COMPARISON BETWEEN FIXED AND MOVABLE SPRINKLER IRRIGATION SYSTEMS

COMPARAISON DES SYSTEMES D'IRRIGATION PAR ASPERSION FIXE ET PORTABLE

Ali Nickmanesh[1], Mohammad Rhimi[2] and Rostan Dashti[3]

ABSTRACT

The use of the center pivot sprinkler system, uniform irrigation coverage is not achieved and small scattered remain, which had not received water. In a case study on the performance of the conventional center pivot system over an area of 445 ha of land in section 7 of Moghan Agro industrial and cattle breeding company in Ardebil province, 345 ha was covered by irrigation and 100 ha remained as non-irrigated lands. The client's requirement was a system with the features: a) Fully automated system to minimize labor and maintenance coasts, b) No obstacles to agricultural activities, particularly in sowing and harvesting.

For selecting a proper system meeting these requirements, the performance of the (A) permanent classic sprinkler irrigation system with (b) moveable sprinklers and fully automated solid-set sprinkler system with buried pipe (with the ability to collect sprinklers) were compared. The comparison revealed that despite the initial15% increase in construction cost, the internal rate of return in (B) was 2.8 times higher than that of (A). Based on further investigations, the system (B) was chosen and recommended for use. Besides giving a higher IRR, it also was suitable for small land holding, variety of cropping patterns and under steep slope condition of the land.

Key words: *Fixed and movable sprinklers, Hydraulic design, Material saving, Investment cost.*

RESUME

L'objectif de l'utilisation du système d'irrigation par aspersion circulaire et la couverture uniforme d'irrigation n'est pas atteint et donc certaines parties de la terre restent non irriguées. Une étude de cas est menée pour évaluer la performance du système conventionnel

1 Managing Director of Roudab Parsian Consulting Eng. Co.; E-mail: namiaus@yahoo.com
2 Faculty of Arak Islamic Azad university and Chairman of Roudab Parsian Consulting Eng. Co.; E –mail: morahimi54@yahoo.com
3 Technical and executive manager of Moghan Agro Industrial Plant; rostan.dashti@yahoo.com

d'irrigation par aspersion circulaire sur une superficie de 445 ha de terre de la Section 7 de la Société Agro-industrielle et de l'Elevage de Moghan dans la province d'Ardebil dont 345 ha de terre est irriguée et le 100 ha de terre reste non irriguée. Le client exige un système – (a) automatisé pour minimiser les coûts du travail et de la maintenance, (b) qui aide les activités agricoles en particulier les semailles et la récolte.

La comparaison a été faite de la performance (A) du système d'irrigation par aspersion classique permanent et (b) du système d'irrigation par aspersion portable et automatisé avec les tuyaux enterrés. Cette comparaison a indiqué que malgré l'augmentation initiale de 15% des coûts de construction, le taux de rendement interne (B) était 2,8 fois plus élevé que celui de (A). Compte tenu des enquêtes supplémentaires, le système (B) a été retenu pour l'usage. A part un 1RR élevé, il sera utilisé facilement sur les petites propriétés, la variété d'assolement et la pente raide de la terre.

Mots clés: *systèmes d'aspersion fixe et portable, conception hydraulique, économie des matériaux, coût d'investissement.*

1. INTRODUCTION

Moghan Agro industrial plants having fertile soil and enough water is one of the important agricultural poles. The total land area is 35000 hectares, from which 10 and 90 percent are dedicated to the garden and farm respectively. There are 60 pivot machines working in Mogham industry and because of the nature of pivot machines, about 20% land between centers pivots remain non-irrigated. One of the important goals of the company is to cultivate that area and equip it with pressurized irrigation system 345 ha in section 7 of the company.

2. AUTOMATED PERMANENT CLASSIC SPRINKLER SYSTEM WITH BURIED PIPE (Fixed sprinklers but automatic irrigation shift)

During the selection process, the solid set irrigation system with buried pipe was rejected due to its high cost and creating obstacles in agricultural mechanization, particularly in sowing and harvesting activities. Then two systems were selected for comparison in terms of technical and economical aspects:

- **Permanent classic sprinkler irrigation system with moveable sprinklers**

  This is similar to solid-set irrigation system with buried pipe, except that the sprinklers could be moved manually and therefore, in addition to less required sprinklers, there would be the least constraints in sowing and harvesting. This system is the most common in Iran, as it can be used in small land holdings. The need for labor force for moving the sprinklers, high labor cost, high energy consumption and high depreciation are the disadvantages of this system.

