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Technical-Economical Comparison of Irrigation Method Replacement on the Irrigation Systems Subject to Rehabilitation

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Abstract

In contemporary conditions the existing Program for Rehabilitation of Irrigation Systems is widely spread in Georgia. In the project tasks, as a rule, notwithstanding the natural-climatic conditions and without justification of the necessity, there is requested reviewing of possibility to replace the gravity irrigation by drip irrigation. The article is dedicated to the appropriateness of such replacement in the course of rehabilitation of irrigation systems. To identify economic efficiency of such requirement, there has been reviewed one of the distributors of the general irrigation system, where the gravity irrigation is to be replaced by drip irrigation. For the both methods there are determined capital and operating costs and there are calculated the values of Pure Net Variation. It has been found that such replacement during the rehabilitation conditions is economically unjustified and is appropriate only when water shortage in a feeding source.

Keywords: Rehabilitation of irrigation systems; gravity irrigation; drip irrigation; capital costs; operating costs; economic efficiency.

1. Introduction

Georgia belongs to the countries, where production of agricultural products depends on irrigation to a great extent and, as a result, faultless operation of the irrigation systems was always seriously considered. Besides, the Eastern and Southern regions of the county – main irrigation zones - encounter shortage of irrigation water, which, due to global climate change, can become even more serious.

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It must be admitted that the agriculture, generally, and irrigation, concretely, are one of the basic consumers of this most precious natural resource, crucial in any sphere of human life, and the mentioned demand will increase with time. Thus, thrifty consumption of water is the current demand, without which the civilized society cannot be imagined.

2. Main Part

At the end of the 1980s, the irrigation areas of Georgia totaled 312 thousand hectares, encompassing both the engineering systems constructed in the 1960s to 1980s and earlier non-engineering systems with a low coefficient of efficiency. During the following years the mentioned area was reduced and in the first decade of the XXI century it equaled only 88 thousand ha. Scanty financing of operational procedures due to changed economic situation should be named the first among the reasons of such reduction. Besides, it should be mentioned that some of the so called "fillable" reservoirs earmarked for irrigation, filling of which by commencement of the irrigation season, was considered through mechanical increasing of the water level and was cancelled due to the increased power supply tariff. Besides, some of the reservoirs, construction of which was planned earlier, were not built.

In the recent years rehabilitation of irrigation systems has been widely developed. It is true, that, unlike the reconstruction, the rehabilitation means restoration of the existing damaged system (structure) without changing of the operating principle, but due to the reasons given above, in the significant part of the project tasks there is also emphasized the possibility of arrangement of contemporary drip irrigation systems [1, 2]. In this regard the economic side of such replacement is interesting – to what extent it is justified conversion of the system (or its part) earmarked for gravity irrigation to other method of irrigation, to drip irrigation in this case.

For comparison there was taken a distributor of the general irrigation system in Shida Kartli region (Kareli, Gori, Kaspi municipalities), providing service to 100 ha area (the land plot length is 3,500 m and average width – 300 m). The works, being similar for the both versions, are not given. Average inventory results, according the comparison of similar facilities' project documentation, are the following:

- Distribution channel – length – 3,500 m, monolithic concrete δ = 15 cm, rectangular section with the sizes b = 0,8 m, h = 0,6 m, finishing damage - 30 %, section littering – up to 12% of the channel depth;
- Distribution wells – monolithic concrete with the sizes - 1,0 x 1,0 m, depth - 0,9 m, wall thickness δ = 20 cm, one-way in each 100 m (total number - 35 pcs), surface shields 80 x 80 cm and 40 x 40 cm, with a manually operated screw crane; shield frames and lifting mechanisms are damaged; the wells are to be cleaned from debris - 20% of the well depth, damaged concrete - 15%.

As while drip irrigation the distance between irrigation pipes and their length are different for agricultural crops, during comparison there was taken arrangement of a dripping system for the following crops: perennial plants (orchard and vineyard), kitchen garden, field crops (Table 1).

Table 1: Drip Irrigation System Parameters

Parameters		**Orchard**	**Vineyard**	**Kitchen garden**	**Field crops**
Distance between irrigation pipes, (m)		2,5 – 3,0	2,5	0,5	0,7
Length of the irrigation pipes (m)		100	100	50 - 60	100
II line distributor Pipeline threshold length (m)		100	100	160	100
Total length (m)	Irrigation pipelines d=12 mm, with drips	346 500	420 000	2 100 000	1 841 000
	II line distribution pipelines d=25 mm	10 080	10 080	6 125	10 080
	I line distribution pipelines d=50 mm	10500	10500	7000	10500
	Main distribution pipeline d=75 mm	200	200	160	200

According to these data, there was determined the volume of the basic distribution rehabilitation works (Table

2).

