A2.3 Water Resources

The main water resources utilized by the irrigation of the agriculture sector, in the study area, can be divided in Groundwater and Surface Water.

The most stable source is the groundwater, which carried to it's over exploitation. The exploitation of the groundwater is concentrated in the south part of the study area, where the density of wells is very high. It is exploited in the form of spring, qanat and wells.

The surface water has two main sources: Gorgan and Gharasu rivers. The most important one is the Gorgan River. The Gharasu River has serious problem of sedimentation and has a very irregular water flow during the year making its use very difficult.

The Gorgan River is exploited by many farmers and irrigation schemes utilizing pumps due to its deep river bed. The Gharasu River, situated near the mountaineous region, has mainly it's tributaries exploited utilizing pumps and diversion structures.

The responsible organization for the water resources management is the Ministry of Energy. This ministry plans the distribution of the water and authorizes it's exploitation.

A2.3.1 Groundwater

(1) General

The groundwater exploitation in the Gorgan Plain is done in the form of spring, qanat and well. The wells are divided in shallow, deep and artesian. The following table shows the estimation of the groundwater exploitation in the Gorgan Plain.

Groundwater Exploitation in the Gorgan Plain

Item	Well				Spring	Qanat
	Shallow	Deep	Artesian			
			Without Pump	With Pump		
Quantity	9,299	3,516	280	331	65	282
Q (MCM/year)	250	383	13	54	24	69
Average Working Days per Year	92	126	228	260	365	365
Average Q (l/s)	7	19	2	18	12	8

Source: Ministry of Energy (Golestan)

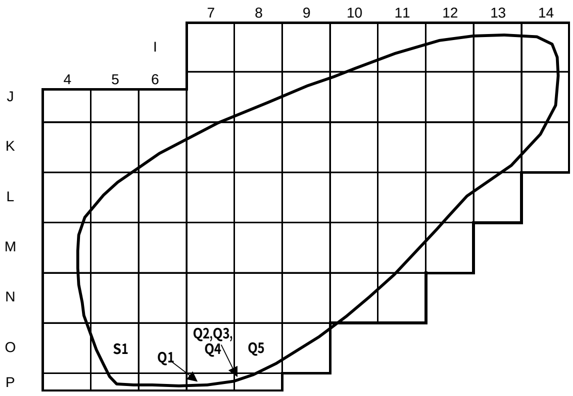
There are 13,426 wells registered in the Gorgan Plain utilizing about 700 MCM/year. The number of springs and qanats are respectively 65 and 282, with a total exploitation of 93 MCM/year. So, the total annual water volume exploited form the groundwater in the Gorgan Plain is 793 MCM/year. The agricultural sector consumes about 690 MCM/year according to the Ministry of Energy estimation.

(2) Groundwater in the Study Area

a) Spring and Qanat

The study area had only one spring in the west part as shown in the right figure (S1). According to the inhabitants, it became out of function 14 years ago.

The number of Qanats (Q in the right figure) in the study area was 5, which one (Q1) became out of function 5 years ago. The size of these qanats are relatively small. The characteristics of the Qanats in the study area are as follows:



Spring and Qanat in the Study Area

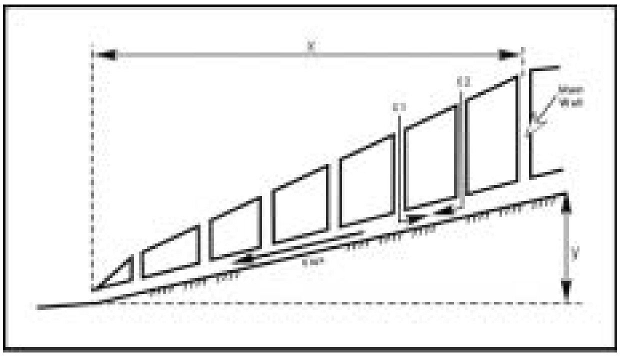
Qanat in the Study Area

Qanat	Age	Main Well Depth (m)	Well Number	Qmean (l/s)	Utilization	Irrigated Area (ha)	Irrigation Period	Maintenance Frequency	Condition
Q1	Out of Function								
Q2	57	18	40	3	Agriculture	0.5	May-Jul	Once/Year	Not Good
Q3	100	12	28	4	Agriculture	2	May-Jul	Once/Year	Not Good
Q4	102	12	40	4.8	Agriculture	2	May-Jul	Once/Year	Not Good
Q5	101	14		3.5	Agriculture	1	May-Jul	Once/Year	Not Good

It is reported that the qanat Q2 used to irrigate 30 ha of cotton 46 years ago, but the irrigation area decreased to only 0.5 ha actually. The Q4's discharge decreased to 1/4 in comparison with 20 years ago, according to the owner. All owners said that the present condition of their qanats is not satisfactory.

So in general the qanats in the study area can not support large agricultural production, being only utilized to supply drinking water or irrigate a very small area.

The maintenance of the qanat usually needs 45 to 60 days, with 3 men working. Those men are specialists in qanat maintenance that are contracted for these services. The maintenance is done by two men entering in the qanat as shown by C1 and C2 directions in the next figure. The maintenance cost seems to be around Rial 1,000,000 for the qanats in the study area. So, according to the qanat owners, it is not economically feasible to maintain a qanat in the in the Study Area. A tipical qanat profile is shown in the right figure.

