INVESTIGATION OF ALTERNATIVE SOLUTIONS TO ILISU DAM AND HEPP

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Abstract

This study is an assessment of a hydraulic solution not only rescues Hasankeyf with countless ancient monuments from inundation, but also supplies the foreseen energy production of the Ilisu Dam and HEPP Project. An alternative composed of five dams on the Tigris River and its branches was developed as a result of the conducted hydro-meteorological, water potential and optimization studies together with considering the topographical and geological characteristics of the proposed dam locations. While there is a 27 percent decrease in the overall reservoir area compared to the existing project, 4426.1 hm^3 of water can be stored in these dams with a fill volume of 14.8 hm^3. Over this storage, determined according to the maximum water levels designated by considering the upstream schemes developed by State Hydraulic Works (DSI), General Directorate of Electrical Power Resources Survey and Development Administration (EIE) and incorporated companies according to Law No.4628, a volume of 3634.4 hm^3 can be used as active storage. In the fully developed upstream stage, according to the conducted consecutive operation studies, while the existing project has an energy production capacity of 3094.3 Gwh/year, the proposed project is capable of providing 3139.1 Gwh/year with a smaller installed power although there is a slight decrease in the produced firm energy.

Keywords: Ilisu Dam, Hasankeyf, Hydropower, Tigris Basin

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1. Introduction

Investigations on energy potential of the Tigris River, came into existence with reconnaissance studies resulted as use of elevations between 500 m and 370 m by Ucagac, Celikhan and Cizre Dams, were finalized in the feasibility report of Cizre Dam, offers a system composed of two dam projects, namely Ilisu and Cizre. However, there was an item not taken into consideration throughout these studies: a submerged international heritage, Hasankeyf [1, 2, 3].

Within the context of this article, an alternative formulation against to the Ilisu Dam and HEPP Project, perceived as indispensable because of flow regulation, enables Cizre Dam to supply water for the Silopi and Nusaybin-Idil-Cizre irrigations, and energy production capacities, was searched in order to rescue Hasankeyf with countless ancient monuments from inundation [3, 4].

2. Proposed solution to the Ilisu Dam and HEPP Project

A hydraulic solution composed of five dams on the Tigris River and its branches was developed as a result of the conducted hydro-meteorological, water potential and optimization studies together with considering the topographical and geological characteristics of the proposed dam locations, as drawn on Figure 1.

According to the studies conducted on 1:25000 scale at proposed sites, have to be the object of a detailed geological surveying to better clarify the conditions with regard to watertightness and extension of grouting works, the overall fill volume was observed as 14.8 hm^3 using the same dam type and section characteristics with Ilisu Dam [4, 5, 6].

Although there is a 10014.6 hm^3 reduction in the storage due to decrease in the crest elevation of the existing project from 530 m to 459 m, the mean elevation around Hasankeyf, the reservoirs volume becomes 4426.1 hm^3, determined according to the maximum water levels designated by considering the upstream schemes developed by State Hydraulic Works (DSI), General Directorate of Electrical Power Resources Survey and Development Administration (EIE) and incorporated companies according to Law No.4628, together with other four dams (Figure 1) [4].

At the designated maximum water levels, the reservoir area declines to 235.3 km^2 which connotes a notable reduction in the expropriation and resettlement process having a budget of 0.75 billion €, a higher value from the costs for the Ilisu scheme civil works, and a fertile land area of 86.1 km^2 rescued from inundation (Figure 1) [7].

The basin management policy of DSI as commissioning of downstream reservoirs firstly shows itself in this project as sediment control structures or waiting for construction of the upstream schemes, namely Garzan, Basoren, Sirvan, Alkumru, Eruh and Silvan Plain Dams. In this study, the minimum water levels of the proposed dams were determined for the fully developed upstream stage according to the sediment amount that would be deposited in the reservoirs as dead volume during the economic life of the projects. This amount was estimated using suspended load concentration data at the gauging stations operated by EIE with adding a 50 percent more due to base load [4, 8, 9].

