JORDAN WHEAT RESEARCH AND PRODUCTION

Project Impact Evaluation

by

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Executive Summary

I. Project Setting

Nearly all Jordan wheat production takes place as dryland farming under semi-arid conditions. Extensive wheat production, usually combined with weedy fallow, takes place in marginal areas. In areas with higher rainfall it is usually grown as part of a two or three year rotation. Rainfall is highly variable with attendent risks of crop shortfalls or failure. Dryland wheat farming has been characterized by low levels of productivity and this has been a matter of concern to the Jordan government.

II. Project Description

The Jordan Wheat Research and Development project, a cooperative effort between the Government of Jordan and the Agency for International Development (AID) was initiated in 1967 and terminated in 1975. The implementing agency was Oregon State University. The objective of the project was to double wheat yields by 1980. During implemenation project operations were often restricted because of security problems and midway, the project was suspended for three years. The active time span of the projects was, therefore, only four years.

The objective of the project was to be achieved by providing technical assistance focused on the testing of improved cultural practices including soil moisture conserving techniques developed in the U.S. Pacific Northwest. The project, as originally conceived, did not include institution building but was directed exclusively to technology transfer. Midway through the project elements of institution building were introduced. A follow on project proposed by the Oregon State technicians put institution building to the fore but the project never materialized. The technical assistance team was very small, at no time exceeding two full time technicians and periodic visits by consultants.

The techniques used by the Oregon State team were trials and demonstrations on farmers fields supplemented by preparation and use of extension bulleting and radio and television broadcasts. Over 500 trials and demonstrations were conducted during the life of the project.

III. Project Impact:Findings

In a limited sense the overall results of the trials and demonstrations indicated the basic package of practices was transferable to Jordan but required adaptation to meet local conditions. The pacakage included clean seeds, shallow tillage using chisel and sweep plows, seed drills with fertilizer attachments, chemical weed control and clean summer fallow. The highest rate of adoption was for clean seeds, followed by chemical weed control and fertilizer. There was little adoption of clean summer fallow or the grain drill. No farmers used the recommended tillage practices. The rate of adoption of the new technologies was positively related to the amount of rainfall. With less than 250mm of rain none of the practices were adopted and it was only in the zones where normal rainfall exceeded 330mm that any of the practices, other than clean seeds, were adopted.

The data show that risk associated with variability in rainfall was an important determinant of the rate of adoption of new practices by farmers. The practices which few or no farmers adopted—clean summer fallow, grain drills and proper tillage—represent major changes in traditional practices and require major investments either by farmers or custom operators. An additional factor affecting adoption of summer fallow was that it eliminated a traditional source of livestock feed. While no farmers adopted the entire package, the evidence indicates farmers will adopt components of the package if they believe it will favorably affect yields and income.

The institution building objective of the project, added about halfway through the project, was to develop Ministry of Agriculture capacity to carry out a long term adaptive research program. However, with the termination of the project, all progress towards the objective was ended and no residual capacity was retained.

The rate of adoption of new practices was not impeded by a lack of supplies and equipment except for certain farm implements. Machinery suppliers did not, and still do not, stock equipment required for moisture conserving activities.

Since the project was initiated changes in the Jordan economy have affected dryland wheat farming. Income from external sources has fueled a boom in the construction and service sectors. One result has been to greatly decrease the importance of agriculture as a source of income and employment. Dryland agriculture appears to have had a shortage of labor and the opportunity cost of farm labor increased dramatically. Additionally, many farm households earn part of their income from non-farm sources. Since 1975 the area under grain production has been decreasing sharply. At the same time, land ownership fragmentation continues to increase. However, because of increased renting of land it appears that the size of farms operated may be increasing.

Government policy has been to keep the price of bread low to consumers through a subsidy program. Prices paid to farmers were held below the economic value of production until 1979 when prices were increased substantially above world price levels. Government has relied on wheat imports to reduce the cost of subsidies. Since 1975 government development policy has discriminated against dryland farming in favor of irrigated agriculture. However, government tax policy was structured to favor investment in all agriculture.

Little attention was paid to socio-economic aspects of introducing new technologies in dryland wheat production. Economic analysis undertaken during project implementation was limited to one attempt to determine the profitability of clean summer fallow. The analysis indicated that net returns from clean summer fallow would be lower than from traditional practices one or two years out of four. Since the end of the project other studies have indicated that the profitability of using the improved techniques was directly related to the quantity of rainfall. Wheat production and income from wheat farming appears to have been adversely affected by the conversion of good

wheat land to other uses and a steep rise in wage rates. There is some indication that reliance on custom cultivation and harvesting has not had a beneficial effect on yields because of conflicting economic interests of farmers and custom operators.

IV. Project Impact: Analysis.

There are a number of factors which can be identified as being partially responsible for failure of the project to achieve institutionalization objectives. The period of time devoted to institution building was extremely short, about two years, and little in either financing or personnel was provided for this purpose. In 1975, just as it was necessary for the Ministry of Agriculture to take over responsibility for institution building, other priorities prevented them from retaining the necessary resources to support such efforts.

The reasons why the proposed technology was not more widely adopted are not clear. It was probably partially due to the project being primarily concerned with trials rather than dissemination. Either the absence of or defects in analyses led to uncertainties about returns to farmers from some of the technology being tried. In addition, institutional support was lacking and supplies and services were to some degree uncertain or not obtainable.

There is little reason to believe that government policies had, in total, encouraged farmers to adopt new technologies. While government tax policy was favorable to investment, this was more than offset by unfavorable investment policies and, until 1979, low producer prices.

In those areas of Jordan with less than 350mm of rainfall, the new technology without clean summer fallow was probably less profitable over time than the traditional methods. Clean summer fallow appears to represent a good way to insure against some of the risks associated with dryland wheat farming in low rainfall areas of Jordan. However, using clean summer fallow represents a drastic shift in farming practices and, as noted earlier, faulty analysis led the agriculture technicians to hold back on recommending clean

summer fallow. During the period following termination of the project when adoption of the new technologies might have been expected to spread, farmers also had other alternatives for increasing family income, either on or off the farm. The evidence indicates this may have lessened interest in adoption of new technologies.

V. Conclusions and Lessons Learned

Because of the paucity of economic and social analysis, it is not possible to appraise the relative importance of technological and physical factors on the one hand and socio-economic factors on the other in trying to examine why adoption rates for the new technology were low. Clearly the risk factor and alternative opportunities for employing resources were important. However not enough is known to draw reasonable conclusions about the effect of these factors or about the effects of land fragmentation and the increase in land rental to enlarge the size of farm operations.

On the other hand, it seems reasonably clear that the technologies introduced, with modifications for local conditions, did favorably affect yields. The trials conducted were, at least, partially successful. Under what physical, social and economic conditions these yield increases would provide satisfactory increases in net returns needs to be determined.

Lessons learned appear to be the following:

A. Risks associated with variations in rainfall must be fully addressed when introducing new technologies to dryland wheat production.

B. Price policy by itself is not sufficient to bring about increased production from farmers operating on low input production functions. Such increases would appear to largely depend on utilization of per unit cost reducing technologies.

C. Farmers are highly unlikely to adopt the whole package of practices proposed to increase output. Technology packages must be developed and made

available to farmers so parts of the package can be adopted alone or in modular units. Projections made on expected yield and production increases should take this into account.

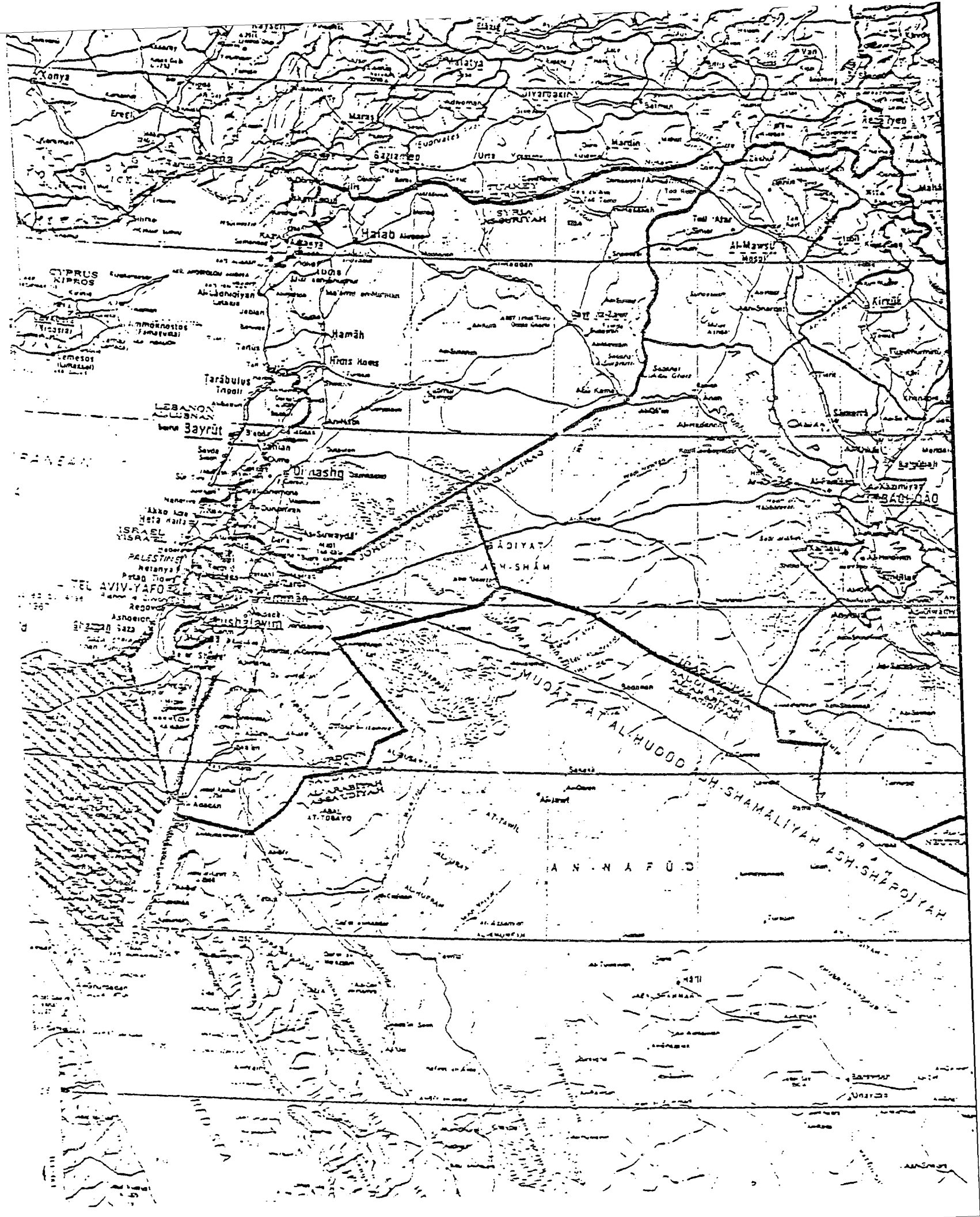
D. Greater understanding is needed of the effects on new technology adoption of increasing separation of management and ownership of dryland farms and increasing opportunities for farm households to maximize income by allocating resources to activities other than cereal production.

