J. Agric. Sci. Technol. (2008) Vol. 10: 215-223

Determination of the Degree, Level and Capacity Indices for Agricultural Mechanization in Sarab Region

V. Rasooli Sharabiani[1]* and I. Ranjbar[2]

ABSTRACT

The purpose of this study was to determ the degree, level and capacity indices of agricultural mechanization in Sarab Region (N: 37º45', E: 47º30') in Eastern Azarbayjan Province, comprising about 65,164 hectares of farming land. The number of tractors, types of machines, and degree, level, and capacity of mechanization were calculated as the method of study. Data showed that the average level of mechanization was equal to 0.83 (hp per ha); partial energy expenditure per hectare (mechanization capacity) by energy producing sources (human, animal and machine), was 1.24%, 2.23%, and 96.35 % respectively. The results show the importance of the role of the machine in production. Although the level of mechanization in this region was higher than the national mechanization level, the degree of mechanization was very low in most of the farming operations. It was estimated that to reach the mechanization level of 1.5 hp ha^{-1}, 775 tractors are required. In this study some overall guidelines for improving mechanization and increasing farm production are also presented.

Keywords: Agricultural mechanization, Capacity, Degree, Level of mechanization.

INTRODUCTION

To make a reliable plan to develop the agriculture of a region, it is important to gain a precise knowledge of the existing situation and the problems facing the development of agriculture. Otherwise, any long-, middle-, and short-term plans will be ineffective and finally problematic and they will lead to a waste of capital and time. This is of crucial importance in both developing and undeveloped countries because of limited capital and economic depression. However there are many areas with potential for development in these countries.

One of the main reasons, and probably the most important one, for this kind of social structure is the dependence of these countries on traditional agricultural systems with a low level of efficiency. Therefore, attempts to find a solution to enhance the effectiveness of agriculture in the economy of these countries must be taken into consideration as one of the main goals. In this light, "the mechanization of agriculture to enhance per capita production of workers, to reduce production costs, to increase the profitability of products, and to extend the agricultural area" and "utilization of scientific resources and researches in the field of appropriate application of potential facilities of water and soil and increase in production per unit area" are the two main ways for evolving traditional agricultural systems. In most cases, these two ways are used simultaneously (Ranjbar, 1989).

By definition, the mechanization of agriculture is the "application of mechanical implements or as a whole, the application of

[1] Department of Agricultural Machinery, Faculty of Agriculture, University of Mohaghegh Ardebili, Ardebil, Islamic Republic of Iran.
[2] Department of Agricultural Machinery, Faculty of Agriculture, Tabriz University, Tabriz, Islamic Republic of Iran.
* Corresponding author, e-mal: v_rasoli@yahoo.com

the state-of-the-art technologies in agriculture to increase productivity and to reach sustainable agriculture". There are three specific indices for the study and evaluation of mechanization in different regions. These indices include degree, level, and capacity of mechanization (Almasi *et al*., 2000).

Although developmental patterns for a region can be provided after investigation into the facilities and limitations of that region, it must be noted that we can never offer a certain pattern for agricultural development alike for all regions since they are not culturally, geographically, economically and socially identical. So each part of the world has its own characteristics and needs a specific pattern of development (Shahbazi, 1989).

This investigation was carried out in Sarab region in the province of East Azarbayjan in Iran in 2002-3 to study the situation of mechanization in the region and to analyze the relevant qualitative and quantitative issues.

MATERIALS AND METHODS

Sarab Region in the east of Eastern Azarbayjan Province stands between the latitudes of 37˚45´ and 38˚00´ N. and longitudes of 47˚30´ and 47˚45´ E. According to the census of 1996, the population of the city is about 148,831 and the population of working men of this city active in the agriculture sector is about 22,923 (Anonymous, 1999). The total area of the city is more than 3,560 km^2 of which 98,460 hectares are arable, 65,165 hectares for irrigated and non-irrigated land and the rest for fallow land.

In terms of the Emberget classification, the climate of the region is semiarid and cold. The annual temperature is 0-10°C and mean annual precipitation in the low and highlands is 300 and 600 mm, respectively. The city, whose altitude is 1,900 m, is under the aquifer realm of Oroumiyeh Lake and the Adji-Chai River (Anonymous, 2001).