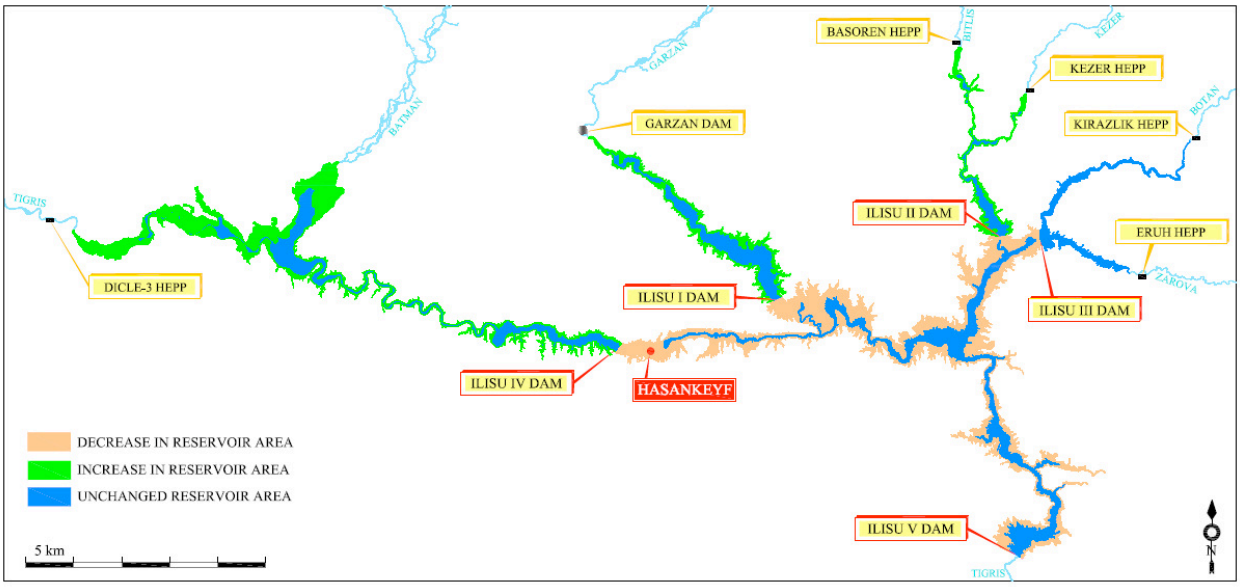

Figure 1. State of reservoir area as compared with the existing project

3. Hydropower potential of the alternative project

Flows in the Tigris River and its tributaries within the catchment are monitored by a comprehensive network of hydrometric stations operated by DSI and EIE, shown on Figure 2 [10, 11]. These records, corrected due to the existing irrigation abstractions, and correlations were used to produce a reasonably representative record of flows at dam sites for the period 1970-2000 [1, 4, 12, 13, 14].

Instead of using directly catchment area ratio to bring these runoff values to the dam locations, a joint operating policy was formulated at each branch for the stage corresponds to full development of the irrigation potential of the Tigris Basin as envisaged by DSI [1, 4, 12, 13, 14]. It includes not only the existing reservoirs, but also the proposed projects developed by DSI, EIE and incorporated companies according to Law No.4628 in order to compensate the effects of the presence of upstream schemes and abstractions (Figure 2) [1, 4, 20, 21].

The consecutive operations of the schemes were simulated on a monthly basis throughout the 30-year historical record with the topographical and technical characteristics of the projects as taking into account net evaporation from the reservoir water surfaces estimated from precipitation, temperature and evaporation records at the meteorological stations operated by State Meteorological Service (DMI), as drawn on Figure 2 [4, 7, 12-30, 31]. From this were determined changes in storage, flows through turbines and spillway releases.

