farm-nonfarm employment balances; and the other supply-demand conditions needed to convert this increased abundance into valuable economic assets.

APPENDIX H - TAIWAN'S AGRICULTURAL DEVELOPMENT (22)

Agricultural conditions in Taiwan are similar to those in many developing countries where population growth is rapid and land and capital resources are relatively scarce. Consequently, the lessons learned from Taiwan's agricultural development experience may be expected to have more applications and greater relevance than those gained from study of the more economically developed countries where population growth is much slower and land and capital resources much more abundant.

Taiwan owes much of its present economic health to three major developments. The first was land reform to encourage ownership of land by small farmers. The second was the 1953 reorganization of farmers' associations and cooperatives to put them under more direct control of farmers. The third was agricultural development planning to achieve effective use of scarce land, water, fertilizer, and other inputs.

Small farms. Land reform in the 1950's to put ownership of land into the hands of farmers was essential to assure social stability in rural areas and to improve economic incentives to farmers. Operators of small farms are often thought to be oriented toward subsistence production and uninterested in commercial production. Taiwan's experience, however, indicates that farm people respond to economic incentives. Farms decreased in size from an average of a little over two hectares in the early 1950's to about one hectare in 1966, but output and sales per farm increased. In fact, farms of less than 0.5 hectare produce over twice as much per hectare as farms with more than 2.5 hectares.

Thus a structural organization of many small farms has been a strength rather than a weakness in increasing agricultural productivity. These small farms have been surrounded, however, with local service organizations that supply new knowledge about superior production methods, markets for farm products, production requisites, and credit which enables farmers to increase their efficiency. In places where these supporting services are not available, large plantation type farms that can provide these services may be more efficient. And in both cases, of course, prices of farm products need to be high enough relative to the prices of the necessary services--improved seeds, fertilizer, pesticides, and other materials--to make the use of these inputs profitable.

Research. Taiwan has relied heavily upon the introduction of new varieties of plants and breeds of livestock from abroad and upon adaptive research. Attention has been given to all phases of farm production and marketing, including the development of new superior varieties of crops and breeds of livestock, pest and disease control, chemical fertilizer and compost to build up soil productivity, and effective use of irrigation water.

Effective research is also responsible for the high level of agricultural technology in Taiwan. The researchers are in close contact with production and marketing problems at the farm level, and they conduct research of practical and immediate value to farmers.

Vocational agriculture and extension. Taiwan's experience with developing improved technology and getting it used quickly on farms suggests that other developing countries should consider the economy of making larger investments in vocational agriculture schools district agricultural improvement stations, and extension services conducted in close collaboration with farm credit and marketing activities. All of these have been used with success in Taiwan.

<u>Mechanization</u>. In Taiwan capital inputs have been used to increase output per hectare and not to substitute for labor. There has been very little mechanization of farming operations: the large labor supply, more than ample relative to capital and land resources, makes much substitution of machines for labor uneconomic. However, the use of capital inputs to apply improved technology and to increase crop production per hectare has indirectly increased output per farm worker.

In many developing countries, agriculture now employs 60 percent or more of the population. With population growth rates of 2.5 percent or more per year and with limited land resources, these countries will need to plan for the use of increasing numbers of agricultural workers. Farms will need to decrease in size or more workers will need to be employed per farm. Taiwan's experience indicates that increased numbers of small farms may be the most effective way to obtain increased intensity of land use.

<u>Government help</u>. Taiwan's experience indicates that national and local governments can play a leading role in accelerating agricultural development. In fact, agricultural output and productivity probably cannot be much improved in most developing countries without strong leadership and support by government organizations.

In Taiwan, American and Chinese officials worked closely together in program planning and formulation. There was great flexibility in choice of activities or projects supported. A high degree of continuity of policy and program was possible. However, it should be recognized that preconditions for an effective joint agency will not be encountered universally. Not all countries would be willing to provide a joint agency like Taiwan's Joint Commission on Rural Reconstruction, which provided the technical support and wide latitude for action necessary for successful operation.

APPENDIX I - AGRICULTURAL INSTITUTIONS IN DEVELOPING COUNTRIES: AGRICULTURAL UNIVERSITIES, EXTENSION, AND VOCATIONAL AGRICULTURE

Long (39) proposes that economic underdevelopment is itself largely a consequence of institutional underdevelopment; countries wishing to jump into the stream of economic progress must be willing to fundamentally alter their institutional structures. The present-day changes in the university structures in developing countries, where agricultural production is increasing so rapidly, are indicative of the above two propositions.

