

Factors Affecting Agricultural Mechanization: A Case Study on Sunflower Seed Farms in Iran

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ABSTRACT

The primary purpose of this research study was to determine the major factors affecting the implementation of national agricultural mechanization programs in Iran. The secondary purpose of this study was to assess the agricultural mechanization level practiced by farmers. This project consisted of two phases. In the first phase of the study, a Delphi technique was used to gather experts' points of view on variables affecting agricultural mechanization implementation programs in Iran. The second phase of the study was designed to assess the agricultural mechanization level practiced by farmers growing sunflower seeds. The Delphi technique investigation showed that the main constraints on farm mechanization were "small farm size" and "fragmentation of holdings". The findings of the second phase of this research indicated that the mean agricultural mechanization level practiced on the sunflower producing farms was about 0.5 kW per ha of cultivated land. However the amount of energy input varied between 0.0149 to 3.4973 kW. Multivariate linear regression of the study indicated that 46.9% ($R^2 = 0.469$) of the variance in the level of agricultural mechanization practiced could be explained by variables such as income, total farming land, and land holdings under sunflower seed cultivation.

Keywords: Agricultural used land, Delphi technique, Exemplary farmer, Mechanization strategy, Sunflower.

INTRODUCTION

Agriculture is basically aimed at growing the various crops native to each diverse local area within the world's ecosystem. This diversity requires different agricultural technologies suitable for each local area. Different technologies and mechanization systems must be provided that match the state of the agriculture. What is expected of the industry is to provide machines suited to certain locations for each production phase. Machines used in the U.S. or Japan are not always appropriate for farms in developing countries. Many efforts have been made in Iran to develop machines for specific agricultural pro-

duction in each local area, and those attempts have been to a large extent successful. However, to meet the demands of each local area it is necessary to form an integrated system in which researchers, developers, manufacturers, and distributors are present locally and are engaged in collaborative efforts to solve farmers' mechanization problems locally (Clarke, 2000). In contrast to developing countries, human beings are used less and less as a source of power in most developed countries and man power is rather utilized solely as a source of monitoring, control, and operation.

Agricultural mechanization technology plays a key role in improving agricultural

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production in developing countries, and should be considered as an essential input to agriculture. The term 'mechanization' is generally used as an overall description of the application of the variety of mechanical inputs (such as tools, implants, and machinery). Proper use of mechanized inputs into agriculture, both the level and appropriate choice, has a direct and significant effect on labor productivity, the profitability of farms, and the quality of life of people engaged in agriculture (Clarke, 2000; Bishop, 1997; Timmer, 1991).

The level of mechanization used in agriculture is vastly different among the various countries and regions of the world. For example, in sub-Saharan Africa there are only 0.12 tractors per 100 ha of Agricultural Used Land (AUL) while, in Japan, there are 50 tractors per 100 ha of AUL (Pawlak, Pellizzi and Fiala, 2002; Baryeh and Raikkane, 2003; Youtai, 1987). Among industrialized countries the history of the development of farm mechanization was quite different. By 1950 a high level of mechanization was observed in USA, while in Western Europe and in Japan farming was still carried out with animal power. A dynamic growth in the number of tractors and farm implements occurred in Western Europe during the 1950's and 1960's, while in Japan it occurred during the 1960's and 1970's.

Some researchers (Binswanger, 1986; Viegas, 2003) have argued that a high level of mechanization does not necessarily imply higher crop productivity, while data from selected Asia Pacific countries indicates that only a moderate relationships exist between a number of tractors 1000 ha^{-1} and cereal productivity. Fertilizer use, on the other hand, has a very strong relationship with cereal yield ($r = 0.84$). Similarly, GNP per capita has a highly positive correlation ($r = 0.86$) with investment in tractors (Viegas, 2003). In countries where GNP is low and there is an ample surplus of labor, land productivity through higher yields and cropping intensity is required, thus providing additional employment.

