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Investigation of EIA Methodologies in Water Resources Management Projects in Arid Regions and Selection the optimized Combined Method

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ABSTRACT

Today Environmental Impact Assessment (EIA) is known as one of the most important tools for decision makers in the construction of civil and industrial projects towards sustainable development. In the past, projects were evaluated based on cost and benefit analysis regardless of the physical and biological environmental effects and its socio-economical impacts. Water resources management projects in arid and semi-arid regions have direct effect on the water crisis and future sanitary problems. Several activities are required in an EIA study, including impact identification, preparation of a description of the affected environment, impact prediction and assessment which all of them have many methods in study. There are many scenarios in evaluation of their method in every where. Weight, importance, intensity, time period of effects, affected zone etc which are variable in EIA study approach in arid region regarding to water crisis and demand and resources function. In this research five main categories of EIA methods like matrices methods, decision analysis, Kane simulation model, overlay method, check list and network methods and their sub methods have been investigated. The results of this research led us to decision making in adopting the optimized and useful method in arid regions according to a 3D function of demand, consumption and resources of water. So that EIA study on water resources management projects in arid regions should be carried out depend on the time and period of year and location of the project according to rule curve of demand and generation potential.

Keywords: EIA, 3D function of demand, consumption and resources, Water resources management projects, arid and semi-arid regions

1. Introduction

A comprehensive Environmental Impact Assessment (EIA), since 1971 mandatory in a growing number of ICOLD[1] member countries, ought to become standard procedure everywhere as part of project conceptualization, that is well before final design and the start of construction [1].

Economic, Social, Physical and Environmental change is inherent to development.

Whilst development aims to bring about positive change it can lead to conflicts. In the past, the promotion of economic growth as the motor for increased well-being was the main development thrust with little sensitivity to adverse social or environmental impacts. The need to avoid adverse impacts and to ensure long term benefits led to the concept of sustainability. This has become accepted as an essential feature of development if the aim of increased well-being and greater equity in fulfilling basic needs is to be met for this and future generations. The imperative for development to remedy these defects may be so great that consequent environmental degradation may be tolerated. With Iran as a water scarce country, with a mean annual rainfall of below 250 mm, the use of water has been critical to the development of the country's industrial base and wider economy and will remain so in future. However, due to past exploitation, and the increasing demand for water, the regulation of our water resources is essential [2]. Literatures indicate that the most negative impacts of large dam construction are loss in the ecological/biodiversity [3]:

a) Impact on the ecology of the freshwater system,

b) Loss in water bird habitat.

World Bank's estimate that roughly ten million people are displaced each year due to dam construction, urban development, and transportation and infrastructure programs [4]: This number is shockingly high, but it still fails to account for large numbers of the displaced. Displacement tallies almost always refer only to persons physically ousted from legally acquired land in order to make way for the planned project, ignoring those living in the vicinity of, or downstream from, projects, whose livelihoods and socio-cultural milieu might be adversely affected by the project [5].

It is during the dam operation phase - which can typically span 50 to 100 years - that the most severe impacts on fisheries and aquatic environments take place [6]. Produced comprehensive reviews of dam impacts on fisheries and aquatic ecology at global level, while carried out detailed analysis of the impacts of dams on aquatic environment and fisheries in Africa and South-east Asia. Impacts can be grouped into two categories: 1) impacts which affect fish directly, and 2) impacts which affect the fisheries environments (upstream river, reservoir, downstream river, estuary, delta, sea) in some manner that leads to a deterioration in fish biodiversity, fish stocks and/or fisheries production. Thus a proper EIA report can predict the all environmental effects and propose the possible techniques for mitigation or reduction of negative effects [6].

There are three principal methods for identifying environmental effects and impacts: Checklists are comprehensive lists of environmental effects and impact indicators designed to stimulate the analyst to think broadly about possible consequences of contemplated actions. This strength can also be a weakness, however, because it may lead the analyst to ignore factors that are not on the lists. Checklists are found in one form or another in nearly all EIA methods. One of the most comprehensive is published in the United States [7]. Matrices typically employ a list of human actions in addition to a list of impact indicators. The two are related in a matrix which can be used to identify (to a limited extent) cause-and-effect relationships and flow diagrams are sometimes used to identify action-effect- impact relationships. The flow diagram permits the analyst to visualize the connection between action and impact. In this research the above three methods were used and the results were compared [2].

The forth and fifth National Development Program (NDP) of Iran call for the uniform protection of all significant water resources, and places emphasis on resource sustainability and integrated water resource management. Department of Environment (DOE) of Iran also required the necessity of EIA report for all hydro-electric projects to assist in their decision-making process. In this paper socio-economical and the environmental impact assessment of the Gotvand hydro-electrical dam has been evaluated. This dam is one of the largest dams in Iran with a volume of 4.5 billion m3 and is going to be the last dam on the Karoon River in the south of Iran. In this paper all socio economical and environmental effects of the dam during the construction and operation of the hydro electric dam have been discussed.

Of the types of development projects that bring about physical displacement, dams and their related infrastructure, including power stations and irrigation canals, stand out as the largest contributor to displace. All dams and reservoirs as many other human activities, become a part of their environment which they influence and transform to a degree and within a range that vary from project to project. Frequently seeming to be in opposition, but not necessarily irreconcilable, dams and their environment interrelate with a degree of complexity that makes the task of the dam engineer particularly difficult. The solution must be to find the golden mean by striking a balance between divergent and sometimes contradictory goals. We need dams and the many benefits which their reservoirs offer all over the world, by storing water in times of surplus and dispensing it in times of scarcity. Dams prevent or mitigate devastating floods and catastrophic droughts. They adjust natural runoff with its seasonal variations and climatic irregularities to meet the pattern of demand for irrigated agriculture, power generation, domestic and industrial supply and navigation.