E. The entire farm operation needs to be taken into account when putting together a package of practices. The project does not have to do something about the entire operation but it is necessary to understand how the technological practices proposed would affect it.

F. Project objectives must be consistent with government policies and practices.

Forward

In October, 1979, the Administrator of the Agency for International Development (AID) initiated an Agency-wide ex-post evaluation system focusing on the impact of AID funded projects. These impact evaluations are concentrated in particular substantive areas as determined by AID's most senior executives. The evaluations are to be performed largely by Agency personnel and are to result in a series of studies which, by virtue of their comparability in scope, will ensure cumulative findings of use to the Agency and the larger development community. This study of the impact of the AID Wheat Research and Production project in Jordan were conducted in October 1982 as part of this effort. A final evaluation report will summarize and analyze the results of all the studies in this sector and relate them to program, policy, and design requirements.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AN-NAFUD

I. PROJECT SETTING

Agricultural land suitable for year around cultivation is scarce in upland Jordan. The major constraining factor is limited and variable rainfall. Over ninety percent of Jordan's total land area (9.25 million hectares) receives less than 200mm of rain. This area is technically considered an arid zone, and except in high rainfall years is generally utilized for natural grazing grounds. The remaining nine percent of available land is divided between three agro-climatic categories. Approximately 563,000 hectares are considered marginal with rainfall averages between 200-350mm. A third category, consisting of 136,000 hectares, is semi-arid (350 to 500mm). In addition, there are 99,000 hectares of land with 500 to 600 mm of rainfall.

Although each of these categories or zones has its own land use characteristics, in varying degrees, wheat constitutes a basic crop in all of them. In good rainfall years, wheat and barley are cultivated in the arid areas. Extensive wheat cultivation occurs in the marginal areas, usually in a grain/weedy fallow rotation. In the semi-arid and semi-humid areas an annual cropping pattern is followed which usually includes a grain/legume/summer vegetable rotation or a two year rotation of grain and some other crop. Livestock production is always a part of dryland farming in Jordan.

About 54,000 hectares of agricultural land is irrigated, most of which is in the Jordan Valley. Immediate prospects for expansion of irrigation in the dryland area is very limited. Groundwater sources are currently being explored, and initial evidence suggests the availability of more groundwater. For the most part, however, Jordan's agriculture is dependent on rainfall. Rainfall is not only limited but it is also highly variable, and this makes farming a high risk enterprise, particularly in the arid and marginal areas where rainfall variability can range as high as forty percent from the average. Instability in rainfall, which cuts across all four agro-climatic zones, is also characterized by variability in distribution over seasons. Early rains are usually expected in October/November, followed by

seasonal rains in January/February and later rains in February/March. However, early and late rains are frequently delayed, or fail to come at all. Such uneven rainfall patterns can produce considerable damage and reduction in crop yields.

The uncertainities imposed by variable rainfall pose a formidable challenge to the process of agricultural modernization. The majority of Jordan's cultivators are small farmers, with holdings of five hectares or less. Within the confines of this limited resource base, they cope with the vagaries of weather by pursuing a risk minimizing rather than a production maximizing cropping strategy. As a consequence, whether in the marginal zones or in the more favorable semi-arid and semi-humid areas, wheat yields remain low. Farmers use modern tractors and combines, but they also employ traditional cultivation practices which expose the soil to excessive moisture evaporation and erosion. Fertilizer use is minimal, and spraying for weed control is only practiced on a limited scale. Farmers also carefully consider the probable returns from alternative uses of farm labor which will maximize family income.

Low levels of productivity in the wheat producing sector has been a constant source of concern for the Government of Jordan (GOJ). Bread is a mainstay of the Jordian diet, and increases in domestic wheat consumption are not being matched by increases in domestic wheat production. As a consequence, a growing dependence on major wheat imports has been the recourse to bridging the gap in domestic food supplies. In order to conserve scarce foreign exchange and reduce the reliance on food imports, the GOJ has sought and continues to seek the assistance of donor agencies in building a base for internal food security, particularly in wheat production. AID has been one of the major donors involved in this effort.

A. The Place of Wheat, Barley and Livestock in the Dryland Agricultural System.

Of the cereal grains, annual barley production is more dependable than wheat in the lower rainfall areas (below 350mm) and where soils are shallow or low in moisture retention capacity. In the Near East, both bread and durum wheats are grown. Durum is more tolerant of the poorer rainfall and soil conditions with bread wheat requiring more moisture and better quality soil. These cereals are not always grown in relationship to their highest potential production and dependability due to differentials in price that in many cases are the result of policy decisions. Where there is a significant subsidy incentive, wheat is the usual recipient. The price of durum is higher than for bread wheat. This tends to encourage wheat to be planted in areas with higher risk than would be the case if price incentive was not a factor. These cropping decisions are also affected by the dependence of many farmers on livestock for the preponderance of their income and as a security system to hedge against emergencies. Livestock act as a substitute for a bank savings account. Thus, barley will be planted because of its greater dependability as it forms a major and required component of the livestock feeding system. Wheat straw also is a basic part of the livestock feeding component and could substitute for barley, at least in part. In areas where barley grain is used for human food, then straw may be the only feed use from barley. Increasingly, there is a preference for wheat bread, so more of the barley grain is used for livestock feed. In this case, a certain amount of barley will be planted for livestock feed because of both higher dependability and the higher feed value of the grain and straw over wheat straw only.

There has been a tendency for a slow shift in favor of wheat over recent years because of price policies favoring wheat, some reduction in the percent of farmers keeping livestock and greater research efforts on wheat improvement that have led to improved varieties of wheat being available along with production packages to encourage their adoption. The same has not been true for barley. More effort on barley improvement is currently under way than in the past. This may change grower perferences because early indications are that very major improvements in yield potential for barley are being

identified in new varieties approaching introduction. Higher livestock prices are also encouraging the establishment of post weaning feeding programs by farmers to increase the weight of the offtake of lambs and kids. Barley forms a ready feed source for this purpose. As a result, there may be increased incentives to utilize more barley in the areas where it is more dependable and less temptation to gamble on high risk wheat production to gain the benefit of price subsidies because improved barley varieties may outyield wheat enough to largely negate the subsidy advantage.

II. PROJECT DESCRIPTION[1]

In 1967, the GOJ established a wheat production project with the objective of doubling wheat yields by 1980. In the same year the GOJ requested the support of AID in achieving this goal, and the AID/Jordan mission responded by engaging the services of Oregon State University to undertake a five year project in assisting the GOJ in the development and application of improved wheat production technologies. The AID project objectives as contained in the 1967 project agreement document read as follows:

Activity Target

A. The activity target during the project life is twofold:

1. To develop, test and prove a modern system of wheat farming in Jordan that will provide the base for doubling present yields.

2. To extend this system into all of the principal wheat growing areas of Jordan and to sufficient numbers of farmers to ensure the successful achievement of the long-range objective.

B. In achieving this target a combination of improved practices will be devloped, tested and disseminated. These improved practices will include the use of better seed, chemical fertilizers, weed control, better seed bed preparation, more efficient seeding methods, summer fallow in the more arid portions of the country and other soil moisture conserving techniques.

Existing documentation does not reveal if the above project objectives were given more explicit operational definition, but several of the objectives were redefined midway through the life of the project. In the early years of the project (1968-1970) most activities were confined to a program of field testing and demonstrations at the farm level. In later years, institutional development objectives emerged as an explicit component of the project agenda, along with a continuous emphasis on field demonstrations.