Methods of Study

In this research, we used field study as the cornerstone for reviewing the gathered data, besides which both extensive and intensive methods were used. Inquiry and observation constituted the main tools of the research. Field observation (which is done in the heart of the society unlike the in vitro observation) is the base of this method, which is used for studying different social, human, vegetative and animal-related phenomena (Sarokhani, 1994).

The extensive method is an important method in large-scale social and regional investigations. In this objective method, questions with low depth are considered (Louimi, 2000). This method is required because it enables the generalizability of results and, finally, unmasks general properties and existing norms (Sarokhani, 1994).

The aim of the intensive method is to analyze phenomena and to provide a report. This method includes a wide spectrum too and is considered more rigorous compared to the extensive method (Sarokhani, 1994).

In view of the definition of the field study and the description of the intensive and extensive methods as subsets of the field study, both methods were used in this experiment. A region was selected as a sample and this sample was studied intensively and thoroughly, for the following reasons

1. Lack of access to all villages around the city;
2. Infeasibility of studying factors such as the degree of mechanization in every village;
3. This region being roughly an agrozone as regards its elevation temperature and general climatic conditions,
4. Farmers being of similar social and cultural conditions and facing similar constraints.

In the statistical analyses, random samples were selected from the villages under the service of public agencies and

[DOR: 20.1001.1.16807073.2008.10.3.1.7]

questionnaires were filled in these sample villages and, eventually, the results of this survey were generalized to the whole region.

Methods of Data Gathering

In this study, the methods used for gathering data were questionnaire, interview, observation and gathering formal statistics.

Evaluation Indices

The Indices and qualitative and quantitative criteria by which the status of mechanization were evaluated were as follows:

- The degree of mechanization, which is the ratio of mechanization area accomplished to the required one. (1

In this study, wheat, barley and potato were selected as dominant and strategic crops (in terms of their productivity to farmers) for extensive investigation. Then the degree of mechanization of different operations on these crops was intensively examined in the sample region (Sharabian Region) and the ratio of the mechanization operation accomplished to the required one was determined.

- The level of mechanization is calculated by the following formula (Almasi *et al*., 2000) where: (2

$$\text{Mechanization level}\left(\text{hp}\ \ \text{hp}^{-1}\right)=\frac{\text{Total power}}{\text{Cultivated area}}$$

The Total power of existing tractors (hp)= Average nominal power of one tractor × Number of working tractors

Total real power of tractors= Total power of existing tractors × Conversion coefficient.

According to the recommendations given (Almasi *et al*., 2000), the conversion coefficient is 0.75.

- The mechanization capacity or consumed horsepower-hour through energy resources (including animal, human and mechanical). (3

Animal energy: To calculate the animal power, the energy produced by an animal during a working day is equal to

Annual functional hours= Number of functional days × Mean functional hours during a day

Animal	Horse	Donkey	Mule	Working cow	Bull
The power corresponding to each one (hp)	1	0.5	0.8	0.8	0.8

Ttotal existing animal power (hp)= Produced power of animal × Number of animals

Animal energy (hp-hr)= Total existing animal power × Annual functional hours (Iran Consulting, 2000):

Human energy: The procedure for calculating human energy is similar to the previous one, but it should be taken into consideration that, firstly, to calculate the number of working population in agricultural sector, all people of the region including farmers and supporting people who play a role in crop production should be involved; secondly, a normal person can produce on average about 0.12 hp during a working day (Iran Consulting, 2000).

Mechanical energy: To calculate the mechanical energy, the first instruction has to be followed. The number of days machinery is used during a year should be noted according to the calendar, as well as the limitations of using machinery on some days. And the mean daily functional hours of machines are separately calculated according to existing resources and field studies. Besides calculating the energy of machines, all existing machines should be considered, whether stationary or mobile, which are producing power for cropping work.

- Calculation of the number of tractors, combines and implements required:

To calculate the number of tractors required we follow inversely the procedure for calculating the mechanization level. Therefore, having a certain mechanization

Table 1. Mechanization degree (MD) of prevalent mechanical operations in potato.

