HASAN KALYONCU UNIVERSITY
GRADUATE SCHOOL OF
NATURAL & APPLIED SCIENCES

THE ENVIRONMENTAL IMPACT ASSESSMENT FOR BASTORA DAM

M.Sc. THESIS
IN
CIVIL ENGINEERING

by
MOHAMMAD JAWAD PIRDAWOOD SINJAWI
July 2018

THE ENVIRONMENTAL IMPACT ASSESSMENT FOR BASTORA DAM

M.Sc. Thesis

In

Civil Engineering Department

Hasan Kalyoncu University

Supervisor

Prof. Dr. Mehmet KARPUZCU

by

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Declaration

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Mohammad Jawad Pirdawood SINJAWI

ABSTRACT

THE ENVIRONMENTAL IMPACT ASSESSMENT FOR BASTORA DAM

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M.Sc. in Civil Engineering

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Dams have been used for thousands of years to regulate river flows and ensure adequate supply of water during dry periods. In the future, as population increase and water consumption rises, many people believe there will be a need for more dams. The main objectives of the EIA study of the Bastora dam was to assess/evaluate the potential impacts of the dam project (BDIP) on the ecology, and socio-economics/health status of the people. The study comprises plenty of field and data collection in order to evaluate environment impacts of dams. This study project has diverted part of the peak flow of the Bastora stream into a 200 million m^3 capacity of stream storage reservoir. The main purpose of the stored water will be to irrigate 4,000 ha out of the 11,000 ha of the total land downstream to grow crops and fruit trees.

In the study area, ground water is an essential input to agricultural, environmental, health, domestic and development, especially in the rural area. According to a new survey about 60% of water demand is met by numerous deep wells dispersed throughout the urban and suburban areas, while about 40 % is supplied from the Greater Zab River by pumping from Ifraz station to the treatment plant near Erbil.

According to the FAO 2004 well depths have only recently increased and most new wells have been drilled to a depth exceeding 100 m. Currently, there may be no more than 1,000 operational deep wells in the entire district of Erbil. It may be concluded that the total amount of exploitable groundwater does not exceed 2.5 m^3/s. The population of the study area is about 60,000 people with a population density of about 450 / km^2. The mean annual rainfall ranges from 260 mm to 515 mm. The mean annual temperature in

the summer exceeds 35^{o}C and in winter ranges from 9^{o}C to 15^{o}C. In conclusion, the positive impacts are significantly higher than negative impacts and because this dam is considered a developing part of this area. Thus, reworking on this dam is highly recommended.

Keywords Environmental impact assessment, dams, watershed, ecology and social impact, reservoir.

ÖZET

BASTORA BARAJI İÇİN ÇEVRESEL ETKİ DEĞERLENDİRMESİ

PIRDAWOOD, Mohammad Jawad

Yüksek Lisans Tezi, İnşaat Mühendisliği Bölümü

Danışman: Prof. Dr.Mehmet KARPUZCU

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Barajlar nehir akışlarını düzenlemek ve kuru dönemlerde yeterli su teminini sağlamak için binlerce yıldır kullanılmaktadır. Gelecekte, nüfus artışı ve su tüketimi arttıkça, birçok kişi daha fazla baraja ihtiyaç olacağını düşünüyor. Bastora barajının ÇED çalışmasının ana hedefleri, baraj projesinin Ekolojiye ve halkın sosyo-ekonomik/sağlık durumuna potansiyel etkilerini belirlemek/değerlendirmektir. Çalışma, barajların çevresel etkilerini değerlendirmek için bol miktarda alan ve veri toplamadan oluşmaktadır. Bu çalışma, Bastora Deresinin tepe akışının bir bölümünü 200milyon.m^3'lük bir akış depolama rezervuarı haline getirmiştir. Depolanan suyun temel amacı, ekinleri ve meyve ağaçlarını yetiştirmek için aşağı yukarı toplam arazinin 11,000 hektarından 4.000 hektarını sulamak olacaktır.

Proje alanında, yeraltı suyu özellikle kırsal alanda tarım, çevre, sağlık, ev ve gelişme için önemli bir girdidir. Yeni bir araştırmaya göre, su ihtiyacının yaklaşık 60%'ı kentsel ve banliyö alanları boyunca dağılmış çok sayıda derin kuyu tarafından karşılanırken, Bu ihtiyacın 40%'ı Büyük Zap Nehri'nden , Ifraz istasyonundan Erbil yakınlarındaki arıtma tesisine pompalanarak tedarik edilmektedir.

FAO 2004'e göre, kuyu derinlikleri sadece yakın zamanda artmış ve en çok yeni kuyu 100 metreyi aşan bir derinliğe kadar inilmiştir. Şu anda Erbil ilçesinde 1.000'den fazla operasyonel derin kuyu bulunmayabilir. Kullanılabilir yeraltı suyu miktarının 2,5m^3/sn'yi aşmadığı sonucuna varılabilir. Proje alanının nüfusu yaklaşık 60.000 kişi olup, nüfus yoğunluğu km^2 başına 450 kişidir. Yıllık ortalama yağış 260 mm ila 515 mm arasinda değişmektedir. Yaz aylarında ortalama yıllık sıcaklık 35^{o}C'yi aşar ve kış aylarında 9^{o}C ile 15^{o}C arasında değişir. Sonuç olarak, olumlu etkiler olumsuz etkilerden önemli ölçüde daha yüksektir ve bu barajın bu alanın gelişmekte olan bir parçası olduğu düşünülmektedir. Böylece, bu baraj üzerinde yeniden işlenmesi şiddetle tavsiye edilir.

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Anahtar kelimeler:. Çevresel etki değerlendirmesi, barajlar, havza, ekoloji ve sosyal etki, rezervuar.

Dedication

To my parents and family who taught me to try my best no matter how difficult the task or great the risk of failure,

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It is pleasure to express my heartfelt gratitude to those who made this thesis possible. First of all I would like to thank God almighty for the unmerited grace and favor bestowed upon me. Secondly I would like to thank my supervisor MEHMET KARPUZCU for his encouragement, guidance and support from the initial to the final level of this thesis enabled me to develop a deeper understanding of the subject. The study reflects your thoughtful comments and unreserved contributions and it has been a great opportunity for me to conduct this study under your supervisions. I thank to Dr. Ali Rashid Khoshnaw for his guidness and support during my study. Also, Thanks to Dr. Dara for his support and helps.

I express my sincere gratitude to general directorate of municipality-Erbil for offering me the chance to study under the two years master‘s program.

Many thanks and a great measure of gratitude is due to my family for the moral,constant encouragement and prayers for me all the time.

Finally, I would like to thank greatly my colleagues, the entire staff and students of the School of Natural and applied sciences, and all those whose support, encouragement, friendship and well wishes made my stay both socially and academically well-spent. Thank you very much.

TABLE OF CONTENTS

page

LIST OF FIGURES

page

LIST OF TABLES

Page

LIST OF ABBREVIATION

EIA	Environmental impact asseesment
BDIP	Bastora dam irrigation project
WHO	World health organisation
FAO	Food and agricultura organisation
WCD	World commission on dams
WB	World bank
m.a.s.l	meter above sea level
IWRM	Integrated water resources management
MOE	Ministry of education
MOH	Ministry of health
MOI	Ministry of irrigation
MOT	Ministry of trading
MOWRA	Ministry of water resource and agriculture
UNEP	United nation environment progam
V	Volt

CHAPTER 1

INTRODUCTION

1.1 Background

Iraq is facing a serious water shortage due to the degradation in the qualities of the water and decrease in the quantities reaching its borders with the two rivers Euphrates and Tigris (Al-Ansari et al., 2015). The Euphrates and Tigris rivers supply more than 98% of Iraq's water demands for the different purposes. Degradation of these rivers has become a serious problem. Previous studies on water resource reached an important conclusion, Iraq face serious water shortage problem (Abd-El-Mooty et al., 2016).

Developments of water resources in Iraq are heavily controlled by hydrologic conditions. Difficulties in terms of water management are present (e.g., difficulties in coordination between users, lack of coordination between reservoirs, lack of organizing management between stakeholders, lack of combination management between surface water and groundwater, lack of water demand measurements and etc…) (Khoshnaw, 2018).

The water resources in Iraq managed by ministry of water resources, ministry of environment , ministry of agriculture and ministry of municipality. These ministries coordinating with the almost the same ministries. They are working for managing Tigris river basin, those stakeholders in low-level management due to the political unstable situation in Iraq, which means that mainly the long-term planning not established, each ministry, planning separately for development of water resources with difficulties coordination. This in turn, caused un-integration water resources.

Generally, existing legal framework is too sartorial. A lack of the sound legal framework is exist, providing an enabling environment for Integrated Water Resources Management (IWRM). There is also a need for water strategy and water policy at ministry of water resource level. Meanwhile, there is a lack of enforcement of main existing laws and regulations, as far as water uses and water pollutions are concerned. In the same way, some polluting activities seem to be happening without any previous Environmental Impact Assessment (EIA) (Khoshnaw, 2018).

However, In Iraq, especially in Erbil government, Environmental Impact Assessment (EIA) should be performed prior to the construction of a dam because the EIA is important study for reducing negative impacts during the construction of infrastructures such as dams and reservoirs and on the other hand incresing the positive impacts. Also, evaluating the effects of dams on the environmental and social aspects.

Some conflicts around water availability (in quantity, quality) and environmental degradation progressively arose during recent years in Erbil government, due to, among others overexploitation of groundwater in various areas especially in the urban area, urban water pollution that creates some difficulties during dry seasons; and gravel mining that damages natural river courses or even some irrigation schemes. These conflicts mainly result from the conjunction of sartorial approaches and the lack of Integrated Water Resources Management in Erbil government. There is no real operational tool to solve the disputes. These conflicts can only increase in link with on-going economic development, which generates more and more pressures on the resource: water withdraws, pollutions, environmental degradation.

The construction of dams play a significant role in the development of Iraq's hydropower and the organizing of water resources. However, it also makes a remarkable influence on region ecological environment. It has become the critical issue of dam and reservoir projects how to coordinate the relationship between construction and environmental protection, and to realize their harmony development (Cai et al., 2007). After dam and reservoir projects are completed, the actual environmental impact can be investigated by environmental agency, and can be compared to the results of EIA. The differences of environmental impact between actual and predicted results can be used to testify the anticipated results of EIA and reasonability of environment-protection design and evaluate the availability of environmental protection measures of the completed projects. Additionally, the environmental quality needs to be repeatedly assessed after completing the projects, and thus some remedial measures should be proposed (Bai et al., 2009 ; Zhang et al., 2010).

1.2 Statement of the problem

The growing attention on the interactions between development actions and their environmental consequences and the issue of sustainability has become an overarching goal and frame of reference of conservation and development strategies. The achievement of sustainable development requires a framework of policies, approaches, and tools. One of these tools is the application of EIA as an appraisal method and decision-aid. Now, it is widely accepted that the environmental and social consequences of development actions must be mitigated within the scope of the project itself by integrating EIA into the process of designing and implementing the project (Feyissa, 2011).

Development projects including dam projects can cause significant environmental damages and threaten the natural resources base, and the socio-economic and public health of the community unless they are properly and adequately planned and managed correctly. It has been broadly accepted that these environmental and social consequences can be reduced to acceptable levels by integrating EIA in the planning and implementation of development proposals. However, the current EIA practice in Erbil government - Iraq is not so effective to help to achieve this crucial objective. Among the factors that are believed to be significantly influencing the effectiveness of EIA are the weak institutional framework, inadequate legislative framework, the omission of stages in the EIA process, quality of EIA reports as well as the ineffectiveness of implementation and follow-up of EIA recommendations.

In environmental context, the impact of water exploitation is persistent and linked to the building of dams. Several unexpected outcomes must be understood before starting any utilization or manipulation of water resources. This understanding could help in mitigating any possible negative environmental impacts. According to the Millennium Ecosystem Assessment, freshwater ecosystems tend to threaten the extinction of a high number of species. Transportation of sediments to agricultural lands are prevented by the presence of dams in the study area. This lead to declining nutrient delivery to farms and farmland. In addition, the erosion rate is increased by non- laden water.

Management of drainage basin plays a significant role in the natural economy of the country, this could be through the appropriate use of land, minimizing natural disasters and developing rural areas, improving water resources (MOI, 1967). Thus, construction of dam continues rapidly, especially in the developing countries, where the water and electricity demand is strongest. Iraq is one of many developing countries where a few dams are currently under construction and/or in the planning process, the said dams are of varying sizes and scopes. The main problems of the dam in the study area are:

- Historical and archaeological places in company with geological and topographical places that are rare with their exceptional beauties disappear after lying under the reservoir.
- Discharge of toxic materials (pesticides, toxic metals .. etc). or waste waters into the reservoir.
- Dams affect the social, cultural and economical structure of the region considerably. Especially forcing people, to migrate and affect their phycology negatively.

The Bastora dam irrigation project (BDIP) is characterised by many features. The feautures of the dams are presented in Table 1.1 and 1.2.

Table 1.1: Features of BDIP dam.

Dam Type	Concrete-face-Rock-fill
Elevation	85m
Level	895
Width	13m
Area	132.5Km^2
High discharge inside reservoir	664.7m^3/s
High level flooding	892.1
Storage capacity	200million m^3

Table 1.2: Hydropower information of the dam.

Number	2
Type	Francis
High discharge per each unit	2m^3/sec
Capacity per unit	1.4Megawat
Capacity of total station	2.8Megawatt
Normal operating unit	891
The lowest operational level	855
Top water compressor	81m
The lowest water compressor	42m

1.3 Importance of the studied dam Project

The resolution of the Ministry of Water Resources of The Republic of Iraq, to embark on the Bastora Dam and the downstream Erbil plain irrigation project, grew from its perception that the natural resources potential of Bastora - Guma Span basin provides a perfect opportunity for effective integration of smallholder farmers into the commercial agriculture sub-sector and tourism activities.

The main goal of the study project is to contribute towards reducing poverty in the Erbil government. Locally, the objectives of the project are to increase household income, enhance food security, and improve approaches to social and health infrastructure for the rural population.

The project will divert part of the peak flow of the Bastora Chai stream into about 200 million m^3 capacity off-stream storage reservoir. The stored water will be suffieciet to irrigate 4000 ha of land to grow wheat, vegetable, and fruit trees.

The project may comprise six main components as follows:

- Impounding structures (including one dam)
- Outlet structures
- Mini-hydro electrical power plant, (of about 1.4 Megawatt)
- Distribution system
- Downstream development
- Recreation development

1.4 Aims and objectives of the study

High awareness of the human and natural environment is necessary to make proper planning of a dam. This study is meeting such requirements and is broadly known as "Environmental Impact Assessment" (EIA).

The objectives of the EIA study are follows:

1. To assess/evaluate the potential impacts of the BDIP on the ecology, and socio-economics/health status of the people;
2. To identify mitigation/improvments measures;

3. Develop an environmental management plan for the dam project.
4. Review necessary data pertinent to the study area to help in the preparation of the planning report or project design;
5. Make recommendations for mitigating adverse effects on the study area.

CHAPTER 2

STUDY AREA

2.1 Study area and location

The study area is located in northern Iraq within the Erbil government, Governorate of Erbil. Pirmum Mountains bound the study dam site and the watershed in the north-west, Saffin Mountains in the north-east, Cheska Mountains in the south-east, and the city of Erbil at the south-west (Figure 2.1).

The study area located within an extended region of longitude (44°02′ to 44°27′) E and latitude (36°07′ to 36°20’) N. The watershed and the irrigation area is 133 Km^2, which constitutes about 0.64% of the area of Erbil Governorate and 0.03% of the total area of Iraq of approximately 438,317 Km^2.

