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Balancing energy and environmental concerns: the case of the Kayraktepe dam, Turkey

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Abstract

In this study, an alternative solution for a large dam, namely the Kayraktepe Dam in Turkey, is investigated. The dam was planned for flood control, energy generation and flow regulation for a downstream irrigation project more than 30 yr ago, but until now the project has not begun due to it receiving severe criticism about environmental and social considerations. The project formulation was redeveloped several times in the past but the options were not found to be feasible. In this study, a detailed analysis of the available feasibility studies is provided and then a new formulation, consisting of the proposed one medium dam and five run-of-river type hydropower stations instead of a large scale dam, is evaluated. The new formulation is equivalent to the existing project in terms of energy production and flood control. On the other hand, there are some benefits relative to other configurations as solutions to some of the environmental and social problems being addressed.

1 Introduction

The idea of building a dam on the Göksu River was proposed more than 30 yr ago. After severe flooding along the river, the Kayraktepe project was designed to control floods, to produce energy and to supply irrigation water in 1982, as a 125 m high large dam. Four different dam locations were studied and finally a rock-fill dam with vertical clay core was chosen as an optimum (Hayashi, 1982). Thenceforth, an international competitive bidding process was initiated and the project was awarded. The World Bank provided loan guarantees of around two hundred million dollars. After the World Bank, Japanese, European and Arab Commercial Banks also provided loans amounting to three hundred fifty million dollars. The implementation of the projects under the investment program was started in 1986, however the World Bank decided not to support the project further after due considerations. The limited funds supplied by the World Bank was used for preliminary works such as camp facilities and access roads. In general, the concerns regarding the impacts of Kayraktepe Dam can be given under two main headings:

- Environmental: The Kayraktepe Dam will have negative effects on the river both upstream and downstream. There are several endemic species in the dam lake area. The Göksu Delta is located downstream from the site which is recognised as a Ramsar site. The dam will cut off sediment supply to the area downstream, which eventually leads to loss of fertility and long term coastal erosion.

- Social: Over the years the area has been heavily populated by people and the main economic activity is agricultural, tourism and husbandry.

The implementation and the commencement of the construction were not on the agenda till 1990s. In 1997, the Kayraktepe Dam and the HEPP Project were revised to reduce the height of dam due to remarkable development of social infrastructures and private properties in the project area (Sever, 2010). Under such circumstances the feasibility of a scheme of the project was reconsidered and a revised report was prepared in 1997. Accordingly, the design and the typical section of the dam were kept as they were and only the height of the dam was lowered by 35.50 m.

In 2000, the infamous report of World Commission on Dams (WCD) concluded that water infrastructure projects, including hydropower schemes, had “too often” been developed at an environmentally or socially unacceptable cost (WCD, 2000). It is the biggest victory of environmentalist and nongovernmental organizations against large dams. In the report, five core values were identified and twenty-six guidelines were listed for the construction of large dams. Turkey and some other developing economies placed strong criticism on the report, claiming that they had the right to economic development. However, from that time onwards, the construction of large dams became difficult due to actions taken by international credit agencies. More comprehensive scientific studies have followed showing the influence of large dams on the surrounding environment, social and climate (Hwang et al., 2007; Hossain, 2010; Wildi, 2010; Degu et al., 2011).

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Eventually, the energy market was liberalised in Turkey. "Regulation about Procedures and Principles for Contract Agreements in Water Usage Rights for Production in Electricity Market" was published in Official Gazette of Republic of Turkey with number 25150 on 26 June 2003 (MENR, 2003). This regulation is one of the most important milestones for the generation and the distribution of electricity in Turkey. Contractual matter of water usage rights have been edited with the publication of June 2003. The aim of this regulation can be summarised as to meet growing demand of electricity in Turkey by the involvement of the private sector, which is more competitive and faster than governmental organizations. A change has been made in the Contract Agreements in Water Usage Rights Regulation on 25 May 2004. With this change, six ongoing Hydroelectric Power Plant construction projects were transferred to the private sector.