Step of operation	Type of operation	MD for concerned operation areally (%)	Comments
Initial soil tillage	Mouldboard plow	95 and more	Nowadays, all cultivated fields are usually plowed at least once.
	Heavy disk	Negligible	It is not prevalent in the region and farmers do not know this kind of operation
	Chisel plough	10 and less	Some farmers use it for gathering vegetative remnants after harvesting potato
Secondary soil tillage	Disking	30	It is used for breaking the clods.
	Harrow	20	It is used for collecting the vegetative remnants and simple furrow-making.
Planting	Potato planter	10	Its application has not extended because of ignorance of farmers and the problems facing field leveling.
	Furrower	70	In recent years, the application of this method has increased because it is simple and time saving.
Protection	Sprinkler	5 and less	This method is not used widely because of its restricted spread.
	Tractor spray	50	In the protection stage, this is used widely for fighting against weeds and pests.
	Knapsack sprayer	50	Farmers who do not have access to a tractor sprayer use this implement either manually or mechanically.
Harvesting and postharvesing	Potato digger	10	Fields cultivated by potato planters are usually harvested by potato diggers.
	Transportation	100	Potatoes are transported to storehouses or market by vehicles.

level, the required number of tractors can be calculated as follows: (4

$$\textit{Necessary tractor power} = \frac{\textit{Determined mechanization level}^{a} \times \textit{Cultivated area}(ha)}{\textit{Conversion coefficient}(0.75)}$$

[a] The mechanization level which is predicted in Third Development Program of the country (*I.R.I*) is 1.5 hp hp^{-1}

Required tractor power= Necessary tractor power - Existing tractor power

$$\textit{Required number of tractors} = \frac{\textit{Required tractor power}}{\textit{Nominal power of an appropriate tractor}}$$

To calculate the required number of combines, the following steps must be followed:

Performance of each combine in workable period= Number of workable days × Feasible capacity of combine (ha day^{-1})

$$\textit{Necessary number of combines} = \frac{\textit{Existing harvestable area}}{\textit{Performance of each combine in workable period}}$$

Required number of combines= Necessary number of combines - Existing active combines

To predict the required number of implements for cropping operations, we take the following steps:

$$\textit{Effective field capacity}(ha\ \ hr^{-1}) = \frac{\textit{Working width}(m) \times \textit{Speed}\ (km\ \ hr^{-1}) \times \textit{Efficiency}\ (\%)}{10}$$

Working area of implement= Field capacity

Table 2. Mechanization degree (MD) of prevalent mechanical operations on wheat, barley (irrigated and non-irrigated) in the region**.**

Step of operation	Type of operation	MD for concerned operation areally (%)	Comments
Initial soil tillage	Mouldboard plow	95 and more	Nowadays, all cultivated fields are usually plowed at least once.
	Heavy disk	Negligible	It is not prevalent in the region and farmers do not know of this kind of operation
	Chisel plough	5 and less	The chisel plough which is used for plowing non-irrigated field is not prevalent because of ignorance of farmers.
Secondary soil tillage	Disking	5 and less	It is used for breaking the clods.
	Harrow	10 and less	It is used for collecting weeds and vegetative remnants.
Planting	Drill seeder	5 and less	Seeding with drill seed is not quite prevalent in the region.
	Seeder	30	Sowing by seeder in non-irrigated fields is developing.
	Top-dressing	10	Farmers do not extensively use mechanical sprinklers because of inaccessibility.
	Disking	95 and more	Almost all fields which were manually seeding are disked to cover seeds.
Protection	Ditcher and border	70	Ditcher and single beam plow perform the relevant activities.
	Tractor sprayer	25	To fight against weeds and pests
	Knapsack sprayer	35	To fight against weeds and pests
	Sprinkler	5 and less	This method is not used widely because of its restricted spread.
Parvesting	Combine	85	This is widely used for harvesting in irrigated and non-irrigated fields where combine application is not problematic.
	Mower	10	Inclined fields which used to be harvested manually are now harvested by mower.
Post harvesting	Bailer	5 and more	Packaging of straw by bailer is on the rise in recent years.
	Thresher	95 and more	Almost all barley and wheat which are mowed manually or by mower are threshed by thresher and then barley and wheat are separated from hay by traditional methoods.
	Transportation	90 and more	

of implement × Number of working days × Mean daily working hours

$$Necessary\ number\ of\ implements = \frac{Total\ working\ area\ of\ required\ operation}{Working\ area\ of\ an\ implement}$$

Required number of implements= Necessary number of implements - Number of existing active implements

RESULTS AND DISCUSSION

Investigation of Mechanization Degree, Level and Capacity

The mechanization degree is one of the quantitative indices (Almasi *et al*., 2000) by which the mechanization degree of different operations within a limit can be assessed. In

[DOR: 20.1001.1.16807073.2008.10.3.1.7]

Table 3. The total power and number of all kinds of tractors active in the region.