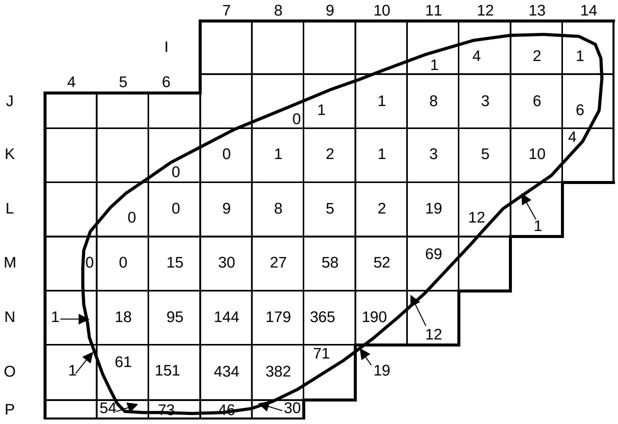


Schematic View of a Qanat

b) Well

There are 2,691 wells registered in the study area. Those wells are divided in the following 5 types:

- Shallow (1,584)
- Deep (950)
- Observation (69)
- Artesian (85)
- Piezometric (3)



Wells in the Study

The observation, and piezometric wells are special wells to collect the groundwater data. The first is constructed to observe the entire groundwater system and the second to check individual wells. The exploitation is done from shallow, deep and artesian wells.

Piezometric Well

It is common in the study area to see the inhabitants utilizing the water flowing from the artesian and piezometric wells for drinking and domestic use. The water flows constantly in this type of wells when the groundwater has enough level and pressure, so the inhabintants are able to use it. It is estimated that the water flows during 3 months in an year.

The shallow well predominates over the deep one. Both are concentrated in the south part of the study area, mainly in the Gharasu River basin, showing that it is the most important water source in Gharasu basin.

The low density of wells in the north and central part of the study area makes necessary the utilization of the surface water for the irrigation of these areas.

63 wells were surveyed in the study area, being 27 shallow wells and 36 deep wells.

Many wells have being closed. It is common to see shallow wells being closed and deep wells being drilled to substitute the closed one. The population said that it is due to the drought.

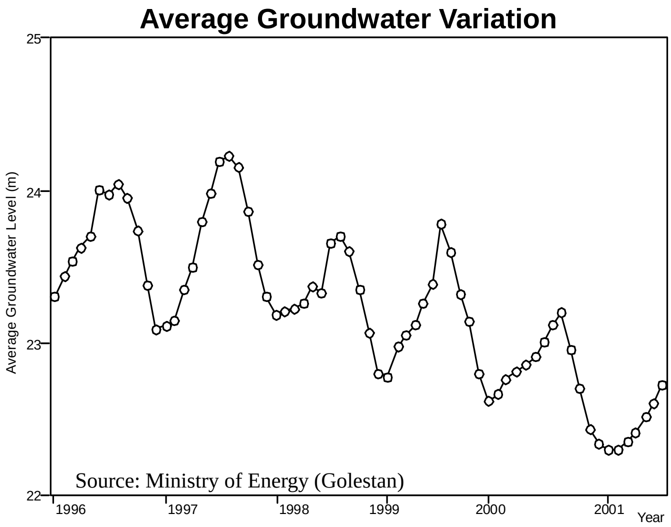
According to the survey, more than 22% of the shallow wells were out of function, while the deep wells had 19% not working. The shallow wells are generally older than the deep one, and the oldest one that was surveyed was located in Kordkuy (construction year of 1950). The average depth of shallow wells is 11 m and the deep one is 134 m.

The following fact was found when the well owners were asked about the condition of their wells.

Well Condition According to the Owners

Well Type	Condition		
	Satisfactory	Not Satisfactory	No Answer
Deep	61.1%	8.3%	30.6%
Shallow	25.9%	44.4%	29.6%

So, the condition of more than 40% of the shallow wells is not satisfactory, while only 8% of the deep wells were not satisfactory.



The right graphic shows that the groundwater level has decreased in average during the last 5 years. It shows the observation result of about 300 observation wells.

According to the Ministry of Energy, the groundwater development shall be avoided.

The high density of the present existing wells in the province made the Ministry of Energy determine that is not permitted, in some areas, to drill new wells in an radius of 500 m around an existing well.

b1. Well Utilization by Agriculture

The survey showed that, generally deep wells are utilized to irrigate large farms (average of 12 ha), while the shallow wells are for smaller farms (average of 3 ha). The average pump capacity for shallow well was 4.5 l/s and for the deep well was 10.0 l/s according to the survey.

The irrigation period is from April to September, but most part concentrates between June to September. The well utilization to irrigate rice is not permitted in some parts of the Study Area, because the crop has a high water demand.

b2. Well Utilization by Industry

There are not many industries in the study area. Most part is situated near Gorgan city, out of the study area.

The following three types of industry were interviewed:

- Soft Drink Industry (Fig. A2.3.1)
  Situated near the Gorgan City (Esfahankalate village), it has an annual production of 100

million bottles. The factory works in two shifts during May to October with a water consumption of 11.1 l/s. During November to April the water consumption decreases to 5 l/s. The water is taken from one deep well.

- Poultry Farm (Fig. A2.3.1)
  The daily production of this farm, in Kordkuy (Yasaghi village), is 5 tons of egg and 1 ton of hen. The peack water consumption is between June to August, with a water demand of 100 m^3 per day. The demand of the other months is 75 m^3 per day.

- Seed Oil Industry (Fig. A2.3.1)
  Situated in Bandar-e-Torkman (Gharanjike village), it produces oil from soybean, colza, cotton and sunflower. The monthly production is 2,700 tons. The water consumption is not high because the utilization is for drinking, machinery cleaning and cooling. The utilized volume is only 20 m^3 per day.

b3. Well for Domestic Utilization

Eight cities (fig. A3.2.1) were surveyed in the Study Area. The main 4 cities and 4 other small villages. The water consumption was as the following:

City	Sherestan	Population	Consumption (m^3/day)	Consump. (MCM/year)	Consumpt. per Capita (m^3/day)	Quantity of Wells
Hashen Abad	Gorgan	2,300	605	0.2	263	1
Sahne Sofla	Aq Qala	3,000	300	0.1	100	1
Arakh Kuchak	Bandar-e-Torkman	700	86	0.03	123	1
Yasaghi	Kordkuy	7,000	497	0.2	71	1
Aq Qala	**Aq Qala**	**27,000**	**545**	**0.2**	**20**	**4**
Gorgan	**Gorgan**	**245,000**	**58,579**	**21.4**	**239**	**29**
Bandar-e-Torkman	**Bandar-e-Torkman**	**49,400**	**10,368**	**3.8**	**210**	**4**
Kordkuy	**Kordkuy**	**2,974**	**315**	**0.1**	**106**	**6**

As the table shows, Aq Qala and Kordkuy have the smaller consumption, while Gorgan has the highest. It can be said that it is very adapted to the region, because Aq Qala is the most dry region in the Study Area.