- **Fully automated Permanent classic sprinkler system with buried pipe (with the ability to collect sprinklers)**

  This innovative system is between a solid – set with buried lateral and permanent system with moveable sprinklers and all the shortcomings of the two conventional systems could

be overcome in it. In this system, sprinklers are fixed at the beginning of the season and removed to facilitate agricultural operations at the end of the season. In comparison with Permanent system and moveable sprinklers, the purpose of sprinkler displacement is achieved here by using automatic controller and solenoid valves automatically.

There are two major problems with solid-set irrigation system:

1) Obstacles in agricultural mechanization, particularly in sowing and harvesting activities, because all sprinklers are fixed. But in innovative system, sprinklers are not fixed and there is quick valve between sprinklers riser and lateral pipes, Quick valves are buried in the soil and protected by concrete box to avoid damage during agricultural operations using tractors, combines, etc., could be prevented (Fig. 1).
2) In solid set irrigation system design, each manifold works separately and respectively, so the pipe diameter of manifolds, submain and mains pipes increases and hence, the project coast increases. But in the innovative system flow is equally divided among the manifolds and all manifolds simultaneously work. So, the pipes diameters are optimized reducing the project costs.

The system components are:

1) Three electric pumps with 75, 90 and 75 kw power.
2) Three frequency converters: although pivot system require constant flow and pressure but surrounding land require different flow in various shifts.
3) Controllers: there are three controllers with following capabilities:
   - Matching irrigation time for surrounding land and pivot rotation speed.
   - Display includes all information needed for current status of electrical valves such as valve opening time mass transit, flow rate, etc.
   - Electrical valves and strings: In this project 2 inch (50 mm) electrical valves (latching type) and Tow types of string 3×0.5 NGYY for data and 3 ×1.5 NGYY for power transmission, are needed.
4) PE100, polyethylene pipes, PN 6 atm, diameters from 50 to 250 mm.
5) Cast iron valves for isolation of main, sub main and manifold pipes.
6) Brass valves to manually open and close laterals.
7) PE fittings such as saddle, three way, reducer, etc.
8) Brass sprinklers 3/4" (19 mm), with flow rate of 1.8 to 2.34 m^3hr^{-1} at working pressure of 2.8 ~ 3.5 atm (Table 1).
9) Regulators: (1" × 3/4") Intel-outlet, 40PSI

2.1. System advantages

- Reduced energy consumption.
- More than 90% reduction in labor costs.
- Increased irrigation efficiency by high distribution efficiency.

- Higher productivity in terms of area coverage, precise control of irrigation time. Run is minimized and soil compaction and dispersion do not occur, helping proper seed germination and increasing crop yield.