The OSU project began in earnest when two full-time advisors, an agronomist and a soils specialist arrived in Jordan in September, 1968. These advisors, assisted by several short-term OSU consultants worked for two years with Ministry of Agricultural counterpart staff, until their departure in September, 1970. In these early years it was the judgement of the OSU consultants that an intensive wheat production and soil management research effort would take many years to develop and that more immediate results could be achieved through direct on-farm field demonstrations. Thus, the initial project strategy was highly action-oriented, focussing almost exclusively on the organization and management of a large number of on-farm demonstrations in testing the transfer of advanced cultivation practices utilized by dryland wheat producers in Eastern Oregon and Washington.

In 1968, over sixty summer fallow and annual cropping demonstrations were established in farmer's fields for harvest in 1969, and a similar round of demonstrations were established in 1969 for harvesting in 1970. The technologies introduced included shallow-tillage using chisel and sweep plows,

drill seeding, and placement of fertilier in close proximity with the seed by use of grain drills with fertilizer attachments, chemical weed control, improved varieties planted with properly treated seed, and in the lower rainfall belts, the use of clean summer fallow to replace the traditional weedy fallow. These practices were utilized as an improved package. Yield samples were collected from each demonstration and compared to similar samples harvested from the portion of each field farmed in the traditional manner.

Civil strife in Jordan brought about the premature termination of the OSU project in September, 1970. After a three year lapse, the project was reactivated in 1973, for another two year period. Thus, in November, 1973, one full-time OSU consultant, an agronomist/extension specialist, returned to work with the Ministry of Agriculture. At this time, the project paper was revised to reflect a stronger emphasis on the development of an institutional capacity within the Ministry of Agriculture to conduct a modern adaptive wheat research and dissemination program. The scope of work for the OSU project reads as follows in the Project Implementation Order of 1973:

> Work by this team will include a review of the administrative and technical problems of the Department of Research and Extension and work with the Director of that Department and with the Project Supervisor to improve the Department capability in planning, designing, implementing and directing a Wheat Research Program. The review will produce: (A) A Master Plan for Research Methodology in wheat production summer fallow practices, sprayer equipment use, soils classification and fertility analysis; (B) the Development of Training Programs in Field Plant technique, collection and analysis of Research Data for both irrigated and Rainfed Wheat Production, organization of farmer field days, and the preparation of technial bulletins and other mass communication material for Radio and TV Programs.

Aside from the above institutional objectives, at a technical level it was recognized that more adaptive research would need to be undertaken in fertilizer and variety trials. Thus, the OSU consultant continued to work with the Ministry in the conduct of a large number of demonstration trials. Unfortunately, because of the 1973 War, the consultant had to postpone his arrival in Jordan from August to late November, 1973, and this did not allow for the planning of field research for the 1974 wheat crop. However, the consultant was able to implement a demonstration effort for the 1974-1975 growing season, which was the last year of the project. Thus, for the total four years of project life, over 500 demonstrations were undertaken in three growing seasons on a total of approximately 1500 hectares of wheat producing land. These activities were supplemented by the preparation and use of extension bulletins, and radio and TV broadcasts of information promoting the use of advanced wheat producing technologies.

III. PROJECT IMPACT: FINDINGS:

A. Technology Transfer

In a limited sense the overall results of the hundreds of field tests and demonstrations indicated that the basic package of technologies used in the U.S. Pacific Northwest were transferable to Jordan, though the need for a continuing research program to adapt cultural practices to local requirements was identified. However, the rate of adoption of these technologies by farmers was minimal The use of improved clean seed was found to be one of the easist practices for farmers to adopt as they only needed to have access to the seed. Once they tried them and were satisfied, full adoption followed as they could use the seed they saved for planting.

The standard chemical weed 2-4-D treatment used in Oregon was satisfactory for control of the weeds commonly found in Jordan and about 25% of the farmers in the demonstration areas started using this practice. The OSU consultants recommended an on-going program for testing alternative chemicals as

experience showed that resistant species tend to increase and that a rotation of chemicals used is the best known solution to this problem.

Fertilizer adoption was more spotty and tended to follow rainfall patterns. In dry years, fertilizer at best fails to give a response. Because fertilized wheat requires more moisture, the plants can run out of available moisture before maturing grain, and thus yields can be less than from unfertilized wheat. This seems to have accounted for the reluctance of farmers in the lower rainfall areas to adopt fertilizer use.

Although use of grain drills in the higher rainfall areas had a high payoff, farmers were reluctant to accept the idea because the centuries old practice of broadcasting the seed on the field and then covering it by tillage gives a solid stand. They could not easily adjust to the idea that the large vacant areas between rows does not reduce yield. In addition, without chemical weed control, drill seeding gives less competition to the weeds. Even with their skepticism, in some instances, farmers indicated a willingness to adopt drill seeding because of increasing shortages of labor to hand seed. However, because few grain drills were being imported this machinery remained unavailable in the agricultural sector.

Changing from the traditional deep plowing with the cover crop disc plow to shallow tillage with the chisel and sweep type plow was also difficult to accept in principle and again impossible to implement due to the unavailability of the plows. There was not only the belief that the deeper the land is plowed the better, but a pride factor in how deep you are able to plow. Deep plowing gives complete coverage of all trash and makes the field look good. These factors were nearly impossible to overcome, in spite of the fact that deep plowing requires about four times as much fuel and time as shallow tillage. Moisture loss is increased by deep plowing as any residual soil moisture dries out to the depth of plowing. In addition, the plowing under of all stubble and surface litter creates ideal conditions for

accelerated erosion. An even larger problem was encountered in obtaining farmer adoption with clean summer fallow. In the lower rainfall areas, there is a lack of dependable moisture for annual cropping. From long tradition, farmers have accepted the need to let the land lay fallow (rest) between crops. They use a system known as weedy fallow in whch they let the land stay idle for a year between crops. Under this sytem, weeds germinate and grow on the field in the non-cropped year. The weeds are used for livestock feed by grazing. This system does little to conserve moisture, but does allow a break in cropping that reduces diseases and other pests and may allow some natural release of soil nutrients. The Oregon State project introduced the use of shallow tillage with the sweep plow and rod weeder to keep the year of fallow free of vegetation that used up the moisture which was stored from the winter rainfall. In addition, the surface mulch of dry soil forms a layer that stops evaporation of moisture from the soil. The Oregon system worked well and overcame much of the lack of crop dependability or in essence reduced risk of crop failure. Since farmers in the lower rainfall areas are strongly influenced toward risk aversion, the new system would appear ideal. It was not adopted because of the strong tradition of not investing time and labor in cultivation during the fallow year and because the weeds were a planned part of the livestock feeding system. Even if the farmers were convinced of the merits of the new system, none of the required equipment needed for adoption was available.

Table 1 shows the percentage rate of adoption of improved practices that made up the package introduced under the project. Farmers gave a variety of reasons for not adopting various practices, The most frequently cited were:

1. lack of profitability, the likelihood of increased cost with low returns.
2. lack of knowledge about how to undertake the new practices.
3. the absence of custom services providing the necessary equipment.

TABLE I

ADOPTION RATE OF IMPROVED INPUTS IN WHEAT (%)

Input	RAINBELTS -250mm	250-300mm	300-400mm	Over 400 mm		Average
Proper tillage	0	0	0	0		0
Clean seeds	0	67	75	100	33%	65
Grain drill	0	0	4	0		1.5
Fertilizer	0	0	14	43	20%	11.5
Summer fallow	0	0	5	3		2.5
Herbicides	0	0	25	53	112%	17

Source - M.H. El-Hurami, Economic Analysis of the Wheat Sub-Sector of Jordan.
Iowa State University 1975

4. unsatisfactory results from using contract services for the new practices.
5. chemical weed control did not contribute to an increase in yield.
6. the inability to finance the practice.

The table clearly shows the relation between annual rainfall and the adoption of new practices. In the zone with less than 250mm of rainfall no farmer adopted the new practices. In the 250 to 300mm zone the only new technology adopted was clean seeds, a very low cost practice both in terms of money and labor and one which does not require any major change in traditional ways of doing things. In the two higher rainfall areas the adoption rates for clean seeds, fertilizer, and herbicides were substantially higher in the above 400mm rainfall belt than in the 300-400mm belt; 1/3 higher for clean seeds, twice as high for herbicides and three times as high for fertilizer. Only for summer fallow was the adoption rate higher in the lower rainfall area. This, of course, is consistent with moisture conserving summer fallow being more important in lower rainfall areas. There is a clear relation between yield variability as a result of the annual variation in rainfall and the adoption of improved practices. Table 2 shows that, for the most part, improved practices were adopted in rainfall zones where average yields in years of poor rainfall were above two-thirds of average yields in years of average rainfall. The only exception was some adoption of clean seeds in the 250-300mm rainfall zone when average yields during poor rainfall years were only 52 percent of that in a year with average rainfall.

It should be noted that few farmers adopted sumer fallow or grain drills and none adopted proper tillage. Adopting the practice of clean summer fallow represents a major change in traditional practices as it requires either a change from annual cropping to bi-annual cropping or the elimination of a significant source of animal feed from weedy fallow. For both proper tillage as well as for summer fallow, adoption of these practices would have required major investments in new equipment either by farmers or private contractors.