In order to achieve an increase in productivity in the agricultural sector, some developing countries have thus proposed the following policy measures: (a) an increase in labor productivity through improved extension services; (b) re-introduction of fertilizer subsidy; (c) increase in total factor productivity through improved seeds; and (d) enhancing agricultural mechanization (Wobst and Mhamba, 2000). Policy instruments that most frequently need to be considered in order to enhance agricultural mechanization, are: exchange rate policy; policies influencing relative agricultural input prices-direct market intervention to manipulate input prices, tariffs and import restrictions, and input subsidies; policies influencing agricultural product prices; policies influencing farm and non-farm employment wages policy; land ownership and tenure policies; transfer of farm power technology; agricultural extension policy; rural transport and marketing infrastructure, irrigation infrastructure; and agricultural financial markets (Patric and Tapela, 2002).

The expansion of agricultural engineering in Iran has been given high a priority by governments over the past three decades. Great challenges have been facing the government with respect to agriculture, such as: ensuring an adequate food supply for national consumption; modernizing production systems; providing suitable on-farm technology to enhance production yields; improving farmers' economical status; and managing and protecting the vital water, soil, and energy resources. Farmers in Iran also face some difficulties in utilizing the required mechanical tools to implement mechanization on their farms. Some of these difficulties are policy and monetary in nature (namely, government support policies and access to bank loans), and some other difficulties are structural and infrastructural in character (such as subsistence farming, a small AUL and its topographical and geometrical shapes, and small land holdings). Various efforts have been directed by provincial governments towards tackling these and other problems facing farmers. Many

farmers' cooperatives have been established to provide support services to individual farmers and to make access to loans and heavy machinery easier and affordable. National governments have focused on working with farmers' cooperatives on AUL engineering (land improvement projects), to implement agricultural mechanization via planting unified crops by all farmers within cooperatives which results in collaborative efforts and turns the farmers' lands into a unit of a considerable size of AUL. This would then be profitable for all individual members to invest more and to take a bigger risk on their lands for a promising future.

Therefore, the primary purpose of this research study was to discover the major factors affecting the implementation of national agricultural mechanization programs in Iran. The secondary purpose of this study was to assess the agricultural mechanization level practiced by farmers producing sunflower seeds and examine its relationship to their professional characteristics.

MATERIALS AND METHODS

This research consisted of two phases. In the first phase of this study, a Delphi technique was used to gather experts' viewpoints on the variables affecting agricultural mechanization implementation programs in Iran. The sample for the Delphi technique was selected from among national experts in agricultural mechanization. Thirty experts were identified and agreed to participate in the study. The Delphi method is effective in obtaining consensus among a purposively selected group of experts. Several studies have described the Delphi technique as a group process used to solicit, collate, and direct expert responses towards reaching consensus (Adams and O'Brien, 2006; Gordon, 1994). In this phase of the study a series of three rounds of data collections (which is typical procedure in a Delphi technique) were conducted using mailed questionnaires. In the first round, an open-ended question was used to generate an array of responses. These responses were used to

produce items for a second round of the data gathering questionnaire. In the second round, panel members were asked to rate each of the variables identified in the first round using a five point Likert-type scale and to revise the order (importance) of the list of variables to more accurately reflect their opinions. The responses were categorized accordingly into a list of variables and sub-variables. From the results of the second round and the comments expressed by respondents, a third round was developed. The third round sought to arrive at a general consensus on the categorized variables. The agreement level was set at 80%, therefore all items which did not receive approval from 80% of the panel were removed from the list of variables. As has been noted by researchers, most Delphi studies reach consensus at the third round, and so was the case in this study. To produce more usable results, the variables were divided into categories using a constant comparative method (Glaser and Strauss, 1967). According to Glaser and Strauss, categories can be developed by the researcher or emerge from the data. The latter method was used in this study by placing each item into a category with similar features and characteristics.