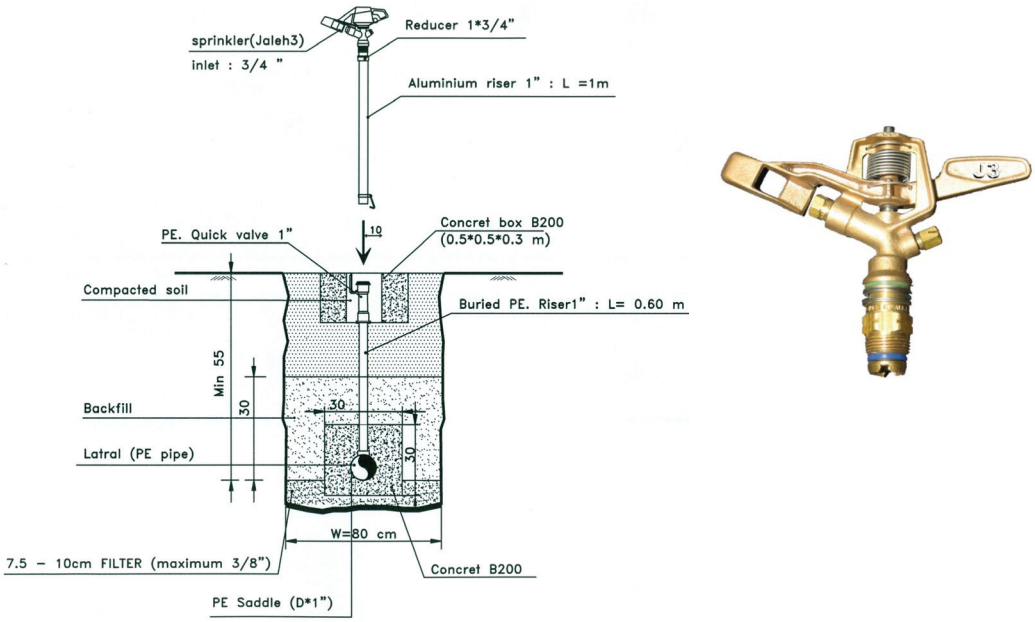

Fig. 1. Sprinkler branch from lateral pipes (left) and close up view (right) : Branche d'arrosage de conduits latéraux : a gauche et vue d'enlarhget : a droite)

Table 1. Characteristic of selected sprinkler (Jaleh3) (Caractéristique de l'arroseur sélectionnés (Jaleh3))

	Nozzle 3/16" x 3/32"		Nozzle 7/32" x 3/32"		Nozzle 15/64" x 1/8"		Nozzle 9/32" x 1/8"	
	Discharge	DIA	Discharge	DIA	Dsicharge	DIA	Discharge	DIA
	m3/Hr	m	m3/Hr	m	m3/Hr	m	m3/Hr	m
2.8	1.81	31.1	-	-	-	-	-	-
3.2	1.91	31.7	2.46	35.4	3.05	37.2	4.01	41.5
3.5	2.01	32.0	2.60	36.0	3.20	37.8	4.21	42.1
3.9	2.11	32.3	2.71	36.9	3.36	38.7	4.41	42.7
4.2	-	-	2.84	37.8	3.51	39.6	4.60	43.6

3. METHODOLOGY

The study area is in the section 7 of Moghan Agro industrial cattle breeding company in Ardebil province, located at 47^0 48' east longitude and 39^0 25' north latitude (Fig. 2). The study was conducted in an area of 445 ha, of witch, 345 ha is utilized with 6 centers pivot machine while the other 100 ha is not irrigated.

Elevation is 130 to 169 m amsl and the slope direction is North West to south east.

3.1. Project Specification and characteristics (land zone scheme)

As the company officials asked that crop patterns of total land to be similar to 3 main pivot machines (7-7-2, 7-7-5, 7-7-6),the classification pivot no 7-7-2 has got the same pattern as zone A, and pivot no 7-7-5 and zone B have the same crop pattern and zone C has a similar pattern to pivot no 7-7-6 (Figs. 3 and 4).

