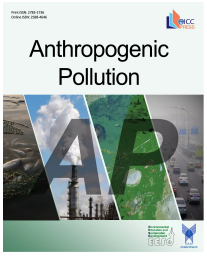

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Suspensioning decision of hydropower dam in the United Nations Educational Scientific and Cultural Organization (UNESCO) World Natural Heritage registered forest

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Abstract:
Environmental Management Plan (EMP) is regarded as a guidance document to attain and measure compliance with the mitigation requirements and environmental protection of projects, which are normally requirements for project approvals. The study mainly aims to present an Environmental Management Plan for dams whose construction was suspended by opposing stakeholders for the harmful impacts on the environment in forested areas. As a case study, the Hyrcanian forests (Caspian forests) are located in western Asia and were inscribed on the United Nations Educational Scientific and Cultural Organization (UNESCO) World Heritage List in 2019. The construction of the hydropower Shafarood dam began in these forests in 1990. Because of budget deficits and the suspensions incurred by opposing activists in 2013, dam construction has only advanced by 23% ever since. To meet that aim, the research data was collected through analysis of documents, letters, articles, field visits to the construction site, and interviews. The semi-structured interviewing method was employed in holding interviews with governmental and environmental NGOs, local people, specialists, and academics because of their good cooperation. The results indicate that the most negative effects in the construction phase have been produced by deforestation and degradation of vegetation, source of material supply, settlement and livelihood of migrants impacted by dam impoundment, water, air and sound quality. Ultimately, an Environmental Management Plan was proposed for this dam and those under construction or suspended in forested areas to minimize the negative environmental effects of the Hydropower Shafarood dam, which technically concentrates on mitigating measures.

Keywords: Environmental Impact Assessment (EIA); Environmental Management Plan (EMP); Hyrcanian forest; Water supply; Hydropower Shafarood dam

1. Introduction

Chief among the resources indispensable to life on earth is water. On account of cumulative population and economic developments, there will be an increasing need for water in the short run (Bates et al. 2008; Safaei et al. 2020; Fataei and Sheikh Jabbari 2005). The fact that water is rare enforces limits on societal integration and economic advancements. This will initially impact the agricultural sector, which accounts for over 80% of the overall water consumption (Tzanakakis et al. 2020). Global hydrological cycles have been altered in the past few decades due to climate change and human socioeconomic development has threatened human water security endangering the health of aquatic environments and rivers (J et al. 2016; Fataei and Sheikh Jabbari 2011). Dams play a significant role in the utilization of water resources. (Tahmiscioğlu et al. 2007; Fataei et al. 2014). An important topic of discussion in the field of environmental engineering since the early 1970s has been the building of large dams. Large hydropower dams have without doubt many advantages such as clean water and renewable energy supply, flood control, increased agricultural products as improved water supply systems for municipal water consumption purposes, etc (Tilt et al. 2009; Asthana and Khare 2022; Fataei 2020).
In industrialized countries, dams have been built on most major rivers. The practice of dam building has experienced

a shift in developing countries in North America and Europe due to a decrease in the availability of sites with hydroelectric potential and public response to major environmental impacts of dam construction (Fearnside 2016; Fataei and Shiralipoor 2011). The historical data attest to a strong relationship between the availability of energy and economic activity (Yuksel 2010). Environmental Impact Assessments (EIAs) were initially designed to eliminate harmful environmental consequences via proposing scientific evaluations of suggested projects, but in practice, EIAs are often outweighed by economic and political concerns, mostly in the developed world (Bratman and Dias 2018). An efficient Environmental Impact Assessment (EIA) system is determined by an appropriate administration of mitigation measures along with monitoring (Somokanta et al. 2021).

While EIA processes are not very distinct globally, their systems are of a broad variety in different territories (Suwanteep et al. 2016). EIAs have been designed to ensure that environmental considerations are factored into socio-economic decisions (Morrison-Saunders and Fischer 2006). Therefore EIA seeks to strike a balance between "developmental activities and socio-ecological losses" (Paliwal 2006). Among the ordinary prerequisites of sustainable development are EIAs which act as a buffer against any negative implication. They are ubiquitously used and are the key factor in tackling environmental issues (Peterlin et al. 2008; Zhao 2010; Ghasemi and Fataei 2006). EIA is defined as a procedure in which numerous stakeholders are engaged in various interests and skills, possibly triggering biased views; nonetheless one might not differentiate bias and manipulation (Salamanca 2018; Hassanpour Kourandeh and Fataei 2013).

In forest areas, the economic value of the forest must be taken into consideration in the economic calculations carried out before construction. Due to the dense vegetation in forest and coastal areas, the construction of a dam can lead to the production of large volumes of greenhouse gases and environmental degradation (Turner et al. 2016). Dam construction and the resulting consequences on forest resources is a complex phenomenon with different aspects, including various stakeholders, many components and parameters involved, and various goals. It includes a variety of ecological, economic, and social variables that have interrelated, complex relationships and interdependencies between their components (Safaei et al. 2020). Development practitioners rely on public participation which mostly focuses on responding to local people's demands and stakeholders' concerns, yet in practice, these endeavors frequently become mechanisms of co-optation, through which the projects of more powerful political and financial actors are planned and the logic of project success are boosted (Mosse 2011; Bratman and Dias 2018). Results of the project are required to be reported to the Stakeholders regularly (Reed 2008; Susanto et al. 2019).