The second phase of the study was designed to assess the agricultural mechanization level practiced by farmers growing sunflower seeds in the province of Qom, (a central province in Iran). The population of this phase consisted of all farmers in the province who cultivated sunflower seeds in their farms ($N=95$) for the planting year of 2004-2005. By a complete randomized sampling technique, 75 farms were selected as the sample for this study. Sample size was determined and supported by the studies of Krejcie and Morgan (1970). A self-designed questionnaire was that constructed that consisted of four parts to gather the necessary information. In constructing a suitable questionnaire, the authors were aided by previous related study (Sadighi, 2002), and numerous documents were reviewed for the conceptual framework of the instrument. The first part of the questionnaire related to the farmers' biographical data, and their professional characteristics. The second part gath-



ered data for the computation of agricultural mechanization levels practiced by farmers. Based on field experience and empirical data, the prominent national mechanization experts (Almasi, Kiani and Loimi, 2000) suggested a formula whereby farm mechanization could be assessed ($Mech. Level = \# \text{ of tractor utilized} * 75 \text{ hp} * 0.75 \text{ Coef. of change/ha of land areas under cultivation}$) and the result was then converted to kW per ha (1 hp= 0.7456 kW) which measured the mechanization level for farms in the central province of Qom. In this formula 75 hp indicates the average power/force of the tractors in the local area (in hp), and 0.75 Coef. of change was used to change the manufacturing claim (on machine power) into an actual field horse power (which was then converted to kW). The third and fourth parts of the questionnaire dealt with collecting data to compute farmers' technical knowledge and their preferred channels for receiving scientific information, respectively.

In order to characterize farmers' level of technical knowledge, the following formula based on the Interval of Standard Deviation from the Mean (ISDM) was applied to obtain a four-level distribution ($Poor = A: Minimum score \leq A < Mean score - St.dev$; $Adequate = B: Mean score - St.dev. \leq B < Mean score$; $Good = C: Mean score \leq C < Mean score + St.dev$; $Excellent = D: Mean score + St.dev. \leq D \leq Maximum scores$), (Sadighi, 2002). Content validity of the instrument was determined by a panel of experts in the field of agricultural mechanization. A pilot study was conducted on similar farms in a different province to determine the reliability of the questionnaire. Cronbach Alpha reliability coefficients of 0.75 and 0.70 were achieved, respectively, for the technical knowledge and channels of receiving technical information.

RESULTS AND DISCUSSION

The results of the first round of the Delphi technique, the open-ended question (What

are the factors affecting agricultural mechanization in Iran?) provided the researcher with a 45 item list. The 16 items of the list with at least 10 occurrences (33.3%) are shown in Table 1.

This list was used for the second round and Table 2 provides the ranked items that present the degree of the respondents' agreement; a coefficient of change was used (instead of the mean, representing a better agreement level) which is derived from dividing standard deviation by the mean score.

Table 3 presents the degree of respondents' agreements which are the result of the third rounds of Delphi technique. Small farming which compromises the majority of agricultural activity in Iran is seen as an inhibiting factor to mechanization (Table 1). Many efforts in recent years have been devoted to cooperative farming systems where farmers' holdings neighboring each other are combined together to form a large enough area to be cost effective for the use of heavy machinery through collaborative activity in order to achieve efficient production. These efforts to a large extent have been successful and are continuing in many parts of the country. Based on information in Table 2, it could be observed that "small farming and scattered agricultural holdings" presents itself as a major inhibiting factor (with 100% agreement) affecting mechanization in Iran. This is consistent with the findings of Blanchandran, (2003) who noted the main constraints on farm mechanization as being "small farm size" and "fragmentation of holdings". In addition to this, other main inhibiting factors are "lack of common understanding of mechanization", "lack of national strategy for agricultural mechanization", "ineffective linkage of research, and agriculture industry", and "lack of state strong support for manufacturer and distributors" which formed the top five items (Table 3).

Table 1. Items generated from the first round of Delphi technique.