Figure 2.1: Location of the study dam area (MOWRA 2006).

2.2 Topography and limits

The study dam site (Bastora Dam) lies on the NE flank of a NW/SE trending geosynclines in the NE part of Iraq (Figure 2.1). The Bastora Dam site and Reservoir are located in the Pirmum Dagh mountain range about 30 km NE of the city of Erbil which is the first of a series of anticline ridges bounding the Erbil Plain in the NE. The series of folds from the physiographic unit High Folds become more structurally complex and topographically higher to the NE. The ample folds trend NW/SE are separated by intermountain valleys that are largely made of resistant limestone and the synclines are etched out of the younger shale, sandstone, and gravel.

The Mountains bound the Dam and Reservoir with altitudes ranging from 810 masl at Dam site to 1900 masl on the northeast peaks. The body of the dam is planned to be constructed at the Goma Span Gorge between Mountain Sartaka and Mountain Geshka near the village of Darband where Bastora River crosses the mountain range at this gorge (Figure 2.2).

The Irrigation area is located between the Pirmum Dagh Mountains and the city of Erbil on the Erbil Plain. It belongs to the so-called physiographical unit Low Fold which is also a series of NW/SE trending anticline ridges and synclinal valleys, but of much less.

Pronounced topographic and structural relief than the High Folds. The ridges represent up folds in young sedimentary rocks derived from erosion of earlier formed structures of the High Folds. The slope within the proposed irrigation area (Erbil Plain) is generally less than 3% around the city of Erbil, increasing steadily towards the east above level 550 masl where it is typically over 3%, and the land above level 650 masl is unsuitable for irrigation with slopes exceeding 10%.

The Access to the dam site is through the existing road linking the city of Erbil with the village of Darband which crosses the irrigation area and leads up to the Goma Span gorge at the dam site (Figure 2.2).

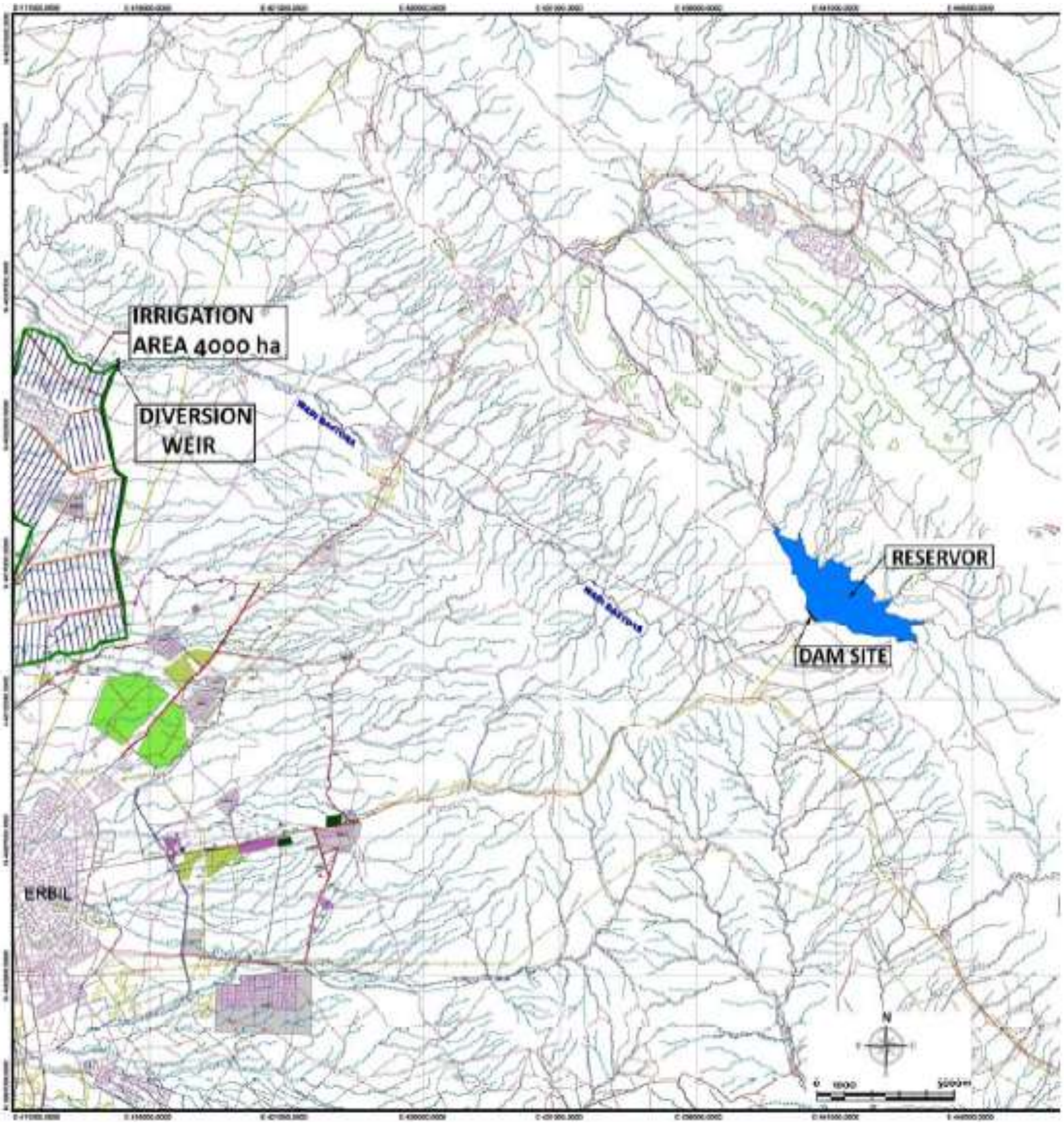


Figure 2.2: Topographic map of the study area shows the dam site (MOWRA 2006).

2.3 Tectonic settings

The geological structural development of Iraq is basically determined and strongly influenced by its position on the border between the Arabian part of the African platform and Alpine geosynclines. Tectonically the Iraqi Erbil government territories can be subdivided into thrust and folded zones. Topographically these zones are known as high and low mountain areas respectively, but the low folded zone is characterized by numerous hills and can be called hilly terrain. A detailed geological description for the watershed area is already available.

2.4 Geology of the dam site

The Geological setting of the studied area is mainly based on the publications of Bellen et al., (1959), Buday (1980), Jassim &Goff (2006). The studied area composed of different geological rock units. The descriptions of geologic rock units (formations) are shown in Figure 2.3 and Table 2.1.

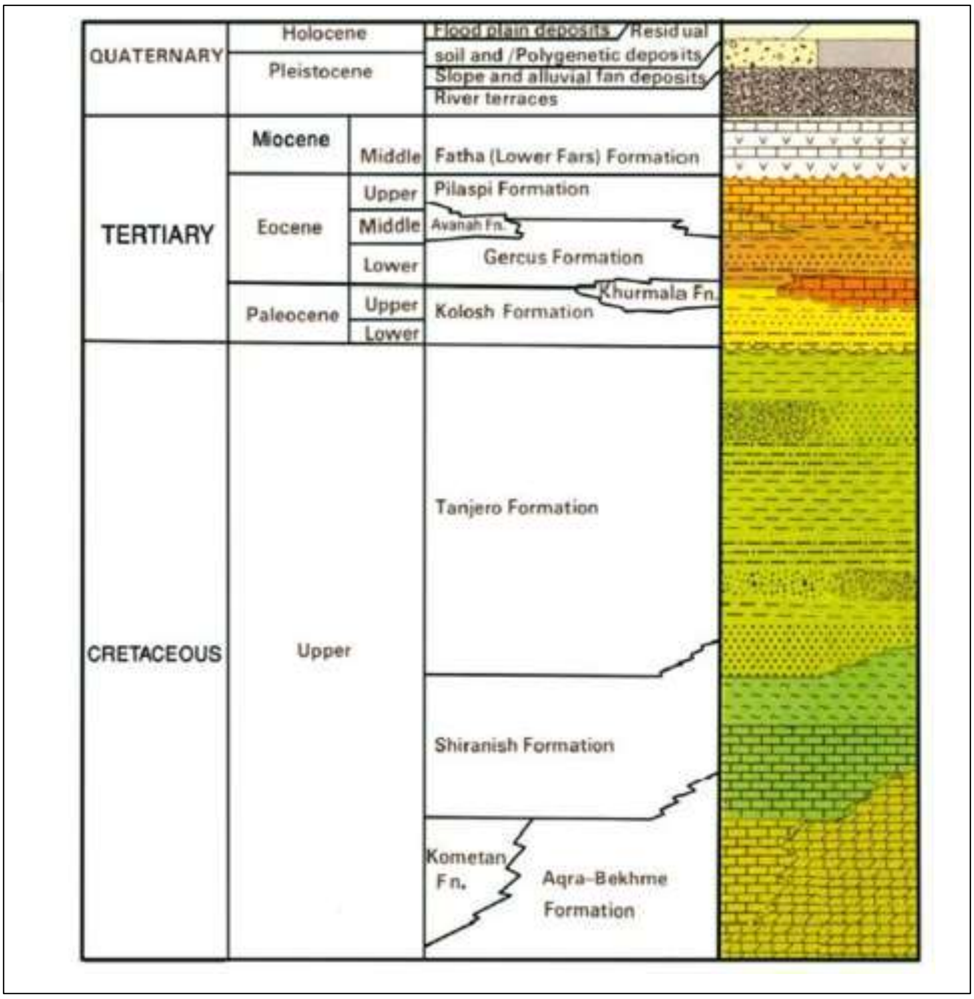


Figure 2.3: Lithologic succession of Bastora Dam and Reservoir Region (Stevanovic, 2004 A and B).

Table 2.1: Geologic descrptions of the study area (Jassim &Goff,2006).

Formation	Age	Thickness (m)	Description
Aqra-Bekhme	Upper Cretaceous.	50	Aqra formation was described as reef limestone with massive rudest, shoal reefs, detrital forreef limestone, locally dolomitize, locally siliceous, locally impregnated with bitumen.
Shiranish	Upper Cretaceous.	100	Shiranish formation is composed of blue marl in its upper parts and thin bedded marly limestone in the lower division.
Tanjero	Upper Cretaceous.	200	The lower division occupying on quarter of the total thickness, consists of pelagic marls and rear marly limestone with silt. The upper division consists of silt, marl, siltstone, conglomerates and sandy or silty organic detrital limestone.
Kolosh	Paleocene- Lower Eocene.	300	Kolosh formation consists of shale's and sandstones composed of green rocks mainly mudstone, siltstone and argillaceous or marly limestone with some detrital limestone interbeds.
Khurmala	Paleocene- Lower Eocene.	65	Khurmala formation composed of well bedded hard limestone, dolomitic limestone and recrystallized limestone marly limestone and marls probably chemical in origin.
Gercus	Lower Eocene – Upper Eocene.	50-100	The formation is composed of red and purple shales, mudstones, sandy gritty marls, with or without pebbles, pebbly sandstone conglomerates and lenticels of gypsum occurs too.
Pilaspi	Middle Eocene – Upper Eocene.	160	The upper is composed of well bedded, bituminous, chalky and crystalline limestone, with bands of white, chalky marl with chert nodules toward the top. The lower part shows well bedded, hard, porous, vitreous or white limestone, chert intercalation, with traces of subooliths and rear concentration gastropod debris from the bulk of the formation.
Fatha (lower Fars)	Middle Miocene	not known	In general Fatha (lower Fars) formation is characterized by reddish brown calcareous clay stone alternating with limestone beds and reddish brown marl containing thin beds of sandstone and gypsum at the lower part.
Quaternary Sediments	Pleistocene	Variable	Most of the deposits of overburden in the vicinity of the dam site are talus deposits derived from the high cliffs includsout wash sediments covering slops along permum mountain, composed of boulders, scree, rock fragments, cobbles, pebbles and soil

2.5 Hydrogeology

Stevanovic and Markovic, (2004) stated that, three major hydrogeological zones for northern Iraq were considered as equivalent to regional tectonic zones. They are the Thrust zone, High Folded zone, and Low Folded zone. The zones were subdivided into basins. In this study, the focus will be on Erbil basin within the Low Folded zone since it includes our irrigation area. The incidence of aquifers in the Low Folded zone is virtually essential to sustainable groundwater exploitation and the supply of water to human consumption, agriculture, industrial and other sectors, and for the study area overall development.

In the Low Folded zone (Figure 2.4), the High-Folded zone old formations (the Jurassic and upper Cretaceous) lie at a very deep level having been covered by younger stratigraphic deposits such as Miocene, Pliocene, and Quaternary deposits (Barzinji, 2003).

Generally, the studied area belongs hydrologically to the Bastora basin which is bounded by the Pirmam Mountain from the north and northeast and the Erbil basin from the west and south. The basin is characterized by a cold rainy winter and hot, dry summer (Ghaib, 2009). The fresh groundwater in the area is come from the infiltration of rainwater during winter and partly spring seasons (Hama Saaid, 2003). The Bai Hassan Formation is the principal aquifer which is exploited in the Bastora area and all the surroundings. Horizontal and vertical lithological variations are common (Hama Saaid, 1998 and 2003).

During the middle and upper Miocene, the sedimentation cycle continues, with the deposition of thick layers of Lower and Upper Fars formation. The layers have a heterogeneous lithology including marl, sandstone, anhydrite, gypsum, conglomerates, clay, and loose sand frequently outcrops at mountain range foothills (edge of Low Folded zone). The upper Bakhtiari sediments are equivalent to the upper Miocene and Pliocene ages and extend into the Low Folded hydro-geological zone. The Pleistocene and recent Holocene deposits (gravel, sand, and clay) cover the Bakhtiari layers in Erbil plain and further southern plains.

The results of geological field mapping, survey, and analyses carried out so far were significantly contributed to the upgrading of the geological and hydro-geological knowledge of this area.

The main characteristics, practical importance, and recommended steps for future groundwater development of Erbil hydro-geological basin are briefly presented in Table 2.2.