In projects with a transnational impact, the scope of stakeholder participation should be broadened to involve local and regional communities, as well as governmental organizations, Non-Governmental Organizations (NGOs), and relevant knowledgeable professionals. Failure of all stakeholders to participate in the EIA report will result in suspensions and delays in the operation of the dams. Such examples would include:

Suspension of dam-construction projects is not very common in unindustrialized countries. Chief among them is the downscaling applied on proposed dams located in the Chinese Nu/Salween River (Han et al. 2014), in addition to another interruption in building the Myitsone Dam in Myanmar and the Kaeng Suea Ten Dam in Thailand (Kirchherr 2018). Tipaimukh Dam in Manipur, a marginal northeastern state in India. Despite comprehensive local and foreign support, the main construction plan was halted (Somokanta et al. 2021). Campaigners managed to persuade important benefactors (the World Bank in particular) to decrease and eventually withdraw their financial support from the Indian Narmada Dam and the Nepalese Arum 3 Dam. Their effort also influenced other dam constructions like Pancheshwar on the Mahakali River despite being a coordinated project between India and Nepal according to the 1996 Mahakali Treaty concluded in between (Del Bene et al. 2018; Varamesh et al. 2014).

Reviewing the literature, it can be concluded that there is limited research conducted on the topic of the suspensioning decision of hydropower dam. Also, due to the significance of the topic and the necessity of environmental protection, this study was conducted to focus on the environmental impact reduction plan, which is an effort to reduce emissions from deforestation and forest degradation (REDD), to support conservation and sustainable forest management and to increase global carbon stocks.

The present research has been carried out by collecting information through a literature review and interviews with stakeholders for and against the construction of the Shafarood dam. This paper investigates the reasons for the suspension and resumption of construction of the Hydropower Shafarood dam in Hyrcanian forests stated by opposing and agreeing stakeholders. According to the collected information and to better elaborate on the topic, the environmental impact assessment of the Hydropower Shafarood dam was performed through the method of large dams based on two criteria of project implementation or termination. In this regard, the environment was divided into three categories: 1) social, economic, and cultural, 2) physical, and 3) biological.

The main objective of this study is to present an Environmental Management Plan (EMP) for dams whose construction was suspended by opposing stakeholders for the harmful impacts on the environment in forested areas.

2. Case study

2.1 Hyrcanian forests

The Hyrcanian forests mostly consist of primeval temperate broadleaved and highly productive forests, Hyrcanian forests fringing the southern coastline of the Caspian Sea from the Talysh Mountains in Azerbaijan eastwards over the northern slopes of the Arborz Ridge to Golestan National Park in Iran (Moradi et al. 2012). The Hyrcanian forests are approximately 800 km long and 110 km wide, covering about 1.85 million ha (Sagheb Talebi et al. 2014).

Figure 1. The vegetation of the Hyrcanian forests.

As a relic of the Arcto-Tertiary forests, they are one of the last remnants of primeval deciduous forests in the world with remarkable densities of large and old trees and are an important biodiversity hotspot of West Eurasia (Akhani et al. 2010). Being lush and humid, the forests receive an average annual rainfall between 530 mm in the east and 1350 mm in the west on average, reaching up to 2000 mm in the west (Sagheb Talebi et al. 2014).

The floristic biodiversity of the Hyrcanian forests is remarkable at the global level with over 3,200 vascular plants documented. Due to its isolation, the property hosts many relict, endangered, and regionally and locally endemic plant species, contributing to the ecological significance of the property, and the Hyrcanian region in general. Approximately 280 taxa are endemic and sub-endemic for the Hyrcanian region and about 500 plant species are Iranian endemic (UNESCO 2019). Figure 1. The vegetation of the Hyrcanian forests. The picture was taken by the first author during a field visit.

Being an indispensable share of the Caucasus biodiversity hotspot, the protection of species-rich habitats in the Hyrcanian forests is widely acknowledged today (Erichsen et al. 2018). The Hyrcanian forests which is a biodiversity reserve of genetic variation for F. excelsior signifying the preciousness of these populations for this species. With the occurrence of any climactic change and ash dieback, European populations are confronted with high selective pressures (Landolt et al. 2016).

The study was performed in Shafarood forest, Gilan Province, northern Iran (between 37°25′11″ N and 37°34′30″ N latitude and 48°6′30″ E and 48°41′56″ E longitude). The elevation is approximately 900 m above sea level (minimum 60 m and maximum 2903 m) (Naghdi et al. 2015). In most parts of the Shafarood basin, we see the geological structure of the second period and the expanded layers sensitive to erosion. This area has a humid climate with annual precipitation of 1431.76 mm and contains a water regimen in autumn (Azizi et al. 2019).