Virtually all aspects of agricultural development hinge on creation of a broad range of educational institutions (2). The rate of increase in agricultural production will in practice normally be limited by the rate at which trained personnel can be provided to operate various developmental institutions. As Wharton (1) says in regard to the future of developing countries, much will depend upon whether or not the necessary manpower is trained in each country to provide a continuing human resource which can produce a constant stream of new technology. His view is that the manpower trained in the Rockefeller Foundation's agricultural program in Mexico has always been a greater contribution than the new varieties developed there. Successful adoption of such varieties should not deflect attention from the importance and role of continuous agricultural research.

The agricultural universities of developing countries must serve all the people of that country--not particular classes. This need is urgent! As expressed by one interviewed American scientist from a land-grant institution, "The agricultural university and college must expand downward to meet the needs of the people." Shuman (35), also, puts the task of the university in terms of resource development: soil must be enriched, and people must be educated. He feels there are four needs: plant food, applied knowledge, a sense of urgency, and a concern for others. This work can be accomplished in developing countries through purposeful research, teaching that motivates, and extension that demonstrates.

Who can do the training of agricultural skills better than these developing agricultural universities? All organizations must join forces immediately--industry, federal and state educational and agricultural departments, USAID, Ford and Rockefeller Foundations, agricultural universities, and others---to develop the agricultural skills necessary for the green revolution to continue effectively.

Rath (8) makes an important analysis in the use of personnel: "It is important to recognize that what is involved is not the importance of agricultural sciences or scientists; their importance is undisputed. We must, however, evolve a system in which their talents are productively exploited and to evolve this is as important as avoiding surplusage in supply which is excessively costly in a poor economy." Pearson (14) refers to such educational problems when he says that India inherited a predominantly agricultural economy with some mineral resources and a small industrial sector, elements of a transport network, and an antiquated educational system. This can be said of too many developing countries.

Agronomics (15) summarizes the American land-grant institutions aid to Indian agricultural universities. During the past decade eight new agricultural universities have been established in India with the cooperation of the American government and six American universities. The new universities (cooperating American institutions indicated in parentheses) were established in the states of Andhra Pradesh 1964 (Kansas State University), Madhya Pradesh 1964 (University of Illinois), Maharashtra in 1969 (Pennsylvania State University), Mysore in 1965 (University of Tennessee), Orissa in 1963 (University of Missouri), Punjab in 1962 (Ohio State University), Rajasthan in 1962 (Ohio State University), and Uttar Pradesh in 1960 (University of Illinois).

Development of agricultural institutions in the United States. Sprague (32) says that the present agricultural technology in the United States rests upon two sequential developments: the long period of trial and error by farmers and the establishment of land-grant institutions. Agricultural education in the United States developed somewhat like the following:

1. The government encouraged county fairs to demonstrate the best and latest in agriculture in the early 1800's.
2. Land-grant colleges developed about the time of the Civil War with the signing of the Morrill Act. Dignity was given to agriculture for the first time.
3. The Rural Life Commission was established in the early 1900's to study the problems of agriculture.
4. A few years later the Smith-Hughes and the Smith-Lever Acts were passed to usher in the vocational agriculture and agricultural extension programs, respectively, without which agriculture would not have developed adequately or with dignity in the United States.

Agricultural universities in developing countries. We should ask, "Why did it take so long for progress to take place in American agriculture?" The Morrill Act which brought the land-grant universities into being was signed by Abraham Lincoln, when the country was nearly 100 years old. Must we wait this long in developing countries? Unless the developing country commits itself to educating the farmer, it will not move very rapidly in developing agriculture.

The university in a developing country is usually traditional in nature. As a widely travelled U.S. agriculturist describes it, the university gives a man a chair, a desk, and an office and says "Teach." The teacher is a part-time professor; he teaches certain hours and leaves. He can be characterized as a "hit-and-run type" educator. This situation approximates the educational system in America about the time of the Civil War. How can the developing countries update their educational facilities so as to provide necessary training and give dignity to vocational agriculture?

Leadership for agriculture must come from the agricultural universities. Too often in developing countries these universities are not respected by the farmers. Industry must be brought into the machinery design and development work at the agricultural university and made to feel like part of the team, so to speak. The developing countries must change their faculties from part-time men to full-time professorships, where a professor can supplement his work with practical research. The teachers of agricultural universities must use their hands so that the student will learn to work with his hands. These students must feel a dignity in creating something new. The developing student must learn to work and to feel an urgency in his labor.