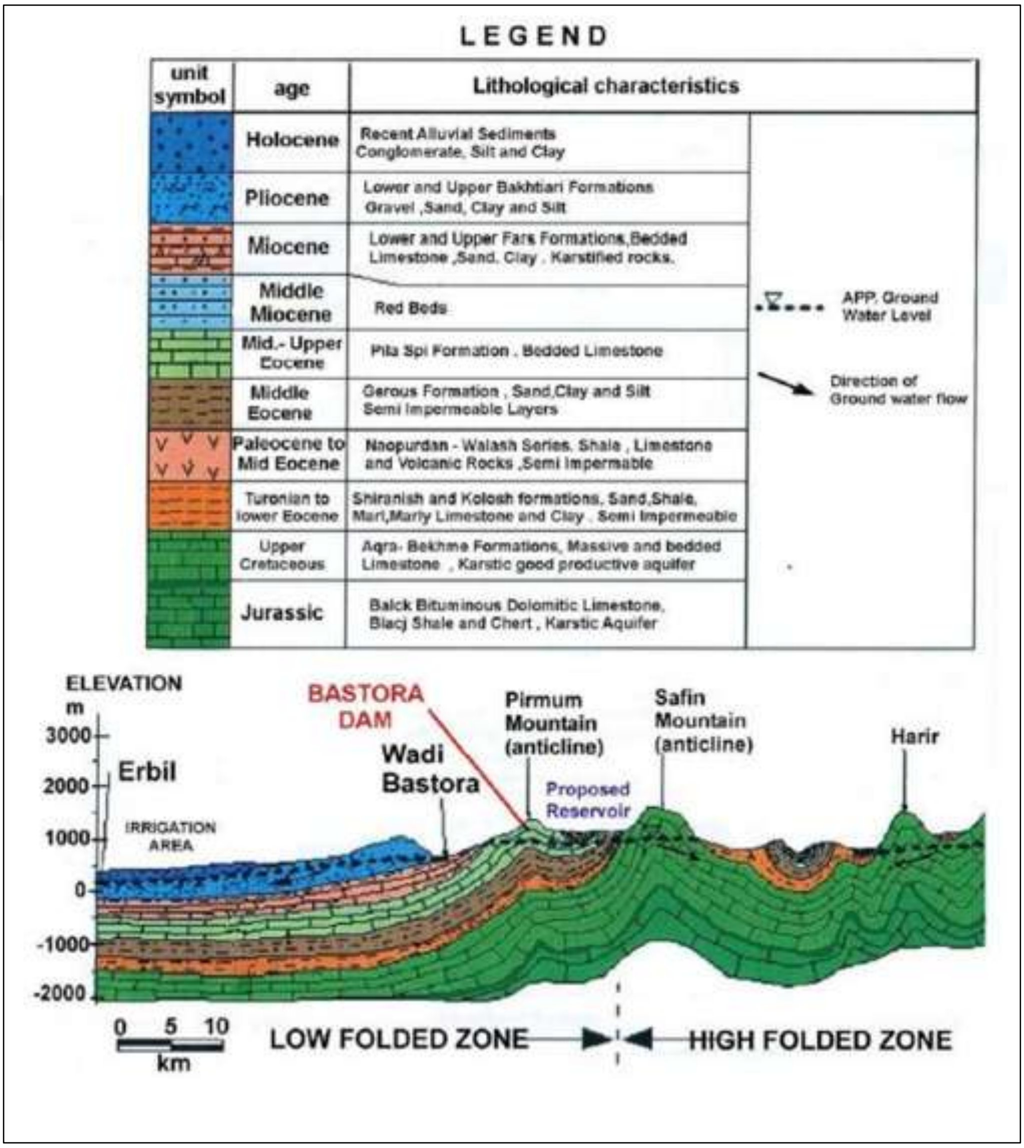


Figure 2.4: hydrologeology map of the studied region (Stevanovic, 2004 A and B).

Table 2.2: Hydrogeological characteristics of dam study region (Stevanovic, 2004 A and B).

zone	Hydro-geological		Main Hydro-geological characteristics	Recommended solutions for ground water use
	basin	Sub basin		
Low Folded Zone	Erbil Basin	North sub basin wadi Bastora Central sub basin, wadi Kurdara South sub basin BashTapa	1- Basins filled with productive recent deposits underline by thick Bakhtiari layers 2- Absence of perennial streams and low rainfall limit aquifer recharge 3- Variable permeability and lateral / horizontal changes in litho-logy of basin deposits 4-TDS increase towards the south	1- Drilling deep wells in recent deposits and deeper Bakhtiari 2- Developing shallow alluvial and terrace aquifers along wadi beds and close to Greater Zab river 3- Rationalize pumping, introduce aquifer control and storage measures (subsurface dams) 4- Introducing aquifer artificial recharge 5- Reducing drilling in the southern part

2.6 Climatology

Precipitation (rainfall and snow) is considered as the main resource of the internal water budget in Erbil city. This contributes to both groundwater and surface water. Besides, the water inflow from Iran and Turkey made up of the total water resources that are theoretically available within the region.

2.6.1 General climate characteristics

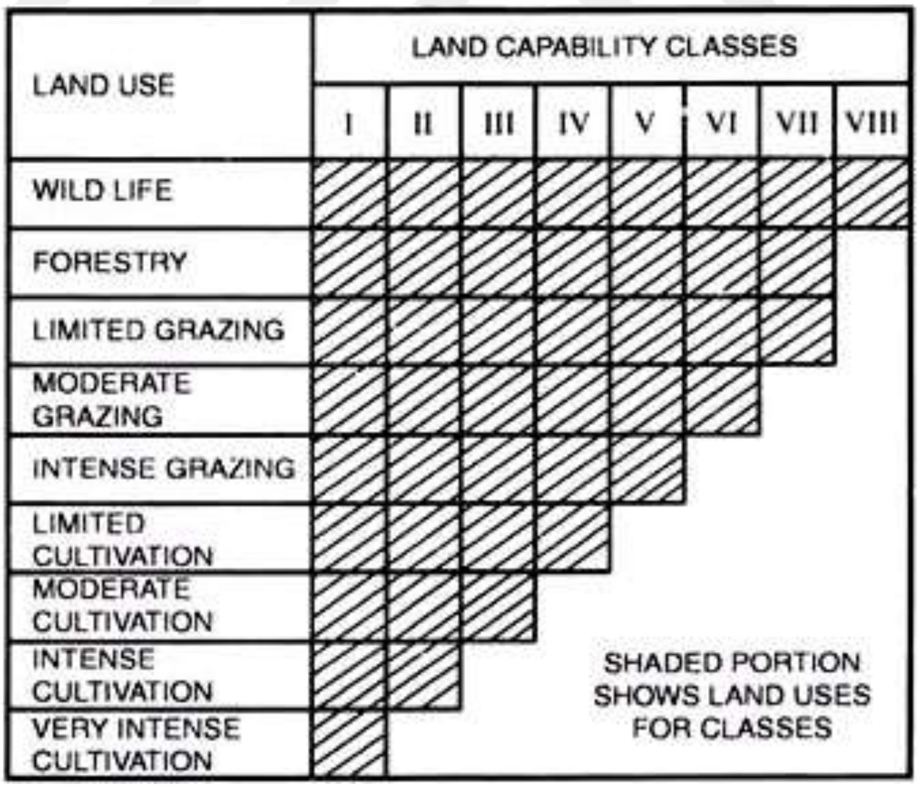
The climate of northern Iraq is primarily characterized by long warm, dry summer and cold and snowy winters. Generally, autumn and spring are very short. Mountainous and hilly areas (such as the Zagros Mountains), as well as the foothill zones in the center and north, have higher precipitation area. Snowfall and lower air temperature, semi-arid climatic conditions are typical on the plains. During the summer, the region falls under the influence of Mediterranean anticyclones and subtropical high-pressure belts moving from the west, southwest to north. Southernly winds blow over the Arabian peninsula developing dust storms raising daily temperatures to a maximum of more than 45 oC in winter. The region is invaded by the Mediterranean cyclones moving east to northeast. The region is also exposed to the influence of a very cold polar air mass that moves with the polar jet stream down towards the Gulf.

Table 2.4 to Table 2.7 are taken based on long-term weather records. Taken into account an average data for Erbil weather during different months (www.erbilia.com/erbil-info/weather/).

2.7 Soil

The dominant soil texture is silty clay (Hama Saaid 2003). It is non-saline soil, the organic matter often ranges from 1.5% to 2.5 %, soil depth and degree of stoniness and rockiness are variable. The land capability class ranges from I to III, for the main plains and the bottomlands, and from V to VIII for the hilly area and mountain slopes (Table 2.3). The different existing granular surface soils include dark to very dark brown, whitish gray, and pink to reddish brown(MOWRA 2005-2006).

Table 2.3: Land use capability classification (Fenton,T.E.2006)



2.8 Land use

The agricultural potential of the upland is limited due to shallow soil depths, steepness, stoniness, and rockiness of slopes where the plain land (Sahl Erbil) at the lower part has an important agricultural potential. Dry farming is widely practiced, however, summer cropping, as well as, orchards is limited to residential backyards.

Table 2.4: Mean monthly rainfall (mm) for Erbil area (including the study area)for the years (2000-2017) , from records of the metrological station of Erbil.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	sum.
2000	128.1	18.8	22.3	14.5	8.0	0	0	0	0	7.9	14.8	51.5	265.9
2001	85.0	42.6	96.5	35.7	12.4	0	0	0	2.2	4.4	19.6	28.9	327.3
2002	8.9	21.4	115.5	71.4	2.2	0.2	1.3	0	0	30.1	30.5	181.9	463.4
2003	60.9	69.2	99.6	43.9	16.4	9.1	0	0	0	15.9	81	100.3	496.3
2004	116	93.3	6.4	82.3	1.3	0	0	0	0	3.7	110.2	44.5	457.7
2005	75.6	84.1	50.7	26.1	17.3	0	0	0	4.2	4.8	15.3	19.4	297.5
2006	84.9	189.0	15.3	77.9	16.9	3.9	0	0	0	89.6	21	16.1	**514.6**
2007	55.5	98.6	39	49.1	15.6	1.4	0	0	0	0	5.3	8.9	273.4
2008	42.4	53.1	61.4	4.6	1.9	0	0	0	32.6	50.1	19.2	32.2	297.5
2009	1.6	29	88.7	28.6	0	5.5	0	0	10.1	26.5	16.3	105.6	311.9
2010	34.9	74.3	71	5.2	25.6	0	0	0	1.2	4.9	0	43.3	**260.4**
2011	113.9	42.8	30.5	101.5	12.7	0	0	0	0	9.2	7.4	25	343
2012	56.1	31.5	72.1	14.5	26.8	0	0	0	0.2	23.4	45.9	95.9	366.4
2013	174.4	55.8	17.7	37.4	40.6	0	0	0	0	0.2	19.1	86.6	431.8
2014	74.9	8.2	93.4	14.7	2.5	0	0	1	0.0	68.7	69.2	56.0	388.6
2015	37.4	44.3	56.8	17.3	5.4	0	0	0	4.5	36.4	104.4	115.8	422.3
2016	45.6	33.0	103.5	46.4	6.4	2.5	0	0	0	0.0	22.3	116.1	375.8
2017	37.9	23.4	77.8	55.8	3.7	0.0	0.0	0.0	0.0	0.0	37.6	29.4	265.6
Average	**68.6**	**56.2**	**62.1**	**40.4**	**12.0**	**1.3**	**0.1**	**0.1**	**3.1**	**20.9**	**35.5**	**64.3**	**364.4**

Table 2.5: Mean monthly relative humidity (%) for Erbil area (including the study area) for the years (2000-2017), from records of the metrological station of Erbil.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	74.00	50.00	35.00	26.00	23.00	24.00	23.00	35.00	53.00	63.00	65.00	65.00
2002	76.00	61.00	59.00	64.00	36.00	22.00	23.00	26.00	28.00	39.00	51.00	73.00
2003	83.00	71.30	63.80	56.30	35.90	25.20	25.00	25.12	32.20	42.10	57.10	75.10
2004	76.40	72.60	51.60	47.80	39.50	23.80	23.20	25.00	24.50	35.10	72.90	69.70
2005	70.10	68.70	58.80	48.00	38.20	28.10	22.00	26.90	29.30	34.50	53.00	57.40
2006	71.60	68.90	53.30	61.30	42.90	25.80	28.80	26.20	32.40	52.20	61.30	53.80
2007	69.40	75.00	64.30	62.80	43.10	32.40	29.40	32.50	32.50	35.60	46.90	57.70
2008	61.70	63.10	48.40	37.20	31.00	27.60	24.30	26.60	32.00	48.80	58.10	58.80
2009	59.50	56.80	61.30	51.20	31.40	24.70	27.00	27.90	33.10	36.90	61.70	72.50
2010	67.00	66.00	60.20	58.60	40.10	27.00	26.20	24.60	30.70	45.60	45.20	59.30
2011	75.40	73.00	65.50	58.40	45.30	39.10	25.70	27.30	34.10	43.60	55.60	56.00
2012	74.40	63.60	61.70	49.00	41.50	25.80	22.10	28.50	29.00	48.60	64.60	77.20
2013	73.90	75.60	61.60	53.90	47.70	31.20	29.10	28.70	37.80	39.40	67.90	66.00
2014	72.10	56.00	66.20	48.60	39.80	30.30	29.10	28.30	39.80	58.60	65.60	74.70
2015	72.50	68.40	64.30	52.20	34.50	33.20	25.40	30.80	29.90	54.60	69.80	67.70
2016	76.40	65.30	55.20	53.90	40.50	32.00	27.30	30.50	39.40	41.00	47.50	76.40
2017	68.84	63.50	65.52	58.30	38.06	34.97	32.19	31.26	31.30	44.06	62.03	60.10
Average	**71.90**	**65.81**	**58.57**	**52.21**	**38.14**	**28.66**	**26.05**	**28.30**	**33.47**	**44.86**	**59.13**	**65.91**

Table 2.6: Mean monthly temperature (°C) for Erbil area (including the study area) for the years (2000-2017), from records of the metrological station of Erbil.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	8.9	10.2	16.05	19.4	27.8	30.7	34.65	34.5	30.1	23.55	14.45	10.8
2002	7.4	10.8	14.6	16.85	28.1	31.4	34.55	32.5	29.55	24.9	16.4	8.05
2003	9.6	8.7	11.55	18.25	25.6	31.15	33.85	35	28.9	24.65	14.95	8.75
2004	9.55	9.35	15.55	18.2	24.45	30.75	34.6	33.05	30.4	25.2	14.6	7.95
2005	8.3	8.55	13.6	20.35	25.45	31.2	35.7	35.25	29.65	23.95	15.3	13.55
2006	8	10.6	15.8	20.6	26.45	33.3	34.55	36.6	30.15	25.7	14.4	8.95
2007	7.2	10	13.25	16.2	27.85	32	34.7	34.45	30.75	25.2	16.05	10.4
2008	5.95	9.65	18.5	23.15	25.1	31.65	34.65	35.6	30.6	23	16.2	10.15
2009	8.2	12.85	13.5	18.15	26.2	32.2	33.75	32.9	27.7	24.35	15.76	12.2
2010	11.86	12.335	16.4	19.3	25.9	32.5	35.35	36.15	31.75	24.775	19.27	13.3
2011	8.9	10.05	13.95	19.4	25.05	31.7	35.45	34.45	29.65	22.35	12.55	10.75
2012	8.2	9.55	11.2	21.95	27.1	33.15	35.9	35.15	30.8	24.45	17.15	6
2013	7.45	12.05	14.95	20.35	25.3	31.4	34.3	34.05	28.8	23.2	17.4	9.6
2014	10.6	11.5	15.8	20.6	27.3	31.8	35	35.3	29.6	22.8	14.6	11.7
2015	9.05	11	14.2	19.2	27.4	31.5	36.15	35.45	32.25	24.6	15.05	9.9
2016	7.9	12.15	17.6	19.65	26.1	32.55	35.45	36.15	29.5	24.5	15.55	8.65
2017	11.69	10.88	17.22	28.29	29.56	34.21	36.58	34.38	27.31	23.64	16.80	13.80
Average	**8.75**	**10.60**	**14.92**	**19.99**	**26.51**	**31.95**	**35.01**	**34.76**	**29.85**	**24.17**	**15.68**	**10.26**

Table 2.7: Mean monthly wind speed (m/sec) for Erbil area (including the study area) for the years (2000-2017), from records of the metrological station of Erbil.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	2.6	2.5	2.7	3	2.7	2.6	3	3.6	2.9	2.6	3.8	2
2002	3	2.7	3.7	3.5	3.7	3.4	2.6	2.5	1.9	2	1.9	2.1
2003	2.2	2.6	3.1	2.7	2.7	2.6	2.3	2.1	1.8	2.3	1.9	2
2004	2.3	5.8	1.7	2.8	3.33	2.8	2.8	2.1	1.9	1.6	1.9	0.5
2005	1.9	2.5	2	2.1	1.9	1.7	1.7	1.8	1.4	1.7	1.1	1.2
2006	1.7	2	1.7	2.1	1.7	1.1	1.2	1.14	0.8	1.8	1	1.9
2007	1.8	1.7	2.2	2.8	3	2.5	2.4	2.2	1.9	1.9	1.4	1.6
2008	2.2	2.3	2.5	2.5	2.6	2.4	2.1	2.5	2.3	2.1	2.5	2.3
2009	1.6	3	2.7	2.7	2.4	3	1.7	2	2	2	1.6	2
2010	3.4	2.3	3.4	2.6	2.9	2.5	2.2	3	1.6	1.6	1.4	1.5
2011	1.9	2.3	2.6	3.5	2.5	2.6	1.9	1.7	1.4	2.2	1.9	1.2
2012	1.5	2.3	1.9	2.9	2.4	2.8	2.5	1.8	1.9	2	1.7	1.7
2013	2.2	1.6	1.9	1.8	1.9	1.4	1.2	1.1	0.8	1.5	1.1	1.1
2014	1	1.4	2	0.8	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2
2015	0.2	0.1	0.2	0.2	0.2	1.7	1.3	1.3	1.9	2.3	1.3	1.5
2016	1.4	1.5	1.9	1.7	1.7	2.2	1.2	1.1	1.2	1.4	1.1	1.5
2017	1.13	1.21	2.03	1.60	1.98	1.19	1.45	1.01	0.79	1.30	1.45	6.70
Average	**1.88**	**2.22**	**2.25**	**2.31**	**2.22**	**2.15**	**1.86**	**1.83**	**1.56**	**1.79**	**1.60**	**1.82**

2.9 Landscape

As a result of the accumulated activities of people in Iraq and due to the exploitation of natural resources for agricultural and animal husbandry, the erosion process has progressively grown. The problem derived from this situation has become particularly acute over the recent decades due to the considerable increase in demographic pressure and landscape deterioration. There are over 5 Million hectares of forests, grazing, and croplands in the northern part of Iraq that suffered from moderate to severe erosion. People's activities are responsible for such destruction include over cutting, uncontrolled fires (due to a series of wars), construction of roads, and random urbanization. It has become necessary to designate a multidisciplinary committee to handle the situation. Except for the programs concerned with hydrological problems of the Tigris and Euphrates and their tributaries aimed at controlling floods and the transport of sediment, the management of watershed in Iraq is a relatively recent endeavor (Hama Saaid 2003).