2.2 Hydropower Shafarood dam

The hydropower Shafarood dam is located in the north of Iran and west of Gilan province in the Shafarood watershed and on the Shafarood river, which is 3 km southwest of Rezvanshahr county and 65 km from Rasht metropolis. This dam is a roller-compacted concrete dam. The components of the hydropower Shafarood dam include the reservoir, hydropower plant with an average annual production of 40 GWh, the Dinachal diversion dam, and water transfer system to the irrigation and drainage network. The water resources used in the project are unique to the river and other available water resources have been put aside (MOE 2015). The location of the Shafarood Dam is shown in Figure 2.

The preliminary research on the hydropower Shafarood dam project was assigned to the Water Engineering Company in 1982, which was subsequently resumed by Mahab Ghods Engineering Company in 1984. The building operations of the dam began in 1990 and continued until 2000 with a physical progress of 20%. Since 2000, the construction has been halted because of the lack of an EIA. Later on, the general report of an environmental impact assessment was sent to the Iranian Department of Environment in 2006 (Mahab GhodsInc 2014). The Iranian Department of Environment, in cooperation with other stakeholders, studied and evaluated the EIA report of the hydropower Shafarood dam until 2013 and because of the many negative environmental effects, the mentioned report was not approved (DOE 2008). The problems of the Hydropower Shafarood dam project were raised at the Water Supreme Council In 2013, a matter

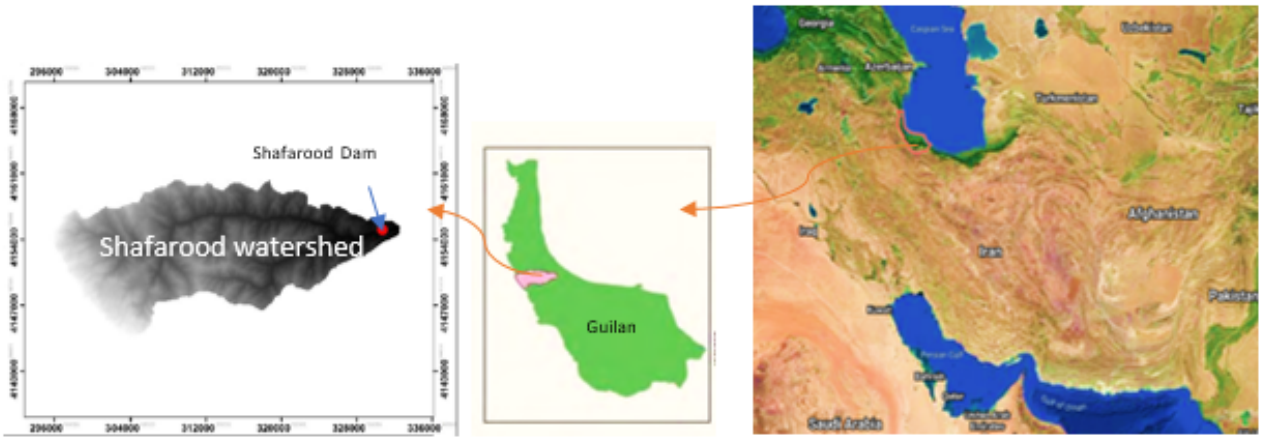

Figure 2. The study districts showing the location of the Shafarood.

which was approved by the members present at the meeting, provided that specific changes are made to the project (WECOMOE 2013). There has been a physical progress of 57% in the hydropower Shafarood dam project by 2020 (see Table 1). The purpose of constructing the dam is to supply the water required for the agricultural sector close to the project area, the drinking water for Rezvanshahr City, and the water needed for the industrial sector usage, especially that for Gilan Wood and Paper Company (Chouka) (Khayatnezhad et al. 2011; Khoshraftar et al. 2020; Zaefizadeh et al. 2011)(GRWA 2016). The borrow and aggregate materials required for the dam are extracted from the bed of the Shafarood River and the quarry situated above the dam in the Hyrcanian mountain range (Mahab GhodsInc 2014).

3. Methods

To gratify the purpose of the study, a descriptive-analytical method was utilized. The research data was collected through analysis of documents, letters, articles, field visits to the construction site interviews, and other related sources. It was attempted to consider viewpoints from all the stakeholders and those well-informed and familiar during the data collection phase. The bureaucratic structure made it too difficult to conduct interviews with constructors, consultants, and employers of the hydropower Shafarood dam and thus, the unstructured interview method was adopted, so that interviewees could address anything that they thought was of greater importance. The semi-structured interviewing method was employed in holding interviews with governmental and environmental NGOs, local people, specialists, and academics because of their good cooperation. The interviews were coded based on a set of predefined topics. The resulting clusters were then analyzed by the authors. A total of 33 interviews were conducted at national and provincial levels (see Table 2).