Aq Qala and Banda-e-Torkmand, that situate in the plain area, receives part of the water demand from Gorgan and Kordkuy respectivelly, that locates in the mountainous region.

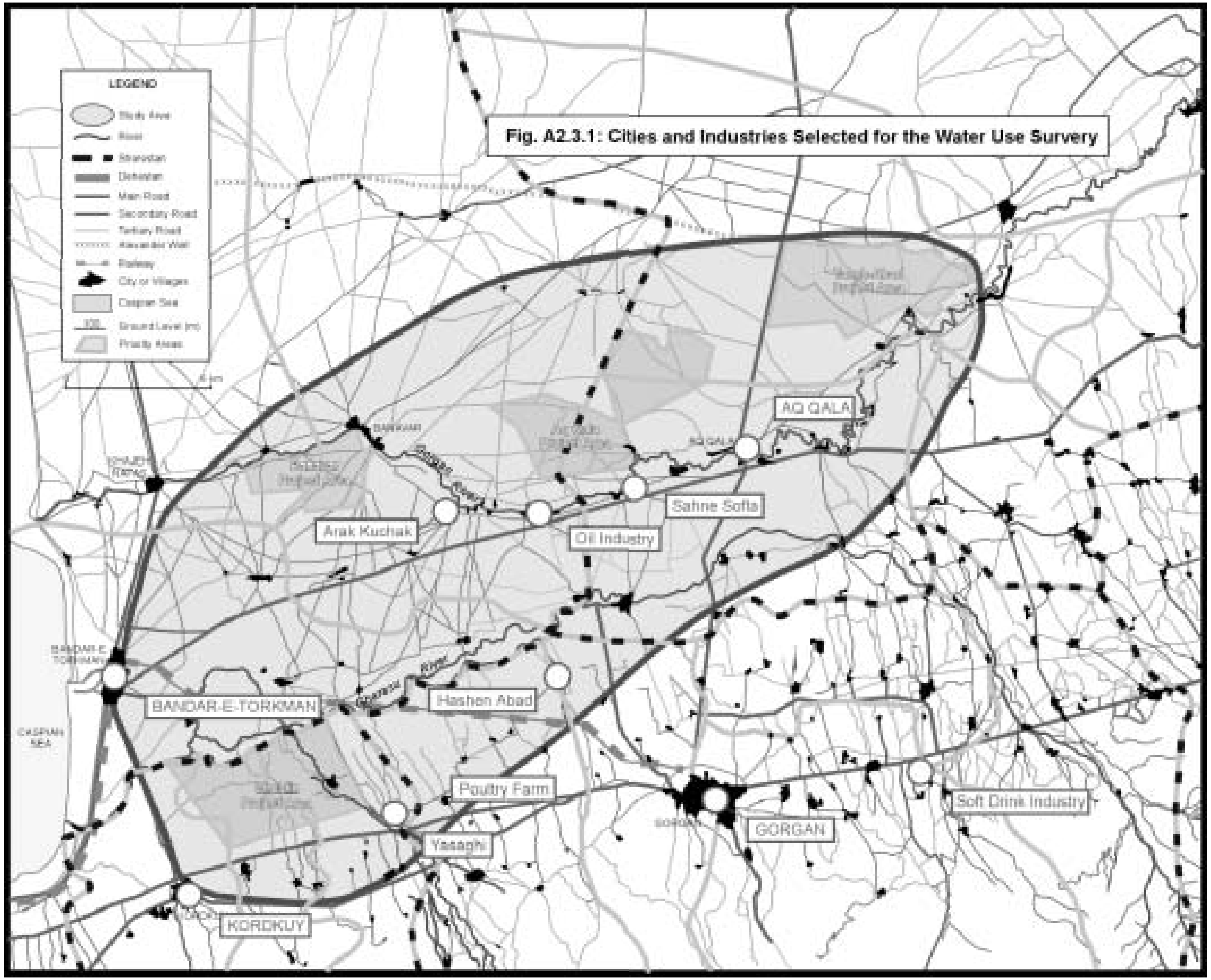
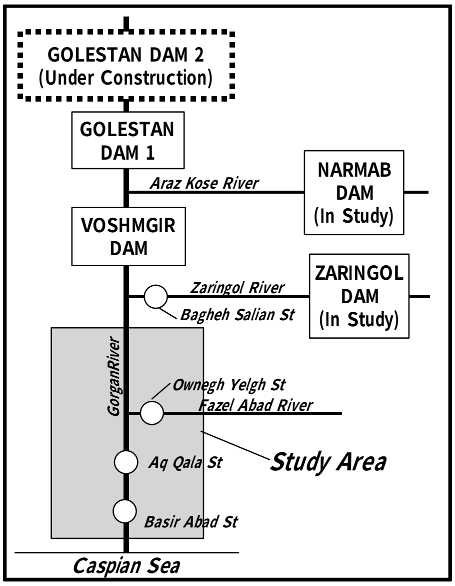


Fig. A2.3.1: Cities and Industries Selected for the Water Use Survery

A2.3.2 Surface Water

The main source of surface water in the study area is, without any doubt, the Gorgan River. It has two important dams, the Voshmgir and Golestan 1 dams, which provides water during the dry season. There is one dam in construction, the Golestan dam 2, situated 30 km upstream of the Golestan 1 dam at the Gorgan River. Another 2 dams are in phase of study: the Narmab and Zaringol dams.