Thus in 2003, through the Water Use Right Agreement, the private sector took its place in energy generation. In 2008, the Kayraktepe Dam and HEPP Project were awarded to a private company for a large scale dam formulation. However, the Kayraktepe project was redesigned by the private company in 2010 by changing the formulation to one medium dam and five regulators instead of a large scale dam (Sever, 2010).

Table 1 presents a chronology of the development plan of the Göksu Basin and the Kayraktepe project along with important national legislations related to water resources projects, inauguration dates of administrations related to water resources projects, and important international developments related to water resources project. It is seen from the chronology that the project has been changed several times. Therefore, in order to eliminate possible misunderstanding, the original formulation, the revised project and newly developed project are named as Kayraktepe-1982, Kayraktepe-1997 and Kayraktepe-2010, respectively, within this article.

In the present article, an alternative solution for the Kayraktepe Dam consisting of the proposed one medium dam and five run-of-river type hydropower stations (Kayraktepe-2010) instead of a large scale dam is evaluated.

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2 General characteristics of the basin

Göksu River is an important river system discharging into the Mediterranean Sea. There are two main tributaries of the river, namely Ermenek Creek and Göksu Creek. While flowing to the southeast, another two small streams (Hocasait Stream and Kurtsuyu) join the river. It has a total length of 260 km and a drainage basin of about 10 000 km^2. It discharges into the sea near Silifke where the Göksu Delta Plain developed due to the sediment carried by the river.

The Kayraktepe Dam and HEPP project is located on 80 km west of Içıl Province and extended between (33°15′ E, 34°15′ E) longitude and (36°15′ N, 37°00′ N) latitude within the Eastern Mediterranean region (see in Fig. 1). There are two plains being considered worth mentioning. One is the Mut plain on the north, and the second is the Silifke plain on the south. Figure 1 shows the location of the basin and a plan view of Göksu River system.

The dam site is characterised geologically by the following features: thick alluvium in the riverbed, high permeability of conglomerate, especially of the right abutment and major fault and sheared zone at the bedrock. Turkey is situated on the Alpine – Himalayan Earthquake Belt, and influenced the Alpine structure of Mediterranean Europe. Although, a fair amount of earthquake activity is observed, the most of the project area is situated within the earthquake free or less important zone. The climate of the project area exhibits typical Mediterranean characteristics as dry and hot summers, and mild and rainy winters. Annual average temperature at Silifke and Mut are 19 °C and 17.2 °C, respectively. Annual average precipitation at the dam site is around 600 mm and most of the snowfall occurs from November to March.

The population of the project area is around 20 000 (Cernea, 1991). It is observed that in rural area, the population tends to increase very slowly or even to decrease in some years. But on the other hand, in the urban centres, the population is increasing at about 5 % a year. This shows that there has been a strong tendency of immigration from rural areas to urban centres in recent years.

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3 General characteristics of the projects

In 1997, the previous feasibility report was revised. The basic idea and typical section of the dam were not modified in the final design report in 1982 except for the dam height. In this revised feasibility, it was concluded that the dam be lowered by 35.50 m; this was economically more advantageous than the original project. The reservoir area was decreased from 133 km^2 to 65.25 m^2, whereas the installed capacity of the project was decreased from 200 MW to 145 MW. In Kayraktepe-2010, the project was disintegrated into smaller projects. The plan view of this newly developed formulation is given in Fig. 2 and salient features of the new project are summarised in Table 2.

4 Evaluation of new formulation

4.1 Energy production

Environmental damage has not been included in cost-benefit analysis of early hydroelectric power projects as in the case of the Kayraktepe project.

The official cost-benefit analyses were carried out for the Kayraktepe project ignoring the project's external costs and only including construction and operational costs. When its external costs are internalised, the net present value of the project falls below zero and the benefit-cost ratio decreases from 1.35 to 0.84, indicating that the project is economically undesirable and the decision for its construction needs to be reconsidered (Biro, 1998). Biro (1998) studied Kayraktepe-1982 project's cost estimations with a more complete and informed economic analysis to estimate some of the local environmental and social costs of the project, and to incorporate these values into the project's cost-benefit analysis. Three major external costs were considered in cost-benefit analysis. These are the loss of agricultural income from the existing fields and trees in the reservoir area, the loss of value from the national forests which will

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be inundated, and the non-use values placed on the environment by the local people (Öztürk, 2011).