Type	Mean nominal power (hp)	Number of active tractors	Conversion coefficient	Total power (hp)
Romania (30-60)	40	7	0.75	210
Romania (60-80)	65	765	0.75	37294
MF (30-60)	45	5	0.75	169
MF (60-80)	75	260	0.75	14625
MF (80-110)	110	5	0.75	412.5
Johndeer (80-110)	105	14	0.75	1102.5
Others (30-60)	40	5	0.75	150
Total	-	1061	-	54113

Table 4. Consumed energy in terms of energy resources (including animal, human and mechanical).

Type	Consumed hp-hr	Consumed hp-hr per hectare	Share of each resource (%)
Animal energy	3941960	60.5	1.42
Human energy	5941642	91.2	2.23
Mechanical energy	257762472	395.6	96.35
Total	267646074	4107.3	100

other words, the mechanization degree is used for determining the extent of different operations carried out by machinery (versus operations carried out by humans, animals or their noncompliance). According to equation (1), and considering the extensive studies, the results were generalized to the entire region. The results for potato, wheat and barley (irrigated or non-irrigated) are summarized in Tables 1 and 2, respectively.

To investigate the mechanization level which is, in fact, per capita power in terms of hp per hectare, it was first of all necessary to determine the number of all kinds of active tractors in the region which are used as the source of draft power. Therefore, the total power of all tractors (shown in Table 3) with respect to their trademarks were deduced from the results of the questionnaire and statistics for existing trademarks as well as the investigation into their life time of these about 30% of the tractors made in Romania (type U650) were either amortized or did not play a role in the agriculture sector. According to this table and equation (2), since the arable area of the region is 65,164 hectares, the mechanization level is 0.83 hp ha^{-1}.

Although this figure is desirable in comparison with the mechanization level of the country which is 0.6 hp per hectare (Kiani, 2000), but it is not reasonable in comparison with the mechanization level of developed countries as well as the predictions of the country’s Third Development Program in the agricultural sector in which the mechanization level has been determined as 1.5 hp per hectare. So, an appropriate solution ought to be sought.

In studying the mechanization capacity or consumed hp-hr in producing crop products via three energy resources (animal, human and mechanical), according to section (3), the total consumed energy via these three sources was calculated and are summarized in Table 4. According to Table 4, total consumed energy in the region is 267,646,074 hp-hr. In fact, with regard to the cultivated area of 65,164 hectares, total consumed energy per hectare via these resources is 4,107.3 hp-hr. Naturally, the greater the mechanization degree of a crop, the higher this figure would be and vice versa. According to the table, animal, human and mechanical energy comprises 1.42% and 2.23% and 96.35% of the total consumed energy, respectively. This shows

[DOR: 20.1001.1.16807073.2008.10.3.1.7]

the vital importance of mechanical aids in crop production.

Required Number of Tractors, Combines and Other Implements

Calculation of the required number of tractors showed that the necessary tractor power is 130,328 hp of which 72,151 hp exists and so 58,177 hp was required. According to previous studies and with reference to existing resources and research, the tractors appropriate for the region are commonly middle-power ones (Iran Consulting, 2000). In this study, the MF285 with a nominal power of 75 hp that is both in the middle-power range and made in Iran and, so, easy to access was the basis of this research. Finally, 775 tractors of the same brand were estimated to meet the requirements of the region.