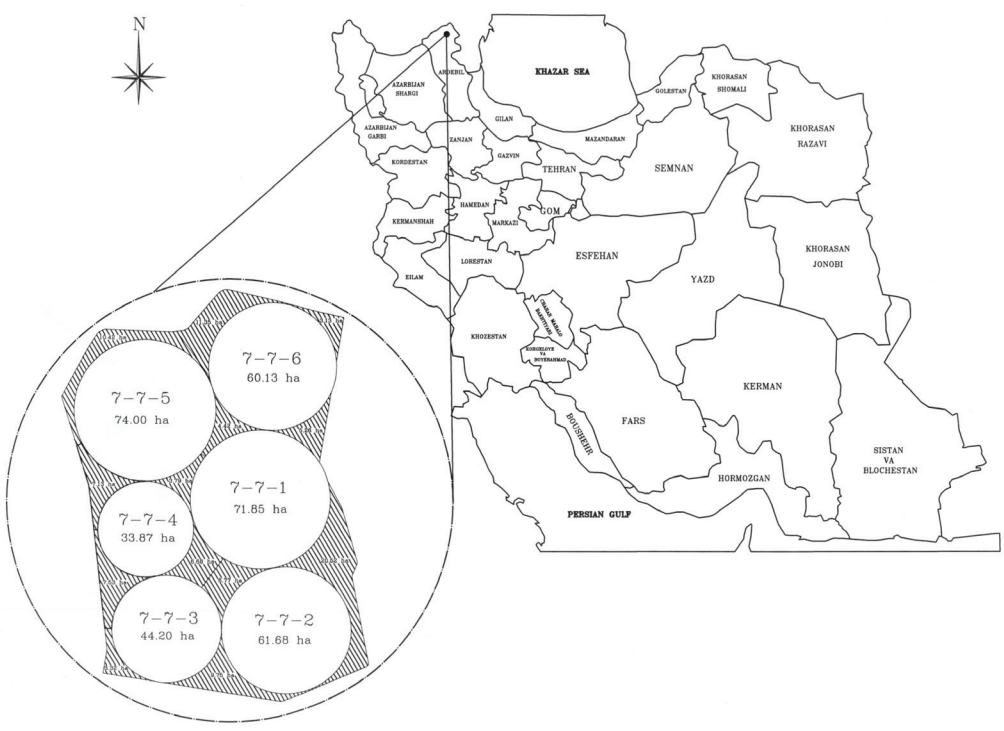

Fig. 2. Project location (Iran) (Emplacement du projet (Iran))

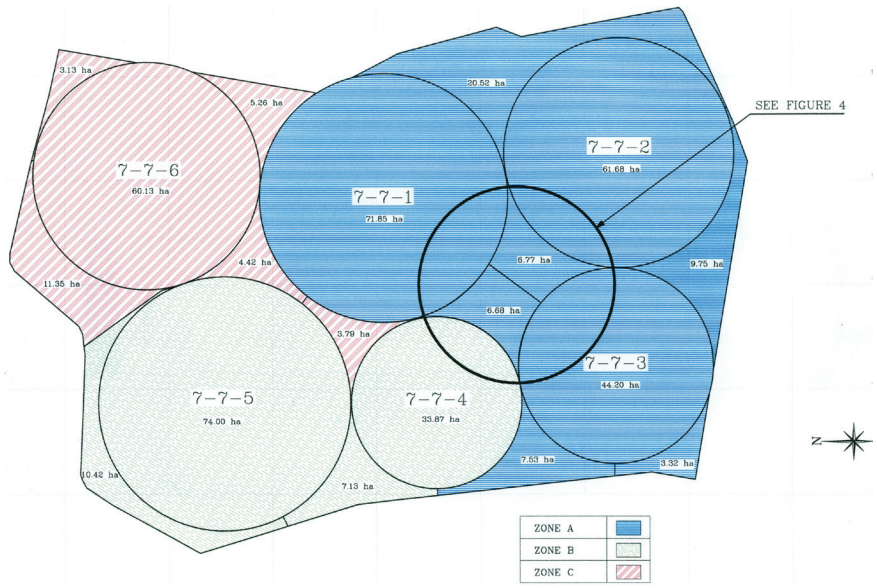

Fig. 3. Land segmentations according to crop pattern (Segmentations des terres en fonction des cultures motif)

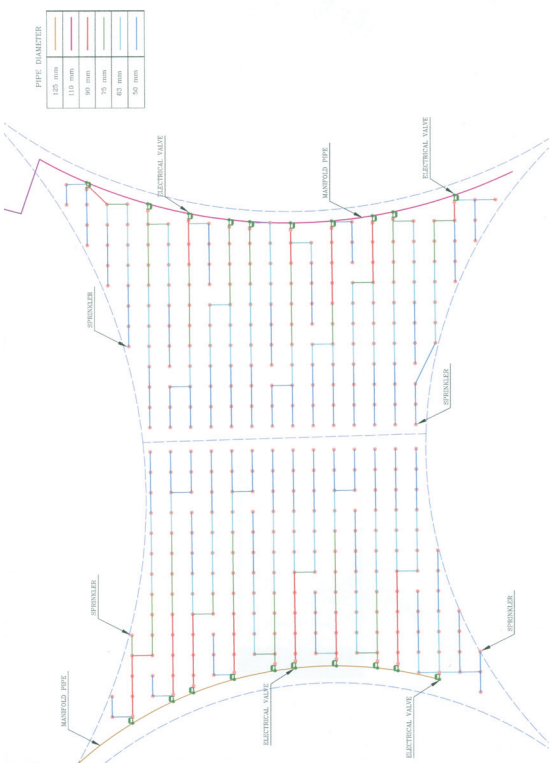

Fig. 4. Part of Irrigation network plan (innovative irrigation system) (Fait partie du plan du réseau d'irrigation (système d'irrigation novateurs))

3.2. Hydraulic design and coordination of the pressure requirement for pivot machine and innovation system

Table 2 summarize the output of the hydraulic software (water Gems). The Table shows that difference in working pressure, between pivot machines and the innovative irrigation system is minimal and there is a possibility of using the same pump.