The benefits of a possible large dam (Kayraktepe-1997) and new formulations (Kayraktepe-2010) were calculated and given in Table 3. It was found that the cost benefit ratio of new formulation is satisfactory, although the total energy production will decrease.

4.2 Analyses of the flood control function

The principle objective of the flood control dam and the reservoir is to protect downstream communities. For this reason, the flood hydrographs of 50,100, 500, 1000 and 10 000 yr return period for the Kayraktepe dam were calculated. For this purpose, firstly the flood hydrograph of the Ermenek Dam, the Gezende Dam, the sub-basin between these dams, the Göksu Creek and the Kayraktepe Dam were obtained by daily average and annual peak flow records of stream gauging stations (SGS). Since the construction and operation starting time of the Mut Dam is unknown, through the planning phase the studies were prepared for both the cases as in operation or not. The outflow hydrographs of the Kayraktepe Dam were obtained from inflow hydrographs and flood routing studies. It should be emphasised that the same hydrological methodologies with the aforementioned feasibility reports were used in this study to make the comparison on an equal basis. However, the hydrological studies of the whole basin, which can be found in detail in Sever (2010), were revised. Firstly, the utilised flow data were updated. While the flow data until 1989 were used in the Kayraktepe 1997 report, the flow data were extended up to the year 2007 in the present study. Then, the characteristics of the projects within the basin were updated. In Kayraktepe 1997 report, the Ermenek Dam's characteristics were taken from the previous feasibility report. In the report, Ermenek Dam's flood storage was given as 160.68 hm^3. But actually, Ermenek Dam was constructed with flood storage of 298.85 hm^3. The differences between two projects are listed in Table 4 briefly.

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The peak value of the Kayraktepe Dam for a 500 yr return period flood, in case the Mut Dam is not in operation, was calculated as 2363.95 $m^3 s^{-1}$ and the volume of the flood was calculated as 2351.42 hm^3. Actually, the basin should be re-examined by more advanced techniques as mentioned in Şarlak (2012). The Kayraktepe Dam flood routing studies were done by using the volume–area curve and the 500 yr return period inflow flood hydrograph. According to flood routing studies, in the case that the Mut Dam is in operation, the needed volume to limit the outflow discharge calculated as 1200 $m^3 s^{-1}$ was 104.73 hm^3. This value is accepted as the permissible outflow peak discharge of the proposed alternative dam.

The results of these hydrological studies show that a smaller dam (like the dam height in the newly developed formulation) is also enough to limit the outflow peak. With this newly developed formulation, the outflow peak discharge could be decreased to 1200 $m^3 s^{-1}$ for a 500 yr return period flood. This discharge can flow inside Silifke District harmlessly.

A desire to control bigger floods with a large scale dam, resulted in a bigger area of land lost to the reservoir, which will lead to the inundation of largely populated areas upstream. Although the reservoir area is one of the crucial environmental and social variables, it has not commonly been allocated much importance. Thus, upstream rights should not be ignored when deciding the dam format. The people upstream from the site are living and producing their needs in their natural habitats. A bigger dam will force them to migrate downstream and they will not be as productive as before. We are responsible for minimizing the construction dam's adverse environmental and socio-cultural impacts rely on assessing trade-offs and on managing risks. Hence, we should take lessons learned from resettlement practise and other effects of large dams distributed around the world.

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4.3 Environmental considerations: analyses of the evacuation of sediments from reservoir by flushing

The dam practise in Turkey shows that the accumulated sediment in the reservoir lakes behind a dam is only considered while calculating the economic life of the reservoir, which is taken as approximately 50 yr in Turkey. In this approach, environmental and social issues are only included at the initial stage of the project and any change over the operation and maintenance period is not included (Tiğrek and Aras, 2011). However, to design a dam with appropriate sediment management may be crucial for downstream ecology.