To teach the student how to work with his hands and to appreciate the dignity of labor, the instructor must operate pertinent equipment in class to teach engineering principles applied to agriculture. For example, to teach surveying methods, the instructor should set up the instrument and operate it himself through a series of demonstrations. In teaching the application of sprays for insect control, the instructor should operate the sprayer as it should be done. To teach welding, machine adjustments, and all other principles, the instructor should demonstrate them. The student follows suit. The instructor does not have a technician do the demonstrating. The joy of accomplishment can soon be detected on the face of a student after he has successfully adjusted a pump, an engine, or a motor during a trouble-shooting exercise.

Every process and principle taught must be demonstrated by the instructor to develop "doers" and the feel for the process, to develop confidence, and to develop creative effort and pride in accomplishment. If the instructor does not develop the ability to successfully demonstrate such processes, he will not be confident of being able to communicate such vital principles to the students.

Agricultural research and extension. It is essential that research be focused on production and marketing problems at the farm level if it is to yield maximum economic returns. Similarly, when it is demonstrated at the farm level that new technology increases economic returns to farmers, it is not difficult to get farmers to adopt the new methods.

One of the great contributions being made by developed countries is guidance in training men in developing countries on how to obtain maximum experimental data in a short time.

Upgrading the present agricultural extension staffs as rapidly as possible is, according to a head of an agricultural engineering department in a northeastern American land-grant institution, often the first approach in a developing country. This indicates an overall educational problem.

Faulkner (25) reports that the Ford Foundation has supported for several years an extension program commonly called the Package Program, officially known as the Intensive Agricultural Districts Program. The common name has evolved from the concept of a complete set of improved agricultural practices to be applied in selected districts in India. Agricultural engineering in this program includes the establishment of workshops in each of seven districts to demonstrate the use of improved implements. These workshops build improved implements as well as perform design and development work.

Tables 5, 6, and 8 in Appendix K show the number of research workers, the ratios of farm holders to extension workers, and the output per worker in developing countries.

As an example, in 1963 Taiwan had a staff of 1,096 working in 34 agricultural research and experiment stations and institutes. About 70 percent were graduates of senior agriculture vocational schools and 30 percent were college graduates (22). Only about 20 had M.S. or Ph.D. degrees. This means there was one agricultural research worker for approximately 800 farmers, and one college trained agricultural research worker for each 2,100 farmers and each $2 million of agricultural production.

Agricultural extension work in Taiwan is conducted primarily by vocational school graduates. In 1966 there were 29 college graduates and 957 vocational school graduates engaged in agricultural extension work at provincial, county, and township levels. Investments and expenditures for research and education in Taiwan have yielded high economic returns, as have investments for irrigation, drainage, flood control, and expenditures for fertilizer, pesticides, and other capital items.

Vocational agriculture for pre-college students. A wide range of training and education is needed to provide for a broad spectrum of manpower (29). Vocational training is a necessity. Skills need to be upgraded to meet the needs of the new technologies which come to fruition in a developing country. The training and educational programs can vary from hour-long discussions and meetings; one-day meetings; weekly, monthly, or specialized conferences; to two-year, four-year, and advanced degree programs.

Johnson (41) states that President Kennedy's Panel of Consultants on Vocational Education in the United States recommended that part-time, short-term training courses be expanded. Millions of workers require updating and upgrading--lifelong learning--in an era of changing materials, processes, tools, and techniques. The Panel was convinced that graduates of vocational and technical education programs are less likely to be unemployed than other high school graduates.

As farming becomes more modernized, organization and work discipline become more exacting (6). The level of rural education must be raised rapidly. A growing supply of technicians and professionals is required. For example, in Chile, Venezuela, and Cuba where there were relatively more trained specialists for rural work than in most other Latin American countries, the shortage of trained manpower nonetheless became a severe bottleneck as soon as vigorous rural development programs were initiated.

Agriculture should be taught to youngsters in developing countries to train them toward the respectability of agriculture as a profession. It should be taught as early as possible so as to identify future leaders of agriculture and keep their interests in it alive. If we really sort out the farm boys who have worked with their hands and have adequate intelligence, who have had agricultural training in their pre-college work, and who have taken agricultural training at the university level, we will finally develop the future teacher needed for successful development of agriculture in developing countries. Dr. R. P. Christensen, Director Foreign Development and Trade Division, USDA, made this analysis to me in an interview.

An agricultural leader from a northeastern U.S. university says that vocational agriculture should be taught as early as fifth grade before large numbers of students leave school. He says to start teaching agriculture much before high school, for the boy knows by this time that he will not go into farming because he will be getting his high school diploma. A high school graduate will probably be too proud to till the soil. Table 4, Appendix K, shows educational levels of the populations in various developing countries.