2.10 Data collection

In order to complete the methodology of EIA, several field and data collection were carried out. These were followed by examining of the collecting data. Based on that, data analysis, mitigation measures and recommendations are presented.

Many resources were tilised to complete the data collection. General information, including technical data was gathered through meeting key informants from the concerned local authorities, namely Erbil Water Directorate, General Directorate of Erbil Municipalities, Groundwater Directorate and the Ministry of Water and Irrigation and General Directorate of Water and Sewerage.

In addition to meeting key personnel from the local authorities, further data was collected through observatory field visits to consolidate the understanding of the environmental setting. The four locations of the proposed boreholes along with the surrounding regions were visited and investigated. Social impacts were assessed through public discourse and interaction during the conducted site visits.

Furthermore, various kinds of tests were performed on the aquifer, for example, biological and chemical tests. The aim of these tests is to examine and evaluate the water quality which extracted from the wells by gathering information regarding water pH, turbidity, etc.

The data collection for environmental assessment is based on:

- Visual observations through many field trips to the study area;
- Information and official data from the historical records of the relevant agencies;
- Field measurements using portable instruments such GPS, measuring tapes, echo sounder, and topographic survey tools etc;
- Pertinent satellite pictures of the study area and some topographic maps; and
- Interviewing local administrators, area residents and villagers of different backgrounds.

CHAPTER 3

LITERATURE REVIEW

3.1 Introduction

A range of literature resources for this study was reviewed with a specific concentration on the evolution of EIA system in dam projects and evaluation of EIA system. Different sources such as books, publications of international organizations including UNEP, journals, reports of the ministry of agriculture and water resource in Iraq were used. These resources were accessed through internet sources, Directorate of dam office and relevant books. Concerning legislative and policy context of Iraq, the national EIA proclamation, Iraqi EIA guidelines, and Environmental policy were consulted.

3.2 Environmental impact assessment practices in dam projects

The major problem regarding the effectiveness of environmental impacts assessments of dams and reservoirs in developing countries is that, in most cases, project corroborators still deem the EIA process as a bureaucratic requirement to be achieved for project consent, isolated from the project planning and implementation cycle. Environmental impacts assessments (EIA) studies are mostly performed on the site after the decision of the dam has been done and engineering studies and projects have been completed. The choice of a dam location is usually determined by engineering and economic criteria, with a very little or no consideration for environmental issues (Feyissa, 2011). As a result, the opportunity is lost for considering dam site alternatives with less damaging ecological and social impacts. Moreover, late EIA studies impede the contribution and exchange of information between environmental specialists and project designers regarding prevention and mitigation of adverse effects (Verocai, 2000).

For assessing the environmental impacts of dam and irrigation project, it is substantial to be aware of the general aspects of EIA. The lack of environmental considerations and assessment in the development of water supply projects may result in severe effects on the natural environment and also on the socio-economic and health status of the community.

Environmental impact assessment (EIA) is a regular process to evaluate, identify, and predict the environmental impacts of proposed development projects (UNEP, 2002). The main aim of EIA is to ensure that influences of policy, projects, and programs are sufficiently and suitably designed and mitigation measures are integrated when decisions are taken. Additionally, EIA provides a forumfor general participants in the decision-making process, which helps to assess the formulation of suitable developement policy (UNEP, 1988).

The EIA process comprises different levels. First, identification of development proposals. Second, checking of the proposal defines if an EIA is needed and at what level the assessment should occur. Third, the scoping stage involves identification of boundaries of the EIA studies, significant matters of concern, essential effects and factors to be deemed. Fourth, the EIA process is undertaking Environmental impact study that involves impact prediction, consideration of alternatives, impact analysis, preparation of management plan (mitigation, monitoring activities), and preparation of contingency plan. Finally, reviewing, decision making and implementation and follow-up will be followed.

3.3 Background information of EIA used in dam

Saytarkon (2015) stated that the construction of dam around the world is far back to 5000 years ago. The majority of those dames were mainly established to accommodate water for drinking and farming purposes. Nevertheless, over the past 60 years, water-related projects and reservoir dams were built to supply the industrial development with a cheap, in terms of operational cost and clean hydropower (Saytarkon, 2015). Currently, more than 40,000 large dams are present all over the world. There are more than 400,000 Km^2 of the area have been immersed by dam reservoirs worldwide. World Health Organization (WHO, 2005), recommends that health should be taken into account and put to the top of the list of issues that must be tackled to secure that dams are supportive of, and not harmful to health, and for all societies. Therefore, this study on Bastora dam gives results that can be used to mitigate the impacts of the dam on the environment and social influences.

3.4 Impacts of reservoir dams

According to McCully (1996), environmental impacts assessments of reservoir dams can normally be classified into two major groups, due to the presence of the dam and reservoir and due to the pattern of dam 18 operation. McCully (1996) summarized these two categories as follows: Positive and negative and positive impacts as are follows:

3.4.1 Positive impacts of reservoir dams

Reservoirs can provide access to irrigation for agriculture by storing water in times of surplus and dispensing it in times of scarcity. Reservoirs can be effectively used to regulate surface water levels (e.g river) and downstram flooding of the reservoir dam by tentatively storing the flood volume and releasing it later (McCully, 1996). Reservoirs can save labor for the elderly and women's families in irrigating the crops (McCully, 1996). Reservoirs can promote aquaculture and fisheries development in a river basin. Reservoirs can promote the development of non-agricultural activities, such as recreation, inland, and navigation ecotourism.

3.4.2 Negative impacts of reservoir dams

Imposition of a reservoir in place of a river valley (loss of habitat). Changes in downstream water quality: effects on river temperature, nutrient load, turbidity, dissolved gases, the concentration of heavy metals and minerals. Reduction of biodiversity due to the blocking of movements of organisms (e.g., Salmon). Change in extreme high and low flows. Changes in downstream water quality caused by altering flow paths. According to Paul Schuler (2007) during the past 20 years, a growing international movement against dams has emerged, rallying behind the charge that governments notoriously ignored human and ecological costs when beginning hydropower projects. The dangers that dams pose to the natural environment have been widely documented. The International Rivers Network (IRN) reports that 60 percent of the world’s major rivers are dammed and just less than one percent of the world‟s land surface has been inundated by reservoirs worldwide. The detriment to rivers, wetlands, and forests have been extensive, and led to irreversible loss of species and ecosystems. However, it examines the social impacts of hydropower dam projects. The WCD identified that between 40 and 80 million people had been physically displaced by dams worldwide. A WB review of projects between (1986 -1993) estimated that 4 million people were displaced annually by the 300 dams (on average) that were constructed each year. This scale of mass-displacement makes it imperative that the potential impacts on livelihood, health, and traditional cultures be carefully monitored and managed. Equity concerns are also relevant.

3.5 Previous studies on the study area

A preliminary study on BDIP was on February 1982 and called the "Interim Report." This study was carried out by EYSER-Inypsa AEPO of Spain and submitted to the Iraqi Ministry of Irrigation. The report comprises a summary volume with eight exhibits of the data obtained and analyzed up to 1982 (MOI, 2006). The primary objectives of the interim report were to:

- Assess information and data as of 1982 to be used in the planning report;
- Conduct necessary studies for which sufficient and adequate information were already available mainly in climatology, hydrology, and crop water requirements;
- Obtain provisional conclusions on the basic alternatives for locating the irrigation zone;
- Assist in the selection of the dam type;
- Define the surveys and investigations required for the planning report phase,
- including topographical survey, and geological and geotechnical studies.

A limited number of studies were carried out on hydro-geo-chemistry in the studied basin. The first study detail was in 1955 by The Parsons Co. Their studies showed that calcium and bicarbonate ions were recorded high concentration in all water samples.

The Parsons Co. in 1955 collected water samples from 73 wells, eight springs, and two karezes (underground channels) in Erbil basin for analysis of dissolved solids, electrical conductivity, and major ions. In general, total dissolved minerals contained in the groundwater from wells varied from about 375 ppm at Erbil plain to 6400 ppm in wells south of Erbil basin. In about 20 % of the wells, the total dissolved solids (TDS) exceeded 3000 ppm in the southern area of Erbil plain (Hassan 1983). There are tests carried out in 1973 by the Iraqi Institute for Applied Research on Natural Resources (IARNR) showed that the TDS ranged from 100 to 300 ppm. Generally, values of TDS of more than 500 ppm were found in a narrow zone of aquifer running parallel to the southwestern border of Erbil basin. In other parts of Erbil area, groundwater TDS values ranged from 300 to 500 ppm, HCO_3 ions predominate (Hassan, 1981).

There is a small area east of Erbil where the TDS values range from 500 to 1000 ppm and an equal predomination of HCO_3 and SO_4 ions. This may be caused by the greater depth of wells in this area.

According to Hassan (1981), there are mostly two types of groundwater in Erbil area: Bicarbonate and Sulfate. He observed that, when salinity is equal or less than 600 ppm, the calcium ion is predominant, with the exception of the southern area, where salinity value increases, because of higher occurrence of the sodium ions instead of Ca. The problem of mixing two water types from opposite sides indicate possible water dilution in the central basin near Erbil town. It was found that the mean TDS value was about 400 ppm (Hassan 1981).

Generally, the TDS increased from east to west of Erbil city in the flow direction. The concentrations of the hydro-chemical constituents decrease during the rainfall period or recharge and rise in summer.

More recent analyses confirmed that the Calcium bicarbonate water type predominates in Erbil basin, with the exception of areas where groundwater originated in Bakhtiari layers mixed with waters from Fars underlying layers, marls, gypsum, and anhydrite. Such mixing increases the salinity up to 1000 ppm or even higher.

Salinity increases on Erbil plain in a southwest direction reaching a maximum at Gwer village close to the lower Fars outcrop. Similar results were obtained by Kandal Co. during their investigations in Erbil basin in 2002.

As far as pollution is concerned, Hassan observed in 1998 that domestic effluents in Erbil city deteriorate groundwater quality. Interpreting nitrate concentration, he found that sewerage courses and septic tanks represent the main source of groundwater pollution. The highest NO3 value was located in the central area of the city. Close to the sewerage course, east of the city (within the study area), nitrate concentrations were almost nil. Various studies and investigations, including FAO surveys in 2002 of the major basins, showed a very low presence of the minor elements, especially heavy metals. These were often below the detectable limit of the method applied. However, these concentrations tend to be within the international standards and WHO recommendations for quality of drinking water (Hassan, 1998).

Bacteria were found in 50% of the wells within Erbil basin. A maximum value of 200 bacteria /10 ml and a minimum value of 10 bacteria/10 ml were reported. Figure (3.1) reveals the distribution of TDS in groundwater boreholes in Erbil plain.

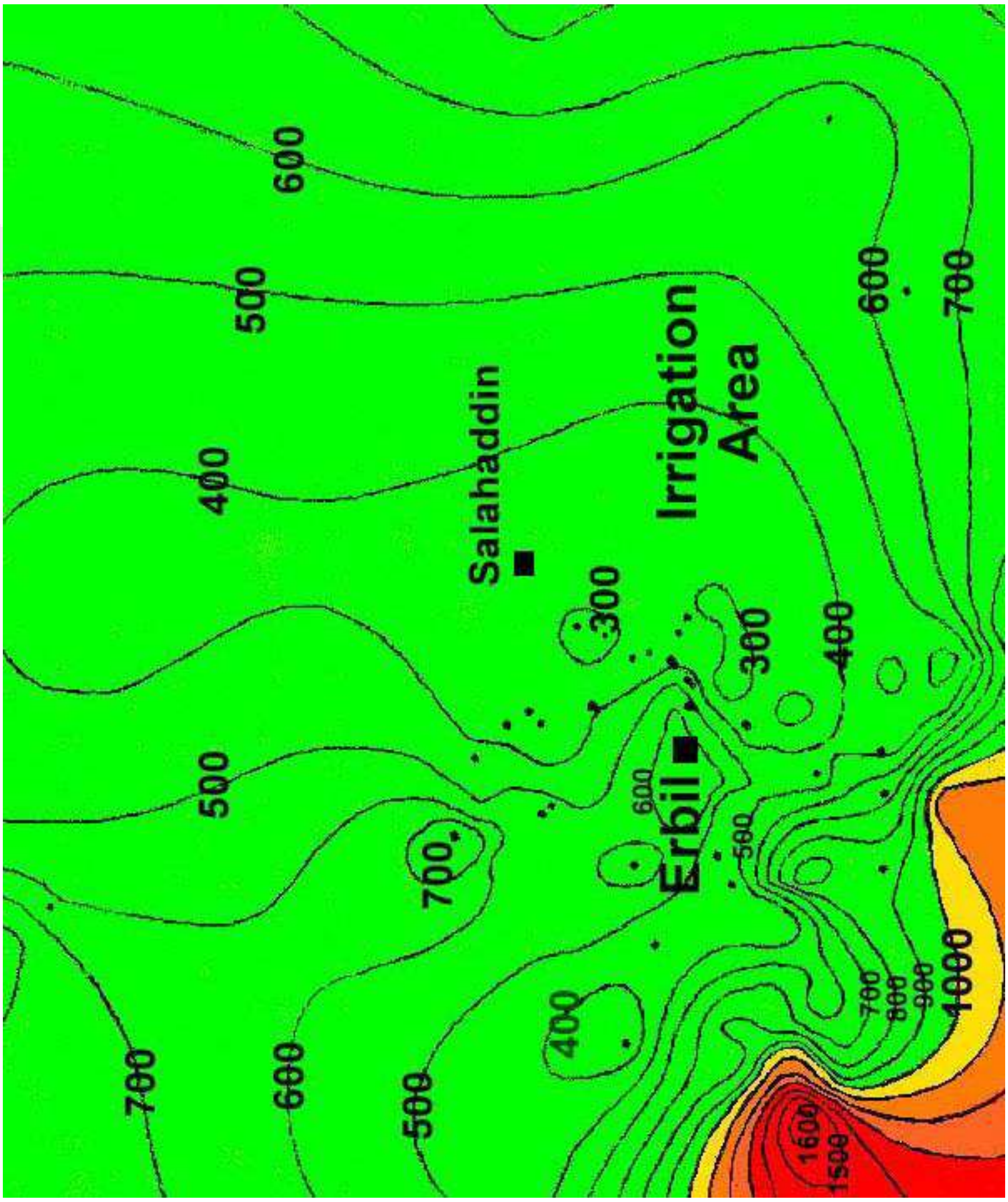


Figure 3.1: Groundwater (TDS in ppm) map of Erbil plain (Hassan 1998).