Poulos and Collins (2002) examined 69 rivers out of 169 in the Mediterranean drainage basin and concluded that construction of hundreds of dams around the Mediterranean Sea, especially over the last 50 yr, has led to a dramatic reduction of approximately 50 % of the potential (natural) sediment supply. Such a reduction is considered to be the primary factor responsible for the loss of coastal (mainly deltaic) land, with annual rates of erosion ranging from tens to hundreds of meters.

There are a limited number of studies examining damming factor of coastal erosion on the coast line of the Mediterranean Sea in Turkey (Çetin et al., 1999; Tiğrek et al., 2008). Çetin et al. (1999) examined the Seyhan, Ceyhan and Göksu basin located in the northeastern Mediterranean where the most active shoreline changes have been occurring (Çetin et al., 1999). They indicated that the construction of the dams have an irreversible effect on the erosion of the deltas on the Mediterranean through inspecting the Ceyhan and Seyhan Rivers. It was observed greatly reduced sedimentation in the delta and erosion started at a rate of 24 696 $m^2 yr^{-1}$ on the mouth of the Seyhan due to construction of the Seyhan Dam on the river in 1954. As a result, from 1954 to 1995, an area of about 1 012 536 m^2 has been lost due to coastal erosion, and the delta became retrogradational. On the mouth of the Ceyhan River to the northeast, an area of 835 779 m^2 was eroded by the sea due to no sediment influx on the abandoned Ceyhan River channel in Yumurtalık Bay between 1948 and 1995. The total amount

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of progradation, from 1956 to 1995, on the mouth of the Göksu River is 398 445 m^2. However, there is erosion on the southwest at a rate of 4548 $m^2\,yr^{-1}$ from 1951 to 1995. The reason for the erosion is not due to damming but to changing of the flow pattern of the Göksu River. The total amount of retrogression here is about 200 125 m^2. The annual sediment amount at the Kayraktepe Dam axis was calculated as $1.13 \times 10^6\,m^3$. Since the dams are having a significant impact on sediment loads in the river (Palmieri et al., 2001; Işık et al., 2006; Lu and Siev, 2006; O'Reilly and Silberblatt, 2009; Bangqi Hu et al., 2009), the amount of retrogression will accelerate if a dam is constructed without sediment management facilities.

In fact, the coming sediments in the region can be transferred downstream before subsiding and solidifying during the flood period by means of flushing through the bottom outlets (Aras, 2009; Tiğrek and Aras, 2011).

The suitability of flushing can be examined by using Basson's Diagram (Basson and Rooseboom, 1997). The results for both the Kayraktepe-2010 and the Kayraktepe-1997 formulations are summarised in Table 5. In the table, K_w (=C_0/MAR) and K_t (=C_0/MSY) are the ratios of storage (C_0) to mean annual river runoff (MAR) and storage to mean annual sediment yield (MSY), respectively. According to Basson's Diagram, seasonal flushing is suggested in regions where K_w value is between 0.03–0.2. On the other hand, there will be excess water for flushing in the lower part of the diagram where $30 < K_t < 100$ (Tiğrek and Aras, 2011). It was found that the Kayraktepe-1997 is not suitable for flushing; however, the Kayraktepe-2010 is suitable for seasonal flushing.

5 Conclusions

The development of the land and water resources and total hydropower potential of the country have been on the agenda in Turkey since the early decades of the Republic. In order to combat fluctuations of the annual flows of many large basins throughout the year and over the years, the state has given priority to developing large-scale projects

(Tiğrek and Kibaroğlu, 2011). On the other hand, the public awareness for environmental protection has increased all around the world as well as in Turkey. Thus, cumulative environmental impacts of a large scale dam on the Göksu River need to be assessed, not only in the vicinity of the dam but river deltas downstream of the dam and river-flow dependent wetlands (Scheumann et al., 2011).