Gorgan River System

The Voshmgir Dam, constructed 32 years ago, has a serious problem of sediment accumulation. The initial storage capacity was 95 MCM, but actually this volume has decreased to about 50 MCM. The high quantity of sediments carried by the Gorgan River is one of the problems for the dam and also for the utilization of its water. A 15,000 ha irrigation scheme is linked to the Voshmgir dam utilizing a water volume of 51 MCM annually.

The Golestan Dam 1, constructed 2 years ago, was projected to cover the problems of the Voshmgir dam and to provide water for the irrigation scheme (10,000 ha) linked to it. The irrigation scheme utilizes 96 MCM of water annually. The Golestan Dam 1 has a great importance also in controling floods. As showed in the last report, it mitigated the damages, at the downstream region, of the last big flood.

Another dam, the Golestan 2, is under construction, with almost 18% concluded, being projected to assist all this system and provide water for an irrigation scheme of 4,600 ha with an estimated annual water consumption of 40 MCM. The conclusion of this dam is estimated to be after 3 years (2005).

The following table shows the characteristics of the existing dams.

Characteristics of the Existing Dams

Dam	River	Storage Volume (MCM)	Catchment Area (km^2)	Situation
Voshmgir	Gorgan	95 (initially)	7,157	Concluded
Golestan 1, 2	Gorgan	116	4,925	Golestan 1: concluded Golestan 2: under construction

Source: Ministry of Energy (Golestan Province)

This system of dams is responsible for major part of the water to be utilized by the irrigation in the agriculture sector of the Study Area.

According to the Ministry of Energy, the following number of pumps are registered in the

Gorgan and Gharasu Basins:

Registered Pump Quantity

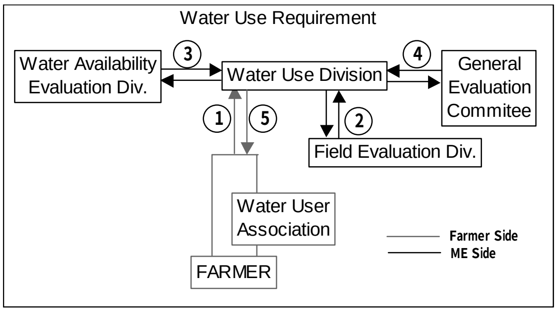
Basin	Pump Quantity	Q (MCM/year)
Gorgan	984	43.6
Gharasu	58	0.5

Source: Ministry of Energy (Golestan)

So, there are almost 1,000 pumps (11.7 km^2/pump) in the Gorgan Basin (11,480 km^2), while Gharasu Basin (1,720 km^2) has less than 60 pumps (29.7 km^2/pump). It shows the high dependency of the Gorgan Basin on the surface water, while the Gharasu Basin is highly dependent on the groundwater.

A2.3.2.1 Water Use Requirement Process

The farmers must realize a requirement to be approved by the Ministry of Energy to use the surface water. The figure shows this process.



The farmer has two ways to realize the requirement:

- Direct to the Ministry of Energy
- Through a water use association

The process is as follows:

1. The requirement shall be sent to the Water Use Division in the Ministry of Energy of Golestan province;
2. The Water Use Division sends the requirement data to the Field Evaluation Division to evaluate the conditions of the farm;
3. After the field check, the Water Availability Evaluation Division evaluates the possibility of water use in the total basin:
4. The General Evaluation Committee will realize the final evaluation before the contract;
5. If all conditions are cleared, the contract is made between the Ministry of Energy and the farmer or association.

This process needs about 2 months to be finished and has a fee of Rial 100,000 per requirement. The water use tax paid by the farmer is about 3% of his gross income.

Three members compose the General Evaluation Committee:

1. Water Use Expert (Ministry of Energy);
2. Agriculture Expert (Ministry of Agriculture);
3. Lawyer.

The river water use without permission results in the confiscation of the pump.

A2.3.2.2 River Discharge

The whole basin of the Gorgan River can be divided in two by the study point of view: Upstream and Downstream of the Voshmgir Dam. The Ministry of Energy has being studied the main Gorgan River water availability utilizing 30 years of measurement data.

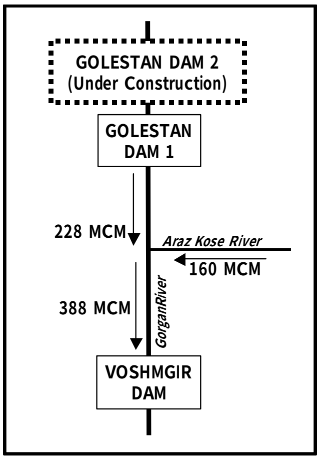
The next table shows the seasonal variation of the water volume at the Voshmgir Dam.

Seasonal Discharge Variation at the Voshmgir Dam

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Qmean (m3/s)	5.8	8.2	10.8	12.3	14.7	19.8	34.3	22.4	10.9	3.8	2.3	2.6	12.3
Qmax (m3/s)	24.3	26.1	22.9	31.2	35.4	46.2	85.9	95.9	39.1	33.0	9.0	10.7	23.5
Qmin (m3/s)	0.6	1.9	2.3	1.2	2.0	1.1	0.3	0.5	0.2	0.4	0.1	0.0	3.8
Monthly Volume (MCM)	15.1	21.3	28.0	31.9	38.0	50.1	91.8	59.9	29.3	10.1	6.1	6.8	388.2
% (month)	3.88	5.47	7.22	8.21	9.78	12.9	23.6	15.4	7.54	2.6	1.56	1.76	100
Season	Autumn			Winter			Spring			Summer			-
Seasonal Volume	64.3			119.9			181.0			23.0			388.2
% (Seasonal)	16.6			30.9			46.6			5.9			100

Source: Ministry of Energy (Golestan Province)

So, in a rough way, the annual discharge around the Voshmgir dam can be as shown in the right figure. The Golestan Dam with the Araz Kose River provides a water volume of 388 MCM per year for the Voshmgir Dam.