3.6 A general review about flora and fauna in north Iraq region

No study concerning fauna and flora, detailed or otherwise, specially focusing on the study area has ever been conducted. The only available scientific reference text book, which deals with fauna and flora of north Iraq region is that written by Izady (1992).

Among his statements; enough stands of chestnut, pin, oak, dwarf oak, cedar, juniper, and wild fruit trees have survived in the region today to convey a glimpse of the ancient forests. Oak and dwarf oak are now the most common trees in the remaining Zagros forests. The oak forests are the ideal ecosystems for several highly prized fungi, such as truffles (Chema), which are available in abundance and are, along with wild chestnuts, a food of the poor. A large array of wild fruits, berries, and nuts, such as cherries, grapes, quince, pears, mulberries, hazel nuts, blackberries, walnuts, and almonds, are also collected in the forests (Izady, 1992).

The land has been known since ancient times for its wealth of luxurious flowers. Erbil government was probably the site of the domestication of many bulb flowers, such as tulips, hyacinths, gladioli, and daffodils, and medicinal herbs such as valerian and cowslip. Its abundance of aromatic flowers and herbs may be the source of the renowned pleasant scent of Erbil government's dairy products (Izady, 1992).

The fauna still retains its richness, with an abundance of black/ brown bears, wolves, hyenas, boars, foxes, beavers, jackals, cheetahs; migratory and resident birds such as eagles, bustards, larks, bluebirds, quail, and partridges; and reptiles such as small and giant turtles, lizards, and snakes. In addition, a variety of fresh-water Lake and river fish like carp, trout, and over forty different spring and subterranean-cave fish, including blind fish, are found in local bodies of water (Hellawell, 1978).

CHAPTER 4

ECOLOGICAL AND SOCIAL IMPACTS

4.1 Description of salient features

4.1.1 Seismology

Figure 4.1 shows the distribition of seismology of the study area within 300 km radius. The data show significant variability within the region. Study area denoted in green color. Earthquake loading is one source of dynamic forces which may act on the dam as well as on any other structure. Such an event depends on the seismic and geologic structures as well as the seismic activity of the region in which the structure (the dam) is to be constructed. Evaluation of this force is based on specific techniques so called probabilistic seismic hazard assessment .Upon its structural and tectonic emplacement, Iraq possesses an applicable level of earthquake activity. The main source of energy release being the Touros- Zagros mobile zones. A list of historical events for earthquakes that occurred in the region are already documented by the Iraqi seismology department .For the next phase of the design, compilation and updating these events together with the other related data may be needed for a comprehensive analysis in a special report. We should consider the dam far from the epicenter of the earthquakes (MOWRA, 2005- 2006). Any movement of earth will lead to the dam failure.

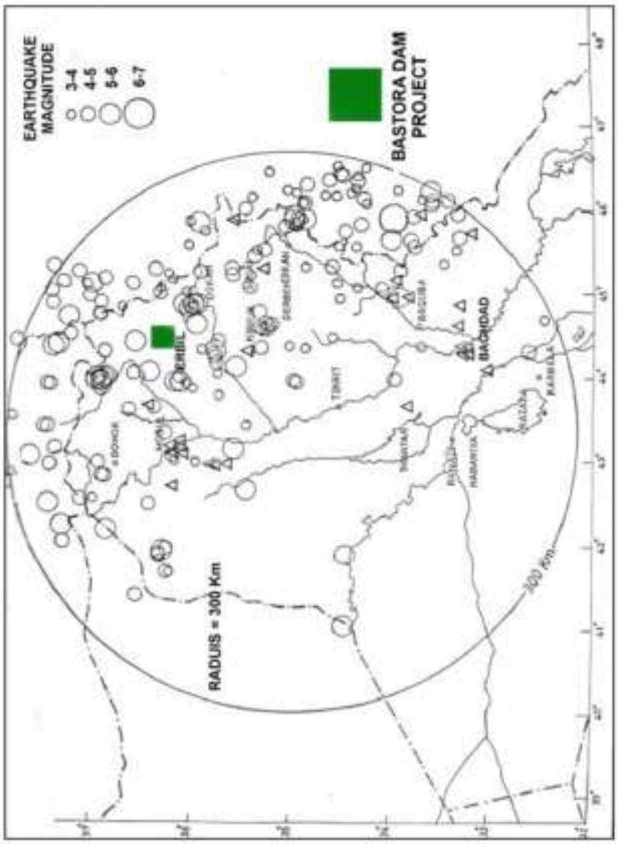


Figure 4.1 : Seismisity map of studied area within (300) km radius (MOWRA, 2005-2006)

4.2 Structure of operation water supply

Directorate of water in Erbil take the responsibility of operation and follow up all the project and water networks in two districts Hawler plain and city center district, the other seven districts managed by water directorate in Erbil surround villages, the both directorates under general directorate of water and sewerage, ministry of municipality.

4.3 Data collections

The details of collecting data were discussed in section 2.9. Table 4.1 and 4.2 show the population statistics and estimated population for the Erbil city, respectivily (GDSRI, 2005- 2006) .

Table 4.1: Table of population statistics in all Erbil governorate (Directorate of statistics)

No.	Year	P. Increase Ratio	Erbil Population
1-	1990	3.1	953697
2-	1995	3.1	1116328
3-	2000	3	1302654
4-	2005	3	1516946
5-	2010	2.8	1755606
6-	2015	2.6	1999908
7-	2017	2.6	2251686
8-	2025	2.2	2510512
9-	2030	2.2	2799089
10-	2035	2.1	3114733
11-	2040	2.1	3455808
12-	2045	2	3822976
13-	2050	2	4220874

Table 4.2: Table shows estimated population in Erbil city center (Directorate of statistics)

No.	Year	City Center P.
1-	1990	442267
2-	1995	517685
3-	2000	604715
4-	2005	704194
5-	2010	815184
6-	2015	930432
7-	2017	1051668
8-	2025	1172555
9-	2030	1307338
10-	2035	1456187
11-	2040	1615644
12-	2045	1789054
13-	2050	1975260

4.4 Water resources and discharge in Erbil center

4.4.1 Intakes and WTP'S

In 1968/69 IFRAZ I intake structure was constructed at the east bank of the Great Zab River at Ifraz village (Old Ifraz Water Project). From there the water is pumped to a treatment plant and then to Erbil. Few years later, a second intake structure was constructed at the same site to increase the water supply bringing the existing transport main to a nominal capacity of 1,600 m^3/h (38,400 m^3/d). Due to inadequate maintenance and wear of pumps the present capacity is only 1,331 m^3/h (31,949 m^3/d).

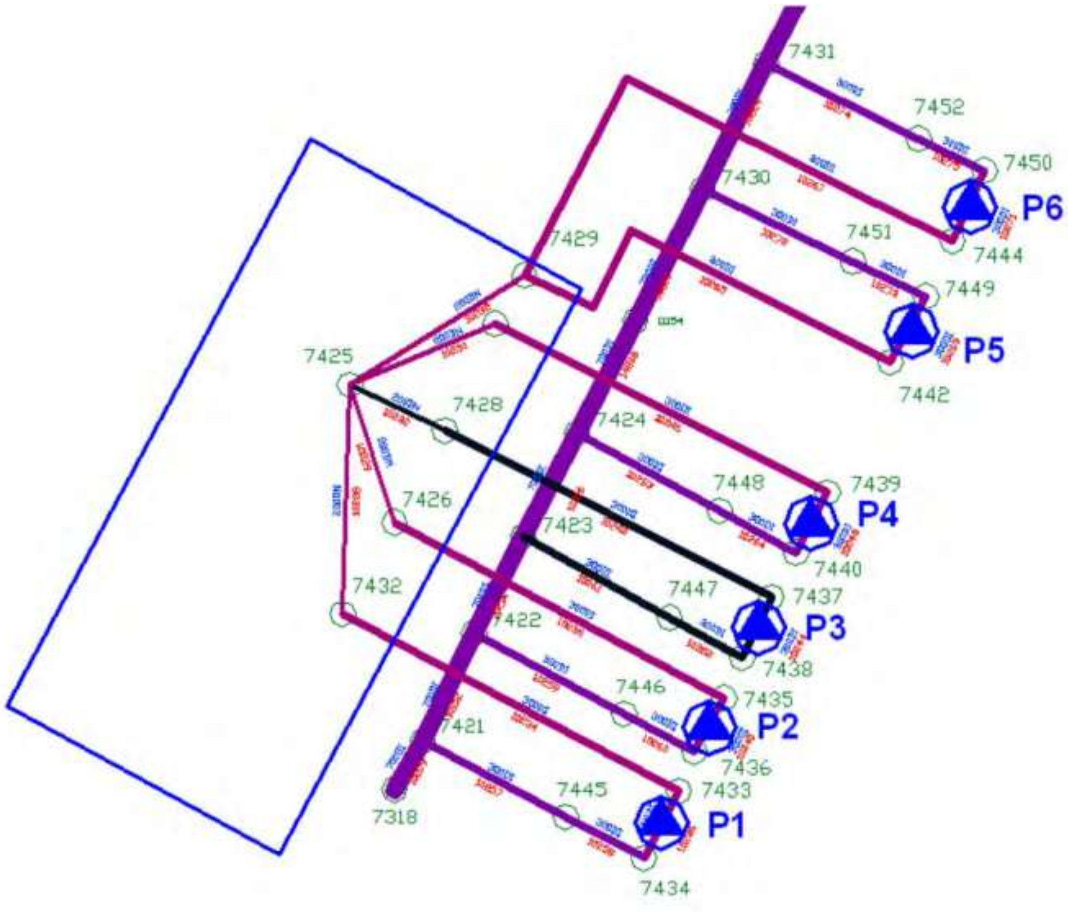


Figure 4.2: Ifraz project design (MOM, 2006).

In 1983 IFRAZ II new intake (New Ifraz Water Project) was constructed at the same site and raw water is pumped to the new water treatment plant in Erbil Ankawa. The treatment plant has a design capacity of 2,880 m^3/h (69,120 m^3/d). Due to unknown reasons the present capacity of the treatment plant is only 1,787 m^3/h

(42,892 m^3/d). The design capacity was never reached. Resent upgrade of the intake chamber and exchange of pumps was insufficient to reach the design capacity. The taken measures increased the capacity only from 1,787 m^3/h to 1,909 m^3/h.

In 2006 IFRAZ III WTP and transmission main DN 1500 were constructed to supply water to the New Dawajin reservoir (24.000 m^3) in the north east of Erbil city to improve the supply conditions. The treatment plant has a current capacity of 6,000 m^3/h (140,000 m^3/d). Restriction in funds did not allow the construction all components to reach the original design capacity of 10,000 m^3/h. An upgrade of IFRAZ III WTP, pump station and intermediate booster station to reach design capacity is in planning stage by WD Erbil.

4.4.2 Deep wells

About more than 1070 deep wells operated by Water Directorate Erbil in Erbil city district and Dashti Hawler district spread all over the supply area (Table 4.3). These are not considered for the hydraulic scenarios of the master planning. This was agreed between the consultant and Water Directorate Erbil due to the increasing risk of contamination and over exploitation of the aquifer. The ground water abstraction shall be gradually phased out. Functioning deep wells may be used for non-potable water supply or in case of emergency only for local supply demand of drinking water. Depth of wells between 200m up to 400 m according to the geological information’s.

Table 4.3: Water resources and discharge in Erbil center (MOM, 2015)

Erbil center			
No.	**Water source**	**Number**	**Discharge m^3/day**
1	Pump station	3 stage	352800
2	Deep wells	800 No.	244500
	Total		597300

Water requirement per person per day is equal to **350 l/p/day** according to the information from directorate of water in Erbil (Table 4.4).

Table 4.4: show water requirement (0.350 m^3/P /day) According to the Erbil water directorate (MOM, 2015)

Year	City Center P.	M^3/day
1990	442267	154793
1995	517685	181190
2000	604715	211650
2005	704194	246468
2010	815184	285314
2015	930432	325651
2017	1051668	368084
2025	1172555	410394
2030	1307338	457568
2035	1456187	509665
2040	1615644	565475
2045	1789054	626169
2050	1975260	**691341**

4.5 Urban and social status

This dam has significant outcomes for people's lives and livelihoods, which include controversial issues such as resettlement and displacement for the study region. The opponents of dam construction argue that the social and economic consequences (and also environmental) of dams are more far-reaching than those associated with other infrastructure projects because of the huge impact across time and space in both the ecosystem and in social, economic, and cultural structures. The impacts, both positive and negative, can be better illustrated in connection with the dam project cycle (Saytarkon, 2013).

4.5.1 Administrative and population status

The reservoir has various effects on its zone comprising elimination of a few villages and the need to build new villages for resettlement of the current inhabitants of the impounded area. Generally, there are 2 villages that are located below the level 900 m.a.s.l. which may be inundated, these villages are Sartika and Haj Ahmed. The geography and administrative division, the reservoir zone, and the surrounding areas and villages are located within the Territory of Salah Al-Din County called Nahiya forming a part of Shaqlawa called Qadaa; this belongs to the Governorate called Mohafada of Erbil. The population of the whole Governorate of Erbil, including the population of the study area, is approximately 1,000,000 people. This is based on a recent updated census carried out in 2005. For the study area alone, the population is about 60,000 people.

4.5.2 Gender and literacy issues

An official data based on the 1997 census indicates that women make up about 70% of the total population of the whole region including the study area. This may reflect the repressive policy and genocide that the previous regime in Iraq had applied against the Kurds in the region, especially males. As a whole, women experience lower mortality but less literate than their male counterparts. Still, the adult male illiteracy rate is about 28%, and 75% for female, however, the situation is worse in the farthest rural area. The average fertility rate in the area is about 7.7. In government employment, there are only 57% male members and 43% female. Women farmers make up 5% of farm workers, they have equal access, but less opportunity to the land demarcated to the project, as well as, credit funds allocated for agricultural development (MOWRA, 2005-2006).

After the dynamic changes in the political situation in Iraq in 2003, the new government established new legislation to identify and address gender issues in the country. Several issues, as having a negative bearing on women’s economic and social capacities, have been identified. These include the lack of control and ownership to land, the inherent biases in civil and customary law which presume ″women as perpetual minority″, and the strong influence of the traditional systems where women are under the control of a male guardian for most of the decision-making. The political fronts advance in the process of drafting the national gender policy as well as legal reform to allow gender equity in all sectors.