We found that a discussion on large scale formulation of the Kayraktepe Dam is very beneficial in the context of balancing energy and environmental concerns. Thus, an alternative solution consisting of one dam and five run-of-river type hydropower stations is proposed and evaluated through comparison with the large dams in terms of energy production and flood control.

The most important advantages of this new formulation can be summarised as

- a very large area containing numerous villages and valuable agricultural areas that were originally marked for expropriation and flooding will be preserved. A dramatic reduction in expropriation area by 83.5 % (down to 16.5 % of original) has been attained, where originally a 5000 ha area has been reduced to approximately 820 ha;

- the citizens living in the region will not be affected owing to significantly reduced expropriation;

- the Wild Life Protection Area to be flooded as per original formulation will be retained;

- the Göksu River Delta that, under the original formulation, would have been deprived of natural sediment inflow will now be completely preserved.

As a conclusion, an entirely renewable and environmentally compliant hydroelectric development yielding flood control and energy production will be realised through this formulation, with the replacement of a large dam by smaller units. The decision makers should consider these advantages for long term sustainable water management in Turkey.

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References

Aras, T.: Cost Analysis of sediment removal techniques from reservoir, Ms Thesis, Dept. of Civil Engineering, Hydromechanics Laboratory, Middle East Technical University, Ankara, Turkey, 2009.

Bangqi Hu, Zuosheng Yang, Houjie Wang, Xiaoxia Sun, Naishuang Bi, and Guogang Li: Sedimentation in the Three Gorges Dam and the future trend of Changjiang (Yangtze River) sediment flux to the sea, Hydrol. Earth Syst. Sci., 13, 2253–2264, doi:10.5194/hess-13-2253-2009, 2009.

Basson, G.: Hydropower dams and fluvial morphological impacts – an African perspective, the United Nations Symposium on Hydropower and Sustainable Development, Beijing, China, 27–29 October 2004, 1–16, 2004.

Basson, G. and Rooseboom, A.: Dealing with reservoir sedimentation, SA Water Research Commission Research Report, South Africa, 1997.

Biro, Y. E. K.: Valuation of the environmental impacts of the Kayraktepe Dam/Hydroelectric Project, Turkey: An Exercise in Contingent Valuation, Ambio, 27, 224–230, 1998.

Cernea, M. M.: Using knowledge from social sciences in development projects, World Bank, Washington DC, Discussion paper 114, 1991.

Çetin, H., Bal, Y., and Demirkol, C.: Engineering and environmental effects of coastline changes in Turkey, Northeastern Mediterranean, Environ. Eng. Geosci., 3, 315–330, 1999.

Degu, A. M., Hossain, F., Niyogi, D., Pielke, R., Shepherd, J. M., Voisin, N., and Chronis, T.: The influence of large dams on surrounding climate and precipitation patterns, Geophys. Res. Lett., 38, L04405, doi:10.1029/2010GL046482, 2011.

Hayashi, S. (project manager): Göksu – Kayraktepe dam and hydroelectric power plant feasibility report, prepared by Electric Power Development Co. Ltd., Japan and Suiş Proje Mühendislik Müşavirlik Ltd. Şti., Turkey, 1982.

Hossain, F.: On the empirical relationship between the presence of large dams and alteration in extreme precipitation, Natural Hazards Review, 11, 97–101, 2010.

Hwang, S. S., Xi, J., Cao, Y., Feng, X., and Qiao, X.: Anticipation of migration and psychological stress and the Three Gorges dam project, China, Soc. Sci. Med., 65, 1012–1024, 2007.

Işık, S., Sasal M., and Doğan, E. :Investigation of downstream effects of dams in the Sakarya River, J. Fac. Eng. Arc., 21, 401–408, 2006.

Lu, X. X. and Siew, R. Y.: Water discharge and sediment flux changes over the past decades in the Lower Mekong River: possible impacts of the Chinese dams, Hydrol. Earth Syst. Sci., 10, 181–195, doi:10.5194/hess-10-181-2006, 2006.

MENR (Ministry of Energy and Natural Resources of Turkey): The Procedures and principles of signing water use right agreement for production activities in electricity market, published in Official Newspaper, No: 25150, 26 June 2003, 2003.