If vocational agriculture is brought in early in a boy's education to develop his agricultural and mechanical aptitudes, especially when he is a poor village boy, he can at least be trained in diploma curricula to take such information back to his village. Christensen (22) makes the observation that vocational agricultural schools provided a trained staff for agricultural extension work and for assisting with agricultural research projects in Taiwan. Because vocational agricultural students came from farms, they had an intimate knowledge and a sympathetic understanding of farmers' production and market problems. The establishment of vocational schools to provide large numbers of trained agriculturists well-qualified to staff farmer service organizations was an essential infrastructure development.

APPENDIX J - AGRICULTURAL ENGINEERING GRADUATES AND JOBS IN INDIA

It is expected that by 1973-74 more than 700 agricultural engineers in India will be unemployed. The Indian government is planning ways to hire as many of the unemployed as possible. It is obvious that many of the positions being planned could and should be handled by a well-trained agricultural mechanization technologist who would work with his hands to demonstrate the job to be done. If agricultural engineers were given many of the positions listed, some of the jobs might seem beneath their dignity and they might feel they were being employed below their abilities (Pearson, 14).

Such a situation is considered under-employment. Although there are no firm estimates of under-employment, it is clear that recorded unemployment in the developing countries understates the problem. Planners in developing countries must carefully consider agricultural mechanization technology as a program to develop skilled men who will do the job that is needed and will not be under-employed.

Following are some statistics relating to agricultural engineering graduates:

Output of Agricultural Engineering Institutions
(Sridharan, 7)

Institution	Year	Graduates	Post-Graduates
Allahabad Agr. Engr. Col.	1942-69	486	
Indian Inst. of Tech. Kharagpur	1958-69	96	67
U.P. Agr. Univ., Pant Nagar	1962-69	238	
Univ. of Udaipur	1964-68	80	
Punjab Agr. Univ.	1965-69	54	
Agr. Univ., Bhubaneswar	1966-69	0	
J.N. Agr. Univ., Jabalpur	1967-69	0	

Growth of Agricultural Education in India (Rath, 8)

	1951	1967
Agr. Degree Colleges	19	71
Agr. Graduates	1065	5884
Agr. Postgraduate College	4	36
Agr. Postgraduates	151	1425
Vet. Degree Colleges	8	20
Vet. Science Graduates	516	1086

Growth Expected in India (Rath, 8)

Graduates	Numbers in 1968	Anticipated 1969-73	Total at end 1973
Agricultural	41,000	19,660	58,065
Agr. Postgraduates	10,015	7,850	17,150
Veterinary	11,900	3,945	15,150
Veterinary Postgraduates	1,300	1,125	2,330
Agr. Engineers	865	1,315	2,040

Estimated Unemployment in 1973-74 (Rath, 8)

Graduates	Number
Agricultural	8900
Agr. Postgraduates	4660
Veterinary	1915
Agr. Engineers	705

Employment for Graduates of the Indian Institute of Technology, Kharagpur (Pandya, 45)

Employer	Percent
Private industry	18
Government departments	40
Education and research	26
Abroad	11
Higher education in India	5

The next several paragraphs report Sridharan's (7) analysis of avenues of employment of agricultural engineers in India.

In the government development programs, agricultural engineers are to be employed for projects on farm mechanization and tractors, irrigation engineering, and soil conservation engineering.

The Government of India envisages establishment of 30 agricultural machinery hire centers with a large number of subcenters or workshops attached to them, involving a capital outlay of Rs. 750 lakhs. Agro-industries corporations in the states of Punjab, Haryana, West Bengal, Andhra Pradesh, Assam, Bihar, and Kerala have already set up one or two centers.

While the rural areas badly lack the essential technical services, engineers and other technical personnel, because of lack of incentive for productive employment in rural areas, are eager to find employment in urban areas where living and working conditions are better. The scarcity of supporting services for the agricultural production programs is a matter of serious concern to the

Ministry; these services include machine hire facilities, facilities for repair and maintenance, prompt supply of parts, and other engineering services.

On several state mechanized farms now being established, engineers would be required in the development of the irrigation layout and in the management of farm implements and machinery. They could also organize a system of farm mechanization engineers.

Irrigation engineers have been confined to the task of taking water to an outlet in the construction of various irrigation projects and in the development of canals and tributaries. Beyond this work, engineering has not so far played any important role in the development of the field-oriented problems. In various parts of the country, work has been started on projects involving land leveling, grading, provision of irrigation ditches, etc., for effective utilization of groundwater. Qualified and experienced agricultural engineers have an important role to play in this program. Such work could even be organized on a block basis.