Table 2. Difference in working pressure, between pivot machines and innovative irrigation system of surrounding lands (Différence de pression de travail, entre les machines de pivot et d'irrigation novateurs système des terres environnantes)

Zone ID	Working pressure (m)	Number of relative center	Working pressure (m)	Pressure difference (m)
A	44	7-7-2	47	+3
B	42	7-7-5	41	-1
C	37	7-7-6	37	0

As illustrated before, crop pattern of each pivot and innovative irrigation of surrounding lands are the same. Therefore, using the programmed PLC coordinates irrigation time of irrigation turns in surrounding lands and rotation speed of pivot. In Figure 5 pressure changes during the length of pivot spans and the minimum pressure of the beginning of pivot are depicted.

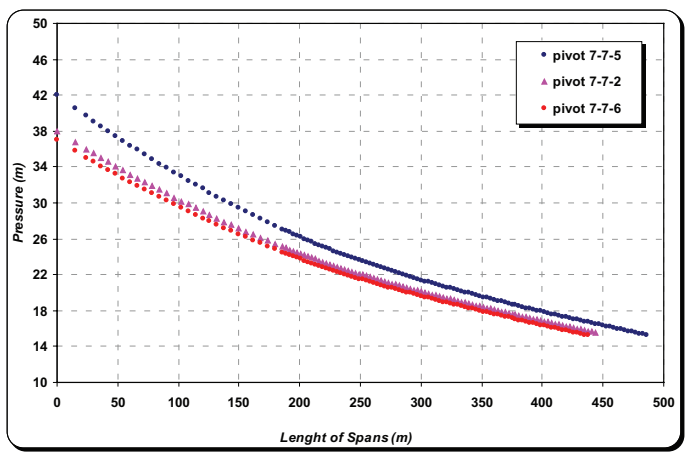

Fig. 5. Pressure changes during the length of pivot spans (Les changements de pression pendant toute la durée de travées pivot)

4. ECONOMIC REVIEW

If there were no demand for automatic system, the only irrigation method that could be recommended was permanent irrigation system with moveable sprinkles, which is most commonly adopted in Iran. Therefore, comparison between the economic coast of innovative system and common irrigation system in 100 ha of the lands around the center pivot has been made. Mean while the characteristics of projects in two irrigation system have been described.

4.1. Permanent classic sprinkler irrigation system with moveable sprinklers

This system is the same of solid-set irrigation system with buried pipes except that the sprinklers could manually be moved; spacing between sprinklers is 25m, also 25m between laterals. Sprinklers flow rate is 2/5 to 3 lit/s, diameter of throw is 50 m and working pressure is equivalent to a water head of 45~50, network of pipes made of PE100 polyethylene material (PN6, SF1.25), size of pipe are 63,110,125,160, 200 mm and their length are 34500,1500, 2300, 5000, 4200 and 840 m, respectively.

4.2. Fully automated permanent classic sprinkler system with buried pipes (with the ability to collect sprinklers)

This system is between a solid-set classic system and a permanent classic system with moveable sprinklers. Table 3 shows the sprinklers characteristics. Sprinklers spacing is 18 ×18 meter. Pipes diameters are 50,63,75,90,110,125,160 and 200 mm and their length are 21750, 3620, 6400, 5300, 3770, 59500, 3300 and 2630 m. It should be mentioned that pressure supply in this project is bypassed from pivots pump but in the economic analysis, the cost of pumping station in the innovative system has been considered. Costs in permanent classic sprinkler irrigation system with moveable sprinklers includes: preparation of equipments, implementation of pumping station, pipe placement, automatic valves and equipment installation and joint stabilizers.

The total costs of implementing these two system in 100 acres (40.47 ha) are 5121.9 & 5380.5 million rails, respectively. In Table 3 total cost in terms of purchasing of components and commissioning are given separately.