For the Ilisu I, II, III and IV Power Plants, the operation studies were conducted in accordance with a rule that guarantees the maximum firm power in 95 percent of the entire period, determined by trial and error in the series of runs, but also maximizes the generation of secondary power unrestricted up to the installed capacity together with a preliminary economic analysis to obtain optimum design discharges. In the optimization, runs were carried out with a range of design discharges plus varying penstock and energy tunnel characteristics in number and diameter for each trial (Table 1) [31, 32].

The inflow values of Ilisu V Dam were obtained by adding the intermediate basin flows to ones through the turbines and spillway releases of other four dams, and the same optimization procedure was applied for this plant with considering the Silopi and Nusaybin-Idil-Cizre projects irrigated from Cizre Reservoir (Table 1) [3].

4. Comparison of the existing and proposed projects

4.1. Energy production

In order to make an evaluation on the same base, the steps followed for the alternative scheme were applied to the existing project. After determination of the inflow values in the fully developed upstream stage, the operation study was simulated under the same rules and efficiencies by using the characteristics detailed in the environmental impact assessment report, listed in Table 1, together with considering the irrigation purposes [2, 3, 7].

The conducted consecutive operations shows that while the existing project has an energy production capacity of 3094 Gwh/year, the proposed one is capable of providing 3139 Gwh/year with a smaller installed power, in spite of a slight decrease in the produced firm energy. The minor differences in terms of water usage ratio and firm energy against a 54 percent decrease in the active storage illustrate the effect of upstream dams on flow regulation (Table 1).

4.2. Economy

Due to lack of knowledge about distribution of the preconstruction estimate of about 1100 million euro, composed of 650 million euro for all civil works and 450 million euro for the mechanical and electrical plant, over units of the scheme and rates tendered by the contractor, a degree estimation process based on topographical and geological studies from index maps, and not on thumb rules, but on experience of cost of previous work of the same type built was carried out in order to make an evaluation on the same base without any possibility of detailed surveys and investigations [4, 7].

In this context, after determination of the allocation of the initial outlay over the components of the project according to the estimate of Alkumru Dam and HEPP, the distributed costs plus the expropriation and resettlement expenses of about 750 million euro were transformed to the units of the proposed ones using the ratios of design discharges, installed powers, drainage areas, reservoir areas and fill volumes together with assuming the same costs as in the existing project for units like building site and 3 to 5 times more for some as injection depending on geological formations at dam sites. In addition, with an increase of 15 and 5 percent in the costs for civil and electromechanical works, respectively, due to contingent expenditures, the results listed in Table 1 were obtained as the possibility of construction of the proposed solution with an amount almost equals to the cost of the Ilisu Project [4, 5, 7, 27].