Engineers will be needed for sinking tubewells, installation of maintenance of suitable pumps, and construction of open wells. It is estimated that about 12.5 lakhs of electric pumps and 6 lakhs of Diesel sets would be required in the Fourth Plan.

Agricultural engineers will have to be involved in a program for development of nonirrigated areas that depend solely on rainfall, with measures for conserving the soil and the moisture.

The Fourth Plan estimated requirements for agricultural engineers as about 1,200 at the graduate level and about 5,000 at the technician level. In the national demonstration program, there is a proposal to have one agricultural engineer in each of the 100 districts where the programs of national demonstration would be intensified. Including requirements of educational institutions, there is scope for employing about 200 agricultural engineers in the Fourth Plan in research and education.

About 100 small-scale industrial units engaged in the production of farm implements do not employ any qualified agricultural engineers. This lack of qualified engineers on the staff is one reason for the low-standard implements these units develop. Larger tractor and implement manufacturing plants could also use agricultural engineers, if not on the production line at least in follow-up programs of distribution, field operations, servicing, etc.

According to the National Herald, New Delhi, November 3, 1969, the government is expected to soon lift the general ban on the filling of vacant technical posts to relieve unemployment among engineers. Engineers may be encouraged to set up cooperatives to undertake construction work or to start repair and servicing facilities for agricultural machinery in rural areas. An ambitious scheme is being drawn up for financial assistance to engineers from the State Bank of India and other nationalized banks for setting up small-scale industries.

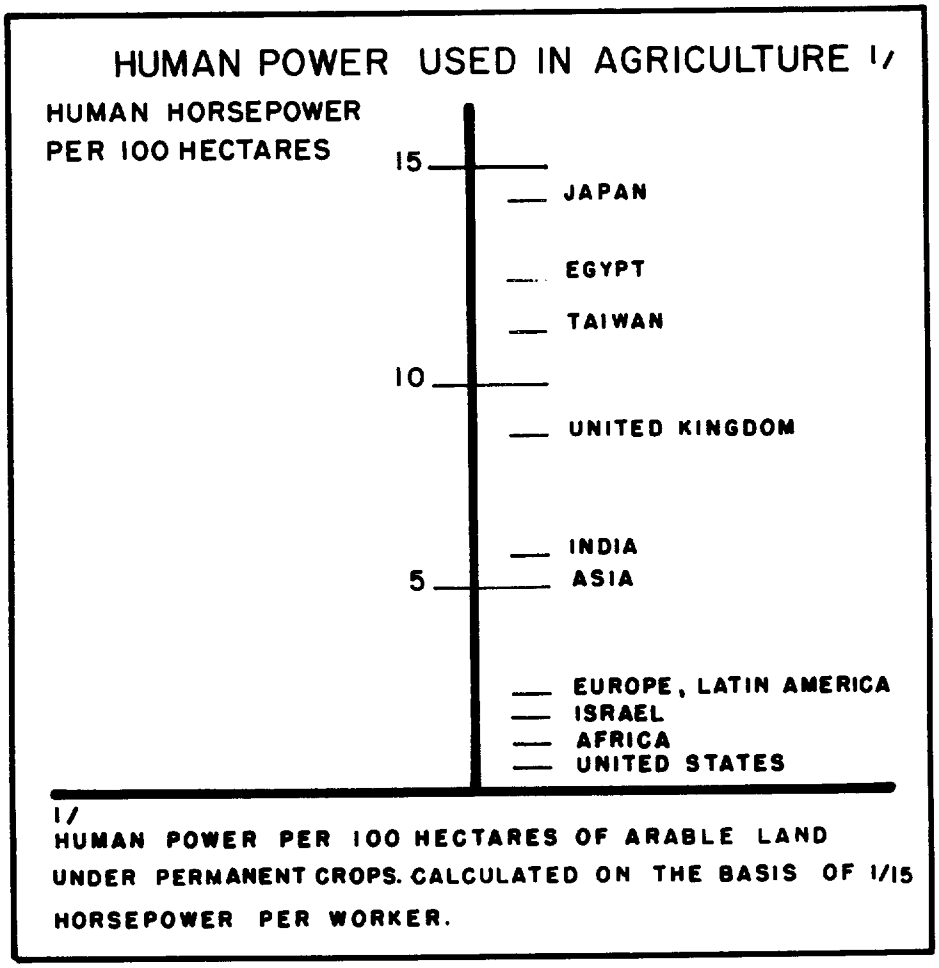
At a meeting on employment opportunities for agricultural engineers in India (9), Dr. M. S. Randhawa, Vice Chancellor, Punjab Agricultural University, Ludhiana, stated most of the first group of over 50 agricultural engineers graduated from the University in June, 1969, had not so far been able to secure jobs. As a result the entire agricultural engineering college is on strike. Since 1966, the Indian Council for Agricultural Research (ICAR) has been advising the states against the establishment of more agricultural engineering colleges because the facilities already created could be used by other states as well.