Table 3. Summery of project costs in irrigation system discussed (million rails) (Estival des coûts du projet dans le système d'irrigation discuté (en millions de rails))

Description	Innovative system	Permanent irrigation Sprinklers system
Equipment cost	3335	2598
Implementing cost	2045	2524
Total project cost	5380	5122
Cost per hectare	53.8	51.2

5. RESULTS AND DISCUSSION

5.1. Polyethylene material saving

After hydraulic analysis and Polyethylene pipe diameter determination, weight of components in both irrigation systems was calculated. Based on calculation per hectare and the total land on project 182 and 18,172 kg of polyethylene material are saved, respectively. It means that the amount of materials in permanent irrigation system is 13.8 % more than of innovative one.

Table 4 shows the amount of material and cost savings in different levels of irrigation networks. According to the Table, by implementing an innovating irrigation system, 14828 million Rails will be saved for an area of 10,000 ha.

5.2. Comparison of investment costs:

Comparing the commissioning costs for both irrigation systems, the total cost of the innovative irrigation system is 258.6 million rails more than that of permanent classic sprinklers system. In other words, total cost of permanent system is 5 % less than that of innovative. The two systems cost differences per hectares corresponds to 2.6 millions rails.

Table 4. Polyethylene material and cost saving in different areas (innovative irrigation system) (Polyéthylène et de réduction des coûts dans différents domaines (système d'irrigation novateurs))

Description	Area (ha)				
	5000	10000	20000	50000	100000
Material quantity (ton)	337	674	1348	3370	6740
Price (million rails)	7414	14828	29656	74140	148280

5.3. Energy cost

Working pressure for the innovative and the permanent system sprinklers are 2.8 and 4.5 atm, respectively. So power required for innovative and permanent system are 38 and 65 Kw., respectively and the number of working pump in both system are 2. Considering the above information, the difference between power consumption of the two systems is:

$$2\times65 - 2\times38 = 54 \text{ kw}$$

Assuming 1,070 hours is working time for each pump in a year and actual prices of electricity is 787 rails / kw, the energy cost saving per year due to innovative system of irrigation per hectare will be:

$$54\times1{,}070\times787 = 45{,}473{,}000 \text{ Rails}$$

Tables 5 to 8 show energy cost saving in a year considering different areas of irrigation net works.

Table 5. Annual energy consuming (Consommation d'énergie annuelle)

Description	Innovative system	Permanent classic sprinkler system
Annual water requirement (m^3)	433,603	495,546
Average of flow (lit/s)	112.32	112.32
Total required head (m)	35	60
Power (kw)	76.5	131.1
Annual energy cost (Rials)	64,535,949	126,437,778

Table 6. Energy cost saving by the different areas of innovative irrigation network (million rials) (Des coûts d'économie d'énergie par les différents domaines du réseau d'irrigation novateurs (millions de rials))

Project cost	Area (ha)				
	100	500	1000	2000	5000
Energy cost saving, Million Rials	45.5	227.5	455	910	2275

Table 7. Total Volume of water requirement (Permanent classic sprinkler irrigation) ((Volume total des besoins en eau (permanents système classique sprinklers))