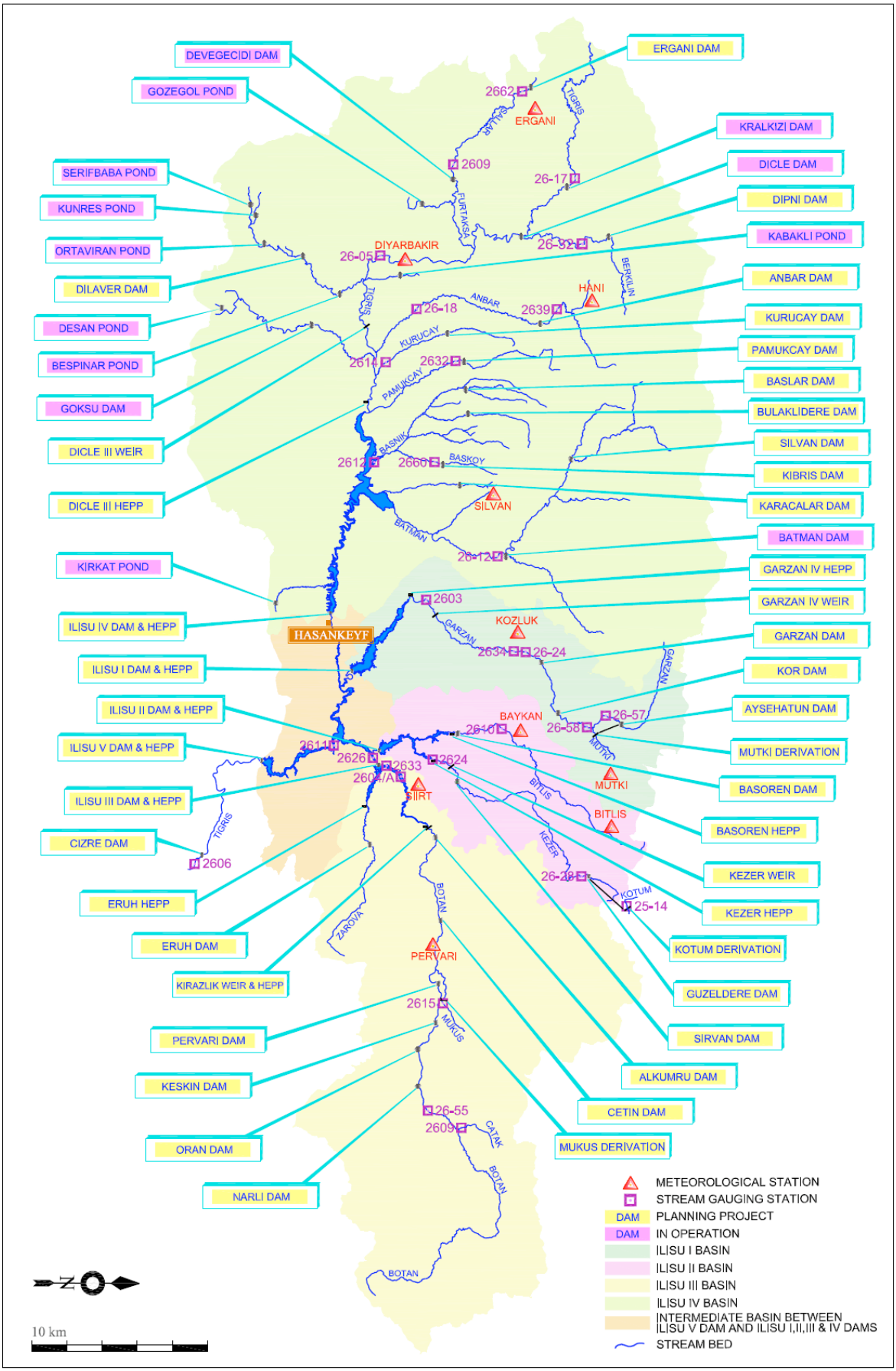

Figure 2. Project area and hydro-meteorological stations

Table 1. Salient features of the existing and proposed projects

Item	Unit	The Existing Project	The Proposed Project					
			Ilisu I	Ilisu II	Ilisu III	Ilisu IV	Ilisu V	Total
General								
Location	-	Sirnak/Dargecit	Batman/Besiri	Siirt/Merkez	Siirt/Merkez	Batman/Hasankeyf	Sirnak/Dargecit	-
River/Creek	-	Tigris	Garzan	Bitlis	Botan	Tigris	Tigris	-
Hydrology								
Drainage Area	km^2	36408.0	2883.0	2510.0	8872.7	20353.7	36408.0	-
Average Discharge	m^3/s	377.4	47.1	56.8	158.7	145.5	421.1	-
Annual Average Runoff	hm^3	11905.9	1481.8	1791.0	5015.4	4582.3	13292.9	-
Annual Average Natural Runoff	hm^3	15139.2	1647.2	1751.2	4798.7	7801.8	15139.2	-
Reservoir								
Max. W. L. during Re-regulation	m	525.0	530.0	530.0	525.0	530.0	457.0	-
Minimum Water Level	m	485.0	485.0	475.0	480.0	515.0	425.0	-
Total Vol. at Max. W. L.	hm^3	**10926.3**	1005.1	462.7	420.7	1625.9	911.7	**4426.1**
Active Storage	hm^3	**7847.6**	964.6	444.2	397.0	1006.9	821.7	**3634.4**
Dead Storage	hm^3	3078.7	40.5	18.5	23.7	619.0	90.0	-
Reservoir Area at Max. W. L.	km^2	**321.4**	41.9	19.8	16.2	109.2	48.2	**235.3**
Reservoir Area at Min. W. L.	km^2	111.4	5.1	2.0	2.2	39.3	8.3	-
Dam Embankment								
Type	-	Concrete Faced Rock-Fill	Concrete Faced Rock-Fill	Concrete Faced Rock-Fill	Concrete Faced Rock-Fill	Concrete Faced Rock-Fill	Concrete Faced Rock-Fill	-
Side Slopes	-	1/1.4 - 1/1.4	1/1.4 - 1/1.4	1/1.4 - 1/1.4	1/1.4 - 1/1.4	1/1.4 - 1/1.4	1/1.4 - 1/1.4	-
Thalwag Elevation	m	400.0	469.0	459.0	459.0	461.0	400.0	-
Crest Elevation	m	530.0	532.0	532.0	527.0	532.0	459.0	-
Crest Lenght	m	1820.0	942.8	1499.4	1674.6	1036.5	978.7	-
Crest Width	m	8	5	5	5	5	5	-
Height of Dam above Foundation	m	130.0	63.0	73.0	68.0	71.0	59.0	-