The objective of the Joshi (Joshi & LATIF, 2004) study was to assess the environmental impacts of the Kalni-Kushiyara River Management Project (KKRMP) in Bangladesh. They have used Two methods - a conventional matrix method and a more sophisticated Multi Criteria Decision Making (MCDM) method - in this study. They found that MCDM method yields a more holistic evaluation of the system, and a ranking in decreasing order of environmental soundness of various future options

The results of Ramachandran's research (Ramachandran et al., 2018) showed higher concentration of TDS, EC, Na, Cl, which indicated signs of deterioration but in the values of pH, Ca and Mg, were within permissible limit as per standards. Also, They have used the geochemical processes piper and gibbs plot for the study.

The main purpose of Adgolign's paper (Adgolign & Rao, 2014) was to review the current level of understanding of environmental impact assessment of water resources development; to assess the major challenges to sustainable environmental systems from water resources development perspectives, and to identify major environmental issues that need to be considered in sustainable water resources planning and development

Environmental Impact Assessment concept in India came in the year 1994 and amendment in the notification about three times is the clear indication that concerned people and organization are not taking a breathe after introducing Environmental Impact Assessment in India. They are constantly monitoring and taking corrective action (Siddiqui et al., 2008) to make this Environmental Impact Assessment concept a real working tool to protect the environment.

2. Project description

The Gotvand Dam which is going to be constructed in the next few years as the last dam on Karoon River is located within the Khozestan Province South of Iran. This dam will have a surface of 96.5 km2 with an approximate water volume of 4445 million m for the purposes of hydroelectric energy with the capacity of 4250 million KW, agricultural and recreational uses.

3. Methodology

3.1. Data Gathering

The research method involved formal and informal interviews with key informants within formal and indigenous institutions. These included key government officials, university professors, environmental consultants, nongovernmental organizations, and traditional leaders. Open-ended questions designed to identify constraints to EIA practice in the country were posed. These were supplemented with content analysis of secondary data and information from official publications and other related literature. Transcripts of interviews, field notes, and relevant literature were analyzed on the basis of themes and patterns of interrelationships among responses that addressed the research goal [8].

3.2. EIA Analyzing Method

The environmental assessment of Gotvand dam and its related installations began by analyzing the available environmental resources. In analyzing the environmental resources of watershed basins of region, the available maps together with land works were used. Furthermore, in the environmental impact analysis of the dam and its related installations, the method of ICOLD matrix was used. The aims of the prediction and

evaluation stages of the EIA procedure are to identify those activities most likely to occur, and to determine the likely importance of these impacts, be they positive or negative. All the implementing activities in connection with the dam construction was predicted in the method , and after the land visit to the studying areas, a list of impacted environmental factors was made ready [2, 9].
The EIA evaluation was made for the important phases during the construction and after operation. The negative impacts of each activity on the environmental resources was then evaluated, and the results were examined. In this method, the environmental resources, which will be affected by “much” and “very much” negative impacts, have been identified. The activities, resulting in resources destruction, have been then specified (Table 1). Magnitude is a quantifiable measure of the size of an impact, and it can be defined as the degree of movement away from the baseline state of the specific environmental ICOLD has prepared a large and comprehensive matrix for use in EIA studies for dams. The system of symbols for each box shows: whether the impact is beneficial or detrimental; the scale of the impact; the probability of occurrence; the time-scale of occurrence; and, whether the design has taken the impact into account, [1]. This comprehensive approach, however, makes the final output rather difficult to use and a maximum of three criteria is recommended per impact to maintain clarity. Ahmad and Sammy suggest that the most important criteria are: magnitude, or degree of change; geographical extent; significance; and, special sensitivity [10]. "Significance" could be further sub-divided to indicate why an impact is significant. For example, it may be because of irreversibility, economic vulnerability; a threat to rare species etc. "Special sensitivity" refers to locally important issues component under consideration. Here the magnitude is expressed on a scale of 1 to 3. Significance is defined as a measure of how important the assessor feels any movement away from the baseline conditions to be. Significance is expressed on a scale ranging from highly detrimental (−5), through negligible (0), to highly beneficial (+5). On the basis of these scores all activities can be ordinal ranked[11].
In order to aid completion of the matrix, domain specific information is presented to the user simultaneous to completing the matrix. This information is of three types: textual information specific to each environmental component (i.e. the vertical axis of the matrix), rule-based information relating to the primary and higher order impacts of specific activities (the horizontal component of the matrix), and baseline biophysical and socio-economic data relating to the project's location (further details are given below). This information is held within a relational database comprised of tables relating to environmental components, project types, activities, impacts, mitigation measures and their inter-relationships. In addition the database contains textual information on each key item, i.e. activities and impacts. In the end, simple and implementable management mechanisms and strategies have been suggested to mitigate the negative impacts resulted from the project implementation .Thus, proper environmental management in the watershed of the region depends on the careful and complete implementation of these proposed mechanisms [12].

Table1. The activities, resulting in resources destruction

Surface water hydrology	**Aquatic habitats**	**Water supply**	**Socio-economics**
Surface water quality	**Aquatic wildlife**	**Food supply**	**Infrastructure**
Groundwater hydrology	**Terrestrial habitats**	**Fuel supply**	**Resettlement**
Soil erosion	**Terrestrial wildlife**	**Navigation**	**Indigenous cultures**
Soil fertility	**Coastal habitats**	**Recreation**	**Aesthetics**
Geology	**Marine life**	**Flood control**	**Noise**
Sedimentation	**Forests**	**Irrigation/drainage**	**Public health**
Air quality	**Protected areas**	**Agriculture**	**Nutrition**
	Endangered species	**Aquaculture**	**Archaeology**
		Agro-industry	

4. Results and Discussion

An assessment of the potential and existing impacts of the extraction of water from the Gotvand Dam on the surrounding environment was based on existing information and specialist studies, the existing and potential impacts have been assessed as shown in table II.

As indicated in table 2, the positive environmental effect received 12 crosses while the negative impact possible get 16 crosses; then it may be concluded that the Gotvand dam construction will have negative impact for the environment especially on biological element. however the number of positive impact especially in term of socio-economical impact significantly affect its negative ones.