O'Reilly, C. and Silberblatt, R.: Reservoir management in Mediterranean climates through the European water framework directive, Water Resources Center Archieves, Hydrology, University of California, 2009.

Öztürk, A.: Sustainability assessment of a hydropower project: A case study of Kayraktepe Dam and HEPP, M.Sc. Thesis, Dept. of Civil Engineering, Hydromechanics Laboratory, Middle East Technical University, Ankara, Turkey, 2011.

Palmierie, A., Shah, F., and Dinar, A.: Economics of reservoir sedimentation and sustainable management of dams, J. Environ. Manage., 61, 149–163, 2001.

Poulos, S. E. and Collins, M. B.: Fluviatile sediment fluxes to the Mediterranean Sea: a quantitative approach and the influence of dams, Geological Society, London, Special Publications, 191, 227–245, 2002.

Şarlak, N.: Flood frequency estimator with nonparametric approaches in Turkey, Fresen. Environ. Bull., 21, 1083–1089, 2012.

Scheumann, W., Baumann, V., Mueller, A. L., Mutschler, D., Steiner, S., and Walenta, T.: Environmental impact assessment in Turkish dam planning, Turkey's water policy: national frameworks and international cooperation, Springer-Verlang, Berlin Heidelberg, doi:10.1007/978-3-642-1936-2, 2011.

Sever, Ö.: Kayraktepe dam and HEPP, environmentally acceptable alternative solution, M.Sc. Thesis, Dept. of Civil Engineering, Hydromechanics Laboratory, Middle East Technical University, Ankara, Turkey, 2010.

Tiğrek, Ş. and Aras, T.: Reservoir Sediment Management, CRC Press/Balkema, Leiden, The Netherlands, 2011.

Tiğrek, Š. and Kibaroğlu, A.: Strategic role of water resources for Turkey, Turkey's water policy national frameworks and international cooperation, Springer-Verlag, Berlin Heidelberg, 27–42, 2011.

Tiğrek, Ş., Göbelez, Ö., and Aras, T.: Technological Perspectives for Rational Use of Water Resources in the Mediterranean Region (Sustainable management of reservoirs and preserving water quality), Bari, Italy, IAM Bari: CIHEM (Centre International de Hautes Etudes Agronomiques Mediterraneenes), Seria A Semnaires Mediterranees, edited by: El Moujabber, M., Mandi, L., Liuzzi, G. T., Martin, I. I., Rabi, A., and Rodriguez, R., No: 88, Options, ISSN: 1016-121X-ISBN: 2-8352-425-6, 2009.

WCD: Dams and development, a new framework for decision making, The report of the World Commission on Dams, Eartscan Publications Ltd, London and Sterling, November 16, ISBN: 1-85383-798-9 Paperback and 1-85383-797-0 hardback or available at: www.dams.org, 2000.

Wildi, W.: Environmental hazards of dams and reservoirs, Near Curriculum in Natural Environmental Science, 88, 187–197, 2010.

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Table 1. Chronology of critical stages of Kayraktepe HEPP projects.