Rank	Variables	Freq.	%
1	Small farms and scattered agricultural holdings	30	100
2	Lack of national strategy for agricultural mechanization	20	66.66
3	Lack of common understanding of what comprises mechanization	20	66.66
4	Low price of harvested agricultural production	20	66.66
5	Lack of motivation to capitalize in agriculture sector	20	66.66
6	High price of agricultural machinery	20	66.66
7	Diffusion problem of innovative agricultural automation system	17	59.66
8	State monopoly on production of agricultural machinery	15	50.00
9	Problem of environment and topography in technology transfer	12	40.00
10	Too few machinery repair service centers available nation wide	10	33.33
11	Lack of strong state support for manufacturers, distributors, sellers	10	33.33
12	State's inefficiencies in distributing agricultural subsidies	10	33.33
13	Lack of agents with mechanization expertise at rural extension centers	10	33.33
14	Perception of low quality of machinery produced internally	10	33.33
15	High tariff imposition for agricultural machinery importation	10	33.33
16	Ineffective linkage of research, and agriculture industry	10	33.33

Table 2. The result of the second round of Delphi technique.

2 nd Round	Coefficient of change ^a	Rank
Variables		
Lack of common understanding of mechanization	0.150	1
Lack of national strategy for agricultural mechanization	0.160	2
Weak state support for manufactures and distributors	0.224	3
Ineffective linkage of research, and agriculture industry	0.227	4
Small farms and scattered agricultural holdings	0.234	5
Low price of harvested agricultural production	0.235	6
High price of agricultural machinery	0.240	7
Problem of topography in technology transfer	0.243	8
Inefficient mechanization implementation program	0.248	9
Inappropriate state monetary policy	0.250	10

^a Is derived from dividing st. dev. by the mean score.

These factors should be taken into account while developing agricultural mechanization implementation plans in Iran. In providing analysis for these data, it could be concluded that the findings of this study are in conformity with reports of the study found in various developing countries. Extensive analysis of the related literature revealed that mechanization should be considered and viewed as a system. The major components of this system to promote agricultural mechanization are: 1) government; 2) financial institutions; 3) research and development sector; 4) education and extension sector; 5) manufacturing sector; 6) and distributing sector. How-

ever, the main groups of directly interested parties in the private sector are: farmers; retailers and wholesalers; manufacturers; and importers. Mutual organic work of those components will make it possible to supply the machines most fitting to the needs of crops and regions.

The results of the second phase of the study indicated that the majority of the farmers (72.5%) had from 12.1 to 56.7 hectares of land (a mean of 39 ha of total cultivated land), with the mean of 6.09 ha devoted to sunflower seed cultivation. The majority of the growers' technical knowledge was designated to be at a "good" level. The



mean agricultural mechanization level practiced on the sunflower-producing land was 0.4921 kW per hectare of cultivated land, however the amount of kW practiced varied between 0.0149 to 3.7457 kW in the farms. The finding of this study indicated that the farmers' main channels of obtaining technical information were (in the order of importance): exemplary farmers; agricultural specialists; commercial companies; and the centers for agricultural mechanization services. When asked about the main obstacles facing agricultural mechanization, the ma-

jority of farmers indicated the "high expense" of purchasing automated and mechanical machinery as the main inhibiting factor. The farmers' level of agricultural mechanization practiced was shown to have a statistically significant and a negative relationship with the farming land areas they possessed (Table 4). This may mean that farmers' land areas are scattered and divided into many farm holdings and a very small amount of lands is devoted to growing sunflower seeds.

Table 3. The result of the third round of Delphi technique.

Variables	3 rd Round	Rank	%
Small farms and scattered agricultural holdings		1	100
Lack of common understanding of mechanization		2	91.3
Lack of national strategy for agricultural mechanization		3	87
Ineffective linkage of research, and agriculture industry		4	87
Weak state support for manufacture and distributors		5	81
Low price of harvested agricultural production		6	80
High price of agricultural machinery		7	80
Problem of topography in technology transfer		8	80
Inefficient mechanization implementation program		9	80
Inappropriate state monetary policy		10	80

Table 4. Bivariate correlation between variables.