Fill Volume (exc. foundation)	hm^3	**23.3**	2.9	3.3	4.7	1.9	2.0	**14.8**
Penstock								
Number	-	3	1	1	2	2	5	-
Diameter	m	11.0	4.1	5.5	6.7	6.1	6.5	-
Length	m	407.0	200.0	200.0	200.0	200.0	200.0	-
Energy Tunnel								
Number	-	-	1	1	1	1	1	-
Diameter	m	-	4.5	6.2	10.6	9.6	16.2	-
Length	m	-	400.0	400.0	400.0	400.0	400.0	-
Powerhouse								
Turbine Type	-	Francis	Francis	Francis	Francis	Francis	Francis	-
Design Discharge	m^3/s	1266.0	65.0	120.0	355.0	290.0	825.0	-
Number of Units	-	6	1	1	2	2	5	-
Tailwater Level	m	400.0	468.0	458.0	458.0	460.0	400.0	-
Gross Head	m	125.0	62.0	72.0	67.0	70.0	57.0	-
Net Head	m	118.4	56.9	67.1	62.8	65.6	53.5	-
Total Installed Capacity	MW	**1200.0**	33.4	72.7	201.4	171.7	398.4	**877.6**
Operation								
Firm Energy	Gwh	**2766.9**	135.1	171.1	488.7	490.8	1205.5	**2491.2**
Secondary Energy	Gwh	**327.4**	8.2	46.1	139.2	130.6	323.8	**647.9**
Total Energy	Gwh	**3094.3**	143.3	217.2	627.9	621.4	1529.3	**3139.1**
Water Usage Ratio	%	98.6	88.8	89.9	92.6	87.9	93.8	-
Economy								
Initial Outlay ($x10^6$)	€	**1100**	131	146	296	275	491	**1339**
Expropriation & Resettlement ($x10^6$)	€	**750**	98	46	38	255	113	**550**
Total Cost ($x10^6$)	€	**1850**	229	192	334	530	604	**1889**

5. Conclusion

As a result of the conducted studies, it was seen that the proposed project is capable of not only rescuing Hasankeyf from inundation, but also providing almost the same benefits with the same cost as of the existing one. Moreover, it would be possible to construct some of these alternative schemes, especially Ilisu I, II and III Dams, by incorporated companies according to Law No. 4628 like other hydropower developments in the tributaries of the Tigris River.

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