Annual	Mar.	Feb.	Jun.	Dec.	Nov.	Oct.	Sep.	Aug.	Jul.	Jun.	May	Apr.	Parameter	Yield
73	5	5	3	2	8	0	0	0	0	6	27	17	Effective pre-cipitation (mm)	Wheat
283	36	18	8	6	8	0	0	0	0	38	94	75	Potential Evapo.(mm)	
210	31	13	5	4	0	0	0	0	0	32	67	58	Net irrigation re-quirement (mm)	
300	44	19	7	6	0	0	0	0	0	46	96	83	Gross irrigation (mm)	
--	0.17	0.07	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.17	0.36	0.31	Average of hydro module ($Lits^{-1}ha^{-1}$)	
55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	Crop intensity (%)	
73	5	5	3	2	8	0	0	0	0	6	27	17	Effective pre-cipitation (mm)	Common Barley
238	36	18	8	6	8	0	0	0	0	14	73	75	Potential Evapo.(mm)	
165	31	13	5	4	0	0	0	0	0	8	46	58	Net irrigation requirement (mm)	
236	44	19	7	6	0	0	0	0	0	11	66	83	Gross irrigation (mm)	
--	0.17	0.07	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.04	0.25	0.31	Average of hydro module($Lits^{-1}ha^{-1}$)	
10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	Crop intensity (%)	
73	5	5	3	2	8	0	0	0	0	6	27	17	Effective pre-cipitation (mm)	Rape (colza)
311	40	20	9	7	9	0	0	0	0	42	103	83	Potential Evapo.(mm)	
238	35	15	6	5	1	0	0	0	0	36	76	66	Net irrigation requirement (mm)	
340	49	21	8	7	1	0	0	0	0	51	109	94	Gross irrigation (mm)	
--	0.18	0.08	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.19	0.41	0.35	Average of hydro module($Lits^{-1}ha^{-1}$)	
35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	Crop intensity (%)	
7	0	0	0	0	0	0	0	0	0	7	0	0	Effective pre-cipitation (mm)	Flint Corn
663	0	0	0	0	0	0	58	214	222	169	0	0	Potential Evapo.(mm)	
656	0	0	0	0	0	0	58	214	222	162	0	0	Net irrigation requirement (mm)	
937	0	0	0	0	0	0	83	306	317	231	0	0	Gross irrigation (mm)	
--	0.00	0.00	0.00	0.00	0.00	0.00	0.31	1.14	1.18	0.86	0.00	0.00	Average of hydro module($Lits^{-1}ha^{-1}$)	
20.0%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20.0%	Crop intensity (%)	
495	46.1	19.5	7.5	6.0	0.4	0.0	16.6	61.1	63.4	90.5	97.4	86.6	Gross irrigation	Crop pattern
100													Area (ha)	
495,546	46123	19487	7549	6019	400	0	16585	61192	63479	90544	97492	86676	Volume of water requirement (m^3)	

Table 8. Total Volume of water requirement (innovative system) (Volume total des besoins en eau (système innovant))

Annual	Mar.	Feb.	Jun.	Dec.	Nov.	Oct.	Sep.	Aug.	Jul.	Jun.	May	Apr.	Parameter	Yield
73	5	5	3	2	8	0	0	0	0	6	27	17	Effective precipitation (mm)	Wheat
283	36	18	8	6	8	0	0	0	0	38	94	75	Potential Evapo.(mm)	
210	31	13	5	4	0	0	0	0	0	32	67	58	Net irrigation requirement (mm)	
263	39	16	6	5	0	0	0	0	0	40	84	73	Gross irrigation(mm)	
--	0.14	0.06	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.15	0.31	0.27	Average of hydro module($Lits^{-1}ha^{-1}$)	
55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	Crop intensity (%)	
73	5	5	3	2	8	0	0	0	0	6	27	17	Effective precipitation (mm)	Common Barley
238	36	18	8	6	8	0	0	0	0	14	73	75	Potential Evapo.(mm)	
165	31	13	5	4	0	0	0	0	0	8	46	58	Net irrigation requirement (mm)	
206	39	16	6	5	0	0	0	0	0	10	58	73	Gross irrigation(mm)	
--	0.14	0.06	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.04	0.21	0.27	Average of hydro module($Lits^{-1}ha^{-1}$)	
10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	Crop intensity (%)	
73	5	5	3	2	8	0	0	0	0	6	27	17	Effective precipitation (mm)	Rape (colza)
311	40	20	9	7	9	0	0	0	0	42	103	83	Potential Evapo.(mm)	
238	35	15	6	5	1	0	0	0	0	36	76	66	Net irrigation requirement (mm)	
298	43	19	7	6	1	0	0	0	0	45	96	82	Gross irrigation(mm)	
--	0.16	0.07	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.17	0.36	0.31	Average of hydro module($Lits^{-1}ha^{-1}$)	
35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	Crop intensity (%)	
7	0	0	0	0	0	0	0	0	0	7	0	0	Effective precipitation (mm)	Flint Corn
663	0	0	0	0	0	0	58	214	222	169	0	0	Potential Evapo.(mm)	
656	0	0	0	0	0	0	58	214	222	162	0	0	Net irrigation requirement (mm)	
820	0	0	0	0	0	0	73	268	278	203	0	0	Gross irrigation(mm)	
--	0.00	0.00	0.00	0.00	0.00	0.00	0.27	1.00	1.04	0.76	0.00	0.00	Average of hydro module($Lits^{-1}ha^{-1}$)	
20.0%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20.0%	Crop intensity (%)	
73	5	5	3	2	8	0	0	0	0	6	27	17	Gross irrigation	Crop pattern
100													Area (ha)	
433,603	40357	17051	6605	5267	350	0	14512	53543	55544	79226	85306	75842	Volume of water requirement (m^3)	

5.4. Depreciation costs

The deprecation costs in both permanent classic sprinkler irrigation systems with moveable sprinkler and innovative system are shown in tables 9 and 10. It should be noticed that, there is no study and documents for some components of irrigation system in terms of their depreciation coefficient, however, regarding the history of execution of pressurized irrigation systems in Iran, this coefficient is extracted for different components of network. Regarding the above table, the difference in depreciation costs between two systems, is 1950 million rials in one year.