Constructing Bastora dam can have significant impacts on the area and people’s lifestyle in which the temperature of the area decreases and all sectores such as agriculture, tourism, livestock, and industry will be boomed. This encourages people to come back from cities to the area. So that, the area can be rich with both genders, thus, the gender equality can be seen in all living life aspects. Also, illetrate people can migrate to the area due to the dam and other benefit projects.

4.5.3 Education

Development of the education services in the study area is an important lateral objective. It is also expected that enrollment rates in schools will also improve with the increased income (MOE, 2005-2006).

The following data provides an indication of education services and enrolment ratio for the academic year 2005 – 2006 (Table 4.5).

On the other hand, constructing dams causing population increase in the area and needs a proper plan to obtain all people's demand such as education and health services.

Table 4.5: Number of schools, capacity and enrolment (MOE, 2005-2006)

Services	No.	Capacity- pupil	% Enrolment
Total primary school	1167	474590	92
Primary school (mixed)	1122	237295	90
Primary school (girls)	14	5544	95
Total secondary school	352	281900	85
Secondary school (mixed)	155	140950	80
Secondary school (girls)	82	58104	90
Total female teaching staff	12421	-----	90
Total male teaching staff	8897	-----	80

Table 4.6: Concerning illiteracy (%) (MOE, 2005-2006)

Religion	Percent
Adult illiteracy rate, total (%)	38%
Adult illiteracy rate, female (%)	45%
Adult illiteracy rate, male (%)	28%

Total allowance spent on education = (US$ 40 million) for the year 2005 (MOE, 2005-2006).

4.5.4 Demographic aspects

In the reservoir zone and the irrigation study area, all inhabitants can be considered as sedentary with fixed permanent residence (no nomadic population). The majority of the population tends to live near the streams and springs. However, a draft comprehensive resettlement plan, as a part of this project documents, is required.

Demographical data based on the 1997 census for the whole region indicates that the total population is 800,000 people (250,000 males and 550,000 females), with over 90% Kurds. In the study area agriculture is the main source of livelihood for over 75% of the population.

Livestock also plays an important role in the social system of the community. The unemployment rate amongst women is comparatively higher than that for men. On average, 54% of the active population is employed, knowing that the majority 75% of the female and male population is between the ages 18 and 45 years. The demographic status may be explained by the following official and field data in 2006 (Table 4.7).

Table 4.7: Demographic data.

Total rural population growth rate	1.5%
Urban population growth rate	1.3%
Population equal and younger than 18 year age	15%
Population equal and older than 75 year age	3%
Dependency ratio	10%
Sex ratio (per 100 female)	43
Female population 17-50 years (% of total population)	53
Male life expectancy (years)	67
Female life expectancy (years)	75
Crude birth rate (per 1000)	25
Crude death rate (per 1000)	10
Infant mortality rate (per 1000)	55
Child mortality rate (per 1000)	80
Maternal mortality rate (per 100000)	500
Total fertility rate (per woman)	7.7
Women using contraception	45%

Note: Beneficiaries are found to be receptive to the project as it is expected to have positive impact on the lives of people in the area.

4.5.5 Rural poverty

Generally, Iraq is classified as high income country. Nonetheless, it currently experiences severe economical and social difficulties as a result of three wars that took up the last 25 years. For 10 of the last 25 years, the country was subject to severe economical and political sanctions. Except for military related activities, all national development plans have been paralyzed. Due to these circumstances, a disproportionate income distribution among the population had been applied, so that 80% of the rural as well as urban population became below the core poverty line. Until the US invasion in 2003 the income per capita per month was equal to US$ 5.00. After the major changes in Iraq in 2003, there have been improvements for people who are working in commercial and governmental jobs, but it deteriorated for rural people who are working in farming land and the agriculture sector. In addition, the current corruption is another cause of the overall deterioration in all respects.

The total beneficiaries of BDIP constitute about 65% of the poor in the study area living below the poverty threshold in Iraq. Their main activity is subsistence farming under variable rainfall with low productivity and low value. This rural group constitutes the majority of the population (MOWRA, 2005-2006).

Furthurmore, job vacancies will rise due to the dam. So, residents can obtain the job in that area. This would directly improve people's life style and leads to decreasing poverty in the area.

4.6 Socio–economic issues

4.6.1 Primarily subsistence

The population of the study area, as based on the ration card system, is about 60,000 people, while the total area is only 133 km^2. Upon this, the density is estimated at 450 people per km^2 about 90% of the land area is considered arable and as the regional area is largely mountainous, there is considerable pressure on the land resources. The population growth rate is 1.5%. The mean annual rainfall ranges from 260 mm to 515 mm, and the mean annual temperature in the summer exceeds 35^oC and ranges from 9^oC to 15^oC in the winter.

Of the 11,000 hectares that are suitable for irrigated agriculture, about 8,800 ha are under crops and fruits trees grown under rain fed condition, while only 2,200 ha are under irrigation. Depending upon the amount of rainfall, it may not allow year round farming since there is only one rainy season from December to March. Whereas potential for irrigation development is substantial, the expansion of the irrigation area is constrained by, among other factors, the limited amount of available irrigation water. People throughout Iraq had faced crucial times between 1990 and 1997 under severe economical sanctions. The application of the ration card system had prevented a possible starvation. Poor people still cannot manage without applying the ration card system (MOWRA, 2005-2006).

4.6.2 Agricultural activities

Iraq is mainly an agricultural society. As has been mentioned in previously, agriculture and livestock are the main sources of livelihood for over 70% of the population living in the study area. It is a major source of employment and income for the area households.

The agricultural potential of the uplands of the watershed is limited, due to soil depth, degree of slope, and stoniness and rockiness.

The relatively flat lands of the lower part of the study area encompass the most agricultural activities. The grazing lands make up a considerable portion of the total area. The perennial species have almost disappeared and been replaced by annual grasses which are grouped under the graminacease family rather than the leguminacease family. The dominant tree species is oak and the areas occupied by orchards are relatively small and mostly vineyards (MOWRA, 2005-2006).

4.6.3 Livestock

Livestock plays an important role both in the economy and the social system of rural people in the study area. The production accounts for 20% of the gross domestic product. This subsector provides employment, milk, and meat for better nutrition for small holders, draught power, and farm manure. The cattle population is estimated at 37,000 in 2006 with sheep and goat cattle are being dominant. Cattle breeding are mostly destined for the local market, except for the production of cows' milk, where it's partially supplied for local food processing (dairy) factories in Erbil.

The official figures of livestock in the flooded area as obtained from Nahiya county are:

- Meat cattle 1,000 to 1,200 heads (MOWRA2006)
- Milk cows 1,000 to 1,200 heads (MOWRA2006)
- Sheep 12,000 to 13,000 heads (MOWRA2006)

The project will have some effects that will occur if cattle outside the reservoir zone are deprived of green forage harvested in the stream valley.

4.6.4 Poultry

In the rural area of the project, it is very common that families raise their own poultry of 10 to 50 heads/family. They normally raise chicken, ducks, geese, turkey, and domestic birds.

The figures poultry in the flooded area as obtained from officials and field research for 2006:

- Domestic poultry 15,000 to 20,000 birds
- Meat poultry scheme N/A (abandoned)
- Eggs poultry scheme N/A (abandoned)

4.6.5 Handicraft and industries

In the past, handicrafts were mainly focused on ceramics and pottery, but currently it has almost disappeared. In the whole region there are other traditional handicrafts but very limited, such as sewing, crewel, carpeting, etc. Light industries producing plastics, aluminum products, weaving, webbing, etc, becomes a rival with which traditional craftsmen cannot compete, i.e. the ancient clay pits which were widespread in the past, are no longer used.

There is only one industrial sector present in the impoundment area, this sector is consisted of gravel and sand pits activities (quarry). The extraction activity is rather significant since deposits of these materials are easily accessible along the length of the stream bed. These quarries are also beneficial for the study area since quarries are located all around the dam site.

4.6.6 Official employment and social benefits

Based on local official sources, the following data have been collected regarding the study area:

- Number of people working in government jobs including police and army is estimated at 9,000.

- Number of people working as official workers is estimated at 3,000.

Every Iraqi citizen is supposed to be supplied with a nutrition allocation decided by the potion card system every month as part of the social benefits. The official number of beneficiaries in the study area is about 60,000 people. The average value of each nutrition allocation is about US$ 15

4.6.7 Land tenure

There are many forms of land tenure in Iraq including the study area as follows:

- The traditional system of communal property;
- The individual or freehold on private or government land;
- Lease hold land; and
- Entailed estate (under religious legislation).

About 70% of Iraqi land is communal and managed by the Finance Ministry of Iraq which has authorized the allocation of land to the public. This allocated land is rarely taken away, and if so the person is compensated fairly. Presently, there are several irrigation schemes in the Kurdish region and experience has shown that there have been no disputes in terms of ownership and usage by individuals.

The individual ownership characterized by small to medium sized lots in the urban areas, and large farms averaging 50 ha in the rural areas. Any Iraqi national male or female can purchase and own private land.

4.6.8 Hunting and fishing

Hunting is very limited in the study area because the population of the wildlife was highly affected by forest degradation, unrestricted hunting, and mismanagement. A limited type of wild birds and rabbits are available for hunting at present.

There are no fishing activities in the study area, Because the subcactment is not on the main river, thus there is not fishing, however, there is fish trading in the civic center of the area, people in the area consume about 51 tons of fish per month. This amount of fish is usually imported from the surrounding lakes such as Dokan and Derbandkhan

(MOI, 1967). One of the advantages of BDIP is to bring the new fishing industry and make fish available locally.

4.7 Inundated property, infrastructure and services inventory

4.7.1 Inundated property

4.7.2 Settlement and villages

Settlement in the reservoir area is very limited. There are only 2 villages which are below the level 900 m.a.s.l. elevation and will be subject to inundation, these villages are Haj Ahmed and Sartika. The population of these villages is about 300 people.

Maps dated back to 1954 show that numerous villages were registered in Bastora Watershed, but are abandoned due to the dislodgment and genocide policy applied by the previous Iraqi regime.

The only new scheme founded on the impoundment area is a residential complex of 15 houses that are located above the 900 m.a.s.l. elevation. These houses are built to accommodating the staff that will operate the Bastora Dam in the future.

4.7.3 Roads and bridges

The road network in the reservoir area consists predominantly of unpaved earth trails which link a few villages. Among these, are two important roads that are being paved with asphalt, the first is the road linking Erbil and Sulaimani, the second linking Erbil and Shaqlawa. The total length of both sections is approximately 1 km long. Both of these roads will be flooded and are located to the north-east of the dam site, at a level of 850 m.a.s.l. It is recommended to construct the new road which would higher that the water level of the dam (should be on safety level). No railway line exists in the reservoir area. The earth trails that will be subject to flooding are approximately 7 km long. There are no bridges situated in the impoundment area below the 900 m.a.s.l, except some culverts located below some earth trails.

4.7.4 Power transmission lines

The villages located in the reservoir area have not yet been linked to the national electric network. There are other nearby villages that are supplied with electricity

(Zyart, khoran, and Kalaseing), which are supplied by local diesel generated power, but none of them is situated below the impoundment level.

4.7.5 Quarries

Most of the quarries in the impoundment area will be flooded. It should create another quarry in areas far from the dam.

4.7.6 Oil pipe lines

No oil pipe line passing through the impoundment area.

4.8 Services inventory

4.8.1 Sanitary services and waste disposal

Villages in the upstream area of the dam lack all kinds of sewerage and sanitary services. The human and animal refuse is normally buried in abandoned latrines and sumps, stocked in animal farms or spread over crops. Various solid waste types will be putrescent in place. In fact, the flooding of the village zone is when impoundment begins which will result in the decomposition of organic matter. However, the situation is not that serious as only a few villages are in the area upstream of the dam.

The area downstream of the dam- about 5% of the rural population- do not have any form of toilets or bathrooms, and about 90% of the rural poor rely on streams and wells for their drinking water. Besides the refuse matter, other man-made sources of pollution in the whole region especially in the uplands are very scarce. For example grease disposal and industrial wastes are very rare. This is a positive factor which may help to keep water pollution problems at low levels.

4.8.2 Water supply

In the rural areas upstream of the proposed dam site, most of the population relies on streams, wells and springs Kehlees for their drinking water. Downstream of the dam site –in the project irrigation area- about 10% of the population use filtered water. Table 4.8 shows the water supply facilities have been obtained from some official and field sources.

Table 4.8: Water supply along the study area.

Water supply	Numbers
Number of wells used for drinking water	270 wells
Number of springs Kehlees used for drinking water	2 spring (Kehlees)
Number of water treatment plants	nil
Number of water compacted units	nil
Total length of water distribution pipes	nil

4.8.3 Electrical services

Shortage in the supply of electricity is a remarkable problem all over Iraq. Based on official and field sources, the following conditions of electrical power may reflect the electrical services available in the study area:

- In the reservoir area upland of the project villages have not been linked yet to any national electrical network;
- In the down land of the project 90% of the population do have electrical services for only 7 hr/day;
- The electrical power is supplied to the region from “Khanzad electrical Plant” , then transmitted to the study area by an 11,000 V line;
- Due to shortage in electricity supplied by the national network, the private sector started a new investment utilizing diesel generators to produce electricity for the public. In the study area currently, there are about 17 private generators producing about 2400 kva.

4.8.4 Recreation and resorts

In the same region and within 30-50 Kilometers to the north of the project site, there are fascinating resorts “Salah AL- Din and Shaqlawa”. Although organized tourism activities are virtually non-existent in the study area at the present time, the dam and lake (reservoir) to be created upstream could become, in themselves, an interesting attraction for tourists and visitors. This will require facilities for bathing, yachting, water-skiing, fishing and accommodations. None of these facilities exists at the present time.

4.8.5 Health services and future diseases

Health services are deficient for people in the project region. The results of an interview held with officials of the Erbil hospital and information gathered about regional health institutions and health care facilities are stated below (MOH, 2005-2006).

4.8.5.1 Health institutions and services

Part of the study includes the survey below which comprise the upstream of the reservoir. It is important because the reservoir will impact by the villages due to the waste water and solid waste from the upstream villages.Moreover, this would be a guidline for increasing the following requirments in the future. All data were collected in Ministry of Health.

- Number of health centers in the reservoir area (upland) = nil.
- Number of health institution and services in the irrigation project area (down land):
  - ✓ Hospital = None
  - ✓ Outpatient health center = 30
  - ✓ Outreach services (ambulance) = 15
  - ✓ Inpatient beds = None
  - ✓ Primary health care center = 5
  - ✓ Ultrasonic and X-ray dept. = 15
  - ✓ Medical investigation labs = 25
  - ✓ Vaccination teams = 25
  - ✓ Family planning clinic = 20
- Doctors of medicine :
  - ✓ General practitioner (G.P) = 50
  - ✓ Specialist = 4
  - ✓ Consultant = 2
  - ✓ Dentists = 25
  - ✓ Pharmacy doctors = 7

- Sub staff:
  - ✓ Doctor assistant = 250
  - ✓ Nursing staff = 40
  - ✓ Midwifes = 17

4.8.5.2 Diseases on the rise

People in the study area suffer from the lack of basic health services. Due to the hot climate, the risk of certain endemic diseases transmitted by different vectors such as insects, crustacean, and contaminated drinking water is evident. Some major diseases are on the rise including Diarrhea and Parasites. The expansion of water surfaces by a new lake of about 8 km^2 may increase the possibility of other diseases. This may be due to the creation of shallow water surfaces along the margins of the reservoir, and the micro-climatic changes such as humidity that favors the proliferation of water-borne diseases. Interchange of infective agents may occur amongst inhabitants and resettled people (MOH, 2005-2006).