The researchers couldn't access the EIA report of the Shafarood Dam. One of the interviewees claimed that researchers couldn't access the dam's EIA report because of the many shortcomings that existed in the report. According to the collected information and to better elaborate on the topic, the EIA of the hydropower Shafarood dam was performed through the method of large dams based on two criteria of project implementation or termination. In this regard, the environment was divided into three categories: 1) social, economic, and cultural, 2) physical, and 3) biological. According to the results obtained from the EIA EMP was proposed to restart constructions and alleviate environmental impacts from the dams built in forested areas.

4. Results and discussion

4.1 Proponents of suspending the construction of hydropower Shafarood dam

4.1.1 Deforestation and forest degradation

Deforestation takes place when the tree cover in a jungle goes below a certain threshold after timber production or land conversion operations (Goetz et al. 2009). Deforestation is one of the leading causes of biodiversity loss and carbon dioxide emissions, which can contribute to climate change. Many governmental and nongovernmental sectors have adopted REDD as an achievable means to reduce global greenhouse gas emissions and implement sustainable forest management practices (Angelsen et al. 2009).

Several environmental NGO members and environmentalists stated that in 2015, 70 NGO members accompanied by experts, university professors, the Department of Environment, and media activists issued a statement indicating that the construction of the hydropower Shafarood dam is unexpectedly underway in the country's rainiest province, targeting hundreds of hectares of ancient Hyrcanian forests, very valuable forests that cannot be restored by any means. This statement was the first step to suspend the construction of the hydropower Shafarood dam.

Several interviewees highlighted that deforestation and forest degradation would lead to the destruction of natural habitats and cut off communication between key areas of the wildlife. A forest and rangeland specialist said that the average per capita forest in the country is 0.8%, which is almost a quarter of the global per capita. During recent years, changes in forest application in the Shafarood catchment area for uses such as agriculture and rangeland have caused the loss of more than 2000 hectares of forests from 2000 to 2013.

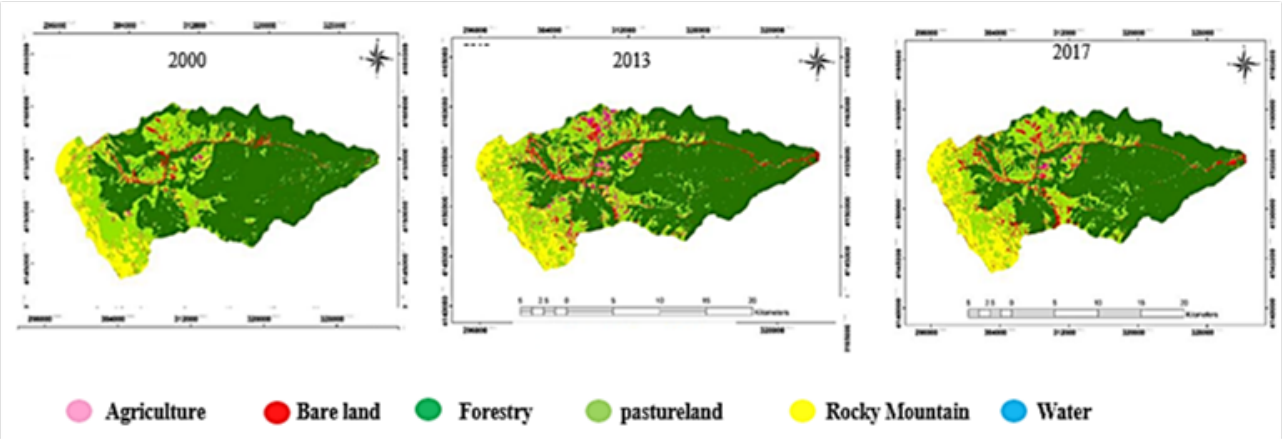

Figure 3. Map of vegetation changes in the Shafarood watershed from 2000 to 2017 (Azizi et al. 2019).

Several experts in the field of natural environment and ecological diversity stated that when the construction of the Hydropower Shafarood dam in 2000 began, the destruction and clearing of the forest accelerated. 320 hectares of forest lands in the Shafarood catchment area were cleared and destroyed in order to supply materials from borrow pits, build access roads, conduct mine blasting and exploitation operations, equip workshops, and construct residential units for housing staff and related facilities, as well as flooding the dam. In the years 2000 to 2013, factors such as change in forest applications and its use for agricultural and rangeland purposes have been the main causes of deforestation in the Shafarood basin.

Shafarood basin is divided into 18 sections and the reservoir of the dam interferes with series 2, 3, 14, 15, 16, and 17. The 37.5% progress in the construction of the Shafarood dam, the destruction and clearing of the forest in the years 2013 to 2017 are related to the construction phase of the Hydropower Shafarood dam (Figure 3) (Azizi et al. 2019). One of the issues that should be taken into consideration in the construction of the Hydropower Shafarood dam is the valuation of the Shafarood catchment forest. 320 hectares of forest in the Shafarood catchment area will be destroyed during the construction and operation phases, making 12%

Table 1. Stages and reasons for stopping the construction of the Shafarood Hydropower Dam (SHD) based on different years.