TABLE 2

ESTIMATED WHEAT AREA, PRODUCTION, AND YIELD

UNDER DIFFERENT WEATHER CONDITIONS AND BY RAINFALL BELT

Rainfall Belt	Area (000 dunums)			Production (00 tons)			Average yield kg/dunum (percent)		
	good year	poor year	average year	good year	poor year	average year	good year	poor year	average year
Desert (150-250mm)	500.0	340.0	416.0	35.1	3.3	16.90	233	33	100
Eastern (250-300mm)	750.0	640.0	393.0	68.0	22.8	44.36	141	52	100
Western Plain (300-400mm)	644.0	544.0	610.0	76.4	27.1	49.5	165	70	100
Upland (Over 400mm)	189.0	180.0	180.0	26.4	13.6	19.0	106	82	100
Total/Percent	2083.0	1704.0	1599.0	205.9	66.8	129.76	140	68	100

Source: Based on Table 1, p. 5, ISSUES OF IMPROVING WHEAT PRODUCTION IN JORDAN RESULTS FROM A SURVEY, by Suleiman Arabiat, David Nygaard and Kutlu Somel.

The data indicate that risk associated with the variability in rainfall is an important determinant of the rate of adoption of new practices by farmers. There is also information which indicates Jordanian farmers are reluctant to borrow funds necessary to adopt new practices. "Only ten percent of the sample has borrowed from organized sources of credit. The average amount borrowed is JD 8318 and it ranges from an average of JD 500 in Karak to an average of JD 17853 in Ghors. One does get the impression that with higher availability of water, borrowing increases, again supporting the risk impact of weather uncertainty. Another evidence from the survey is that quite high proportions of the sample have indicated that they would not borrow money to pay for practices or inputs even though they had previously expressed the usefulness of such practices or inputs." Finally, the evidence indicates that, though farmers may not adopt an entire package of practices, farmers will selectively adopt one or more parts of the package if they believe it will favorably affect yields and income.

In summary, in a limited sense, it would appear the OSU effort was successful in demonstrating that the technology used in the Northwest U.S.A. was transferable to Jordan, even though local refinements were identified as needing further study. Increases in output from the technology transfer increased yields 60 to 100 percent. Those practices that did not create a major change in tradition such as weed control and improved seed were readily adopted. Those that required significant changes in traditional practices and/or equipment that was not readily available have the lowest adoption rates. Only a very few of the larger farmers adopted these practices. Summer fallow was not adopted largely because it broke with tradition, eliminated the livestock feed from weedy fallow and required new equipment not available on th local lmarket.

B. Institutions

Institution building activities of the OSU project were to assist in developing a capacity within the Ministry of Agriculture to implement a long-term adaptive research program with the objective of doubling wheat

production by 1980. Thus, in 1974, the OSU consultant prepared a long-term Master Plan which callled for adaptive research on tillage procedures, soil testing for fertilizer responsiveness, weed control and herbicide use, and variety trials for both summer fallow and annual cropping in the dryland wheat producing areas. The 1974-1975 demonstration trials represented an initial effort to implement this research effort, but with the termination of the OSU project in 1975, implementation of the plan quickly lost momentum and was not translated into a sustained effort to increase wheat production. As a consequence, in the post 1975 era, few new wheat producing technologies have been developed or adopted at the farm level. The static nature of the dryland wheat producing sector is revealed in the national statistics for wheat production (See Table 3). The current per hectare yields remain about where they were prior to the OSU project. Indeed, because there has been a major decline in total area of wheat grown, there has been an absolute decline in total national production.

C. Support Services.

The rate of adoption of the new practices proposed in the Oregon State package does not appear to have been adversely affected by the inability of private or public entities to supply inputs except for certain farm implements. The equipment necessary for carrying out moisture conserving tillage practices, seed drilling and summer fallow was not and still is not readily available for use by farmers. There are ample numbers of small private farm implement sales firms who are potential suppliers of such equipment. However, as yet these firms have not demonstrated a willingness to risk capital importing new types of equipment not now in widespread use.

The combined public and private suppliers of other farm inputs have for the most part made available such things as fertilizers, seed and credit. This does not mean there are no problems with input supply. Rather, scarcity of these inputs does not appear to be an important factor in limiting their use given current levels of demand.

TABLE 3

JORDAN: WHEAT ACREAGE AND PRODUCTION 1961-81

YEAR	AREA 000 DUNUMS	PRODUCTION 000 MT
1961	2100	105
1962	2210	95
1963	1570	58
1964	2320	200
1965	2200	230
1966	1500	80
1967	2700	180
1968	2100	120
1969	2000	195
1970	1200	55
1971	2050	150
1972	1900	160
1973	1500	40
1974	2355	227
1975	1111	50
1976	1307	65
1977	1213	62
1978	1302	53
1979	960	16
1980	1301	134
1981	970	51

Source: USAID Jordan Agriculture Office.

Fertilizer importing and distribution has been a function of private businesses in Jordan. Companies which import fertilizers also import seeds and pesticides. These operations are mostly in the irrigated areas of the Jordan Valley but they also supply wheat farmers. The dealers attempt to promote the use of fertilizer by employing agronomist-salesman who advise farmers on the use of fertilizers.[2] Fertilizer distributers and retailers extend seasonal credit at no interest to farmers. There is some public involvement in fertilizer procurement and distribution. Government does at certain times import fertilizer which is distributed through cooperatives.

There are two problems related to fertilizer distribution. First, additional research is needed to determine much more accurately the types of fertilizer needed for wheat production in various areas. Second, farmers in the remote areas are limited by the distance from retail suppliers and the necessity to use public transport to obtain fertilizer. "The further the farmer is from sources of imputs, the easier it is for him to postpone using new technology. The educational process is limited in the same manner, indicating the need for greater extension services by the private sector as well as by government.[3]

The production and distribution of improved wheat seed in Jordan is carried out by the Ministry of Agriculture and the cooperative movement. Improved seed is subsidized to some extent. "Low prices established for improved seed does not allow private seed companies enough profit to justify private seed production."[4] However, some private farmers do save excess seed from their wheat harvest and sell it to other farmers. Government does pay farmers a premium price for seed quality wheat, usually in excess of 10 percent above the price for top quality bread wheat. At the end of the project, the amount of improved seed available in the market was not sufficient to meet demand. The same shortage of seed probably continues, though it is very difficult to be at all precise about the magnitude of any shortage.

Quantitatively, private tractor and implement firms are providing adequate equipment to wheat farmers and contract operators. It should be noted that different firms supply tractors and implements. There does not appear to be a major problem with the supply of spare parts even though they are taxed at import while new equipment is not. The problem with the supply of tractors and equipment is qualitiative. Suppliers do not import the kinds of equipment essential to the package of practices recommended under the project and endorsed by the government and subsequent projects by other donors. It also appears to be true that contract operators who buy more than half of all tractors or implements used in wheat farming may be resistant to new types of equipment.

The government in cooperation with the Jordan Cooperative Organization is attempting to overcome current obstacles to the import of equipment required for the package of improved practices. They are establishing three machinery centers to demonstrate there is a demand for the improved equipment. One center is in operation and the other two will become operational shortly. The JCO plans to operate these centers or demonstration units only, with the expectation that private business will meet additional demand for these types of equipment.

Farmers have four potential sources of credit in Jordan—the Jordan Cooperative Organization, the Agricultural Credit Corporation, private firms selling farm suplies and traditional loans from relatives or others in the village. Most ACC credit goes for crops other than wheat. The JCO makes four different types of loans. There are seasonal, medium term of five years or less, long-term up to ten years and in kind loans repaid at the end of a growing season. Loans from private retail firms appear to be limited to short-term seasonal loans for procuring annual inputs not medium or long-term for purchase of equipment. While there is credit potentially avialable from this variety of sources, credit extended to wheat farmers, except possibly that from traditional sources, is quite limited. Large wheat farmers appear to have few problems in obtaining credit but the amount flowing to other

farmers is not large. Credit certainly could become a constraint to adoption of new technology where cooperatives are not well established or if medium and long term loans for equipment procurement are necessary.

Extension services in the dryland wheat areas of Jordan leave a great deal to be desired. During the project period extension demonstrations were carried out by project staff with little involvement of the extension service. "However, in its zeal to conduct a large number of demonstrations throughout the various wheat growing regions the project tended to be centrally conducted with little meaningful inputs by the local extension staff or cooperating farmers in the absence of central project personnel. Consequently, wheat project staff have become very knowledgeable and well experienced in growing wheat with the new technologies. Unfortunately, the local district staff, farmers and other private and public agency personnel have not learned the simple details of the new technology."[5]

The effectiveness of the Ministry of Agriculture extension service was further weakened by the decision of the government to focus development efforts in the irrigated Jordan VAlley. Not only were financial resources concentrated on irrigated agriculture but substantial numbers of staff, including extension personnel, were selected on the basis of merit and transferred to the Jordan Valley. Some extension work is done by the Jordan Cooperative Organization and private supply firms. As mentioned above, fertilizer retailers have agronomist-salesman on their staff who advise farmers on the use of fertilizers. JCO provides advice to farmers in connection with the distribution of improved inputs including agricultural implements. Despite these efforts extension activities in the wheat growing areas are less than adequate and have not played a major role in bringing information on improved practices to farmers.