The environmental effects of the Gotvand Dam construction on biological, physical and socioeconomic aspects using ICOLD technique is shown in table III, IV and V, respectively.

The description of each sign, item and abbreviation of the ICOLD technique in table III, IV and V is as the following [2].

I, II, III determine the priority of the waster consumption, the sign + and – show the negative or positive impact, no. 1, 2, and 3 indicate low, medium and high impacts respectively, C indicates the Certain impact, P indicates the Probable impact, I indicates the Improbable impact N shows the Non probable impact, P shows the permanent and T indicates the Temperate impact, L, M and I define Long term, Middle term and Instantaneous effect and finally Y shows the yield impact and N not defined impacts.

Based on above description the ICOLD matrices shown in tables 3, 4 and 5 indicate the impacts of each activity of the Gotvand dam on physical, biological and socio-economical environment.

The table III biological impacts demonstrates that (E501) vegetal destruction has the maximum effect while fun (E 506) and flora ranked less negative impacts.

The table IV physical impacts shows that (A207) vegetal destruction, (A208) raw material supply and (A301) discharging water vegetal area have the high negative impacts.

Water use in agriculture (A 101), tourism (A 403), industrial development (A415), fish industry (A 401) and infrastructure construction for the region (A 405) have the greatest positive impacts.

Vegetal destruction (A 207) has very negative impacts on the physical, biological and socio economical environment.

A change in the type, distribution and coverage of vegetation may occur given a change in the climate; this much is obvious. However, to what extent particular plant life changes, dies or thrives, depends largely on the model of prediction used. In any given scenario, a mild change in climate may result in increased precipitation and warmth, resulting in improved plant growth and the subsequent sequestration of airborne CO_2. Larger, faster or more radical changes, however, may well result in vegetation stress, rapid plant loss and desertification in certain circumstances [13].

The biological impacts of the Gotvand reservoir are felt in the areas of weeds, and environmental health including bilharzia [13], malaria and onchocerciasis[15]. Weeds different plant species usually proliferate with the execution of water projects. These aquatic weeds have very serious impacts on water supply and other reservoir based economic activitie. This has greatly contributed to the decline of fishing as an occupation in most settlements. Perhaps the most serious aspect of aquatic weed growth[16] is its direct impact on the incidence and spread of water borne diseases such as schistosomiasis, encephalitis and filariasis.

Table 2. The potential impacts of dam on physical, biological and socio-economical environment

For each environmental effect place a cross (X) in one of the columns		Positive impact very likely	Positive impact possible	No impact	Negative impact possible	Negative impact very likely	No judgment possible at present	Comments
		A	B	C	D	E	F	
Hydrology	1-1 Low flow regime							
	1-2 Flood regime							
	1-3 Operation of dams	×						
	1-4 Fall of water table							
	1-5 Rise of water table				×			
Pollution	2-1 Solute dispersion				×			
	2-2 Toxic substances				×			
	2-3 Organic pollution				×			
	2-4 Anaerobic effects							
	2-5 Gas emissions							
Soils	3-1 Soil salinity							
	3-2 Soil properties							
	3-3 Saline groundwater							
	3-4 Saline drainage				×			
	3-5 Saline intrusion				×			
Sediments	4-1 Local erosion				×			
	4-2 Hinterland effect							
	4-3 River morphology							
	4-4 Channel regime							
	4-5 Sedimentation							
	4-6 Estuary erosion							
Ecology	5-1 Project lands							
	5-2 Water bodies							
	5-3 Surrounding area							
	5-4 Valleys & shores							
	5-5 Wetlands & plains							
	5-6 Rare species				×			
	5-7 Animal migration							
	5-8 Natural industry	×						
Socio-economic	6-1 Population change	×						
	6-2 Income amenity	×						
	6-3 Human migration					×		
	6-4 Resettlement				×			

5. Conclusions and recommendations

There are three main groups that require the water resource from the Gotvand Dam: Hydro-electric power generation, Agriculture, Industry and Tourism. In analyzing the environmental impact of Gotvand dam, the available maps together with land works were used. Furthermore, in the environmental impact analysis of the dam and its related installations, the combining method of Leopold and ICOLD matrix was used. All the implementing activities in connection with the dam construction, was predicted in the method, and after the land visit to the studying areas, a list of impacted environmental factors was made ready.

The discussions highlight specific avenues to improving the EIA procedure in Iran and much of the developing world. A contentious issue is the need to include local people and their experiential knowledge in the EIA process. Indigenous experiential knowledge not only has the potential to complement Western scientific knowledge in ways that would improve assessment studies; it could also encourage local participation and bottom-up approaches to environmental and planning decisions. The involvement of local people may also help the assessment team to understand local resource-use and nuances, and use local value sets to interpret, evaluate, and monitor project impacts on local communities. If indigenous knowledge is to be preserved and passed from generation to generation, it will have to be recognized by institutions of power and influence. Policy makers would have to learn that indigenous knowledge is not just a relic of the past, but is something that is important now and will be worth having in the future. To achieve this, education must be geared toward the transmission from one generation to the next of the accumulated wisdom and knowledge of society, and the preparation of the young for effective participation in society's maintenance and development. In this sense, EIA could become part of the solution to the continued loss of indigenous knowledge by enhancing the participation of indigenous people in assessment studies.

The negative impacts of each activity on the environmental resources were then evaluated, and the results were examined. In this method, the environmental resources, which will be affected by “much” and “very much” negative impacts, have been identified. The activities, resulting in resources destruction, have been then specified.In the end, simple and implement able management mechanisms and strategies have been suggested to mitigate the negative impacts resulted from the project implementation. Thus, proper environmental management depends on the careful and complete implementation of these proposed mechanism.