Date	Event
1936	General Directorate of Electrical Power Resources Survey and Development Administration (EİE) was founded to investigate issues on how rivers in the country could be utilised for energy production.
1953	Initial investigation in the basin was started; Stream Gauging Stations were installed.
1954	State Hydraulic Works (DSİ) was established. The basin scale studies for 26 hydrological basins have been started.
1971	Ramsar Convention or the convention of wetlands was accepted on 3 February 1971.
1977	The Kayraktepe Dam and HEPP project was identified by EİE. The contract awarded to the consortium of EPDC, Su-İş, Su-Yapi and TMB.
1979	Construction of Gezende Dam on the Ermenek Creek was started.
1982	The feasibility report of Kayraktepe Dam and HEPP project released.
1986	The construction of Kayraktepe Dam was awarded by DSİ to EPDC under finance from the World Bank. Small preliminary works done.
1990	Construction of Gezende Dam was completed.
1994	The Göksu Delta was recognised as Ramsar site as .Turkey ratified the Convention.
1997	Kayraktepe Dam and HEPP Project was revised.
2000	The World Commission on Dams published an infamous report as "Dams and Development".
2001	Act No: 4628 released: Aims to form a stable, transparent and competitive electricity market to generate sufficient, sustainable and cheaper electricity.
2002	Construction of Ermenek Dam was started.
2003	Regulation for increasing involvement of private sector in the electricity market was established.
2004	Six on-going HEPP developments were transferred to private sector.
2005	Act No: 5346 released: Aims to increase electricity generation from renewable sources.
2006	The construction of Blue Tunnel was started (water transmission from the Göksu River to Konya Plain).
2008	Kayraktepe Dam and HEPP were awarded to a private company. The company, namely BM holding decided to revise the project in order to eliminate environmental effects.
2009	Construction of Ermenek Dam was completed.
2011	Negotiations with DSİ for the new formulation of Kayraktepe Dam and HEPP project were settled. This project was rejected. Although this formulation is enough capable to prevent flood as well as economical and sensitive for both environment and social, the DSI insisted on large scale dam formulation.
2012	The project revision was restarted according to large scale dam formulation.

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Table 2. Salient features of Kayraktepe-2010 formulation.

	Kayraktepe I Diversion weir and HEPP	Kayraktepe II Diversion weir and HEPP	Kayraktepe III Diversion weir and HEPP	Kurtsuyu Diversion weir and HEPP	Kayraktepe Dam and HEPP	Kayraktepe IV Diversion weir and HEPP
Location	Göksu River and Ermenek Creek	Göksu River	Göksu River	Kurtsuyu Creek	Göksu River	Göksu River
Type of weir	RCC	RCC	RCC	RCC	–	RCC
Thalweg Elevation (m)	117.00	106.00	95.50	115.00	41.50	27.00
Operating Elevation (m)	120.00	110.00	104.00	120.00	85.00	37.00
Flood Level (m)	–	–	–	–	93.00	–
Dam Crest Elevation (m)	–	–	–	–	94.50	–
Tailwater Elevation (m)	110.00	104.00	85.00	85.00	37.00	28.30
Design Discharge (m^3 s)	227.00	232.00	237.00	8.00	369.22	369.30
Installed Power (MW)	20.53	12.53	36.53	2.48	152.13	29.35
Energy Production (GWh)	58.80	39.37	114.40	9.68	308.58	57.40
Length of Canal (m)	–	–	5 925.00	2 285.00	–	–
Length of Tunnel (m)	–	–	513.95	–	–	–
Type of spillway	uncontrolled spillway	uncontrolled spillway	uncontrolled spillway	uncontrolled spillway	controlled spillway	uncontrolled spillway
Head pond	–	–	+	+	–	–

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Table 3. Benefits for the dam formulations of Kayraktepe project (Sever, 2010).

	1997 Formulation	2010 Formulation
Firm Energy (Gwh)	401.3	329.043
Seconder Energy (Gwh)	254.4	259.186
Total Energy (Gwh)	655.7	588.228
Investment Cost (TL)	999 119 575	541 829 049
Annual Income ($\$\,yr^{-1}$)	61 504 660	55 175 786
Annual Outcome ($\$\,yr^{-1}$)	103 789 001	38 896 343
Income/Outcome ratio	0.59	1.42

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Table 4. Comparison table of the studies related to the flood calculations.

Kayraktepe-1997 Project	Kayraktepe-2010 Project
Flow data (SGS) till 1989 were used	Hydrology of the basin was revised. Flow data (SGS) till 2007 were used
Ermenek Dam information was taken from the previous feasibility report. In this report, Ermenek Dam flood storage was given as 160.68 hm^3.	Ermenek Dam information was revised (according to the real state). Ermenek Dam flood storage is 298.85 hm^3.
The permissible outflow peak discharge of the dam was given 800 $m^3 s^{-1}$. In that report, 160 hm^3 storage was found to be adequate.	The permissible outflow peak discharge of the dam is accepted as 1200 $m^3 s^{-1}$. This value was taken from DSI – Adana Region. This value is also confirmed by calculating the water surface profile (HEC-RAS) in Silifke District.
But, according to the revised hydrology, this storage is adequate to decrease the peak outflow just to 1110 $m^3 s^{-1}$ (Q_{500}, In case the Mut Dam is in operation).	