To calculate the number of combines required, considering equation (4) and the results shown in Table 1 which indicate that the mechanization degree for harvesting by combine is 85% and the total area of wheat and barley is 34,500 hectares in the region, altogether a 29,325-hectare area will be harvestable by combine. According to the agricultural schedule of the region and limitations in using machinery from July 10 to August 20- the harvest season-, allotted the time (or workable days) for harvesting is 32 days in the region. Extensive studies show that the mean performance of combines is 10 hectare per day (Kiani, 2000). So, 92 combines are needed of which only 21 combines exist. Now, it may be asked whether the remaining 71 combines need to be to procured. If necessary, how have farmers met their needs as yet? The answer is that Azarbayjan (eastern western and Ardebil itself) is a region with various climates, therefore the harvesting of wheat starts from the northern part, the Moghan plateau, and with increases in temperature in the first months of summer it extends to the western and southern parts of the region. So, annually, combine owners in Ardebil and Moghan regions are dispatched to this city after completion of harvesting the wheat of their own regions and thus the need for combines in Sarab is met. On the other hand, since the purchase and maintenance costs of combines are high and it is applied annually over just a short period of time, it seems that the procurement of this number of combines is not economical. However, it must be noted that the lack of service and maintenance centers for combins in the region is a severe problem that prevents owners from repairing their combines and so leads to a waste of harvest time (due to delays in of repairing and replacing accessories). Furthermore, since drivers are not skillful and do not know how to adjust their combines, seeds break and are scattered in different parts. All of these problems incur high costs for farmers.

To predict the number of implements required, the instructions given in equation (4), should be followed. The results of this model have been summarized in Table 5.

Table 5. The number of required implements to carry out the prevalent operations (with the assumption that mechanization degree is 100%).

Implement	Existing number	Working area (hectare)	Allotted time of operation (day)	Real time (day)	Area capacity (ha hr^{-1})	Implement performance in real time (ha)	Required number
Mouldboard plow	1247	43056	40	20	0.31	45	957
Chisel plough	418	22108	40	20	0.86	125	177
Disk	448	65164	40	20	1.05	153	426
Seeder	60	14000	50	24	0.67	117	120
Potato planter	1	5000	50	21	0.29	45	111
Potato digger	2	5000	60	40	0.47	137	37

Allotted time has been calculated according to the agricultural calendar of the region. Besides, the real period of time for using these tools has been calculated according to the limitations of applying the implements (Iran Consulting, 2000). As shown in the table, the number of existing implements such as mouldboard plow, disk and chisel plough are excessive is superabundant. Although this is a positive point, with respect to the degree of mechanization, it is clear that these implements are being misused. Conversely, there is a severe shortage in some other implements such as seeders, potato planters and potato diggers which needs to be resolved and calls for further investment.

CONCLUSION

The results show the importance of the role of machines in production. Although the level of mechanization in this region was higher than the national mechanization level, the degree of mechanization was very low in most farming operation.

However, it must be noted that there are other restrictions in terms of water, soil and human (expert) resources and particularly investments in infrastructure e.g. construction of dams and supply of machinery which, together, are responsible for the poor level of mechanization.

According to the extensive studies, the following solutions are recommended:

1) To enhance the mechanization degree and especially the mechanization level from 0.83 to 1.5 hp per hectare, it is essential to provide 775 middle-power tractors as well as the required implements, namely 120 seeders, 111 potato planters, and 37 potato diggers.
2) Long-term planning for integrating fields via the reform of inheritance laws. Although this program needs large-scale decision-making and national will, it should be noted that for transition from a traditional structure to a developed structure of agriculture, legal and financial support in the first level of management are needed.
3) Establishment of specialized committees involving graduates in the field of agronomy and their recruitment to villages and agricultural centers for training and promotion of information to farmers. This can help to solve the problems of farmers as well as employment of graduates.
4) The conduct of targeted training classes and demonstration of suitable and proven patterns to the farmers, because it seems that the main reason for the low efficiency coefficient is the ignorance of the users of the machines.
5) The establishment of central service stations at least in central villages and provision of after-sales services for machines and accessories in these stations.