Table 3. Environmental effects of the Gotvand Dam construction on biological aspect

				Terrestrial and Aquatic Flora									Terrestrial and Aquatic fauna									
				E501	E502	E503	E504	E505	E506	E507	E508	E509	E601	E602	E603	E604	E605	E606	E607	E608	E609	E610
		task	water usage priorities	jungle	released and unused lands	grass plant growth	agricultural lands	organic plants	active plants	phytoplangtons	rare and extincting pla	other plants	mammels	birds	insects	Reptiles	economical fish	other fishes	macroinvertebrate	zooplanktons	micro-organisms	rare and extincting typ
	A101	irrigation	I				+3CPMY	+2CPMY		-1PPMY					+1PPMY		-1CPMY		+1PPMY	+1CPMY		
	A102	energy	II	+1IPMY			+1PPMY						+1PPMY	+1PPMY	-1PPMY							
	A103	regulating water							+1CPMY	+1CPMY										+1CPMY		
	A104	balancing river flow	III				+1CPMY	+1CPMY	+1CPMY	+1CPMY			+1PPMY	+2PPMY	+2PPMY		+2CPMY	+1CPMY	+1PPMY	-1PPMY		+1PPMY
Water Consumes	A105	industrial usages	III			-1PPMY		-1PPMY	-2PPMY	-2PPMY				-1CPMY	-1PPMY	-1PPMY	-1PPMY	-1PPMY	-1PPMY	-1PPMY		
	A106	marine transport																				
	A107	fire station																				
	A108	fishing	III						+1CPMN	+1CPMN			-1PPMY	+1CPMY			+2CPMY	+1PPMY		-1CPMN		
	A109	water sports								-1PPLY	-2PPLY		-1PPMY	-1PPMY	-1PPMY		-1PPMY	-1PPMY	-1PPMY	-1PPMY		
	A110	other consuptions																				
	A201	being of reservoir dam		-1CPTY	-1CPTY	-1CPTY	+3CPMY						+1CPLY	+2CPLY	+1PPMY		+3CPMY	-1CPMY				-1CPTY
	A202	dam reservoir		-3CPTY	-2CPMY	-2CPMY	-1CPMY	+3CPLY	+2PPMY	+2PPMY			-1CPLY	+2PPMY	+2PPMY	+1PPMY	+3CPMY	+1CPMY	+1PPMY	+2PPMY	+1CPMY	+1PPMY
	A203	diversion system during construction		-1PPTY	-1CTIY	-1CTIY	-1CPTY		-2CTIY	-2CTIY	-1PPTY	-1PTIY		-1PTIY	-1CTIY	-1PTIY	-1CTIY	-2CTIY	-1CTIY	-2CTIY		-1CTIY
	A204	dam site construction		-1CPTY	-1CTIY	-2CTIY	-2CPTY	-2CPTY	-2CTIY	-2CTIY	-1PPTY	-1PTIY	-1PTIY	-2CTIY	-1CTIY	-1CTIY	-1CTIY	-2CTIY	-1CTIY	-1CTIY	-1CTIY	-1PTIY
	A205	coffer dam		-1PPTY	-1PTIY	-1CTIY	-1PPTY	-1PPTY	-1CTIY	-1CTIY	-1PPTY	-1PTIY			-1PTIY		-1CTIY	-2CTIY		-1PTIY		
	A206	emporary and permanent buildings at the dam sit		-1CPTY	-1PPTY	-1CPTY		-1PPTY	-1PPTY	-1PPIY		-1PPIY					-1CTIY			-1PPTY		
	A207	deforresting and bush cutting at the dam site		-3CPTY	-1CPTY	-1CPTY		-3CPTY	-1PTIY	-1PTIY	-3CPTY	-2CPTY	-1CPIY	-2CPTY	-1CTIY	-1CPTY		-1PPTY	-1CTIY	-1PTIY	-1CTIY	-2CPTY
physical Factors	A208	borrow area extraction		-2CPTY	-1CPTY	-2CPIY	-1PPTY	-2CPTY	-2CPTY	-2CTIY	-2PPTY	-2PPTY	-1PTIY	-1CPTY	-1CTIY	-1CPTY	-1CTIY	-2CTTY	-1CTIY	-2CTIY		-1CPTY
	A209	way for boyance solids																				
	A210	water conveyance channels to tourbines																				
	A211	water releaser				+2CPMY	+3CPMY	+2CPMY	+2CPMY	+2CPMY	+1CPMY	+1CPMY	+1PPMY	+1CPMY	+1CPMY	+1PPMY	+3CPMY	+3CPMY		+2CPMY		+1CPMY
	A212	intact system and permanent diversion system		-3CPTY	-2CPMY	-1CPMY	+3CPMY		+1PPMY	+2PPMY	+1PPMY			+1PPMY	+1CPMY	+1PPMY	+3CPMY	-1PPMY	+1PPMY	+1CPMY	+1CPMY	
	A213	power lines																				
	A214	diversion dam and channel and water conveyand		-1CPTY		+2CPLY	+2CPMY				-1PPLY		+1PPLY	+1CPLY	+1PPLY			-1PPLY	-1PLMY	-1PPMY		-1PPMY
	A215	other factors																				