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Table 5. The flushing coefficients for both formulations.

	Kayraktepe-2010 Formulation	Kayraktepe-1997 Formulation
C_0 (Mm^3)	174.50	1 726.90
MAR (Mm^3)	3010.55	3010.55
MSY (Mm^3)	1.13	1.13
K_w	174.50/3010.55 = 0.058	1 726.90/3010.55 = 0.573
K_t	174.50/1.13 = 154.42	1 726.90/1.13 = 1 528

Discussion Paper | Discussion Paper | Discussion Paper | Discussion Paper |

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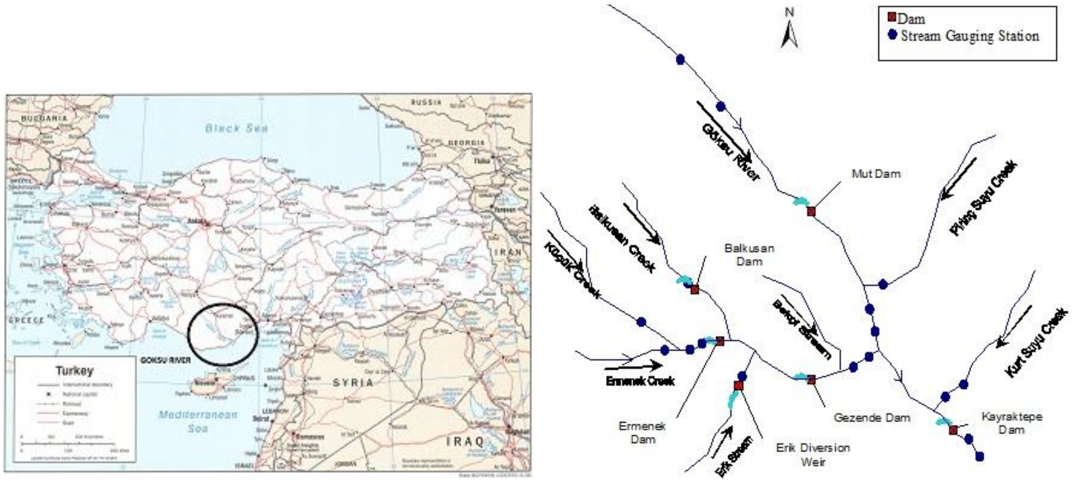

Fig. 1. The location of the Göksu river system and infrastructural development of Göksu Basin.

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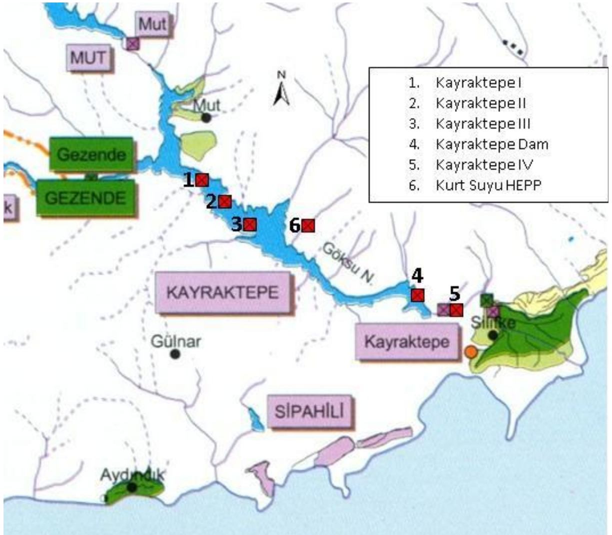

Fig. 2. Kayraktepe-2010 formulation.

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The case of the Kayraktepe dam, Turkey

Ö. Sever et al.