Table 9. Annual Depreciation costs (Permanent classic sprinkler irrigation system) (Les coûts annuels d'amortissement (permanents système classique aspersion))

No.	Description of project component (preparation and installation)	Life cycle (n)	Annual Depre-ciation (1/n)	Weight Per-centage (%)	Annual Weight Per-centage (%)	Annual Depre-ciation Costs (million rails)
1	Pipes & joints	30	0.03	46	1.5	312.1
2	Quick valves	5	0.20	9	1.8	
3	Sprinklers	5	0.20	6	1.2	
4	Pumping station	25	0.04	20	0.8	
5	Order components	25	0.04	19	0.8	
Total		--	--	100	6.1	

Table 10. Annual Depreciation costs (innovative system) (Les coûts annuels d'amortissement (système innovant))

No.	Description of project component (preparation and installation)	Life cycle (n)	Annual Depre-ciation (1/n)	Weight Per-centage (%)	Annual Weight Per-centage (%)	Annual Depre-ciation Costs (million rails)
1	Pipes & joints	30	0.03	35	0.3	228.9
2	Quick valves	15	0.07	5	1.3	
3	Sprinklers	15	0.07	19	0.7	
4	Pumping station	25	0.04	18	0.2	
5	Electrical valves	30	0.03	5	1.2	
6	Order components	25	0.04	18	0.6	
Total		--	--	100	4.3	

6. CONCLUSIONS

The primary investment for permanent system and system innovative system (considering the automation costs) is estimated about 5122 million rials and 5381 million rials , respectively. Also the present value of current costs including O&M costs, annual electricity consumption and depreciation of equipment according to the cash flow table with interest rate of 7% for permanent system is calculated as 13529 and for innovative system is calculated as 9052 million rials. Also, the annual electricity consumption is estimated to be 160.7 in permanent system and 82 Megawatt-hours in 100 ha. Based on the economical analysis, application of this innovative system can result in cutting the costs by 45 million Rials per hectare and also increasing revenue during the life of the project (30 years) in comparison with permanent system. this is about 7500 million Rials during the effective life of the project. In addition, considering the increase in productivity, a rise of about 15% could be considered in the project revenue. Therefore the internal return rate for the permanent system and innovative system is estimated to be 7.1 and 19.7 % respectively.

Based on further investigations, the new proposed system, not only was chosen as the best alternative to fill the gaps between the center pivots of the study area but also in other farmlands, it is strongly recommended as an independent system regarding the fact that it could have the most conformity with small land holdings, variety of cropping patterns and steep slope pieces of land.

The least impact of substituting this system with the common permanent classic system with moveable sprinklers for areas of 1000, 10000, 100000, 1000000 ha is cutting in present value of costs by 45, 450, 4500 and 45000 billion rilas respectively and increase of present value of national revenues by 30, 300, 3000 and 30000 billion rials respectively.
Moreover, in the same order, there would be a decrease in electricity consumption by 880, 8800, 88000 and 880000 Megawatt-hours per year.

REFERENCES

Allen, R.G., Pereira, L.S., Raes, D. and Smith, M., 1998. Crop vapotranspiration: Guidelines for computing crop water requirement. FAO Irrigation and drainage paper 56, FAO, Rome.

Sanks, L.R., 1998, Pumping station design: second edition. 441P.

Joseph. S. T., Standards Engineering practices and data. ASAE, 1990. 37th edition. MI49085.

Burt, C.M. and Keller, J., 1997. Very low-pressure sprinkler Irrigation, NSAE paper No. 76-2517.

Keller, J. and Bliesner R. D., 1990. Sprinkler amd trickle irrigation. Van Nostrand Reinhold Publishing. New York. 625P.