	A301	Imerged Lands		-2CPTY	-1CPTY	-1CPTY	-1CPTY	+1CPTY	+2CPTY	+1CPTY	-2PPTY	+1PPTY	-1CPIY	+1CPTY	+1CPLY	-1CPLY	+2CPLY	-1CPTY	+1PPMY	+2CPTY		
	A302	adjacent areas at reservoir		-3CPTY	-1CPTY	-1CPTY	-2CPTY	+1CPTY	+2CPTY	+2CPTY	-2PPTY	+1PPTY	-1CPIY	+1CPMY	+1CPMY	-2CPTY	+2CPLY	+2CPMY	-1CPMY	+2CPTY		
	A303	water level variations of reservoir		-1PPMY		-1PPMY		+2PPMY														
	A304	reservoir-upstream river				+1CPTY	-1PPMY		-1PPTY	-1PPTY										-1PPTY	-1PPTY	
Affected Areas	A305	reservoir-downstream river			-1PPMY	-1CPTY			+2CPMY	+1CPMY	+1CPMY	+1CPMY	+1PPMY	+1CPMY	+2CPMY	+1PPMY	+2CPMY	+2CPMY	+1PPMY	+2CPMY	+1CPMY	+1CPMY
	A306	irrigation channels																				
	A307	groundwater					-1PPLN															
	A308	sea coasts																				
	A309	other lands																				
	A401	fish production management							+1PPMY	+1PPMY				+2PPMY			+3CPMY	+2CPMY		+2PPMY	+1PPMY	+1PPMY
	A402	guarantee for safe-environmental overflow				+1CPMY		+2CPMY	+2CPMY	+2CPMY	+2CPMY	+2CPMY	+1PPMY	+2CPMY	+2CPMY	+1CPMY	+2CPMY	+3CPMY	+2CPMY	+3CPMY	+1CPMY	+1PPMY
	A403	Tourism development		-1PPLY		-1PPLY	-1PPLY	-1PPLY	-1PPMY	-1PPMY	-1PPLY	-1PPLY	-1PPLY	-2PPLY		-1PPLY		-1PPMY	-1PPLY	-1PPMY	-1PPMY	-1PPMY
	A404	controlling of water level variations			+1PPMY	+1PPMY		+1PPMY	+1PPMY	+1PPMY	+1PPMY				+1PPMY		+2CPMY	+2CPMY	+1PPMY	+2CPMY	+1CPMY	
	A405	Infrastructures		-2CPTY	-1PPTY	-1CPTY	-1PPTY		-1PPTY	-1PPTY	-1PPTY		-1CPIY	-2CPTY	-1CPTY	-1CPTY		-1PPTY		-1PPTY	-1CPTY	-1PPTY
	A406	Foresting aroun the reservoir		+1CPMY		+1CPLY		+2CPMY	+1CPMN	+1CPMN	+1PPMN	+1PPMY	+1CPMY	+2CPMY	+1CPMY	+2CPMY	+1CPMN	+1CPMN	+1CPMN	+1CPMN	-1CPMN	+1PPMY
	A407	erosion control with terrace making, planting		+1CPMY		+1CPLY	+1CPMY	+1CPMY	+2CPMY	+1CPMN	+1PPMN	+1PPMY	+1CPMY	+1CPMN	+1CPMN	+1CPMN	+2CPMN	+2CPMN	+1CPMN	-2CTIY	+1CPMN	+1PPMN
	A408	dragging						-2CTIY	-3CTIY	-2CTIY	-2PTIY	-2PTIY		-1PTIY	-2PTIY	-1PTIY	-2CTIY	-2CTIY	-1PTIY	-1PTIY	-2CTIY	-2PPTY
physical Restoration	A409	dam's spillway		+1PPMY	+1PPMY	+1PPMY	+2PPTY	+1PPMY	-1CTIY	-1CTIY	-1PPTY				-1CTIY	-1PTIY	-2CTIY	-2PTIY	-1OTLY	-2PPMN	-1PTIY	-1PPTY
	A410	Chech dam			-1CPMN	-1CPMN	-1CPLN	-1PPMN	-1PPMN	-1PPMN	-1PPLN			-1PPLN		-1PPLN	-2PPMY	-2PPMN				-1PPLN
	A411	compensative reservoirs for controlling the river				+1PPMY	+2PPMY	+1CPMY	+2CPMY	+1PPMN	+2PPMY	+1PPMY	+1PPMN	+1PPMN	+1PPMY							
	A412	oom to serve the dam equilibrium against floating-			+1PPMY																	
	A413	controlling and conservation of the basin		+1PPMN		+2CPMN		+1PPMN	+2CPMN	+2CPMN	+1PPLN	+1PPLN	+1PPMY	+2CPMY	+3CPMY	+1PPMN	+2CPMY	+2CPMY	+2CPMY	-2CPMN	+2CPMN	+1PPMN
	A414	water detoxification				-1PPLN	-1PPLN	-1CPMN	-1PPMN	-1PPMN	-1PPLN			-1PPLN	-1PPMN					-1PPMN	-2CPMY	
	A415	improve the industries and preventing their damag		+1PPMN		+1PPMN	+2CPMN	+1CPMY	+2CPMY	+2CPMY	+1PPMY	+1PPMN		+1PPMN			+2CPMY			+2CPMY	+2CPMY	+1PPMN
	A416	rehabitation				+1PPMY	+2CPMY										+1PPMY				+1CPMY	
	A417	other damage refining																				
Legal Acts	501	taxes																				
	502	reassessment to the land value					+2CPMY															
	503	planning for civilian and rural measures		+2CPMY		+1CPMY		+1CPMY	+2CPMY	+2CPMY	+2PPMY	+1PPMY	+1CPMY	+2CPMY	+1CPMY	+2CPMY	-1CPMY	+1CPMY	+1CPMY	+2CPMY	+1CPMY	+1PPMY