Discharge Upstream of Voshmgir Dam

A2.3.2.3 Authorized Water Use

According to this 30 years data, the Ministry of Energy, responsible for the water resources management, estimated the annual available water volume for the agricultural sector. This water volume is utilized for the water distribution plan in the agriculture sector.

The water use from Gorgan River usually is done by pumps due to the deep river bed. The actual authorized water use is shown dividing the basin in the Voshmgir Dam upstream and downstream.

a) Voshmgir Dam Upstream

The following table shows the water volume authorized by the Ministry of Energy to be used for agriculture between Golestan Dam and Voshmgir Dam.

Authorized Water Volume for the Voshmgir – Golestan Dam System (MCM)

Item			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sub-total	Total
Between Voshmgir / Golestan Dam	Voshmgir Dam Irrigation System (15,000 ha)		2.8	0.2				0.5	5.9	11.3	15.8	22.1	21.5	15.9	96.0	96.0
	Associations								0.9	2.2	3.1	5.8	7.3	5.8	25.0	25.0
	Individual Farmers	Grain						3.7	7.4	11.1					22.2	34.6
		Cotton								0.5	1.2	1.7	1.6	1.4	6.4	
		Fishery			2.0	2.0	2.0								6.0	
Voshmgir Dam Downstream			0.8	0.6	0.4	0.4	0.7	2.2	6.0	5.8	3.6	6.4	5.1	2.0	34.0	34.0
TOTAL			3.7	0.8	2.4	2.4	2.7	6.4	20.2	30.8	23.7	36.0	35.6	25.1	189.6	189.6

Source: Ministry of Energy (Golestan Province)

As the table shows, more than 90% (171.3 MCM per year) of the water allowed for agriculture concentrates between April and September.

The irrigation scheme linked to the dam can utilize 96 MCM per year, while associations and individual farmers situated between the Golestan and Voshmgir dams are permitted to utilize respectively 25 and 34.6 MCM. A 34 MCM of water is reserved to the downstream part of Voshmgir dam. So, the total water volume designed to the agriculture is 189.6 MCM per year.

There are 101 pumps registered at this part of the Gorgan River utilizing the water of the river as shown in the next table:

Water Use Between Golestan and Voshimgir Dams

Location	Pump	Irrigation Area (ha)		
	Quant.	Cotton	Grain	Fishery
Gazzagly - Golestan Dam	66	597	6004	-
Gazzagly - Voshimgir Dam	28	277	1383	251
Confluence of Araz Kose river and Gorgan River	7	34	23	-
Total	101	908	7410	251

Source: Ministry of Energy (Golestan Province)

b) Voshmgir Dam Downstream

The actual authorized water volume use at Voshmgir Dam downstream by the Ministry of Energy, which is discharged from the Voshmgir Dam, is 34 MCM per year. There are 3 important irrigation schemes in this part of the Gorgan river: Tazel Abad, Aq Qala and Banaver. The registered irrigation area, including the 3 irrigation schemes, is 13,000 ha with 457 pumps taking water from the Gorgan River.

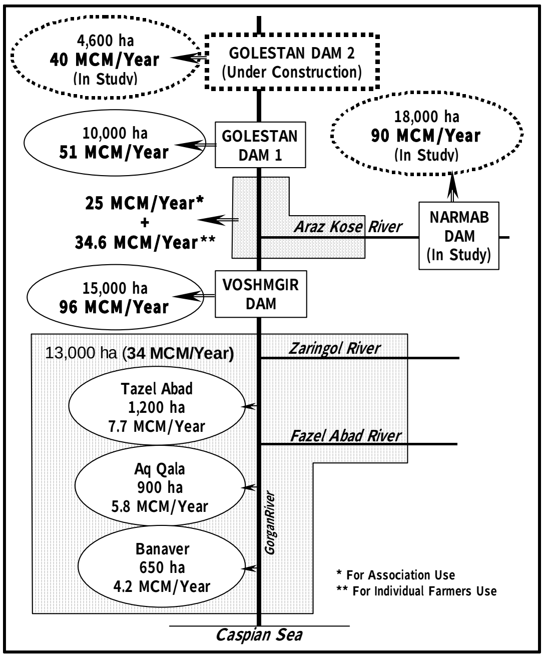
c) Resume of the Authorized Water Use

The allowed water volume for agriculture use, by the Ministry of Energy, in all Gorgan River can be summarized as follows:

Allowed Water Volume for Agriculture

Location	Demand (MCM)
Golestan Dam 1	51
Between Golestan 1 and Gorgan Dam	59.6
Voshmgir Dam	96
Voshimgir Dam Downstream	34
Sub-total	240.6
Golestan Dam 2 (in study)	40
Narmab Dam (in study)	90
TOTAL	370.6

So, the actual water demand for the agriculture sector is 240.6 MCM per year in the whole Gorgan River. This volume shall increase to 370.6 MCM after the conclusion of the Golestan dam 2 and if the Narmab dam will be constructed.



Allowed Water Use

A2.3.2.4 Actual Water Use

The water use per hectare can be calculated, in a rough way, using the main schemes demand as follows.