Years	Stages and reasons for stopping the construction of the Shafarood Hydropower Dam (SHD)
1982	The start of the feasibility study of the construction of a Hydropower dam in Shafarood by Mahab Ghods Engineering Company (Mahab GhodsInc 2014).
1984	Interruption in the feasibility study and restarting the feasibility study by Mahab Ghods Engineering Company (Mahab GhodsInc 2014).
1990	The start of construction of the SHD without carrying out the environmental impact assessment (EIA) report (Mahab GhodsInc 2014).
2000	Stopping the construction of the SHD with 20% progress by the environmental organization due to the failure to complete the EIA report (Mahab GhodsInc 2014).
2006	Preparation of a report about EIA for SHD by Mahab Quds Company and sending it to the Iranian Department of Environment (DoE) (Mahab GhodsInc 2014).
2013	Non-approval of the Shafarood dam's EIA report due to the destruction and clearing of 175 hectares of Hyrcanian forests in the reservoir area Dam and related construction operations by the Iranian DoE (DOE 2016)
2013	Referral of the EIA report to the Supreme Water Council and conditional approval in case of changes (see Table 3) (MOE 2013)
2020	The slow progress of construction operations (physical progress 57%) due to economic problems and protests of non-governmental organizations (NGOs) (GRWA 2020).

Table 2. Frequency and details of participants in the interview.

The interviewed	Frequency of the interviewed
Ministry of Energy	3
Gilan Regional Water Authority	5
Department of Environment	5
environmental NGOs	6
Local individuals	8
Forestry Association	2
specialists and academics	4
Total	33

of the total cost of building a Hydropower Shafarood dam (Amirnejad and Khalilian, 2006).

4.1.2 Sediment load prediction at Shafarood watershed

Stratigraphically, the area under study consists of Precambrian, Paleozoic, Mesozoic (Jurassic and Cretaceous), Cenozoic, and Late Cretaceous zones and has been strongly influenced by Alpine orogeny since the late Cretaceous to the present. The highest amount of sediment is in the unit of marl, the second highest amount is in sandy to silty units and the third highest amount is in sandy lime unit. The lowest amounts of sediment are in calcareous (P) and tuff shale (V) units respectively (Akhani et al. 2010).

One of the university professors of hydraulic structures design was of the belief that totally clearing the forests of the Shafarood area increases soil slippage, which in turn increases the sediment load of the watershed. An expert from the Rezvanshahr Natural Resources and Tourism Organization told us that the Shafarood watershed is so steep that the lowest slope in the basin is 30%, and it reaches between 70 and 90 degrees in the reservoir walls and on the left and right edges of the Hydropower Shafarood dam. A geography professor maintained that the soil in the Shafarood watershed is mostly composed of marl with a high percentage of clay. After the dam impoundment, these soils become saturated and lose stability which in turn increases the sediment load.

4.1.3 faults

Astara fault

Although only about 166 km of the length of Astara (also known as Talesh) fault in Iran can be traced on geological maps, its total length reaches about 400 km. This fault, with a north-south direction and low slope (about 9 degrees) to the west and reverse mechanism, is located in the west of Astara city. Along the Astara fault, N 170 E and its maximum vertical displacement is 8.1 km. Geological and geophysical morphological data signify the eastward expansion of the fault plates to the coastal plain as well as the Caspian watershed (Barzegari et al. 2017).

The Astara fault has seismic potential and has had a compressive mechanism in the 1953 and 1978 earthquakes in the Caucasus. The focal concentration of the earthquakes in the last century and the deformation observed in the new and thick sediments of the southern Caspian bed deposits on the western side have been attributed to the Astara fault system as a sign of the eastward expansion of progressive fold and fault structures (Brunet et al. 2003).

Shafarood fault

Stretching for about 14 km in the direction of northeast-southwest and with a left-lateral (wrench tectonic) mechanism, the Shafarood fault is situated in the southeast of Khalkhal. This fault passes through Upper Cretaceous sandy limestones, and in its middle fragments, forms the boundary of Paleocene volcanic rocks with these limestones. Several acute andesitic dikes stretch up until this fault at an acute angle, which, if considered as tensile veins, the fault would be a left-lateral one.

4.1.4 EIA defects

The evaluation revealed that Iran's EIA system suffers from weaknesses such as insufficient EIA legislation, Culture of decision-making, inadequate screening and scoping, lack of alternative consideration, public participation, EIA implementation, and follow-up.

One of the interviewees claimed that the Hydropower Shafarood dam's EIA studies began when the dam had physical progress of 21%. Two interviewees claimed that the perpetrators of ongoing construction projects that lack an EIA report, whether from the public or private sector, are differently punished. If the private sector starts their project without EIA, they are only forced by Iran's Islamic Penal Code to pay fines for destroying the environment. The fines are so small that project proponents can easily pay and continue their projects. In the case of a project under construction without an EIA report run by the public sector, if not accompanied by protests from NGOs and the Department of Environment, it is usually accompanied by more negligence in law enforcement.