Table 4. Environmental effects of the Gotvand Dam construction on physical aspects

		Task	priority of water consumptions	Geophysical Impacts													Effects on Water									Climate
				E201	E202	E203	E204	E205	E206	E207	E208	E209	E210	E211	E212	E213	E301	E302	E303	E304	E305	E306	E307	E308	E309	E401
				morphology	erosions	suspended Sedi	River bed load	Sedimentation in	slope stability	inductive earthqu	soil salination	flood	new geomorphol	drainage and lar	Flactuation of Wa	other cases	water biology	Physic and cher	salinity	Turbidity	Tempereture	Evaporation	river flow	water loss	ground water lev	local variations
	A101	irrigation	I	-1PPMY	-2 CPMY	-1 CPMY	-1 CPMY		-1 PPMY		-2 PPLY		-1 CPLY	-2 PPLY	-1CTIY				-1PPLY	-1 PPMY		-1 CPMN		-2 CPMY	-2 PPLY	
	A102	energy	II												-1CTIN						-2PPMY		-1PTMY	-1CPMY		
	A103	regulating water																								
	A104	balancing river flow	III	-1CPIY	-2 CPMY	-1 CPMY	-1 CPMN	-2 CPLY	-1 PPMN	-2 CPMN		+3 CPMY		-2 PPLN			-2 PPMY	-2 PPMY	-2 PPLY	+1 CPMY	-2PPLY	-2CPMY	-1CPMY	-1PPMY	-2CPLY	+2PPLY
Water Consumes	A105	industrial usages	III											-1 PPLN			-1 CPMY	-2 CPMY			-2PPMY	-1PPLY		-1CPMY		
	A106	marine transport																								
	A107	fire station																								
	A108	fishing	III				-1 CPLY	-1 CPLY									-1 PPMY	-1 PPLY		-1 CPLY						
	A109	water sports																-1 PPMY								
	A110	other consuptions			-1 PPMY	-1 CPMN	-1 PPMY	-1 PPLY	-1 PPMN								-1 PPMN	-1 PPMN		-1 PPMN						
	A201	being of reservoir dam		-1CPMY	-1 CPIY	-1 CPMN		-2 CPLY	-1 CPIY	-2 PPMY	-1 PPLY	+3 CPMY	-2 CPIY	-1 PPLY	+3 CPMY		-2 PPLY	-2 CPLY	-2 PPLY	+2 CPLY	-2PPLY	-2CPLY	-2CPTY	+2CPMY	-1CPLY	+2PPLY
	A202	dam reservoir		-1CPMY	-1 CMPY	-1 CPMN		-2 CPLY	-2 CPIY	-3 PPMY		+3 CPMY	-1 CPMY	-1 PPLY			-2 CPLY	-2 CPLY	-2 PPLY	+2 CPLY	-2PPLY	-2CPLY	-1CPMY	+3CPMY	-1CPLY	+2PPLY
	A203	diversion system during construction		-1CTIY	-2 CTIY	-2 CTIY	-2 CTIY		-1 CTIY			-1 CTIY	-2 CTIY	-1 CTIY						-1 CTIY			-2CTIY	-1PITY		
	A204	dam site construction		-2 CTIY	-2 CTIY	-2 CTIY	-2 CTIY		-2 CTIY			-1 CTIY	-1 CTIY	-2 CTIY			-1 PTIN	-2 CTIY		-2 CTIY	-1PTIY		-2CTIY	-1CTIY	-1PTIY	
	A205	coffer dam			-1 CTIY	-1 CTIY	-1 CTIY		-1 CTIY				-1 CTIY	-1 CTIY			-1 PTIN	-2 CTIY				-1PTIY	-1CTIY		-1PTIY	
	A206	mporary and permanent buildings at the dam s							-1 CPIY					-1 CTIY			-1 PTIY									
	A207	deforresting and bush cutting at the dam site		-2 CTIY	-2 CTIY	-2 CTIY	-3 CTIY	-2 CTIY	-2 CTIY			-2 CTIY	-1 CTIY	-2 CTIY			-1 CTIY	-2 CTIY	-1 PTIY	-2 CTIY			-1PTIM	-1CTIY	-1CTIY	-1PTIY
physical Factors	A208	borrow area extraction		-2 CTIY	-2 CTIY	-2 CTIY	-2 CTIY	1- CTIY	-2 CTIY			-2 CTIY	-2 CTIY	-2 CTIY				-1 PTIY	-1 [TIY	-1 CTIY			-1CTIY	-1PTIY	-1CTIY	
	A209	way for boyance solids																								
	A210	water conveyance channels to tourbines			-1 CPMY	-2 CPMY	-1 CPMY	+1 PPMY	-2 CPMY			-1 PPNY														
	A211	water releaser		-1 CPMY	-2 CPMY	-1 CPMY	-1 CPMY	-2 CPLY		-3 PPMY		+2 CPLY	-2 CPMY				-1 CPMY	-1 PPMY	+1 CPLY		+2PPLY		-1PPMY		+2CPLY	
	A212	intact system and permanent diversion system															-2 CPLY	-2 CPLY		+2 CPLY	-2PPLY	-2CPLY	-2CPMY	+2CPMY	-2CPLY	+2PPLY
	A213	power lines		-1 CPMY	-1 CPMY	-1 CPMY	-1 PPMY	-2 PPLY	-1 CPMY			+2 CPMY	-1 CPIY													
	A214	liversion dam and channel and water conveyar															-1 CPLY	-1 CPLY	-1 PPLY	+1 CPLY			-1CPTY	+2CPMY		