Actual Water Demand per Hectare (Estimated)

Scheme	ha	MCM/year	Average (m^3/ha/year)
Golestan 2	4,600	40	8,695.7
Golestan 1	10,000	51	5,100.0
Voshmgir	15,000	96	6,400.0
Narmab	18,000	90	5,000.0
Total			6,298.9

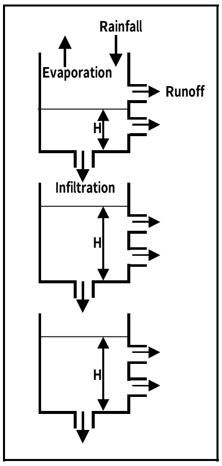
This necessary water is for irrigation with an estimated application efficiency of 50%. The average water use for those schemes is 6,300 MCM/ha per year. The values show that the Golestan 1 scheme has the most efficient water use utilizing 5,100 MCM/ha/year.

A2.3.2.5 Remaining Exploitable Water

As shown above, the Ministry of Energy has done studies on the water availability for the existing dams. According to those studies, the same ministry stipulates the maximum water available to be utilized for the agriculture sector. As the amount of water coming from the Voshmgir dam is already fixed for the agriculture sector, the only remaining sub-basins of the Gorgan River to be exploited, as a new source in the study area, are the Zaringol and Fazel Abad rivers basins.

A2.3.2.6 Water Volume Estimation of Zaringol and Fazel Abad Rivers

The Tank Model was utilized to estimate the runoff of the Zaringol and Fazel Abad Rivers. This model visualizes the basin as a system of reservoirs. This reservoir is a virtual tank with side and bottom outlets representing the runoff and infiltration respectively. The 'H' represents the storage. A system of several tanks can represent the base runoff, interflow and surface runoff. The right figure shows a typical scheme of a Tank Model.



Tank Model

a) Model Calibration

- **Rainfall**

The rainfall data of the Iranian Year of 1376 (1997) was utilized to calibrate the model. The following table shows the stations that were utilized for the estimation.

Measurement Stations Utilized in the Simulation

River	Hydrological St.	Area (ha)	River	Utilized Climatological St.
Zaringol	Bagheh Salian	1,720	Zaringol	Bahalkeh Dashly Laleh Bagh Ramian
Fazel Abad	Ownegh Yelgh	810	Fazel Abad	Fazel Abad

The Ownegh Yelgh station's basin only has one climatological station (Fazel Abad). But the Baghe Salian station basin has four climatological stations that are: Bahalkeh Dashly, Laleh Bagh, Ramian and Shirin Abad. The Shirin Abad climatological station's rainfall, in Bagheh Salian station basin, was discarded due to their short time of measurement.

A weighted rainfall was generated to each basin by the Thiessen Method for the Bagheh Salian station. The coefficients utilized to generate the rainfall are as follow:

Thiessen Weight Coefficient

Station	Catchment Area (km^2)	Weight Coef.
Bahalkeh Dashly	384.3	0.22
Laleh Bagh	649.2	0.38
Ramian	686.5	0.40
BAGHEH SALIAN	1,720.0	-

The figure A2.3.2 shows each basin of the Bagheh Salian and Ownegh Yelgh stations.