REFERENCES

1. Almasi, M., Kiani, S. and Louimi, N. 2000. *Principles of Agricultural Mechanization*. Ma'soumeh (PBUH) Publication.Ghom, Iran. PP. 19-40.
2. Anonymous. 1999. *The Statistics of East Azarbayjan Province*. Tabriz. Management and Planning Organization of Eastern Azarbayjan Province. Tabriz, Iran.
3. Anonymous. 2001. *The Maps and Geographical Information of Sarab City*. Tabriz Map Department, Management and Planning Organization of East Azarbayjan Province. Tabriz, Iran.
4. Clark, L. J. Chief. 2000. Strategies for Agricultural Mechanization Development. FAO. Rome, Italy.
5. Gaolianxing, L, and Ionghu, Z. 1999. Development Situation and Tendency on Rice Production Mechanization in Northeast of China. Proc. *99 Int. Conf. Agr. Eng*. Beijing, China.
6. Iran Consulting. 2000. *The Plan of Studying Mechanization in Aras and Oroumiyeh Aquifer Realm*. Agriculture Organization of East Azarbayjan Province. Tabriz, Iran.
7. Kiani, S. 2000. Evaluating Present Agricultural Mechanization Situation and Presenting Development Guidelines for Izeh

City-Iran. MSc. Thesis. Shahid Chamran University, Ahwaz, Iran.

8. Louimi, N. 2000. Evaluating Present Agricultural Mechanization Situation and Presenting Development Guidelines for Northern Ahwaz City-Iran. MSc. Thesis. Shahid Chamran University, Ahwaz, Iran.
9. Ndaeyo, N. U., Umoh, G. S. and Ekpe, E. O. 2001. Farming Systems in Southeastern Nigeria: Implications for Sustainable Agricultural Production. *J. Sust. Agr.*, **17(4)**: 75-89.
10. Ranjbar, I. 1989. Mechanization and its Implications on the Development of Agriculture. Seminar on Probing the Agricultural Problems of Iran. 19 and 20 December. Tabriz, Iran.
11. Salokhe, V. M. and Ramalingam, N. 1998. Agricultural Mechanization in the South and Southeast Asia. International Conference of the Philippines. Society of Agricultural Engineers, Las Banos, Philippines, 21-24 April. PP. 1-23.
12. Sarokhani, B. 1994. Research Methods in Social Sciences (I). Liberal Arts and Cultural Studies Center Publication. Tehran, Iran. pp. 45-78.
13. Shahbazi, I. 1989. Agriculture Advancement: The Requirements of Change and Renewal of Agriculture. [Translation.] Publication of Agriculture Dissemination Organization, Tehran, Iran. PP. 22-35.
14. Witney, B. 1988. *Choosing and Using Farm Machinery*. Logman Scientific & Technical. New York, US.

تعیین شاخصهای درجه، سطح و ظرفیت مکانیزاسیون کشاورزی درمنطقه سراب

و. رسولی شربیانی و ا. رنجبر

چکیده

این تحقیق به منظور تعیین شاخصهای درجه، سطح و ظرفیت مکانیزاسیون کشاورزی در منطقه سراب، (N: 37º45', E: 47º30') واقع در استان آذربایجان شرقی با سطح زیر کشت 164 , 65 هکتار انجام گرفت. تعداد تراکتورها، انواع ادوات کشاورزی و شاخصهای مورد نظر با توجه به روشهای علمی موجود محاسبه شد. نتایج نشان داد که میانگین سطح مکانیزاسیون در منطقه 0/83 اسب بخار بر هکتار می‌باشد. همچنین سهم انرژی مصرف شده از منابع انسانی، دامی و ماشینی بر واحد سطح به ترتیب %1/24، %2/23 و %96/35 براورد شد. این نتایج نشان‌دهنده نقش مهم ماشین در تولید محصولات کشاورزی است. اگرچه میانگین سطح مکانیزاسیون این منطقه نسبت به متوسط آن در کل‌کشور بیشتر است ولی درجه مکانیزاسیون بسیاری از مراحل عملیات کشاورزی در سطح پایینی قرار دارد. در این تحقیق تعداد تراکتورهای لازم برای رسیدن به سطح مکانیزاسیون 1/5 اسب بخار بر هکتار، 775 دستگاه محاسبه شد. در نهایت نیز پیشنهادهایی برای بهبود وضعیت مکانیزاسیون و افزایش تولید محصولات زراعی در منطقه ارائه شد.

[DOR: 20.1001.1.16807073.2008.10.3.1.7]