D The Farm Economy

Beginning in the mid 1970s, the Jordan economy began undergoing a process of accelerated change which is likely having a profound impact on the farm household in the wheat producing sector. Remittances, investments from the oil-producing gulf states, and the relocation of commercial services from war-torn Lebanon to Jordan, have combined to produce a boom expansion in the construction and service sectors within and around the Amman metropolitian area. Among the five administrative governates in Jordan, the Amman Governate itself now accounts for 55 percent of the country's population, 59 percent of all employment and 65 percent of all economic activity. Average income per employee is 27 percent higher in the Amman Governate than in other governates. In order to correct for this regional imbalance, over the past decade the GOJ has sought to achieve a more equitable pattern of economic and social growth within the other four governates. Thus, vast improvements have been made in the extension of public services (water, communication, health, education, transportation) to outlying areas. It now appears that most of the regions are equipped with basic infrastructure. However, in spite of these achievements, foreseeable trends indicate a further concentration of people and employment in the Amman area.

The rapid growth of the construction, services and manufacturing sectors, of which 73 percent is located in the Amman area, has served to greatly reduce the relative importance of agriculture as a source of income and employment. Agriculture now accounts for less than ten percent of GDP and approximately ten percent of total employment. The enormous increase in demand for skilled and unskilled labor in Amman continues to act as a magnet in attracting labor from the rural sector (including from other countries in the Middle East and South and Southeast Asia). It now appears, that the dryland agricultural sector is experiencing shortages in labor and a corresponding rise in wage rates. Furthermore, many farm households now have multiple sources of income, which derive from both the rural and urban sectors. More importantly, for many rural households income from farming is likely declining in proportion to the rise in available non-farm income.

It is not clear how the rapid expansion of economic growth and non-farm employment is impacting upon the structure and composition of the agricultural economy. There are reported increases in absenteeism and the growth of sharecropping as more rural landowners move to urban occupations. There are also reports of farmers simply abandoning their land in preference for lucrative employment in the Amman area. National statistics on area under grain cultivaton shows a dramatic and abrupt decline of nearly fifty percent in the post 1975 era (see Table 3). The causes of the precipitious reduction have not been studied. A prevailing view is that many areas in the arid and marginal zones , where yields are usually low and quite unpredictable, farmers are taking land out of production and trading the prospect of uncertain farm income for more secure employment in the Amman area.

The "pull" factors associated with rural to urban migration may be accompanied by the operation of a number "push" factors within the rural sector itself. A primary cause of concern for many observers is the fragmentation of landholding associated with traditional inheritance practices that require dividing land among hiers. Subdivisions of land has created many holdings of under five hectares and it is suggested by some that many farms are so small and economically unviable that their owners and/or family members are forced to seek non-farm employment in the urban sector. Under such conditions, there are questions as to whether units of such size are sufficient to generate farmer interest in more advanced production practices.

Land fragmentation and rural to urban migration may help to explain the fact that farm ownership and farm management are becoming less coterminous. The apparent growth in sharecropping, contracting farming and even long-term leasing suggests that a trend may be emerging where tenants are reaggregating small-holdings into larger scale management enterprises. In this case the problem of land fragmentation may be less constraining than is the case with the short-term time horizons associated with some new management arrangements. Tenancy agreements are usually only one year in duration, and

many observers are of the opinion that this does not offer sufficient security to attract longer term investment in land and technology improvement.

In the absence of research on the rural sector it is difficult to determine or even confirm the impact of the above conditions on farm productivity and the adoption of new technology. What is known is that ten percent of Jordan's labor force are involved in agriculture, and that a large proportion of this number are producing wheat at very low yield levels. It is also clear that no conclusions are warranted which suggest that existing conditions in the agricultural economy are acting as a major brake to the adoption of new technology. In the absence of a dynamic and sustained program to promote improved technologies in the wheat producing sector, the presence or non-existance of farm level constraints remains undetermined.

E. Government Policies.

During the 1960s and early 70s the Jordan government increased its involvement in wheat trade and in 1973 took over all wheat imports and became the dominant force in determining the price paid to farmers. The price of bread is set by the government at subsidized rates. From 1962 to 1975 the price of bread increased by only 16 percent, from 43 fils/kg to 50 fils/kg. Since 1975, the price of bread has been increased by 50 percent and sells for 75 fils/kg. Until 1979, government price policy for wheat was entirely consumer oriented. Large amounts of wheat were imported and sold to millers at greatly reduced prices, ranging from 30 percent to 70 percent of the import price depending on world market price fluctuations.[6] This forced down the price received by local producers below the economic value of production. In 1979, in response to pressure exerted by wheat farmers, government, which had purchased wheat locally only for special purposes during the past five years, announced that it would, over a two month period following harvest, purchase wheat at a price of 75 JD/ton, a price 50 percent greater than the local market price for locally produced wheat and above the CIF price of wheat.[7]

Prices paid to farmers by the government have been increased each year and are now 120 JD/ton, about 50 percent above the CIF price of wheat. It should be noted that this price increase has not had a discernable positive effect on the amount of wheat produced. However, the combined effect of subsidized prices paid to farmers for wheat and the subsidized price of bread has led to some increase in wheat marketing., It pays farmers to sell wheat and buy bread for consumption rather than to use their high priced wheat to make cheap bread. There is some indication that farmers are also buying cheap bread to use as animal feed. The increased prices paid for wheat have, of course, increased incomes of farmers selling wheat on the market. The subsidized price paid for locally produced wheat means that revenue is no longer being transferred from the wheat sub-sector to the rest of the economy. Rather, the price received by the farmer is, in part, a transfer from the rest of the economy to agriculture.

The Jordan government has used tax policy to encourage agricultural investment and production. Imports of agricultural equipment and supplies are exempted from all import duties. Additionally, income taxes are not levied on farm income and the land tax is not applied to agricultural land.

With the initiation of the 1976-81 five year plan, the government put into place an investment policy which had adverse implications for wheat production. Government decided to concentrate five year plan investment in irrigated agriculture in the Jordan Valley. Additional investments were not made in dryland agriculture and skilled personnel were taken from work on dryland agriculture and transferred to the Jordan Valley. As a result, from the development investment perspective, wheat farming went through a five year period of benign neglect.

Socio-Economic Situation.

It was only late in the game that the OSU project began to grapple with the institutonal and economic unknowns which might be constraining farmer adoption of new practices. Thus, at the end of the project the full-time OSU consultant made the following observation:

"It is believed that more rapid adoption of new methods would take place with more personal involvement by the farmer and the extension agent and a greater contribution on the farmer's part. Emphasis should be placed upon a program making better use of the facilities the farmer has available to him. Less sophisticated implements than demonstrated in the past should be tried as a more practical means to increase wheat production."[8]

The consultant's report ended with the conclusion that..."To achieve the potential increase in production the cultural, social or economic constraints hindering research and the adoption of improved methods and techniques of producing wheat will need to be minimized."[9]

In 1975/1976, the AID/Jordan mission was ariving at assessments similar to those advanced by the OSU consultant. Thus, in the initial projections of a follow-on project, the mission concluded that a "farming systems" approach would need to be adopted in redirecting Jordan's wheat production campaign. The farming systems approach would enable "...the Research and Extension staff...to view the farmer as the farmer does. Only in this way can agronomic and technical research be properly directed to overcome the constraints which the farmer perceives."[10] It was anticipated that a new project would have to focus attention on a wide range of social and economic factors at both the micro and macro levels. At the micro level, new technologies would need to be assessed in terms of the financial risks they posed to the individual farmer. Likewise, factors which controlled farmer access to input goods and services, such as farm size, tenure arrangements, market structures, would need to be examined. Finally, at the macro level more attention would need to be devoted to an analysis of policy and input subsidies as constraints or facilitators of technology adoption. Had a follow-on more comprehensive project been launched, it would have initiated a process of illuminating those deeper social and economic issues which account for low levels of productivity within the wheat producing sector. However, there was no follow-on project.

As noted elsewhere the Wheat Research and Production project focused on technology transfer. Consequently, almost no socio-economic research or analysis was undertaken during project implementation. The contractor did send an agricultural economist for a short period late in the project to do an economic evaluation of the improved wheat technologies. However, the trials undertaken were for the most part structured so they would not produce data which could be used for economic analysis of returns to the technology package. For most of the trials the economic costs and benefits for either the total package of technology or its component parts could not be compared to those of traditional practices. Thus, the analysis undertaken was limited to an attempt to determine the profitability of summer fallow. Even there the data was limited so that the results can only be considered more or less indicative of returns to grain production. The analysis indicated "that adopters of the technology in Aman and Kerak governates would incur losses in about one of every four years. In Irbid governate the incidence of loss appears to be one of every two years.[11] These losses occurred in years of poor rainfall. As noted earlier the analysis ignored the returns on straw and so underestimated the value of the crop.

Since the completion of the Wheat Research and Production project, some limited work has been done on economic analysis of dryland farming including wheat production and the utilization of improved technology under the project. An Australian Land Classification Study looked at comparable gross margins for alternate crops and livestock using improved technologies in various rainfall zones with poor, average and good rains.[12] This analysis indicates that the use of modern husbandry techniques with mechancal harvesting can produce a gross margin 2.6 times as large as that realized from traditional husbandry using mechanical harvesting. The study also shows the way in which gross margins using modern techniques vary widely among various rainfall zones and as rainfall varies from good to poor. Wheat grown with modern techniques on good land in the better rainfall zones is profitable during years of poor rain only with the current high level of producer price subsidies. For most poorer land and/or lower rainfall areas wheat is not profitable even with the subsidy.