Diseases on the rise that require priority preventive measures include Malaria, Bilharzias, Typhus Paratyphus, Intestinal Parasites-amoebae and Ascaris.

A control program for Malaria has been implemented in Iraq since 1968. Within three years of launching this program, the number of malaria cases significantly diminished. Since malaria is transmitted through mosquitoes, the Bastora Dam Lake will favor the creation of zones of stagnant water in the form of creeks, swamps and humid zones along the shoreline of the lake. These conditions are favorable for mosquitoes to deposit eggs where the larvae can develop. Appropriate measures need to be taken in the development of BDIP to eliminate the development of malaria.

Bilharzia is another endemic disease provoked by schistosomiasis and transmitted by water snails. Infection of this disease occurs through direct contact with contaminated water which is expected to rise in connection with the lake impoundment and with the possible creation of irrigation channels since these conditions are the preferred breeding habitats for the vector (MOH, 2005-2006).

Presently, Bilharzias does not seem to have made an appearance in the study area; therefore, the risk is very low but it should not be completely dismissed some cases of Bilharzias have appeared in areas where no such disease existed before.

There are other risks of water and other environmental pollution factors related to the impoundment of human habitat and the related economy. The flooding of land results in the decomposition of organic matter and the washing out of human and animal refuse buried in abandoned latrines and sumps, stocked in animal farms, or spread over crops. The infective agents of the expected diseases may proliferate in the lake and create a new risk for use of non-treated water. The self-purification properties of the lake may restrict the survival of pathogenic micro-organisms. Other man-made sources of water pollution are grease, floating vegetation, and waste matter, but these pollutants are very scarce in the study area.

4.8.5.3 Factories

Table 4.9 shows the data regarding the existing study area factories (Light industry) has been obtained:

Table 4.9: Number of factories (MOT, 2006).

Factories	Numbers
Factories producing plastic and aluminum goods	25
Dairy factories	Nil (domestic only)
Dehydrated fruit and canning factories	nil (domestic only)
Quarry factories	50
Building materials factories	40

4.9 Natural resources

The region is classified as “Internal Mediterranean” and falls in different classes such as mild winter, dry semi-arid climatic moisture type to semi-humid class and dry and hot summer.

4.9.1 Water resources

4.9.1.1 Surface water

The main stream in the watershed is classified as perennial, intermittent stream flow; therefore, water flow disappears at the upper parts of some of the perennial minor streams during the summer season (Hama Saaid, 2003). This implies that there is always a shortage of water for irrigation and sometimes for domestic uses during the summer months. The annual average flow rate of Bastora Stream, including snowmelt runoff, is estimated at 4 m^3/s.

The snowmelt runoff forms a considerable proportion of the total runoff in most streams of northern Iraq. The lack of records about this part of water resources requires an estimation of the snowmelt rate and simulating the daily runoff, which can be done efficiently through using remote sensing technique and GIS (Fattah, 2004).

This can be undertaken in a separate report to accurately compute this portion of water sources of the uplands of the project watershed (MOWRA, 2005-2006).

4.8.1.2 Groundwater

Groundwater is essential to the agricultural, environmental, health, domestic, and development of the rural area.

The obvious shortage of water in the study area is being compensated by groundwater pumped from many scattered wells especially on the project irrigation area. The following data had been confirmed from official records and field research:

- Total number of wells = 270
- Minimum well depth = 100 m
- Maximum well depth = 300 m
- Minimum well capacity discharge = 2 l/s
- Maximum well capacity discharge = 15 l/s.

There is only one main water spring (Kehlees) located in Kasnezan complex, with a discharge rate ranging from 2 l/s to 15 l/s.

Groundwater exploitation in the Erbil plain was carried out in several forms including hand-dug wells, water springs, drilled wells and keyless. A considerable expansion for local agriculture and urbanization commenced in the early 1980´s where the total annual production of water wells was estimated at 51.44 X 106 m^3 or 1.63 m^3/s. This was still below the safe yield, and accordingly, more wells could be drilled as a supplementary water source for irrigation.

According to a recent survey, about 60% of water demand is met by numerous deep wells dispersed throughout the urban and suburban areas, while about 40% is supplied from the Greater Zab River by pumping from Ifraz station to the treatment plant near Erbil.

According to the Stevanovic and Markovic (2004), the depth of wells has only recently increased, and most new wells have been drilled to a depth exceeding 100 m. Currently, there may be no more than

800 operational deep wells in the entire district of Erbil and the amount of exploitable groundwater in Erbil is approximately 2.5 m^3/s. Figure 4.3 shows the number of water wells drilled in Erbil governorate.

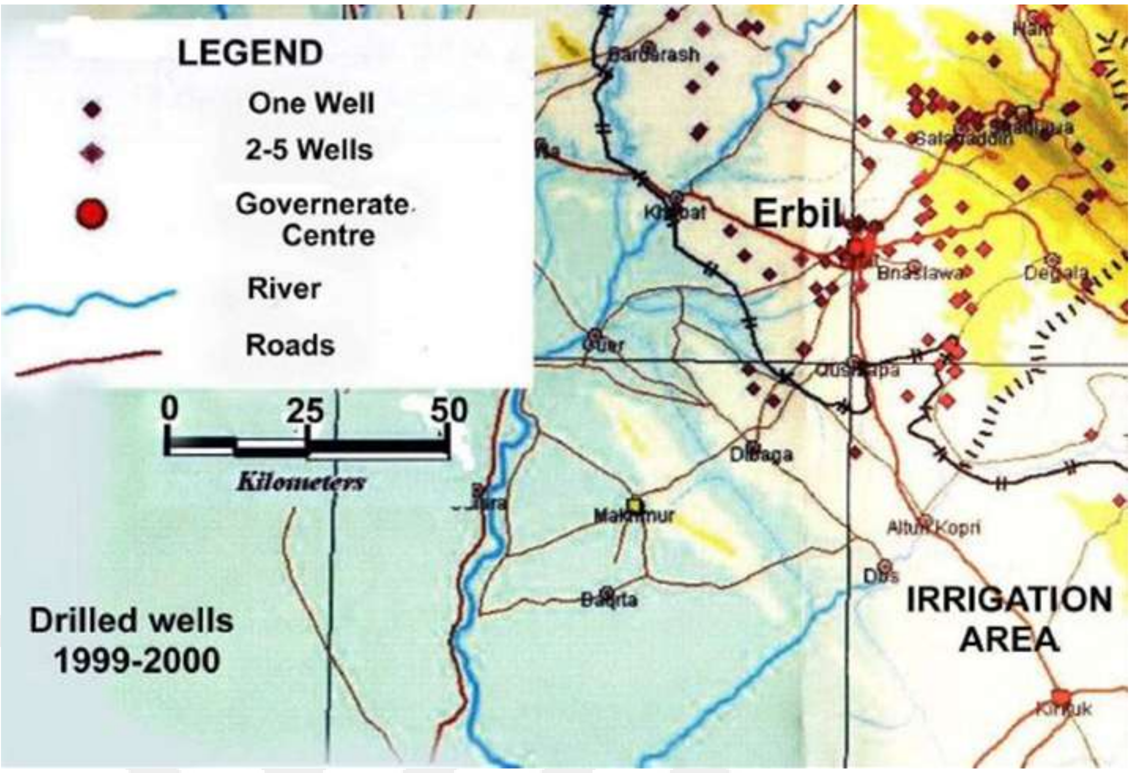


Figure 4.3: Wells drilled in Erbil Area (FAO 1999-2000).

4.9.2 Water quality

4.9.2.1 Groundwater quality

The quality of groundwater is the resultant of all the processes and reactions that act on water from the moment it condenses in the atmosphere to the time it is discharged by a well. Therefore, determination of groundwater quality is important to observe the suitability of water for a particular use. The problems of ground water quality are more acute in areas that are densely populated and thickly industrialized and have shallow groundwater tube wells (Hama Saaid, 2003).

For evaluating the suitability of groundwater for different purposes, understanding the chemical composition of groundwater is necessary. Further, it is possible to understand the change in quality due to rock- water interaction (weathering) or any type of anthropogenic influence (Todd, 1980). Such improved knowledge can contribute to effective management and utilization of this vital resource. In this view, monitoring the quality of groundwater (chemical, physical, and biological constituents) is as important as assessing it’s quantity.

Table 4.10 shows water chemistry analysis (physical nad chamical variables) for eight groeundwater samples. Data shows wide variability among wells. The minimum, maximum and mean of the data viariables are shown in Table 4.10. The PH of water samples ranges between 7.2 to 8, this is mostly considered as a neutral sample except sample Gomaspan 8. The highest electrical conductivity (EC) (1050 micromohs/cm) were recorded in well Gomaspan 6 and lowest value recorded in well Gomaspan 3 (369 to 1050 micromohs/cm). However, the highest Total dissolved solid (TDS) were measure in well Gomaspan 6 (525 ppm). This range is not exceeded the WHO guidlines Table 4.11. Generally, all cation and anios were not exceeded the WHO guidlidens for drinking water purposes Table 4.11.Thus, all grounwater samples in the study area are suitable for drinking purpose.

4.9.2.2 Surface water quality

Eight surface water quality were collected and analysed along the gomaspan stream (Table 4.12). Surface water chemistry data shows great variability among samples. All data variables not exceeded the guidlines of WHO for drinking water. Lowest PH was recorded in sample 6 and highest in sample 8. Apparently, EC range between 500 to 690. The lowest EC (500 micromohs/cm) in surface water is higher than in groundwater. All cations and anion are within a range that standard by WHO .

Table 4.10: ground water wells

Test Names	G.S. 1	G.S. 2	G.S. 3	G.S. 4	G.S. 5	G.S. 6	G.S. 7	G.S. 8	Min	Max	Mean
Turbidity	0.3	1	0.9	0.4	3	0.2	0.2	0.2	0.2	3	0.78
PH	7.2	7.2	7.2	7.2	7.8	7.9	7.8	8	7.2	8	7.54
EC	735	790	369	370	1036	1050	892	596	369	1050	730
TDS	368	395	185	185	518	525	446	298	185	525	365
CL^-	20	22	14	15	33	22	15	18	14	33	19.9
Alkalinty	211	200	150	160	210	210	220	200	150	220	195
Hardness	410	395	200	210	466	460	445	265	200	466	356
Ca^{++}	66	77	40	54	64	67	65	61	40	77	61.8
Na^+	17	18	11	12	18	19	14	14	11	19	15.4
K^+	1.3	1.2	0.8	0.8	1.3	1.3	1.2	1.1	0.8	1.3	1.13
Mg^{++}	60	49	24	18	74	71	69	27	18	74	49
NO_3^{-1}	8	8	20	22	6	6	5.8	7	5.8	22	10.4
SO_4^{-2}	27	17	2.2	2.6	16	27	21	6.6	2.2	27	14.9

Table 4.11: WHO standard for drinking water.

Variables	WHO (2006) mg/l
Ca^{++}	75-200
Na^{+}	200-250
K^{+}	10-12
Mg^{++}	50-100
NO_3^{-1}	50
SO_4^{-2}	250
CL^{-}	250
T.H	--
TDS	1000
PH	6.5-8.5
Turbidity	5NTU

Table 4.12: surface water quality

Test Names	S.1	S.2	S.3	S.4	S.5	S.6	S.7	S.8	Min	Max	Mean
Turbidity	0.9	1.4	0.6	1	4	6.2	8	8.4	0.6	8.4	3.81
PH	7	7.5	7.4	6	7.4	7.2	7.7	8	6	8	7.28
EC	570	500	520	560	530	660	690	650	500	690	585
TDS	280	250	295	270	265	320	345	330	250	345	294
CL^{-}	25	17	23	19	24	20	32	28	17	32	23.5
Alkalinty	330	285	305	300	270	300	325	320	270	330	304
Hardness	290	254	280	220	225	267	260	200	200	290	250
Ca^{++}	68	65	71	59	50	60	60	50	50	71	60.4
Na^{+}	5	5	8	9.5	10.5	20	23	15	5	23	12
K^{+}	1	1	0.8	1	1.5	2.5	2.9	2	0.8	2.9	1.59
Mg^{++}	23	25	26	18	18	25	22	17	17	26	21.8
NO_3^{-1}	7	8	2	4	2.5	5	6	7	2	8	5.19
SO_4^{-2}	30	20	30	33	32	48	50	49	20	50	36.5

4.10 Vegetation

4.10.1 Forests

It is difficult to draw boundaries between one zone of vegetation and another, however, the following zones of vegetation in the whole region of Erbil government area can be distinguished as:

- Alpine zone, over 2,800 m.a.s.l
- Mountainous forest zone:
- Thorn-cushion zone, 1800–2800 m.a.s.l
- Forest zone, 500–1800 m.a.s.l

In the study area, mountainous forest zone may be distinguished. A forest and high mountain scrub is within approximately 52 km^2 of the study area is. The forest density varies from closed boundary forest of 5 to 10 m high trees in relatively inaccessible mountains, to treeless spots (completely eliminated) near densely populated districts. Forests in the area may be classified as:

- Riverian forests where the tree species found alongside the mountain streams include Salix Acomophylla, Populus Euphratica, Juglans Regia, etc. Shrubs include Vitis, Vinifera, Rubus, Sunctus, Nerium Olender, etc.
- Oak forests which consist of many sub-zones and area found over much of the mountains at altitudes ranging from 700 to 1400 m.a.s.l..

Though an intensive reforestation program has been initiated during the last decade, the forest lands diminished due to improper management and over cutting. Reforestation practices can be noticed now as almonds, pines, and morus are progressively planted.

4.10.2 Grazing lands

Nearly more than half of the study area is considered as grass steppe or predominantly under cultivation with or without trees. The cultivated lands cover the main and sub valleys or the limited plain area (Sahl Erbil) which constitutes the irrigation area of the project.

Grazing lands may include forest trees, shrubs, perennial and annual herbs; its density depends on the annual rainfall. Some other characteristics of grazing lands in the study area are as follows:

- The perennial species have disappeared and been replaced by annual grasses;
- There are no grazing rotations and the lands near water sources or the main roads and villages have been over grazed; the opposite is true for the inaccessible lands at the upper parts of the watershed uplands;
- The grazing lands are subject to repeated burning to reduce growth of weeds;
- The natural plant species may include bromus, wild oat, wild barley, midik, vivia, wild carrot, etc. The common weeds found in the orchards, vineyards, and cultivated lands are Lagonichium Farctum, Srghum Halepense, and Cyperus Rotundus, etc.

Those lands protes the land from the weathering and erosion.

4.11 Fish and wildlife

Fish and wildlife resources may represent a major portion of the environmental concerns that should be addressed before construction.

The resulting reservoir can be of significant benefit to the fish and wildlife species when the biological requirements of these species are considered during the planning, design, and operation of the reservoir.

4.11.1 Fish

In the study area fish resources are very trivial; this is due to the lack of bodies of water such as lakes and rivers. The proposed reservoir may provide a good fishing opportunity if the planning studies of the project are based on accurate data to assist in the design of alternatives that will maximize fishery benefits in the new reservoir.

The types of fish that normally live in the regional waters and the surrounding regions are called by their local names: Biz, Shabot, katan, Shsan, etc. After filling the reservoir and perhaps for several years afterwards, and due to gradual changes in water quality, depth and food sources, new species of fish will be certainly defined.

4.11.2 Wildlife

It is assumed that wildlife and water resources development can exist in harmony. There are some direct and indirect impacts resulting from the construction and operation of a reservoir. Certain impacts such as inundation of habitat within the reservoir area are unavoidable if the project objectives are to be met. Some of the negative impacts can be reduced through design considerations, and others can be offset only by including separable wildlife features. In developing countries, the severe impacts on wildlife are mostly resulting from the society. In the study area this is caused by forest degradation, over cutting, unrestricted hunting and mismanagement.