Another interviewee claimed that shirking legal responsibilities by government organizations and institutions is the most important factor in implementing projects that violate environmental standards. An interviewee asserted that the EIA report of the Shafarood Dam is just a booklet and its confirmation has been done unconventionally. Another interviewee claimed that there have been 8 zoological criteria ignored in the EIA report of the dam. Construction of the hydropower Shafarood dam has caused the migration of 180 residents of Shalam, Shishar, Varzasht-Dowran, and Sarak villages. One of the interviewees claimed that no study or report had been carried out on how these people should be employed and housed. Another interviewee announced that the rate of deforestation in the Hyrcanian forests estimated by experts and specialists in the EIA report of hydropower Shafarood dam is about 30%. Another interviewee said that the Ecological Water Requirements (EWRs) have not been included in the goals defined for the hydropower Shafarood dam project.

4.1.5 Sequencing of water supply options

An interviewee said that, due to frequent droughts in Iran throughout the last decade and the reduction of water resources, the pertinent consequences have become more tangible and planners and managers have been seriously

challenged. Gilan province has not been spared from this drought trend. Another interviewee asserted that there has been no study conducted on water supply options other than the construction of the hydropower Shafarood dam to supply water in the area. A water resources management expert said that water supply options studies will not be performed in Iran. Studies on the construction of water supply projects in Iran include two options, the preferred option and the zero option (which necessitates no action).

Sequencing has long been used to identify water supply projects that maintain water supply security and minimize water supply costs (Butcher et al. 1969). Presented an approach to the minimum-cost sequencing of surface and groundwater supply projects. Techniques for sequencing have generally been applied to traditional water supply sources, for instance, the expansion of multiple reservoirs (Dandy and Connarty 1994) and groundwater supply (Chang et al. 2009).

Nonetheless, over the recent years, confidence in traditional water supply sources, such as reservoirs and groundwater supplies, has waned as a result of increasing demand and reduced reliability of supply due to climate factors (Chartres and Williams 2006; Somokanta et al. 2021). In response, there has been a significant increase in the use of alternative sources of water, such as desalination, reclaimed wastewater, and harvested stormwater and rainwater, in an attempt to improve water supply security in times of drought and in response to potential climate change impacts (Coombes and Lucas 2006).

4.2 Proponents of completing and continuing the construction of the hydropower Shafarood dam

4.2.1 Improving the economic and social condition

One of the interviewees acknowledged that the local economy is based on agriculture and livestock farming. Accelerating the construction operation of the hydropower Shafarood dam will improve the business environment and mitigate the migration of local people in search of employment. Another interviewee asserted that the least expensive way to meet the water needs of the people in this region is to build the Shafarood Dam. The hydropower Shafarood dam will produce an average of 40-gigawatt hours of energy per year, which can reduce power outages during the consumption peak. One of the purposes of constructing the hydropower Shafarood dam is to supply the water required by the agricultural sector, which increases the area under cultivation from 6900 hectares to 16000 hectares. One interviewee maintained that water shortage is one of the main issues dealt with by people in the region, which has led to the destruction of agricultural products and has reduced crop production per unit of harvested area by 30 to 40 percent. One of the interviewees said that many lawsuits have been sent to the competent authorities on disputes between farmers over water quotas.

Another interviewee asserted that the prolonged operation of the Shafarood dam has incapacitated the central government to make payments to those working on the dam, which has led to protest rallies. According to the estimates, the manpower required for the construction of the hydropower Shafarood dam in the construction phase is between 137 to 170 individuals, and the operation phase requires between 15 to 20 individuals. The construction of the hydropower Shafarood dam has prevented the loss of 174 million cubic meters of water per year that would otherwise flow into the Caspian Sea. The purpose behind constructing the hydropower Shafarood Dam is to meet the water needs of agriculture, industry, and drinking in the region, with the following allocations:

4.83% for agricultural purposes, 2.10% for industrial use, and 4.6% for drinking. The operation of the hydropower Shafarood dam can employ 800 people in the industrial sector (GRWA 2016).

4.2.2 Foreign investor

Some interviewees stated that Iran-China relations are expanding gradually. China has invested in projects such as subways and dams, as well as fisheries and cement factories. Iran's strained relations with the United States and the European Union have made Iran an attractive market for China. One of the interviewees held financing as one of the reasons for the delays in the construction of the hydropower Shafarood dam. With the efforts made by the government at the time, the required capital was provided through the International Foreign Investment Facility (China).

Another interviewee said that the construction project was financed in 2020. The foreign investor provided 85% of the total construction costs and Iran's share is only 15%. Several interviewees acknowledged that delays in the operation of the hydropower Shafarood dam would cause dramatic economic losses, one of which is the payment of fines in-

Table 3. Changes applied to the specifications and objectives of the hydropower Shafarood dam by the Water Supreme Council in comparison with the original design.

Changed items	Original specifications and objectives	Changed specifications and objectives
Dam's height	159 meters	137 meters
Lake's volume	125 million cubic meters	98 million cubic meters
Ecological water requirements	Not predicted	48 million cubic meters
Area of irrigation and drainage network	16,000 hectares	11,000 hectares

Table 4. Descriptions of the views intended to assess the environmental impact of the Shafarood hydropower dam.