	1	2	3	4	5	6	7	8
1. Age	1							
2. Education	-0.276*	1						
Sig.	0.016							
3. Experience	0.820**	-0.450*	1					
Sig.	0.000	0.000						
4. Technical knowledge	-0.250*	0.267*	-0.236*	1				
Sig.	0.030	0.020	0.040					
5. Mechaniz. levels	-0.073	0.044	-0.158	0.013	1			
Sig.	0.531	0.709	0.173	0.912				
6. Income (Total)	0.258*	0.247*	0.234*	0.181	0.05	1		
Sig.	0.025	0.032	0.042	0.117	0.968			
7. Income (From sunflower cultivation)	0.168	0.336*	0.130	0.174	-0.339*	0.182	1	
Sig.	0.147	0.003	0.262	0.133	0.003	0.115		
8. Land Area (Total)	0.366*	-0.192	0.372**	0.020	-0.422**	0.228	0.358**	1
Sig.	0.001	0.104	0.001	0.864	0.000	0.053	0.002	
9. Land (Under sunflower cultivation)	0.169	0.023	0.276*	0.010	-0.689**	0.077	0.582**	0.551**
Sig.	0.144	0.841	0.016	0.932	0.000	0.510	0.000	0.000

**p<.001; *p<.05.

Table 5. Multivariate regression analysis.

	Unstandardized coefficients		Standardized coefficients		
	B	Std. error	Beta	T	Sig.
Constant	47.706	6.770		7.047	0.000
Income (X1)	2.168	3.111	0.063	0.697	0.488
Land area (X2)	-0.046	0.060	-0.082	-0.765	0.447
Land under sunflower cultivation (X3)	-3.318	0.542	-0.644	-6.126	0.000

$R^2 = 0.469$.

The independent variables with interval data were used in a multivariate linear regression. Utilizing the BackWard Elimination method, the multivariate linear regression indicated that 46.9% ($R^2 = 0.469$) of the variance in farmers' agricultural mechanization levels could be explained by their income, farming land areas, and land under sunflower seed cultivation. This means that about 53% of the variations in the mechanization level are due to variables that were not investigated by this study and should be followed up in later studies. The regression analysis provided variables with statistically significant levels (Table 5), so the following predication equation was formulated to estimate the mechanization level.

$Y = \text{Mechanization degree}; Y = 47.706 + 2.168(X1) - 0.046(X2) - 3.318(X3)$

CONCLUSION

1. Delphi technique investigation showed that the main constraints on farm mechanization were "small farm size" and "fragmentation of holdings". These facts have been known and understood by authorities in national decision and policy making circles, but what has been done so far on a national scale remains to be thoroughly evaluated and critiqued.
2. Modern agriculture requires an innovative capacity which goes far beyond the individual farmer, researcher, industrialist, and even beyond the abilities of any one of their organizations or institutions. Considering the fact that "ineffective linkage of research and the agriculture industry", and "lack of a national strategy for agricultural mechanization" are the other main factors found in the Delphi technique phase of this research, the challenge is therefore to develop strategies and approaches for optimum involvement of extensionists, researchers, development agents, and the eventual users of the technology as a unified body in order to be effective. Since all mechanization inputs have to be paid by the farmers, they (farmers) must be the main focus of all activities.
3. In a free market economy the amount and choice of mechanization inputs is demand driven, whereas in a planned economy it is supply driven (Binswanger, 1986). Considering the fact that "lack of strong state support for manufacturers and distributors" was another important factor stated by the Delphi panel of experts, it should be stated that government support for manufacturers, and distributors is essential during the transition to reaching an optimum economy status (which would be dynamic and fully demand driven). Until then the state should continue to support subsistence farmers to modernize and expand their farming systems, as they stated "high expense" as a main obstacle for purchasing automated and mechanical machinery.
4. The mean agricultural mechanization level practiced by sunflower seed producing farmers has been considered relatively low, and below the national mechanization norm. This may be due to the economy, geography, and support



policy as they relate to this particular population.