Table 2: Volume of the Distribution Rehabilitation Works

№	Works	Gravity irrigation	Drip irrigation system			
			Orchard	vineyard	Kitchen garden	Field crops
1	Manual cleaning of the distributor and well section from debris (m^3)	175	-	-	-	-
2	Restoration of the distributor and wells with monolithic concrete B-15 (m^3)	312	-	-	-	-
3	Dismantling of the distributor finishing and wells, disposal of the debris in 10 km (m^3)	-	1071	1071	1071	1071
4	Dismantling of the damaged shields (kg)	-	1920	1920	1920	1920
5	Rough leveling of the territory by means of a bulldozer (m^2/m^3)	-	28 000 1400	28 000 1400	28 000 1400	28 000 1400
6	Replacement of the damaged shields (unit/kg)	70 4025	-	-	-	-
7	Installation of a plastic main distribution pipeline d=75 mm (m)	-	200	200	160	200
8	Installation of a plastic I line distribution pipeline d=50 mm (m)	-	10500	10500	7000	10500
9	Installation of a plastic I line distribution pipeline d=50 mm (m)		10 080	10 080	6 125	10 080
10	Installation of a plastic drip irrigation pipeline d=12 mm (m)	-	346500	420000	2100000	1841000
11	Installation of a centrifugal pump with the capacity up to 20 m^3/hrs. water head of 10 m (unit)	-	1	1	1	1
12	Reservoir construction	-				
	Monolithic concrete B-15 (m^3)		52	52	63	78
	Reinforcement (kg)		3100	3100	3800	4650

Comparative volumes of the annual operating works (Table 3 [3, 4]) were defined considering the following:

- According to the data of Georgian Amelioration LLC, in the case of gravity irrigation the irrigating flow equals 20-25 l/sec and using this flow each irrigator can irrigate 2 ha area per day;
- Duration of drip irrigation per single case of irrigation is as follows: for an orchard – 10 hours, for a vineyard – 7 hours, for a kitchen garden – 4 hours and for field crops – 4 hours; the irrigation is carried out with interruptions during one-three days;
- Filling of the drip irrigation underground reservoir is meant with the help of a main channel using

gravity after each case of irrigation so that the deposits are settled down prior to the next irrigation;

- Supplying of water to the drip irrigation systems is considered by means of a pump;
- The irrigation pipeline for an orchard, kitchen garden and field crops is arranged directly on the earth, thus, at the beginning of each irrigation season it should be installed and dismantled at the end of the season. The irrigation pipeline for a vineyard is to be fixed to the lower wire of the vine line trellis.

Table 3: Volumes of the Irrigation System Operating Works

№	Works	Orchard	Vineyard	Kitchen garden	Field crops
s					
1	Manual cleaning of the distribution channel from sediments and debris (m^3)	90	90	90	90
2	Digging of temporary channels by means of a channel digger with the foundation width of 0,4 m and depth – 0,3 m (m)	10 500	10 500	10 500	10 500
3	Operation of irrigators for area irrigation (man/hrs.)	3600	3600	7200	4800
Drip irrigation					
1	Installation of a plastic irrigation pipeline with drips d=12 mm at the beginning of the irrigation season (m)	346500	-	2100000	1841000
2	Cleaning of the system filter (unit)	6	7	7	6
3	Power consumption (kW/hrs.)	240	210	510	84
4	Dismantling of a plastic irrigation pipeline with drips d=12 mm at the end of the irrigation season (m)	346500	-	2100000	1841000
5	Manual cleaning of the reservoir from sedimentation at the end of the irrigation season (m^3)	20	20	25	30

It is experimentally confirmed that, as a results of application of the drip irrigation, the yield of agricultural crops is increasing by 30-35%. Bearing the above in mind, Table 4 shows the construction and operating cost [5] and economic indicators of the distributor to be discussed.

Table 4: Economic Indicators of Various Irrigation Methods

№	Indicator	Orchard	Vineyard	Kitchen garden	Field crops
Gravity irrigation					
1	Cost of rehabilitation (thousand GEL)	412,45	412,45	412,45	412,45
2	Operating cost (thousand GEL)	33,15	33,15	59,07	41,79
3	Discount coefficient	0,12	0,12	0,12	0,12
4	NPV accumulation term (year)	20	20	20	20
5	NPV (thousand GEL)	397	398	870	74
6	Return term (year)	6	6	4	13
Drip irrigation					
1	Cost of rehabilitation (thousand GEL)	333,47	372,82	1222,5	1143,37
2	Operating cost (thousand GEL)	17,77	0,433	102,52	92,73
3	Discount coefficient	0,12	0,12	0,12	0,12
4	NPV accumulation term (year)	20	20	20	20
5	NPV (thousand GEL)	567	558	203,0	-664,0
6	Return term (year)	4	4	10	-

Table analysis shows that using of drip irrigation systems to irrigate vegetables and field crops is related to the necessity of frequent installation of irrigation pipelines, causing increasing of the costs of both construction and operating works.

In order to determine the economic efficiency of replacement of the gravity irrigation by drip irrigation while rehabilitation of the irrigation systems over the entire site or its part, it should be taken into consideration that the irrigation system is not meant for only a single crop and in the discussed example the area of a general distributor service (100 ha) should also be divided according to the crops produced by a general holding. The location of the irrigation system in Shida Kartli and region's agricultural direction discussed in the article – basically fruit-cultivation and partially viticulture and field crops – stipulates area division: orchards – 40%, vineyard – 20%, field crops – 25% and kitchen garden- 15%. Respectively, using the data of Table 4, average weighed values of the Pure Net Variation (NPV) will be the following: rehabilitation with gravity irrigation restoration – GEL 387,4 thousand; arrangement of a drip irrigation system on the distribution service area – GEL 202.85 thousand.

3. Conclusion

While rehabilitation of irrigation systems the following factors are to be considered:

- In common conditions replacement of gravity irrigation by drip irrigation over the entire site or its part is not economically advisable;
- The mentioned replacement will be justified in the event of increasing the irrigation area in the conditions of water shortage or refusal to construct a reservoir on the feeding source (as it was the case with the river Tedzami);
- While arrangement of drip systems the priority should be given to perennial plants – orchards and vineyards.

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