El-Hurani used production function analysis to show the varying effect of rain on wheat production under traditional and improved technology package practices.[13] His results show that with good rainfall on land normally receiving between 300 and 500mm of rain the traditional farmer "produces in uneconomic stages of production."[14] The farmer using the improved technology package operates near the optimum point. However, in a poor rainfall area, with, say 200mm of rain, the farmer using improved practices operates where his marginal product is negative while the traditional farmer operates "at the optimum point in his production function."[15].

All three analyses of the economics of dryland production clearly demonstrate the risk associated with the utilization of improved packages of technology. (It should be noted however that neither the Australian or El-Hurani studies analyzed new technologies using clean summer fallow.) While increased yields are obtained with the improved technical packages with adequate rainfall, with less amounts of rainfall yields from the improved package may be less than from traditional practices and they are even more likely to be unprofitable. Thus, in a dryland farming area such as Jordan where annual fluctuations in rainfall are both frequent and large, the risk associated with the improved package of practices is likely to be great except in the better rainfall areas, over 350mm.

There are a number of other economic events which have had some influence on agricultural production in general, including wheat production, which need to be briefly mentioned. First, since the end of the project, the price of land in Jordan has increased substantially, probably a hundredfold since the beginning of the project. Perhaps as much as 10 percent of good wheat land has been converted to urban uses over the past decade. Second, wage rates have increased substantially. Unskilled construction labor in urban areas earns 15 dollars per day, an increase in the wage rate of 4 to 5 times over the past few years. During this same period labor has flowed from farms to urban areas at a greater rate than physical migration. Thus, there has been both an absolute loss of labor on the farms and an increase in part-time farming. The number of farm families depending solely on farm income for family security

has been decreasing. In making decisions on farming operations income from alternate uses of labor has become a part of the calculus in considering the allocation of labor resources. Third, opportunities for production of crops bringing higher net returns have increased since the project was initiated. In particular, returns from tabacco and tomato production in the higher rainfall areas are substantially higher than returns to wheat production. Additionally, the number of wells in the highland areas providing sufficient water for irrigation is increasing. Under irrigation farmers have a number of alternative crops of higher value than wheat which they can, and do, produce. Finally, most farmers depend on contracting with private entreprenuers for tillage and harvesting wheat. The economic interests of the contract machinery operators and the farmers may differ in ways which inhibit the adoption of new technologies. If machine operators do not perceive that they will increase profits by using machinery required for the new technologies, they will not buy machinery and make it available for hire by the farmer. The operators of machinery are generally interested in completing a job as quickly as possible in order to maximize net income. This often means they will plow up and down slopes rather than on the contour or they will set openings on the combine harvester to speed up the threshing process and waste considerable grain. The machine operators thus may maximize their profits at the expense of the farmer.

IV. PROJECT IMPACT: ANALYSIS

Why did the OSU project produce such a neglible impact on the adoption of new wheat producing technologies, and similarily, why did it not succeed in setting in motion a longer-range research and extension program which would eventually yield major increases in wheat production? Various reasons have been enumerated in the previous section as to why farmers did not adopt most of the practices demonstrated by the OSU project. Deeper underlying factors which are institutional, economic and social in character must be examined however, in seeking to fully account for the poor record of technolgocial change in the wheat producing sector. This issue will be examined in a later

section. For the moment, the analysis will focus on those factors which constrained the OSU project from advancing the development of a self-sustaining wheat research program within the Ministry of Agriculture.

A. Institutions.

The original OSU project objectives (1968-1970) included no mention of building in-country institutional capacities. Rather, the primary purpose was to determine through on-farm trials whether the improved dryland wheat technologies used in the dryland areas of Eastern Oregon and Washington could be transferred to Jordan. It was in the second phase of the project (1973-1975), that the institutional component received explicit mention and attention. Thus, the one field based OSU consultant worked with the staff of the Research and Extension Directorate within the Ministry in seeking to improve thir capacity to design and implement a more effective adaptive research and extension effort in wheat production. This activity included the preparation of a long-term research plan and an effort to initiate a more interdisciplinary and coordinated applied research effort. However, the consultant met with only limited success in this area. Few skilled and experienced personnel were available to work with the consultant as counterparts, and facilities, equipment and logistical support for research were very limited. At the end of his assignment in 1975, the field consultant judged that a modest start had been made in building research capacities within the Ministry, but it was his recommendation that further technical assistance would be needed to sustain and expand this effort.

The U.S. AID/Jordan mission was interested in promoting and financing a follow-on project to continue and expand the work undertaken by OSU. Thus, in 1976, the mission initiated discussions with the Ministry of Agriculture to develop a framework for a new wheat production project. However, these initiatives were soon overtaken by other events. Preparation of the new national five year development plan were underway in 1975, and it was clear that GOJ investment priorities were shiftying away from dryland agriculture to a primary emphasis on expanded irrigated agriculture in the Jordan Valley.

The King Talal Dam was to be completed in 1977, and this would open the prospect for the cultivation of high value cash crops for domestic consumption and export. In light of this emphasis on the Valley, the Mission was not able to generate sufficient interest in the GOJ to continue with an AID assisted wheat producton project.

In the absence of a new follow-on project the OSU effort gradually faded into the shadows of history. Two of the three Jordian officials who had worked as the primary counterparts with the OSU effort resigned or retired out of the Ministry of Agriculture in 1976. Their departure was part of a larger movement of officials out of the Ministry to higher paying and more prestigeful appointments in the Faculty of Agriculture (Un. of Jordan), newly established in 1973, and to the Jordan Valley Authority, an autonomous parastatal established in 1976. The exodus of some of its most talented and resourceful personnel seriously constrained the Ministry from assuming the kind of leadership role envisaged by OSU in its plan for expanded research and extension to increase wheat production.

The OSU project had a lasting impact in the sense that many of the senior officials in the Ministry of Agriculture and instructors in the Faculty of Agriculture remember the project, particularly from the viewpoint of the technological package which OSU was seeking to test and advance in its many on-farm demonstrations. Most of these individuals, as well as technicians from other donors—FAO and Australia—who have worked on wheat production in Jordan, believe that the basic components of the OSU package, with proper support and in modified form, will constitute the technological base for initial advances in wheat production in Jordan.

In the final assessment it would be going to far to hold the OSU project responsible for the little impact the project had on generating a sustained institutional capacity for increasing wheat production. The initial project objectives (1968-1970) emphasized the function of technology transfer

development and dissemination, or at least they were so interpreted, from a purely technical and non-institutional perspective. It was only in 1973, after a three year hiatus in project activities, that institutional objectives emerged in the project agenda. However, the project was grossly underfinanced and undermanned in supporting this effort. Few funds were earmarked for short or long-term out-of-country training or for the purchase of needed equipment. Finally, during a major portion of the contract period, the project operated under circumstances of some risk and uncertainty in security conditions. In summary, the OSU wheat production project was simply not equipped with sufficient resources and time to address the major issues involved in initiating and sustaining a process of institutional change.

B. Technology.

The second issue to be addressed is why the technologies which the OSU project promoted, were, for the most part, not adopted. The answer to this question must be addressed specifically within the OSU experience, but also in more generic terms as well. Other donors, both before and after the OSU project, have been active in promoting wheat producing technologies similar to those advocated by OSU. As with the OSU experience, however, all have met with only marginal success in securing farmer adoption.

The OSU project experience revealed little about why farmers were not adopting the new technologies. Thus, the full-time OSU consultant indicated in his end-of-tour report in late 1975, that..."the reasons for non-adoption are not fully known at the time".[16] The lack of knowledge about constraints on adoption reflects the fact that the project objectives give little if any emphasis to actual farmer adoption. Rather, the emphasis was on the development, testing and proving of a modern system of wheat farming in Jordan..."that would provide a base for doubling yields." As a consequence, the project assumed a heavy technology transfer emphasis, with primary attention focussed on testing and demonstrating cultivation practices developed for Eastern Oregon and Washington within the Jordian context. A mission evaluation of the project in 1976 noted that .."adoption/extension was, per se, not a project objective."

Social, economic and institutional factors which might have been constraining farmer adoption only began to assume some importance in the second phase of the project. Thus, in 1975, OSU short-term consultants undertook a brief economic evaluation of the advanced technology, reviewing as well possible shortcomings in the service capacity of the agri-business sector.The economic analysis suggested that the OSU technology package was profitable for annual cropping zones, but of questionable profitability in summer fallow regions. Unfortunately, this analysis had a major omission that greatly understated economic return. Because straw has almost no cash value in the U.S., it was ignored in the analysis. In Jordan it is usually of equal value to the grain as livestock feed. Because increased grain yield is associated with comparable increased straw yield, this oversight was of major importance. Without giving straw a value, the return on fallow was about breakeven. However, if the rather large increase in straw (about 75%), had been added, it would have been a highly profitable innovation. Because of this flaw, Oregon State was reluctant to recommend clean fallow.

The OSU review of the agri-service sector revealed that business firms had the capacity to supply goods and services for modern farm technologies, but that the performance of such services were uneven and variable in a number of service categories. Thus, shortages were discovered in the supply of improved seeds, and urea with appropriate levels of nitrogen analysis was not available. Tractors, combines, and traditional farm implements, including sprayers were in adequate supply at least at the retailer level, but grain drills and chisel plows were not available from equipment dealers. The review did not provide any in depth analysis on the variation in prices and accessibility of these services at the actual farm level.