	A215	other factors		-1 CPMY	-2 CTIY	-1 CPMN		-1 CPMY	-2 PPIY	-2 PPMN		+2 CPMY	-2 CPMY	-2 CPMY												
	A301	Imerged Lands		-1 CPMY	-2 CTIY	-1 PPMY		-1 CPMN	-1 PPIY				-1 CPMY	-1 PPMY			-2 PPLY	-2 PPMY	-2 PPLY	+2 CPMY	-2PPLY	-2CPMY	-2CPTY		-2CPMY	+2PPLY
	A302	adjacent areas at reservoir												-2 CPMY			-1 PPMT	-1 PPMY	-1 PPLY	-1 PPMY			-1CPTY			+1PPLY
	A303	water level variations of reservoir			-1CPIY	-2 PPIY			-1 CPIY				-1 CPTY							-1 PPMY			-2CPMN		-1CPMY	
	A304	reservoir-upstream river		-1 CPMY	-1 CPMY	-1 PPMY			-1 CPMY				-1 CPTY	-1 PPMY			-2 PPMY	-1 PPMY	-2 PPLY	-1 PPMY			-1CPMY			
Affected Areas	A305	reservoir-downstream river															-1 PPMY		-1 PPLY	-1 CPMY	-1PPMN				-2CPMY	
	A306	irrigation channels									-1 PPLY			-2 PPLN												
	A307	groundwater									-2 PPLY														-2PPLY	
	A308	sea coasts																								
	A309	other lands				-1 PPMY	-1 PPMY	-1 CPLY																		
	A401	fish production management			-1 CPMN	-1 CPMY	-1 CPMY	+2 CPMY	-1 PPMY				+2 CPMY	+1 CPMY			-1 CPMY	-1 PPLY		-1 PPMY						
	A402	guarantee for safe-environmental overflow		-1 PPLY	-1 PPLY	-1 PPLY	-1 PPLY	-1 PPLY	-1 PPMY			-1 PPLY	-1 PPLY	-1 CPLY			+2 CPMY	+2 CPMY	+2 CPMY	-1 CPMY	+1CPMY		+2CPMY		+2CPMY	
	A403	Tourism development				-1 CPMY	-1 CPMY	-1 CPMY	-1 CPMY				+1 CPMY				-1 CPMY	-1 PPMY	-1 PPLY	-1 PPLY						
	A404	controlling of water level variations		-1 CPIY	-2 CPMY	-1 CPMY	-1 CPMY	-1 CPMY	-1 PPMY			-1 PPMY	-1 CPMY	-1 CPMY			+2 CPMY	+1 PPMY					+1CPMY			
	A405	Infrastructures		+1 CPLY	+2 CPLY	+2 CPLY	+2 CPLY	+2 CPMY	+2 CPLY			+3 CPLY	+2 CPLY	+2 CPLY				-2 CPMY		-1 PPMY						+1PPLY
	A406	Foresting aroun the reservoir		+1 CPMY	+3 CPMY	+2 CPMY	+2 CPMY	+2 CPMY	+2 CPMY			+3 CPMY	+2 CPMY	+2 CPMY			-1 PPLY	+1 PPLY	+2 CPLY	+2 CPLY			+1CPLY	+1CPLY	+1CPLY	
	A407	erosion control with terrace making, planting			-2 CTLY	-2 CPLY			-1 CTLY			-1 PTLY	-1 PTLY				+1 PPMY	+1 PPLMY	+2 CPMY	+2 CPMY			+1CPMY	+2CPMY	+1CPMY	
	A408	dragging			-1 PPMY	-1 CTMY	-2 CTMY	+1 CPMY	-1 CTMY			-2 PTMY	+1 PTMY	+2 PPMY				-1 CPLY		-2 CTLY						
physical Restoration	A409	dam's spillway			-1 CPMY	+2 CPMY	+1 CPMY	+3 CPMY					-1 CPMY				+1 PPMY	+1 CPMY	+2 CPMY	-2 CTMY	+1PPMY	+1PPMY	+2CPMY	-2PPMY	+2CPMY	
	A410	Chech dam			-1 PPMN	-1 PPMN	-1 PPMN					+2 CPMY	+2 CPMY	+1 CPMY			+1 PPMY		+2 CPMY	+2 CPMY						
	A411	compensative reservoirs for controlling the rive															+1 CPMY	+2 CPMY	1- PPMY		+1PPMY		+2CPMY	+1PPMY	+2CPMY	
	A412	om to serve the dam equilibrium against floatin																								
	A413	controlling and conservation of the basin			-1 CPMY	+2 CPMY	+2 CPMY	+2 CPMY	-1 CPMN		+1 CPLY		+1 CPMY				+1 PPMY	+3 CPMY						+2CPLY		
	A414	water detoxification			+1 CPMY	+1 CPMY	+1 CPMY		+1 PPMY				+1 PPMY	+1 CPLY			+2 CPMY	+1 PPMY	+1 CPMY	+1 PPMY						
	A415	nprove the industries and preventing their dama		-1 PPMN	+1 CPMY	+1 CPMY	+1 CPMY		+1 PPMY			+1 PTMY	+1 PTMY	+1 PTMY			+2 CTMY	+2 CPMY	+1 PPMY	+1 PPMY	+2CPMY		+1PPMY	-2CPMY		
	A416	rehabitation															+1 CTMY	+1 CPMY	+1 CPMY	+1 CPMY			+1PPMY			
	A417	other damage refining																								
Legal Acts	501	taxes																								
	502	reassessment to the land value		+1 PPLY	+1 CPMY	+1 PPMN	+1 PPMN	+1 CPMN	+2 CPMY			+1 PPMN	+1 PPLY	+1 CPLY			+1 PPMN	+1 PPM	+1 PPMN	+1 PPMN				+1PPMY		
	503	planning for civilian and rural measures																								