It was also brought out at the meeting that in the Fourth Plan, ending 1973-74, even though 3.8 lakhs of tractors, 18.5 lakhs of pumpsets, and other equipment are proposed to be provided for farms and new agro-implement practices are to be popularized, there is a lack of qualified engineers at block and district levels. This situation may prove to be a serious handicap in the smooth functioning of mechanization, irrigation, and other engineering-based schemes and production plans.

It was suggested at the meeting that agro-industries corporations and manufacturers of agricultural machinery be used to find employment for agricultural engineers. A recommendation was made to provide assistance to agricultural engineers for the purchase of tractors, boring sets, and other agricultural machinery, along with workshop equipment for setting up centers for hire and service. Another recommendation was that the state governments enlarge their extension services so that at least in selected blocks there is a graduate agricultural engineer entrusted with extension activities in the field. The meeting also recommended that ICAR evolve a policy of expansion of agricultural engineering education, including control of enrollment in existing institutions.

APPENDIX K - FIGURE AND TABLES

Figure 1



Source: Reference 11.

Table 1 - Average Annual Rates of Growth in Electric Energy Production, 1948-67 (per cent)

Developing Countries	10.5
Africa	11.5
South Asia	12.4
East Asia	12.8
Southern Europe	11.1
Latin America	8.6
Middle East	18.3
Industrialized Countries	7.7

Source: Reference 10.

Table 2 - Tractors Used in Agriculture per 1,000 Hectares, 24 Study Countries, 1949-50 and 1961-62

Country	Tractors per 1,000 hectares of arable land		
	1949-50	1961-62	
		All tractors	Garden tractors
		Number	
Israel	--	19.24	.95
Sudan	.02	--	--
Mexico	--	1.96	--
Costa Rica	--	1.95	--
Philippines	.19	.60	--
Tanganyika	.23	.16	--
Yugoslavia	.86	4.55	--
Taiwan	--	.56	--
Turkey	.16	1.68	--
Venezuela	--	4.11	--
Greece	.78	6.11	2.16
Iran	--	.36	--
India	.05	.21	--
Poland	.90	4.45	--
Argentina	--	3.69	--
Chile	--	[1]2.72	--
Japan	--	[1]1.55	232.82
Spain	.72	3.07	.13
Colombia	--	4.66	--
Nigeria	--	.02	--
UAR	--	4.28	--
Pakistan	--	.15	--
Tunisia	1.37	--	--
Jordan	.09	.97	--

1 Number as reported for 1960.
Source: Reference 10.

Table 3 - Rural Population, 26 Study Countries Arrayed by Size of Total Population, 1950 and 1960

Country	Total population, 1960	Rural population				
		1960		1950		
		Size	Percentage of total population	Size	Percentage of total population	1960 as a percentage of 1950
	Millions	Millions	Percent	Millions	Percent	Percent
India.......	429.0	353.6	81.9	293.2	82.8	121
Pakistan....	92.6	84.2	87.2	69.8	89.9	121
Japan.......	93.2	34.0	36.9	51.8	62.5	66
Brazil......	71.0	39.0	54.9	33.4	63.8	117
Nigeria.....	35.1	NA	NA	NA	NA	NA
Mexico......	35.0	17.2	49.1	14.8	57.4	116
Spain.......	30.3	22.2	73.0	17.7	63.0	125
Poland......	29.7	15.4	51.9	20.8	83.9	74
Turkey......	27.8	19.0	68.3	16.4	78.1	116
Philippines.	27.4	NA	NA	14.9	73.1	NA
Thailand....	26.4	23.2	88.2	17.3	90.5	134
UAR.........	26.0	16.2	62.5	13.9	68.0	117
Iran........	20.2	NA	NA	13.0	80.0	NA
Argentina...	20.0	NA	NA	NA	NA	NA
Yugoslavia..	18.4	NA	NA	13.2	82.9	NA
Colombia....	14.1	NA	NA	7.2	63.7	NA
Sudan.......	11.8	NA	NA	NA	NA	NA
Taiwan......	10.6	NA	NA	3.5	46.2	NA
Tanganyika..	9.2	NA	NA	NA	NA	NA
Greece......	8.3	4.8	57.8	4.8	63.9	100
Venezuela...	7.4	2.4	32.4	NA	NA	NA
Chile.......	7.7	2.4	32.9	2.2	38.3	109
Tunisia.....	4.2	NA	NA	NA	NA	NA
Israel......	2.1	0.3	14.3	0.2	17.7	150
Jordan......	1.7	0.9	56.2	0.8	64.4	112
Costa Rica..	1.2	0.8	66.7	0.6	66.5	133