C. Policy

There is little reason to believe that government policies have, in total, been of a nature which would encourage farmers to adopt the new technologies introduced under the project. Some policies have been favorable. Certainly

government tax policy should have increased the attractiveness of investing in new technologies. While government kept prices paid farmers below the shadow price of wheat, C.I.F. Aqabah, during the project and through 1978, the evidence does not indicate that higher prices by themselves would have resulted in adoption of new technologies and increased production. In the five years since the price of wheat was incrased substantially above import parity, production has averaged 74.6 thousand tons per annum compared to 91.4 thousand tons average per annum during the previous five years. Even if one eliminates the particularly poor harvest year of 1979, average annual producton in the five years before the price increase was two thousand tons greater than in the period following the price increase. The decision of the government to shift investment and the best trained agricultural workers from dryland agriculture to the Jordan Valley meant that government resources were not available to support needed changes that would move producers to higher production functions which would have made it possible for farmers to make a noticeable supply response to the price increase. Neither was the private sector in a position to give such services to farmers. It is extremely doubtful that many farmers will be inclined to move towards new technologies without a more favorble public policy mix and improved public and private institutional support and input supply.

D. Economic

Such economic analyses as have been undertaken on the introduction of new wheat production technologies in Jordan strongly indicate that high risk is associated with highly variable rainfall. Rain in Jordan is highly irregular with poor rainfall on the average expected about two years out of five, with perhaps one good and two average years. In this situation Jordan's dryland farmers place the highest priority on risk aversion and selecting among probabilities for maximizing family security. For the most part farmers operate on a low input production function which minimizes risk. This means

that in years of average or better rainfall these farmers operate below optimum ouput. Given the annual variability in effective rainfall, Jordan farmers engaged in annual cropping including weedy fallow may optimize income over the long run in areas with average rainfall of less than 350mm by using the traditional low input system. However, with clean summer fallow farmers would move to a new production function and utilization of the traditional inputs might cause farmers to operate below optimum output. In a real sense clean summer fallowing is insurance against low rainfall for users of high technology. Risk aversion thus mitigates against adoption of new technologies requiring higher inputs as the farmers seek to minimize losses when rainfall is low. Because risk aversion results in less than optimum production during years of average and good rainfall, in effect, an insurance premium in foregone production is paid to minimize losses during years of poor rainfall. This premium is paid to foreign wheat producers in an amount equal to wheat procured on world markets as a result of ouput forgone by operating on a low input production function.

Farmers also seek to maximize family income and security by diversifying their economic activities. In Jordan, diversification includes use of labor and captial in both farm and non-farm activites. The opportunity cost of farm family labor is high and income maximization is often achieved by shifting labor to non-farm activities or farm production other than wheat. Farmers may, and often do, substitute capital for labor in wheat production by contracting for mechanical cultivation, harvesting, etc. Alternatively, farmers may leave land in weedy fallow and use labor for which the opportunity cost is low, child labor for example, in sheep or goat production. Finally, with the increasing price of land, family income maximization may be achieved by renting or selling land either for agricultural or other purposes. The point is that income maximization combined with risk avoidance can be achieved through various combinations or alternate opportunities which may have either positive or negative effects on technology adoption and wheat input.

The increasing price of land due both to rapid urbanization and the large inflow of remittances has negatively affected wheat production. As the opportunity cost of land increases, substantial economic (and financial) losses may accrue to farmers from wheat production, particularly if the farmer is operating on a low technology production function. In this situation the farmer may increase family welfare by finding alternative uses for the land either in some higher value crop or in non-agricultural uses; e.g. residences. One tendency is for farmers to attempt to increase the per unit value of the crop by investing in wells so they may use the land more intensively to produce higher value crops.

Increases in wage rates have had effects on wheat production similar in some respects to the increase in land values. The opportunity costs of labor are such that the real losses are significant in applying labor to wheat production, particularly with production functions based on low levels of input. Family income is often maximized by seeking alternate employment and substituting capital for labor through contracting for machine operations. As labor transferred out of farming is usually the younger more vigorous males, there is generally an aging labor force with consequent reductions in labor energy available for farm work. Alternatively, farmers may rent land out rather than apply labor to it or let it lie in weedy fallow to be used as animal feed. As noted above this permits the use of labor with low opportunity costs.

There appears to be little doubt alternate cropping opportunities such as tobacco have led to some decreases in land planted to wheat in the higher rainfall areas. The substitution of other, higher value crops usually takes the form of adding the higher value crop to the rotation, thus reducing to say, one out of three rather than one out of two, the years in which wheat is grown.

While substitution of machinery for labor in wheat production through the contracting process may well bring about an increase in family incomes, the

impact on wheat production and the quality of technological inputs may be negative. The interests of private farm machinery contractors and private farmers may be in conflict in two ways. First, private contractors for the most part do not have in their inventory the best cultivation equipment for moisture conservation or other output increasing practices. Farmers are therefore unable to adopt improved practices with consequent adverse effects on production and income. Second, private farm machinery operators seek to maximize profits by completing work as soon as possible. This often leads to such practices as plowing up and down hills rather than on the contour and maximizing throughput on the thrasher of a combine with consequent high loss of grain. Again these practices mitigate against adoption of new practices.

E. Other Donor Activities in the Dryland Sector.

The effort to induce farmer adoption of new wheat producing technologies did not begin or end with the OSU prject. As mentioned earlier the FAO has been active in the dryland sector since the mid 1960s. Their project activities continued at various locations in Jordan until the late 1970s, and in all cases they produced only marginal rates of technology adoption. It appears that, as with the OSU project, the character of their projects served as a self-limiting factor in achieving a positive impact. All of the FAO projects were shortlived (two to three years in duration), and involved less than adequate levels of technical assistance. Most had poor linkages at the national level with public and private institutions serving the agricultural sector. One of the more promising FAO dryland projects was initiated in 1975, in the Irbid Governate, north of Amman. This project used the Jordan Cooperative Organization in securing the cooperation of farmers in joining their contiguous plots together in order than cultivaton could be undertaken along the contour rather than using the traditional more costly and soil eroding method of cultivating up and down the slope. Grain drills and chisel plows were provided through the FAO, and together with the contour cultivation, these techniques produced a major increase in per hectare wheat

yields. Unfortunately this project terminated in 1978 before any of these initial advances in farmer organization could be consolidated and replicated on a larger basis.

In summary, wheat projects sponsored by donor agencies in Jordan have been relatively discontinuous and circumscribed in scope. The OSU proect assumed an almost exclusively technological orientation. In reviewing the project documents and studies generated by OSU and other donor projects, almost nothing is revealed about the farmer as a resource manager, and the economic and social factors which influenced the calculus of decision-making in the farm household. All of the projects embodied a faith in agronomic and engineering solutions. Diagnostic studies of economic, social and institutional variables, or working with farmers in a mutual problem-identification and problem-solving process was never an important element in their frame of reference.

Strongly committed to a predesigned flight path it was way beyond the point of no return before these projects found themselves to be considerably off-course. Abrupt crash landings were inevitable. Thus, the earlest OSU project floundered because of an exculsive reliance on advanced technologies. Concurrntly, two successive FAO projects ran aground because of their reliance on major earthworks as a solution to moisture retention and erosion control.In one instance, the project came onboard with the construction of absorption banks, but they soon fell into disrepair because of the expense and time involved in their maintenance was more than most farmers could manage. A successor project in a different area and with a different consultant team embarked on a construction program of building stone terraces across the contour for moisture retention. When the project team departed the farmers had the stones removed.

The fact that the farmer was simply left out of the development equation did not go unnoticed by some observers. In 1975, an FAO consultant examined past

donor projects in the Jordan dryland sector in order to determine why they had failed to secure farmer adoption. He attributed the failure to a number of causes including:

1. "Advisers who had had no previous experience with small farmers."
2. "Projects which did not take into account the simple basic changes needed to increase production but got involved in purely academic research."
3. "Lack of communication between the farmers and the advisers."[17]

F. Agricultural Services.

Because of their vital role in the retention and use of ground moisture, the availability of farm equipment, particularly grain drills and chisel plows, would constitute one of the most essential elements of any effort to achieve higher wheat yields in Jordan. In a survey of farm machinery dealers in 1974, an OSU consultant noted that "very few grain drills have been imported by farm machinery dealers because the dealers are not aware of the type of grain drills needed in Jordan."[18] A similar survey of farm machinery retailers nearly ten years later in 1983, revealed that the situation has remained unchanged. Only one retailer is dealing in grain drills, and he has sold only one grain drill in three years. A similar story prevails with respect to the availability of chisel plows. In 1974, the OSU consultant discovered that chisel plows were not available from farm implement dealers. The 1983 survery revealed the persistence of these conditions. The same is not true for spraying equipment. Spraying equipment is available from equipment dealers and spraying services are being made available through custom operators and the Jordan Cooperative Society.

The acceptance and use of heavy agricultural equipment is not a constraint in the agricultural sector. Tractors and combines, and traditional farm implements such as the disc plow are frequently owned by larger farmers, with custom operators making these services available to smaller farmers. However, the supply of new types of farm machinery remains unprofitable as long as the demand for such equipment remains uncertain and attentuated. Sufficient

numbers of farmers have yet to b convinced of the value of such implements as the chisel plow and grain drill to encourage private risk-taking in the acquisition of such equipment.