Descriptions of the views intended to assess the environmental impact of the Shafarood hydropower dam	Perspectives
The equal value of all the environmental factors	1
It is for employers and decision-makers who prefer economic impacts to environmental factors. In this view, the priorities are as follows: the Physical environment 20%, the social, economic, and cultural environment 55% and the biological environment 25%	2
Preventing and opposing any negative change in the natural conditions of the region. In this view, the priority is as follows: the Physical environment 15%, the social, economic, and cultural environment 35% and the biological environment 50%	3

curred for late payment of the loan installments.

4.3 Interaction between proponents and opponents

Owing to the absence of an understanding between the stakeholders for and against the construction of the hydropower Shafarood Dam, the project was referred to the Water Supreme Council of the Ministry of Energy for further investigation and the resolution of disputes in between. To coordinate policies concerning the supply, distribution, and consumption of water in the country, a council named "the Water Supreme Council", consisting of ministers of Energy, Agriculture; Industries and Mines and Interior ministries, Head of Management and Planning Organization of Iran, Head of Department of Environment, and a member of the Agriculture, Water and Natural Interests Commission elected by the parliament as an observer, and two agricultural experts appointed by the president. The supreme chairman of this council will be the country's president or vice president. The decisions of this council, with the approval of the Cabinet or the mentioned commission, shall be binding for the relevant bodies according to Article 138 of the Iranian Constitution (SWC.MOE 2016) Suspensions and delays in the construction of the Hydropower Shafarood dam were investigated in the 18th session of the Supreme Water Council. In the 25th session, further investigations were conducted. The majority of the members agreed to make changes to the objectives initially defined for constructing the hydropower Shafarood Dam. These changes were approved by the majority of members and thus, were binding. The most important changes applied were decreasing the dam's height from 159 meters to 137 meters (see Table 3). Table 3 shows the changes applied to the specifications and objectives of the hydropower Shafarood dam by the Water Supreme Council in comparison with the original design.

4.4 EIA Shafarood hydropower dam

One of the most unavoidable effects caused by building the Shafarood hydropower dam is the destruction and clearing of 175 hectares of forest lands in the construction and operation phases. Another inevitable adverse effect of the construction of the Shafarood Reservoir Dam is the withdrawal of borrow pits. To provide coarse-grained resources and stone for the construction of the dam, many materials would be removed from the bed of the Shafarood and Dinachal rivers and the banks of the Shafarood causing significant adverse effects on the environment. Other effects include the relocation of the residents of the villages near the reservoir of the dam. To evaluate the environmental impact of the Shafarood hydropower dam, two states can be taken into consideration and compared with each other. The first is non-implementation of the project where the question is how would the environment in the region change compared to the current situation considering the trend of environmental changes in the past? The second is the assumption that the project would be implemented and assess the effects of constructing a Shafarood reservoir dam and power plant, building a diversion dam on the Dinachal River, and constructing a water transmission system. There are several ways to evaluate these two options.

In this research, the International Commission on Large Dams (ICOLD) matrix method was used for evaluation. The aim of using the ICOLD matrix in this report is to show the effect of the characteristics and qualities of the project on environmental components, which are represented by the symbols in the matrix. In this regard, the environment was subdivided into three parts: 1) social, economic, and cultural environment, 2) physical environment, and 3) biological environment. Matrices of effect were presented separately for each environment. The results show that air

Table 5. Summary of the results of the environmental impact assessment Shafarood Hydropower Dam according to three perspectives.

Options	1st perspective (Equal value of all the environmental factors)	2nd perspective (priority of economic and social factors)	3rd perspective (priority of the region's natural conditions)
Project implementation	-46	+91.5	-106.85
Non-implementation of the project	-1183	-351.55	-430.85

quality, sound quality, surface water quality, and natural habitats received the most negative impact during the construction phase. In addition, to understand the true extent of the environmental impacts according to the characteristics of the project, the macro-strategies at the international level as well as the national interests were taken into consideration. To do so, the assessment of the environmental effects was based on the weighting model, and three perspectives were picked up to facilitate analysis (see Table 4). The first perspective is the equality of the values for all the environmental factors. The second perspective is for employers and decision-makers who prefer economic impacts over other environmental factors.

In this perspective, the share of impact for each sub-environment is as follows: 20% for the physical environment, 55% for the social, economic, and cultural environment, and 25% for the biological environment. Thus, the numbers obtained from the tables for each factor are multiplied by the numbers 0.2, 0.55, and 0.25, respectively, and put back in the checklist. The third perspective is the view that any negative change in the natural conditions of the region must be prevented and opposed. In this perspective, the priority is as follows: 15% for the physical environment, 35% for the social, economic, and cultural environment, and 50% for the biological environment. Therefore, the numbers obtained in the table are multiplied by 15%, 35%, and 50% respectively, and are placed in the checklist again. In the first perspective, the calculations show that the algebraic sum of all the raw scores in the two phases of construction and operation for the project implementation option is -46. After applying the weighting coefficients of the three environments, i.e. the social, economic, and cultural environment, the physical environment, and the biological environment, the project implementation option in the second perspective (considering the economic effects of the project on the region) received the +91.5 value. In the third perspective, the result of adopting the project implementation option is negative. However, the effects of project implementation have received less negative scores than non-project implementation in the first and third perspectives (see Table 5).