Source: Reference 10.

Table 4 - Indicators of Educational Levels, 26 Study Countries Arrayed by Per Capita Gross National Product

Country	Annual compound rate of change in crop output, 1948-63	Literacy rate[1]	Percentage of population 25 years and older, by level of schooling completed[2]				Percentage of children in primary and secondary schools, 1950	Education rating[3]
			Less than first level	First level	Second level	Third level		
	Percent							Rating
Israel	9.7	96	[4] 43	[4] 32	[4] 21	[4] 4	58	1
Venezuela	4.5	52	NA	NA	NA	NA	30	2
Poland	3.0	95	52	35	10	3	53	1
Argentina	2.8	86	[5] 38	[5] 57	[5] 4	[5] 1	51	1
Chile	2.8	80	24	55	19	2	50	1
Spain	2.7	87	[6] 28	[6] 67	[6] 4	[6] 1	43	1
Japan	2.8	98	3	66	25	6	69	1
Mexico	6.3	65	[7] 40	[7] 53	[7] 5	[7] 2	30	2
Greece	3.7	80	[8] 45	[8] 44	[8] 9	[8] 2	53	1
Turkey	4.5	39	[7] 83	[7] 12	[7] 4	[7] 1	24	3
Costa Rica	5.6	79	63	33	3	1	37	2
Colombia	2.6	62	53	40	6	1	22	3
Yugoslavia	5.1	77	[9] 37	[9] 51	[9] 11	[9] 1	51	1
UAR	2.0	20	NA	NA	NA	NA	20	3
Jordan	-1.9	32	NA	NA	NA	NA	15	3
Tunisia	1.6	16	NA	NA	NA	NA	15	3
Brazil	4.2	49	80	16	3	1	21	3
Iran	3.6	15	94	5	1	--	13	3
Philippines	5.2	75	[10] 70	[10] 25	[10] 2	[10] 3	59	2
Taiwan	4.5	[11] 54	57	34	5	4	38	2
Nigeria	2.6	11	NA	NA	NA	NA	12	3
Thailand	4.4	68	61	36	3	--	38	2
India	3.1	24	[8] 97	[8] 2	[8] 0.5	[8] 0.5	19	3
Sudan	8.0	7	[5] 89	[5] 10	[5] 0.5	[5] 0.5	4	3
Pakistan	1.8	[6] 19	91	6	2	1	17	3
Tanganyika	5.2	7	NA	NA	NA	NA	7	3

1 For population 15 years and older.
2 The first level includes those completing 4 years of primary schooling but less than 4 years of secondary school; the second level includes those completing 4 years of secondary but less than 4 years of higher schooling; and the third level includes those completing 4 or more years of higher schooling
3 These are based on ratio of primary and secondary school enrollment to size of population in eligible school enrollment ages in 1950. Countries with ratios of 40 percent or more are rated 1, those with ratios of 30 to 39 percent are rated 2, and those with ratios under 30 percent are rated 3.
4 1954. 5 Population over 20 years of age. 6 All ages. 7 1950. 8 1951. 9 Population over 10 years of age. 10 1948.
11 Population over 6 years of age.

Source: Reference 10

Table 5 - Agricultural Research Workers per 100,000 People Active in Agriculture, 14 Countries, 1960

Country	Agricultural research workers	Country	Agricultural research workers
	Number		Number
India..........	1.2	Iran............	10
Philippines....	1.6	Greece..........	10
Mexico.........	3.8	Argentina.......	14
Pakistan.......	4.5	Yugoslavia......	29
Thailand.......	4.7	Japan...........	60
Colombia.......	9	Taiwan..........	79
Spain..........	10	Netherlands.....	133

Source: Reference 10.