Table5. Environmental effects of the Gotvand Dam construction on socioeconomic aspects

		task		Social, Economical and Cultural Effects															
				E101	E102	E103	E104	E105	E106	E107	E108	E109	E110	E111	E112	E113	E114	E115	E116
			water useage priorities	industrial,trade preblems of dam construction	employment	tourism	agriculture and	road access	Local Income	increase in land value	approvement and acceptance of local people	recreation	Heritages and Cultural Indexes	Aesthetics	water supply	Land Purchase and investment	reduction and growth c	Natural Disaster Protec	Sanitary Effects on Local People and Labors
	A101	irrigation	I	+2CPMY	+2CPMY	+1PPLY	+3CPMY		+2CPMY	+1CPMY	+2CPMY	+1CPMY				+1CPLY	+2CPLY		
	A102	energy	II	+2CPMY	+3CPMY	+2CPMY	+1PPMY		+2CPMY	+1CPMY	+1CPMY	+3CPMY					+3CPLY		
	A103	regulating water																	
	A104	balancing river flow	III	+1PPLN	+2CPMY	+1PPLY	+3CPMY		+1CPLY	+1CPMY	+2CPMY	+1PPMY				+1CPMY	+2CPMY	+3CPMY	
Water Consumes	A105	industrial usages	III	+2CPMY	+1CPLY				+2CPLY	+1CPMY	+2CPMY					-2CPMY	+1CPMY		
	A106	marine transport																	
	A107	fire station																	
	A108	fishing	III		+1CPMY	+2CPMY			+1CPMY	+1CPMY	+1CPMY	+2CPMY	+1CPLY			+1CPMY	+1CPMY		
	A109	water sports		+1PPLN	+1CPMY	+3CPLY			+1CPMY	+1CPMY	+1CPMY	+2CPMY	+1CPLY			+1CPMY	+1CPMY		-1CPMY
	A110	other consuptions																	
	A201	being of reservoir dam			+3CPLY	+2PPLY	+3CPMY	-1CTIY	+2CPMY	+2CPLY	+2CPMY		-1PPIM				+1CPMY	+3CPLY	
	A202	dam reservoir		+2CPLY	+2CPLY	+1PPLY	+3CPMY		+1CPMY	+2CPLY	+1CPMY	+2CPLY	-1CPIY	+2CPMY			+1CPLY	+3CPLY	-2PPLY
	A203	diversion system during construction									-1CTIY			-1CTIY				-1PTTY	-1PTIN
	A204	dam site construction				-1CTIY	-1CTIY	-1CTIY			-1CTIY	-1PTIN	-1CPIY	-2CTIY			-1CPIY	-1CTTY	-2CTIY
	A205	coffer dam		+1PTIN					+1PTIN					-1CTIY					
	A206	mporary and permanent buildings at the dam s		+1PTIN	+2PTIN				+1CPIN		-1CTIY		-1CPIY	-1PTIY					-2PTIY
	A207	deforresting and bush cutting at the dam site				-1CTIY	-1CTIY	-1CTIY	-2CTIY		-2CTIY	-1CTIY		-2CTIY				-2CTTY	
physical Factors	A208	borrow area extraction		+2CTMY	+2CTMY	-1CTIY	-1CTIY	+1PPIN	+1PTIN					-1CTIY				-1CTIY	
	A209	way for boyance solids																	
	A210	water conveyance channels to tourbines																	
	A211	water releaser			+1PPLM	+1CPLY	+2CPMY		+1PPLN		+1CPLN	+1CPLY		+1CPMY				-1PPMY	-2PPLY
	A212	intact system and permanent diversion system									+1CPLN	+2CPLY							
	A213	power lines		-1CTTY				+1CPMN					+1PPMN						
	A214	iversion dam and channel and water conveyar			+2CPMY	+1PPLY	+2CPLY		+1CPMY	+1CPLY	-1CPMY						+1CPLY	+2CPLY	
	A215	other factors																	
	A301	Imerged Surfaces				-1PTIN	-1CITIY			-1CPIY	-1CPIY	-1CPIY				-1CPIY	-1CTIY	+2CPMY	-1CTIY
	A302	adjacent areas at reservoir		-1CTIY	-1CITTY	-1PTIN	-1CTIY	-1CPIY	-1CTIY	-2CPIY	-1CPIY	-1CPIY	-2CPIY	+2CPMY		-1CPIY	-1CTIY	+2CPMY	-2CPMY
	A303	water level variations of reservoir																	
	A304	reservoir-upstream river																	
Affected Areas	A305	reservoir-downstream river		-1PPLN	-1PPLN							-1PPLY		-1CPMY		-1CPLY		-1CPMY	
	A306	irrigation channels																	
	A307	groundwater		-1PPLN	-1PPLN		-1PPLY				-1PPLN					-1PPLY			-1PPLY
	A308	sea coasts																	
	A309	other lands																	
	A401	fish production management		+2CPLY	+2CPLY		+2CPMY		+2CPMY	+1CPMY	+2CPMY					+2CPMY	+2CPLY		
	A402	guarantee for safe-environmental overflow		+1CPMY	+1CPLY	+2CPLY	+1CPMY		+1CPLY	+1CPMY	+2CPMY		+2CPMY		+1CPMY	+2CPLY			
	A403	Tourism development		+2CPLY	+2CPLY	+2CPLY		+1CPLN	+2CPLY	+1CPLY	+2CPLY	+2CPMY	+2CPMY			+2PPLY	+2CPLY		
	A404	controlling of water level variations			+1PPLN	+1PPLN	+1CPMY		+1CPLN	+1CPLY	+1CPLN					+2CPMY		+2CPMY	
	A405	Infrastructures		+2CPLY	+2CPLY	+2CPLY	+2CPMY	+2CPLY	+1CPLN	+2CPLY	+2CPLY	+1PPMN	+1CPLY			+1CPMY	+1CPLY	-1PPLN	
	A406	Foresting aroun the reservoir		+1CPLN	+1PPLN	+2CPLY													
	A407	erosion control with terrace making, planting			+1PPLN	+1CPLN	+1CPLN		+1PPLN		+1CPMN	+1PPMN	+1PPLN					+2CPLY	
	A408	dragging		-1PPMN															
physical Restoration	A409	dam's spillway		+1CPMY	+1CPLY	+1PPLN			+1PPLN	+1CPMY	+1CPMY	+1CPMN				+1CPMY		+1CPMY	
	A410	Chech dam			+1PPLN	+1PPLN	+1CPLN											+1CPMY	
	A411	compensative reservoirs for controlling the rive		+1PPMN	+1PPLN	+1CPLN			+1CPLN	+1PPMN	+2CPMY	+1CPMY		+2CPMY		+1CPLY	+1CPMY		+2CPMY
	A412	om to serve the dam equilibrium against floatin																	
	A413	controlling and conservation of the basin								+1CPLN		+1CPLN							+2CPLY
	A414	water detoxification																	
	A415	nprove the industries and preventing their dama		+1CPLY	+2CPLY	+1CPLN		+1CPLN	+1CPLY	+2CPLY	+2CPLY					+2CPLY	+2CPLY	+1CPLN	+1PPMY
	A416	rehabitation		-2CTIY	+2CPLY	+1CPLN	+2CPLY	+1CPLN	+2CPLY	+2CPLY	+2CPLY	+1PPMN	+2CPLY	+1CPMY		+1CPMY	+2CPMY		+1CPMY
	A417	other damage refining																	
	501	taxes																	
Legal Acts	502	reassessment to the land value					+2CPMY		+2CPMY		+2CPMY					+2CPMY	+2CPLY		
	503	planning for civilian and rural measures		+1CPLN	+1CPLN	+2CPMY	+1CPMN		+1CPLN		+1CPMY	+1CPMY						+2CPMY	+1CPMY

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