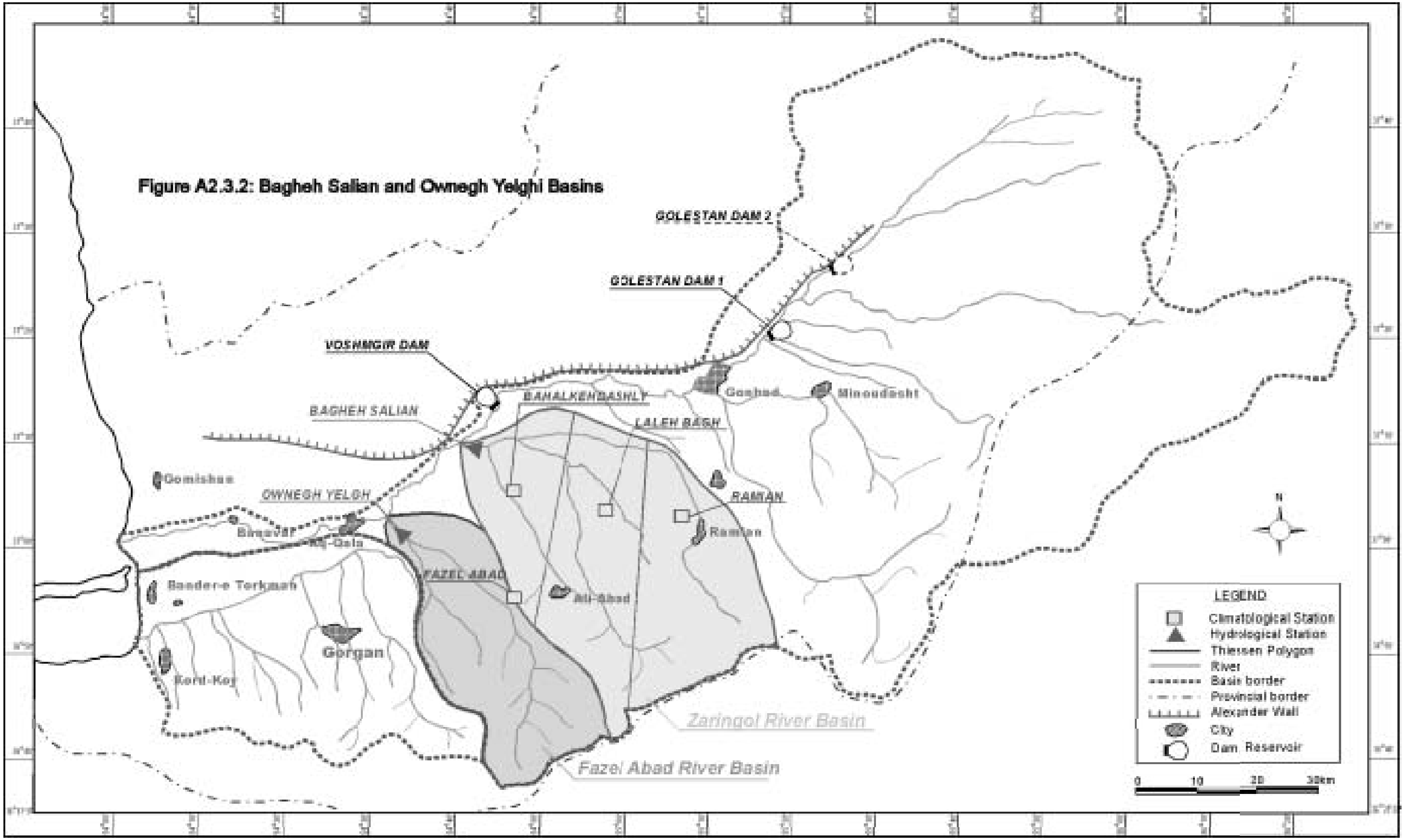


Figure A2.3.2: Bagheh Salian and Ownegh Yelghi Basins

- **Discharge**

The daily average discharge of 1376 (1997) at Bagheh Salian and Ownegh Yelgh hydrological stations was utilized to calibrate the model.

- **Evaporation**

The following average evaporation was utilized for the estimation.

Evaporation Data

Evaporation (mm) - Ownegh Yelghi

Station	Jan Bah	Feb Esf	Mar Far	Apr Ord	May Kor	Jun Tir	Jul Mor	Aug Sha	Sep Meh	Oct Aba	Nov Aza	Dec Dey	Annual
Fazel Abad	52.0	65.6	98.3	147.0	205.7	245.0	242.1	217.5	151.5	118.0	65.0	54.0	1,536.0

Evaporation (mm) - Bagheh Salian

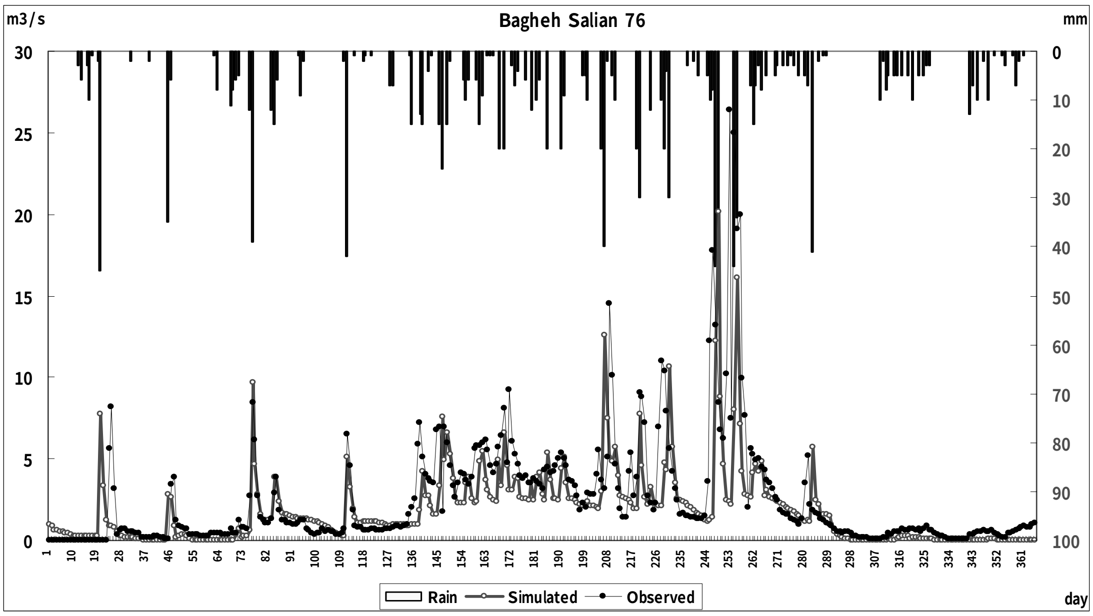
Station	Jan Bah	Feb Esf	Mar Far	Apr Ord	May Kor	Jun Tir	Jul Mor	Aug Sha	Sep Meh	Oct Aba	Nov Aza	Dec Dey	Annual
Bahlakehdashly	27.6	37.4	61.6	116.3	201.1	268.8	270.3	232.3	138.7	88.8	45.4	34.3	1,562.9
Ramian	44.9	53.0	73.6	115.0	165.7	195.4	204.8	190.5	135.1	101.5	59.4	48.6	1,387.7
Laleh Bagh	32.2	36.1	66.5	121.5	186.4	236.2	254.0	232.9	136.0	92.0	50.5	32.7	1,347.0
Average	34.9	42.1	67.3	117.6	184.4	233.5	243.0	218.6	136.6	94.1	51.8	38.5	1,432.5

Source: Ministry of Energy (Golestan Province)