5. The finding of this study indicated that the farmers' main channels of obtaining technical information were "exemplary farmers", and "agricultural specialists". So special efforts should be directed to the educational and motivational (incentives) needs of exemplary farmers and specialists, simply because they are the important sources of education and interaction with the larger farmer population.
6. The result of the multivariate linear regression indicated that about 53% of the variance in farmers' agricultural mechanization level could not be explained by the variables investigated in this research study. In an open and natural environment, agricultural production could be affected by a whole array of inter and intra activities of variables through the holistic system and sub-systems of nature, therefore this result could have been expected. The finding implied that there are other factors that may have contributed substantially to variations in the mechanization levels that were not investigated in this study and that should particularly be a topic of research study on a similar population.

Certainly, successful agriculture production in Iran requires advanced technology with collaborative government and NGO support to be sustainable. Government organizations or institutions, and NGOs consisting of farmers, advisers, researchers, industrialists, and distributors should work collaboratively to implement national mechanization development plans and programs. The findings of the Delphi technique of this research are valuable achievements that could broaden our national understanding related to the challenges of agricultural mechanization. Empirical field studies (similar to this study) should be conducted in various different geographical areas to reciprocate the findings in attempt to find generalized factors. The challenges facing the agricultural mechanization implementation plan are how best to capitalize on factors

that affect agricultural mechanization positively and minimize the effects of inhibiting factors. Agricultural extension that functions through a participatory approach has a great potential to play a key role in facilitating a national, long-range agricultural mechanization developmental plan. There are many government policies that affect the way in which mechanization inputs are made available and will determine the effectiveness of the sub-sector. Examples of such policies are those which affect privatization and the national markets. In a free market economy the amount and choice of mechanization inputs are demand driven whereas, in a planned economy, they are supply driven. Farmers in Iran face a great challenge in this regard, as the government tries to down-size and as the country moves through a transition process from a supply driven to a more demand driven economy. Definitely, we could have a successful mechanization implementation plan if we view agricultural inputs within broader agricultural production systems, and try to tackle any challenges between and within systems through a short- and long-term development plan while following a general national agricultural development-strategy.

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عوامل تأثیرگذار بر مکانیزاسیون کشاورزی: مطالعه موردی در مزارع آفتابگردان

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چکیده

هدف کلی این تحقیق تعیین عوامل تأثیرگذار بر میزان مکانیزاسیون به کار گرفته در مزارع کشاورزان بود. روش انجام تحقیق پیمایشی و از نوع توصیفی - همبستگی بوده است. جامعه آماری آن را آفتابگردان کاران استان قم (N ۹۵) تشکیل می دادند که از این میان تعداد ۷۶ نفر به روش نمونه گیری طبقه ای متناسب با بزرگی به عنوان نمونه آماری انتخاب شدند. برای گردآوری اطلاعات مورد نیاز از پرسشنامه استفاده شد. روایی محتوایی پرسشنامه با کسب نظرات متخصصان و اساتید ترویج و آموزش کشاورزی مورد بررسی و اصلاحات لازم صورت گرفت. ضریب اعتبار پرسشنامه نیز با استفاده از نرم افزار SPSS برابر با ۰/۷۱ به دست آمد. یافته های تحقیق نشان داد که میانگین سطح مکانیزاسیون مزارع آفتابگردان ۰/۴۹۲۱ کیلووات در هکتار بوده است. حدود یک پنجم از کشاورزان مطالعه شده در دوره های آموزشی مرتبط با مکانیزاسیون کشاورزی شرکت کرده اند که اغلب این دوره ها نیز مربوط به نحوه کاربرد و نگهداری از تراکتور بوده است. در آزمون رگرسیون خطی، متغیرهای میزان درآمد، میزان زمین زراعی و تعداد قطعات مزارع زراعی در مجموع ۴۶ درصد از تغییرات در میزان مکانیزاسیون در مزارع کشاورزان را تبیین کردند.