Table 6 - Ratios of Farm Holdings and Economically Active Persons in Agriculture to Extension Workers in Selected Countries, 1959[1]

Country	Total extension workers	Farm holdings per extension worker[2]	Economically active in agriculture per extension worker
	-----------	Number	-----------
Israel........	610	38	157
Philippines...	1,623	1,010	3,497
Taiwan........	884	NA	1,698
Turkey........	1,758	NA	5,539
Venezuela.....	332	749	2,331
Thailand......	328	6,438	34,555
Greece........	4,851	206	403
Iran..........	648	NA	5,130
India[3]........	48,579	913	2,696
Argentina.....	544	1,005	4,193
Chile.........	154	980	4,208
Japan.........	13,566	[4] 445	728
Spain.........	206	NA	23,316
Nigeria.......	950	NA	NA
Jordan........	90	1,023	NA

[1] These ratios are merely crude indicators of the adequacy of the supply of extension personnel. The total number of extension workers rather than the number of field workers was used for the computations due to data limitations.
[2] Data for farm holdings pertain to a year around 1950.
[3] Including all community development employees
[4] Data for farm holdings pertain to 1960.

Source: Reference 10.

Table 7 - Relationship Between Seed Status, Proportion of Crop Area in Improved Varieties, and Crop Yield Changes for Rice, Wheat, and Maize, Selected Countries, 1948-62

Commodity and country	Seed status[1]	Proportion of crop area in improved varieties	Yields per hectare		
			1948-52	1960-62	Change
Rice	Rating	Percent	---100 Kg/Ha----		Percent
Japan..........	1	100	40.0	50.5	26
Taiwan.........	1	95	19.1	25.4	33
Venezuela......	2	90	11.4	15.1	33
Chile..........	3	65	29.0	27.0	-7
UAR............	3	35	37.9	52.8	39
Pakistan.......	4	5	13.8	15.9	15
Iran...........	4	3	19.3	19.6	2
Wheat					
Japan..........	1	100	18.5	26.1	41
Netherlands....	1	100	36.5	43.8	20
Mexico.........	1	85	8.8	16.7	90
Chile..........	2	80	11.9	13.7	15
Pakistan.......	2	7	8.7	8.1	-7
UAR............	3	30	18.4	25.1	36
Colombia.......	3	20	7.2	9.1	26
Iran...........	3	10	9.0	[2] 7.8	-13
Jordan.........	4	15	7.0	5.4	-23
Maize					
Venezuela......	2	20	11.4	11.0	-4
Pakistan.......	2	8	9.8	10.0	2
Chile..........	3	50	13.8	20.7	50
Colombia.......	3	20	10.7	11.2	5
UAR............	3	7	20.9	24.1	15

[1] Index of present efficiency in the chief factors influencing development production, distribution, and use of better seeds, using rating of 1 to 4 with quality highest for rating of 1.

[2] 1960-61.

Source: Reference 10.

Table 8 - Value of Agricultural Output Per Agricultural Worker and Per Hectare of Arable Land, 23 Study Countries, Specified Years

Country[1]	Total agricultural workers, 1960	Agricultural workers per 100 hectares of arable land, 1960	Agricultural output, 1960: Per agricultural worker	Agricultural output, 1960: Per hectare of arable land	Changes in agricultural output per agricultural worker, 1950-60
	(1)	(2)	(3)	(4)	(5)
	Thousands	Number	U.S. dollars	U.S. dollars	Percent
Argentina	2,161	4.9	1,080	78	NA
Chile	646	11.8	547	59	NA
Jordan	134	14.7	NA	NA	NA
Tunisia	971	18.5	NA	NA	NA
Iran	3,743	22.2	NA	NA	NA
Spain	4,803	22.7	656	150	NA
Mexico	5,948	24.4	369	110	NA
Venezuela	751	31.2	500	150	NA
Israel	122	33.3	1,825	557	33
Turkey	9,737	38.5	326	127	NA
Poland	6,541	41.7	616	252	NA
Colombia	2,544	52.6	531	270	1
Greece	1,940	52.6	391	205	48
Yugoslavia	4,693	55.6	250	141	NA
Costa Rica	214	71.4	438	320	NA
Brazil	13,555	71.4	229	104	10
India	128,214	83.3	114	91	NA
Pakistan	18,636	83.3	182	133	NA
Philippines	5,383	83.3	181	139	NA
Thailand	11,334	111.1	94	106	NA
Taiwan	--	166.7	228	477	50
UAR	4,403	166.7	365	643	NA
Japan	14,346	250.0	402	961	76

[1] Ratio of workers to arable land not ascertained for Nigeria, Sudan, and Tanganyika because of inadequate statistics on land area or number of agricultural workers.

Source: Reference 10.