Finally, it is not clear if existing credit capacities would need to be enhanced in order to support the adoption of new technologies. Traditional production technologies in the wheat producing sector are not dependent upon extensive supplies of credit from the formal sector. The adoption of the OSU technology package would require major increases in capital outlays at the individual farm level, whereas a similar FAO package developed in the Irbid project (1975-1978), requires only minor additions in capital expenditure. The Jordan Cooperative Society provides subsidized credit to farmers for small input purchases, and while growing in chapters and membership, these credit services are still not widely dispersed throughout the wheat producing sector. On the other hand, adoption of these technical packages at the farm level also needs to be backstopped by large capital outlays for new equipment purchases, particularly for grain drills and chisels plows. In this instance investment capacity within the dryland sector seems relatively high as many larger farmers and custom operators possess their own heavy equipment.

V. CONCLUSIONS AND LESSONS LEARNED

The descriptive and analytical material above suggests the technological, socio-economic and institutional variables might not warrant equal treatment as explanations of why donor projects have had so little impact on wheat production in Jordan. The major unknown is the role of socio-economic factors in determining farmers' willingness to adopt new technologies. Little socio-economic analysis has been undertaken either by Jordanian institutions and individuals or under donor projects. Such evidence as is available strongly indicates that risk avoidance and alternative opportunities for allocating resources among competing or complimentary ends are indeed important influences on farm managers' decisions. However, the way in which decisions on utilization of improved technologies are affected by these

factors needs additional clarification. There are also a number of other possible socio-economic influences about which little or nothing is known. For example, little is understood about the effect of land fragmentation among a large number of land owners on adoption of new technologies, particularly in view of the increasing separation of ownership from farm management.

In contrast to the socio-economic situation as it affects wheat production and the adoption of new technologies, there appears to be little mystery about what kinds of technology are appropriate. With some variation, donor projects over the past decade and a half have advanced a common technological regime—chemical control of weeds, moisture conserving tillage and seed/fertilizer drills which maximize benefits from using fertilizer and clean seed. This technology is endorsed by the Ministry of Agriculture as appropriate for dryland cereals production in Jordan. Thus, in varying degrees, major elements of current donor projects in the dryland farming areas are built around the same core technologies which the AID project demonstrated.

There is evidence which suggests that the flexibility of the existing farm structure may be reasonably responsive to the introduction of new technologies. Wheat farms in Jordan are highly commercialized enterprises. Most farmers, both large and small, are well acquainted with the use of machinery for various farm operations. All are reasonably well integrated into the market system. If indeed this flexibility exists, a proper mix of external inducements might be effective in obtaining widespread adoption of improved technologies. It well may be that the institutional or organizational variable, rather than socio-economic or technological factors, is the major constraint to technology adoption. The Jordanian government has focused development efforts on irrigated agriculture in the Jordan Valley and largely ignored dryland agriculture. No sustained research and extension effort or private sector initiative has been mobilized to bring the benefits of modern technology to the wheat farmer. Donor projects have largely not focused on improvement of public or private institutional capacity. Thus, the private sector suppliers do not risk investments in the supply of new

services, equipment and supplies to farmers in view of uncertainty about demand and farmers remain either unaware of or unable to utilize the new technologies.

Within the context of the above, the following appear to be some of the lessons learned in examining developments in wheat farming in Jordan over the past 15 years.

A. Variations in rainfall with the consequent risk of adverse effects on yield are associated with the willingness of farmers to adopt new technologies. Within the dryland agriculture sub-sector, farmers in areas with rainfall in excess of 350mm per year in normal years have been reasonably responsive in adopting recommended improved technologies when supplies and equipment have been available in the market. In areas with less than 350mm of rainfall acceptance of new technologies has been pretty much limited to clean seeds, a technological improvement that requires little or no additional investment by the farmer. Risk associated with rainfall must be accounted for and addressed when new technologies are introduced.

B. Price policy which assures returns to farmers substantially above border prices has not, by itself, brought about increased production of dryland wheat by Jordan farmers. It appears that one reason for this is that alternate uses of land, labor and capital within or outside of agriculture offer better opportunities for increasing family income. Lack of access to yield increasing improved technologies also appears to be a factor limiting supply elasticity. In this regard it should be noted that while utilization of new technologies such as chisel or sweep tillage might well increase net returns to farmers, the same may not be true for contract machinery operators whose services are extensively used by wheat farmers. It has been these contract operators who have largely determined the tillage technology used in dryland farming.

There are real questions about how high wheat prices would need to be set in order to call forth increased supplies of wheat. Given the government's policy of maintaining low subsidized prices for bread, the costs of effective incentive wheat prices might well impose an intolerable burden on the Treasury. Within the probable limits on producer price subsidies provided by the government, it appears that price incentives are a necessary but not sufficient condition for increasing wheat production. Such increases would appear to be largely dependent on utilization of per unit cost reducing technologies.

C. Development of improved packages of practices provided a useful function in demonstrating how combining improved technologies can bring about increases in output greater than the sum of individual practices. However, the evidence clearly shows that adoption of the total package as a whole by farmers is highly unlikely. Adoption of one or two practices at a time is a much more likely scenario. Because benefits from adoption of some practices may be partially dependent on the adoption of other practices, it is important to identify sequential priorities for the various practices making up the package. For example, in areas of lower rainfall with high rates of variability, use of fertilizer may become a useful yield increasing technology only following the adoption of clean summer fallow and the use of seed drills which band fertilizer. Proposed technology packages must be developed and made available to farmers so parts of the package can be adopted individually or in modular units. In estimating expected increased in yields and production it is necessary to take into consideration the probable piece meal adoption of a package of practices.

D. Two elements which need to be recognized and better understood as influences on the adoption of new technologies are the increasing separation of management and ownership of dryland farms in Jordan and the increasing opportunities for dryland farm families to maximize income by allocating resources to activities other than cereals production. These two elements, which may be interrelated to some degree, are evolving in ways which could have major influences on the adoption of new technology and the function of institutions supplying agricultural services, supplies, equipment and information.

Focusing on ownership might make it appear that land fragmentation could be a constraint on the adoption of certain improved technologies when, in fact, the increasing separation of ownership and management may be bringing about increasing consolidation of land resources. The allocation of some farm family resources outside of cereal production may both reduce the risk of using new technologies and increase resource availability for investment in new technologies. Given the current direction of economic development in Jordan, it is likely that both elements will continue to increase as important features of the farm community and understanding of how they may affect adoption of technological improvements will probably increase in importance.

E. The entire farm operation needs to be taken into account when putting together a package of practices. In Jordan the evidence indicates that adoption of summer fallow to replace weedy fallow substantially reduces the amount of fresh fodder available for consumption by livestock. It may also reduce employment opportunities for low priced family labor. On the other hand, summer fallow will probably increase the amount of aftermath available for use as livestock feed. Just how these factors will affect livestock production and resource allocation needs to be examined as do the effects of other alternative cropping patterns.

It is important to stress that understanding of these interrelationships within the farm operation are important. It is equally important to emphasize that this does not mean that all issues and constraints have to be addressed by a particular project. It does mean that these factors need to be taken into account in developing and spreading new technologies.

F. Government Policies and priorities must be consistent with project objectives if resources necessary to obtain desired changes are to be made available. In Jordan dryland agriculture had a low priority in government development plans. This meant that little or no resources were allocated by the public sector to research, extension, input supply and oher institutional support for dryland farming. Similarly, private sector investment opportunities were perceived to be in activities associated with or supportive of irrigated

agriculture. Thus, there was no sustained institutional or organizational support provided to the development and introduction of yield increasing technologies for dryland wheat production.

Footnotes

1/ Suleiman Arabiat, et al, "Issues of Improving Wheat Production in Jordan, Results From a Survey," University of Jordan and ICARDA, 1982, p. 33.

2/ Leonard Halderson, "Availability of Goods and Services for Improved Wheat Production in Jordan", Wheat Research and Production, Final Report, Oregon State University, March 31, 1976, p. 167.

3/ Ibid., p. 172.

4/ Ibid., p. 183.

5/ Ibid., p. 201.

6/ M. Haitham El-Hurami, "Economic Analysis of the Development of the Wheat Subsector of Jordan", Iowa State University, 1975, pp. 41-2.

7/ Interview, Hassan Nabulski, Director General, Jordan Cooperative Organization and Farmer.

8/ Eugene P. Winters, An End of Tour Report, "Wheat Research and Production, Final Report", Oregon State University, March 31, 1976, p. 157.

9/ Ibid., p. 158.

10/ John D. Hyslop, "Preliminary Note on Project Evaluation and Design for Dryland Cereals in Jordan", Nov. 10, 1975, pp. 15.

11/ W.E. Schmisseur, "Economic Evaluation of Dryland Wheat Technologies Produced in Jordan", Wheat Research and Production, Final Report, Oregon State University, March 31, 1976, p. 102.

12/ D.J. Watkins, et al., "Land Use Capability Planning Study" - Jordan, Sorgic International Planning, Ltd., March, 1983.

13/ El-Hurami, op.cit., pp. 77-82.

14/ Ibid., pp. 78-90.

15/ Ibid., p. 77.

16/ Winters, op.cit., p. 156.

17/ John Greenfield, Final Report: "FAO Project Integrated Agricultural Development of the Rainfed Areas", March, 1977, pp.2-3.

18/ Halderson, op.cit., p. 179.

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