4.5 Environmental Management Plan (EMP)

EMP aims to implement mitigation measures to reduce the negative effects of the dam (Siciliano et al. 2016). Considering the environmental impact assessment, the major impacts the hydropower Shafarood dam exerts are the destruction

Table 6. Measures proposed to reduce the environmental impact of hydroelectric dams under construction or suspended in forested areas.

Reduction measures	Description, suggestion, and solution	Authors
Reduce the height of the dam	Flood control and water supply in agriculture	(Nguyen-Tien et al. 2018)
Appropriate location to supply the required materials for the dam	The required materials for the dam should be supplied from areas that have a minimal environmental impact. unmanned aerial vehicle (UAV) or Geographic Information System (GIS) software can be used to achieve this goal	
Replacing modern agriculture with traditional agriculture	Collecting farmers' opinions and protecting biodiversity and Paddy ecosystems	(Khalkheili and Zamani 2009)
Alternative methods of water supply for the drinking and industrial sectors	Examining alternative methods of water supply such as the use of wastewater treatment; Groundwater and desalination of seawater and ocean drinking water and industry	(Xi and Poh 2013); (Awadh et al. 2021)
Forest Rehabilitation and Enrichment Plan	Rehabilitation of degraded or non-forested land is initially a multidisciplinary, multi-sectoral, and multi-sectoral action that requires good governance. Hemat and mediation rights Differences between stakeholders help to achieve predetermined goals and maintain a resource base.	(Guariguata and Brancalion 2014)
Reduce sedimentation rate	Control dams are effective short-term measures for sedimentation. Control, while a land-use change to increase vegetation reflects long-term sustainable conservation measures.	(Zhao et al. 2017)
Livelihood resilience	Land ownership, housing value and assets (parts of livelihood capital), social cooperation, participation in welfare projects (parts of livelihood transfers), emergency costs, and relocation attitudes (parts of livelihood buffer) are the factors that have the most impact. On livelihood resilience.	(Gong et al. 2020)
Environmental water ownership	Accurate estimation of the minimum required flow downstream of the dam (based on studies, the amount of environmental water is estimated at 48 million cubic meters per year)	
Supervise the good performance of work	Use this independent Health and Safety Environment (HSE) observer who monitors the proper implementation of mitigation measures and sends its reports to the competent authorities on a continuous monthly basis.	

and clearance of 175 hectares of Hyrcanian forests, extraction of the required materials from the riverbed, and migration and resettlement of villagers. To manage the impacts of dam development, it seems necessary to take mitigation measures to minimize pertinent direct and indirect impacts and develop and implement a comprehensive environmental management plan. Table 6 shows the measures proposed to reduce the environmental impact of hydroelectric dams under construction or suspended in forested areas.

5. Conclusion

Given the findings, one of the uncontrollable factors hindering dam construction in Iran appears to have been economic problems over the recent decades. Quality of an EIS is of great importance in informing the public and decision-makers about the consequences of a proposed project and mitigation measures. As a result, it can be inferred that a quality review of EISs is crucial in providing effective feedback for the improvement of EIAs.

Low-quality environmental impact assessments performed in Iran for the Gotvand and Sivand dams and those dams built in the drainage basin of Lake Urmia are quite evident. According to the collected information and to summarize opinions from opponents and proponents of the hydropower Shafarood dam's construction, the environmental impact assessment was performed based on two criteria of project implementation or termination. In this regard, the environment was divided into three categories: 1) social, economic, and cultural, 2) physical, and 3) biological.

The results show that the most negative effects in the construction phase have been produced by deforestation and degradation of vegetation, source of material supply (borrow material), settlement and livelihood of migrants impacted by dam impoundment, water quality, air quality, and sound quality.

To minimize the negative environmental effects of the Hydropower Shafarood dam, an environmental impact reduction plan was proposed, which mainly focused on mitigating measures. Reduction measures in this plan include reducing the height of the dam, proper localization of supply materials required for the dam construction, replacing modern agriculture with traditional agriculture, looking for an alternative water supply for drinking and industrial sector via conventional and unconventional methods, forest rehabilitation and enrichment plan, reduction of sedimentation, livelihood resilience, provision of ecological water requirements and performance supervision.

In total, to satisfy the rising demands of energy and guarantee sustainable development, several enhancement and mitigation measures need to be incorporated into the project planning's first stages. Moreover, proper mitigation measures not just for hydropower development which is recently designed and implemented in the future, but for the upgrading of hydropower dams which are nowadays in operation, have to be devised.

Conflict of interest statement

The authors declare that they have no conflict of interest.

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