The population density of wildlife is very low in the project watershed; however, different categories of animals and birds are present. Examples of existing small animals are Rats, Jerboas, Rabbits, Hedgehogs, Reptiles, wild cats, Badgers, Fox wolfs, Wild goats, Gazelles and Porcupines. The large animals in the uplands of the watershed are Pigs, Bears, Hyenas and Tigers. Except for Pigs, the number of the other large animals is very limited; Bears and Tigers are almost extinct. Birds of various types are present such as Sparrows, Wood Pickers, Larks, Starlings, Partridges, Quails, See-See Partridges, Falcons, Crow, and Vultures.

4.12 Mineral, mining and quarries

Based on the available information taken from local official sources and field research there are no mineral extractions and / or mining activities within the boundaries of the reservoir and project irrigation area at the present time. To be more certain, a more specific and detailed report can be prepared.

There are certain activities for extracting construction materials such as sand, gravel, rocks and soil fill from some queries and pits in the reservoir area.

An important surface feature in the area is the steep slopes and ridges which are subjected to landslides, rock falls, and soil fill. This is of great importance for obtaining construction materials for the project. At the present time, there are several active quarries and pits.

4.13 Compensation measured by the authority

Generally, a government committee will be created from Ministry of Agriculture and Water Resources, local government, general union of farmers and Ministry of Municipality. This committee works on compensation for those things that affected by the dam project as follows.

1. Land compensation

Those lands that located on the dam study area classify as follows.

A. Private landowner : 385 ha is belonging to private landowner.

First the land will be estimated by the committe, then for this kind of land 12% of the land price will be compensated by the government.

B. Public land : : 215 ha is belonging to public land.

Those lands were already given to the residence farmers by a contract between government and resident farmers. This compensation is lesser in which only 3% of its price will be compensated.

2. Available tree compensation

First a survey will be carried out for the available trees in the study area. The survey includes the quantity and quality of trees. Based on that survey, the estimation will be given to owners by the government committe.

3. Enterprice (e.g., Shops, houses, poultry, local water wells… etc) There are 3 poultries and 65 houses in the study area.

This will be compensated in full.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

5.1 Discussion and conclusions

BDIP is described as one of the prospective projects that support the development of water resources in northern Iraq. One of the main project objectives is to provide irrigation infrastructure and to enable smallholder farmers to intensify and diversify their agricultural production by building on existing market linkages with the private sector.

This study concluded the following:

1. The project will divert part of the peak flow of the Bastora stream into a 200 million m^3 capacity of stream storage reservoir. The main purpose of the stored water will be to irrigate 4,000 ha of the 11,000 ha of the total land downstream to grow crops and fruit trees.

2. The project will increase regional household income, enhance food security and improve access to social and health infrastructure for 60% of the rural population by developing subsistence-level smallholding farms into small-scale commercial farms.

3. The total project cost, loan resources and loan agreements are not yet specified. The project could be financed by the Arab Bank for Economic Development, the European Union, the European Investment Bank, the International Fund for Agricultural Development etc., as the project falls within the national outline of the poverty reduction strategy.

4. At full development, the income for each household will be increase from 5$ to 15 $ per month, monthly from 150$ to 450$ and yearly from 1800$ to5400$$, they depend on the local products. The income for each could be 300$ to 600$ and having continual job vacancies in the area.

5. 4,000 ha of the 11,000 ha that is suitable for agriculture will be irrigated for agriculture. Year-round farming is unachievable since there is only one rainy season from November to March and the amount of water available for irrigation is very limited. The project will yield improvements to the overall irrigation problems; however, shortage of irrigation water will remain a problem.

6. The population in the Bastora dam irrigation study area is mainly agricultural. Agriculture and breeding livestock are the major sources of employment and income for rural households.

7. The dominant food crops include maize, wheat, potatoes, pumpkins, groundnuts, melons, casaba etc. A considerable amount of cereal has to be imported to cover the domestic shortfall. This situation may remain even after the project has been completed.

8. Expansion of irrigated agriculture is constrained by the available amount of water resources, and any further expansion of irrigation agriculture will have to be matched by the expansion and development of additional water collection and storage facilities. BDIP will directly address this constraint through the provision of a storage facility.

9. The current agricultural production is generally constrained by many factors, including off-farm incentives, high cost of input, lack of credit, recurring droughts, wars and displacement, lack of specialised extension in veterinary staff, lack of training, and bad transportation. BDIP will mitigate most of these shortcomings.

10. People in the study area are affected by the lack of health services. The expansion of the water surface from the new lake of approximately 8 km^2 may increase the incidence of other diseases. Diseases of concern that will require preventive measures are malaria, bilharzias, typhus paratyphus, intestinal parasitic amoebae, and Ascaris.

11. Approximately 70% of the regional land is owned through the traditional system of communal property, which the Finance Ministry holds in trust for the nation. Other forms of land tenure are individual or freehold and leasehold land.

12. The inherent biases in civil and customary law consider women perpetual minors, under the control of males for most decision making. Since the major political changes

in Iraq, in 2003, new legislation has been issued in this respect, and legal reform has advanced to allow gender equality in all sectors across the country.

13. In the study area, ground water is essential for the areas of agriculture, the environment, health, domestic use and development, especially in rural areas. According to a new survey, approximately 60% of water demand is met by numerous deep wells dispersed throughout the urban and suburban areas, while approximately 40% is supplied from the Greater Zab river, pumped from the Ifraz station to the treatment plant near Erbil. According to the FAO (2004), well depths have only recently increased and most new wells have been drilled to depths exceeding 100 m. Currently, there may be no more than 1,000 operational deep wells in the entire district of Erbil. It can be concluded that the total amount of exploitable groundwater does not exceed 2.5 m3/s.

14. Groundwater quality is almost within the WHO acceptable limits as drinking water and conveniently good for livestock and most agricultural crops. The domestic effluents represent the main source of groundwater pollution.

15. Soils in most of the study area are relatively well drained and non-saline, very shallow to shallow silty clay overlying different types of limestone. Soils on the mountain slopes and hilly areas are subject to moderate to intensive erosion at 15 – 50 tons /ha/yr.

16. BDIP will serve about 640 individual schemes at an average of about 6 ha each. The choice of an on–farm irrigation system will be limited to either sprinkler or mainly surface furrow irrigation depending on the soils types and topography of the areas to be irrigated.

17. BDIP is expected to have major positive impact on the surrounding area and on the region as a whole. These positive impacts include minimization of random settlement, intensification of production, reduced soil erosion, creating recreation investment, supplementary input to livestock feed, improving health conditions of the local population, and rising fish catch.

18. BDIP primary negative impacts include possible unequal allocation of resources with unequal benefits between different ethnic groups or tribal belongings, required

resettlement communities, displacement of some riffraff (lower social classes), loss of natural vegetation within the reservoir area, increased threat to endangered species of flora and fauna, sediment transport, water quality problems and creating some endemic diseases.

19. The annual average flow rate of the project stream is estimated at 4 m^3/s which may be applied to a mini hydro electrical plant of two small turbines.

20. The reservoir area is essentially under rain fed agricultural lands. Hence the built infrastructure is very limited in both extent and importance. Upon the very little villages, no settlement of a higher rank and economic importance exists in the future impoundment area, the selected site for the dam can be considered advantageous in this respect.

21. Maps dated back to 1954 indicate that many villages were registered in the impoundment area; however, almost all the registered villages have been abandoned due to the dislodgment applied by the previous regime.

22. The two villages earmarked for impoundment and situated below the level 900 m.a.s.l and are known as Sartika, Haj-Ahmed.

23. The only new scheme founded on the impoundment area is a residential complex of 15 houses above the level 900 m.a.s.l to accommodating the staff (river basin board) that will operate the project in the future.

24. There is no mining exploitation activity within the watershed, but there are a few quarries producing basic construction materials gravel, sand, and rock and are exploited by using simple machinery.

25. Exploiting forest and productive trees in the uplands areas of the watershed is minimal. The valleys and the slopes of the valleys being moderately covered with relatively low vegetation amongst which wild shrubs are predominant. Most of the mountainous uplands area lies within the forest zone with various degrees of degradation ranging from completely treeless spots to dense forests.

26. The minor roads in the reservoir area consist predominantly of earth trails. Among these roads which will be flooded there are only two sections, 2 Km long, with a metal

surface. No railway line exists in the reservoir area and no fuel pipelines will be affected by the flooding.

27. The remote villages located in the upper lands of the watershed have not yet been linked to the national electric power network. There are no transmission lines, mast, or local power station that will be affected by flooding.

28. There are three types of water supply sources are utilized for domestic use as follows:

Direct intake of the available surface water from intermittent streams;

- Extraction of groundwater from water wells;
- Pumping from the greater Zab River to the treatment plant through Ifraz pumping station near Erbil.

This comprises 40% of the total water demand for domestic use. Villages near the city of Erbil are the only ones supplied from the water filtering station and few compacted units. No major water supply installations will be flooded except some very minor facilities within the irrigation scheme that may be affected.

29. There will be no sanitary facilities in the planned reservoir or the irrigation area except for some private sanitary services and latrines which will be abandoned as a result of the resettlement in the area.

30. There is no significant noise impact in connection with the dam construction as the dam site and its surroundings are scarcely populated.

31. The vicinity of the planned reservoir includes fascinating sites suitable for recreation and could possibly create tourism business and promising investments. For the time being, there is difficulty in accessibility and there is lack of buildings and other essentials. Organized tourist activities will virtually exist after BDIP is completed.

32. The water impoundment will cause some climatic changes in the environments\ where evaporation will be a decisive factor. Meteorological data indicate that evaporation could reach 2.0 m/year. Consequently, significant relative humidity

increase will take place; however, it is expected to balance out over the year since most of the evaporation will occur in the summer months.

33. In semi-arid regions such as the study area, terrestrial fauna is not abundant in number and in the case of impoundment area; the species will be able to spontaneously find new habitats in the adjacent zones.

34. The local flora of the study area has already changed. Nearly most of the perennial species have disappeared and had been replaced by annual grasses. This sub-region had been rich in its number of floristic species, as well as being active in the formation of species. BDIP is expected to help save and transplant the unique biota if measures are taken before the reservoir zone is impounded.

35. The rural areas are suffering from lack of sanitary facilities. People have poor or no access to treated water and sanitation. BDIP is expected to positively impact this area of concern and resolve some of these issues as well.

36. Due to the lack of flowing or stagnant water, fisheries are not currently important activities in the study area. BDIP with the planned lake will create new fishing.

37. The area of the dam is considered a drought area due to the recent climate change conditions. This dam helps the area from being drought by creating a reservoir with 200 Million m3. This reservoir can cause temperature declining by about 5 C compared to surrounding areas.

The positive impacts are significantly higher than negative impacts and because this dam is considered a developing part of this area. Thus, restarting works on this dam is highly recommended according to bellow comparison (table 5.1).

Table 5.1: Illustrates comparison between negative and positive impact.

Negative impacts	Positive impacts
Losing of agricultural lands 600 ha due to submerging by reservoir	Creating tourism area by reservoir capacity 200M.$m^3$with surface area 132.5 km^2
Submerge 2 Km long main roads and 2 villages	Dry land becomes wet lands 4000 ha from 11000 ha, land cropping by different seasons due to water availability by the dam.
Right now the Bastora watershed facing shortage of water especially in agriculture sector due to dry area.	The weather in the Bastora watershed will be more humidity and low temperature forecasted by decreasing 5C therefore the basin will be more productive.
Erbil city facing big problems regarding to the water supply due to shortage in the water availability for domestic use.	Average water supply to Erbil city 5000m^3/day from reservoir , 10% of the reservoir capacity is for domestic use.
The ground water level decreased around 90m during 25 years past as well as the well product else going to the down.	Recharge ground water in the Bastora watershed due to creating big reservoir and the ground water level increase by 30m according to the study.
The villager worked only on the agriculture sector on the other hand they faced problems regarding to the (scarcity) water shortage.	Creating the new jobs for the villager by creating the reservoir . the new works for the villager will available in the Bastora watershed such as (tourism project, fishing, boating, construction juice fruit factories, ….etc).
Due to shortage in electricity supplied by the national network, the private sector started a new investment utilizing diesel generators to produce electricity for the public. In the study area currently, there are about 17 private generators 2400 kva,it is extra cost on the rural people and also cause production gases CO_2.	Producing electricity (2.8 Megawatt) for the study area.
The houses are too old and there are randomly created.	Minimization of random settlement due to preparing master plan for future and construction new building.

5.2 Recommendations

5.2.1 Dam management

- Government authority should support and encourage the utility of agro-forestry in the societies due to having a high amount of water resource. This is the practice of growing trees with livestock or crops on the same piece of land. In the meantime, natural forest in the catchment area should keep it or be diminishing the need to exploit it.

- In order to assist in combating the problems, government authority should put a computer-based technology system in place by providing up-to-date, reliable, and comprehensive data on environmental variables and land use change.
- A health awareness team should also be put in place by authority and introduce health education in the catchment areas which is a necessary measure to control prevalent diseases.
- Construct new villages in elevated areas (in areas which are not located within the study area) to accommodate people of the affected study area.
- Government authority should encourage people to open local factories in the area. This can depend on the local fruit products and would be a source of living for residents.
- Establishment of a River Basin Board which composed of 10 members for managing the reservoir as follows:

Head of salahaddin subdistrict	1 member
Representative of general directorate of aggreculture	1 member
Representative of general directorate dams	1 member
Representative of Erbil general directorate of municipality	1 member
University	2 member
Villages representative	2 member
Representative of Farmers Unions	1 member
Local authorities	1 member
Chamber of commercial and industry	1 member
Representative of directorate of investment to manage the reservoir	1 member

- Construction check dams, retaining walls for reducing sedimentation and controlling erosion at the upstream of the reservoir.
- Training residents in order to get familiar with changes after constructing the dam.
- Providing lands for investors in order to make the tourist project.
- Construction waste water treatment plant at downstream side of villages before inter the reservoir.

5.2.2 Policy makers

- The study advices the advanced protection and restoration of ecological frameworks and biodiversity in the catchment area.
- This study recommends that, guideline and policy should be put in place to organize the use of water for irrigation and supply effective plan and consistent manners of irrigation.
- It is recommended that a study dam project should be started to consider a priority to ensure that clean water is provided for use by the local community. To do that, treatment plant away from the dam shore can be established. Hence, residents can obtain potable water for domestic use.
- For sustainable management and development of water resources, there is a substantial need to enhance research funding. This helps to create useful information for design, planning, and decision making.
- Water governance should be improved in northern Iraq region. For example, the government should be present in meeting water demand.
- Training for the water technology should be one of the targets and need to be motivated by government intervention.

5.3 Future research

- Further research is necessary for the study sample comprising intensive statistical analysis for environmental and hydrological variables.
- There is a need to broad on the study site and perform a similar study in other locations.
- Establishment of continuous data collection, water quality monitoring and mapping at strategic areas along the reservoir to alert policy makers on possible reservoir contamination. This will be managed by river basin board.

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APPENDICES

Figure A.1: General view of the gorge of Bastora Dam View from Downstream

(a)

(b)

(c)

Figure A.2: The dominant plants in hilly areas are low spiny and dwarf shrubs

Figure A.3: Residential Units Under Construction

Figure A.4: Predominant Type of Materials at the Stream Bed

(a)

(b)

Figure A.5: Bastora Chai (Stream)