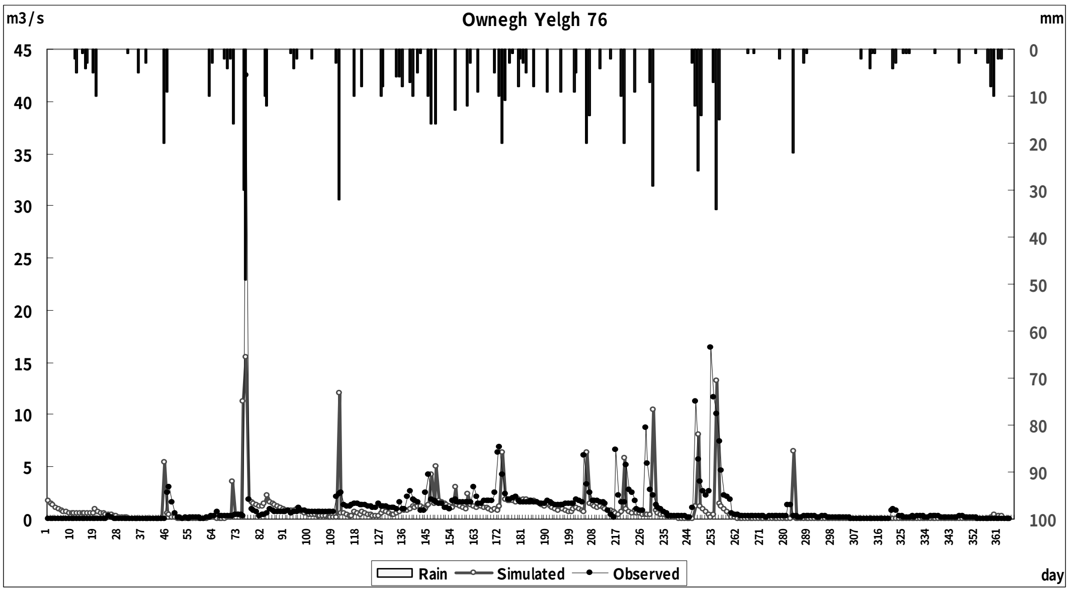
- **Calibration Results**

As shown in the next graphics, the model could realize a satisfactory simulation and is able to realize the runoff estimation for the two target basins: Zaringol and Fazel Abad rivers basins. The graphic shows the rainfall (mm), observed discharge (m^3/s) and simulated discharge (m^3/s).

Model Calibration Output (Bagheh Salian)



Model Calibration Output (Ownegh Yelgh)



A2.3.2.7 Water Volume Estimation

The project rainfall, to calculate the available water volume for both basins (Bagheh Salian and Ownegh Yelgh stations), was set for a minimum rainfall of 10 years probability. It is the same probability utilized by the Ministry of Energy for this type of calculation.

The rainfall period was divided in two periods: wet and dry periods. The wet period was set between October to May and the probability analisys was carried for each rainfall as follows:

Minimum Rainfall with 10 Year Probability

BAHALKEH DASHLY

Return Period (T)	Wet Period (mm)	%	Dry Period (mm)	%
200	189.9	100.0	0.0	0.0
100	195.8	99.7	0.6	0.3
50	204.3	98.1	3.9	1.9
40	207.9	97.5	5.3	2.5
30	213.0	96.7	7.3	3.3
20	221.9	95.4	10.8	4.6
10	***242.9***	***92.7***	***19.0***	***7.3***
5	275.2	89.7	31.7	10.3
2	356.2	84.9	63.5	15.1

Obs: Wet Period (Oct-May)
Dry Period (Jun-Sep)

LALEH BAGH

Return Period (T)	Wet Period	%	Dry Period (mm)	%
200	308.1	92.5	25.0	7.5
100	311.8	92.0	27.0	8.0
50	317.2	91.4	30.0	8.6
40	319.4	91.1	31.2	8.9
30	322.7	90.7	33.0	9.3
20	328.3	90.1	36.0	9.9
10	***341.4***	***88.8***	***43.3***	***11.2***
5	361.7	86.9	54.4	13.1
2	412.7	83.4	82.3	16.6

Obs: Wet Period (Oct-May)
Dry Period (Jun-Sep)

RAMIAN

Return Period (T)	Wet Period (mm)	%	Dry Period	%
200	503.9	91.2	48.4	8.8
100	511.0	90.9	51.2	9.1
50	521.3	90.4	55.4	9.6
40	525.5	90.2	57.1	9.8
30	531.8	89.9	59.6	10.1
20	542.5	89.5	63.9	10.5
10	***567.8***	***88.5***	***74.0***	***11.5***
5	606.8	87.1	89.7	12.9
2	704.5	84.5	128.9	15.5

Obs: Wet Period (Oct-May)
Dry Period (Jun-Sep)

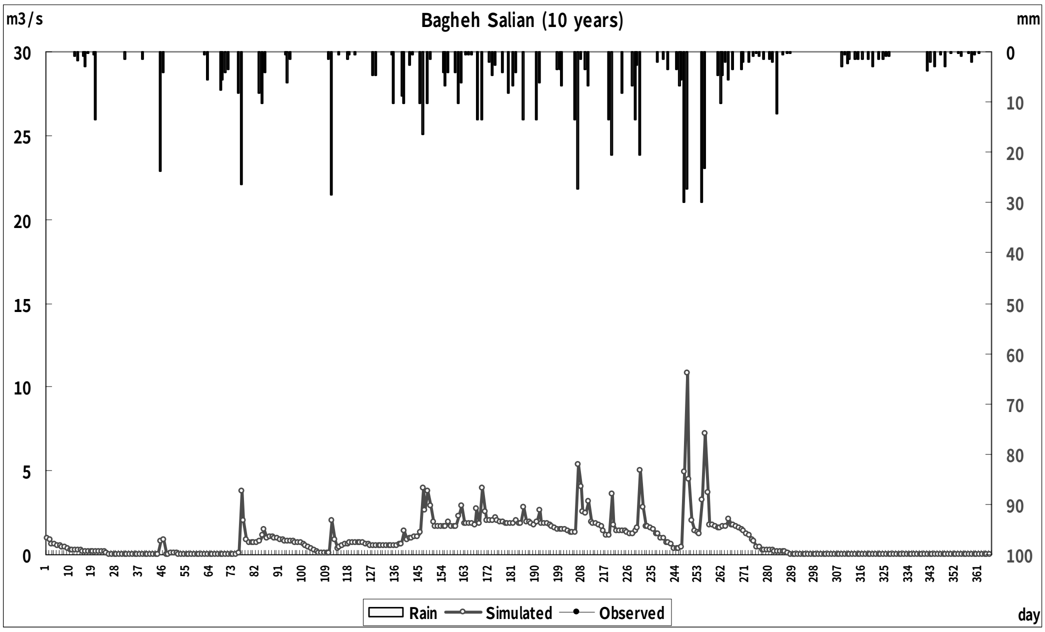
FAZEL ABAD

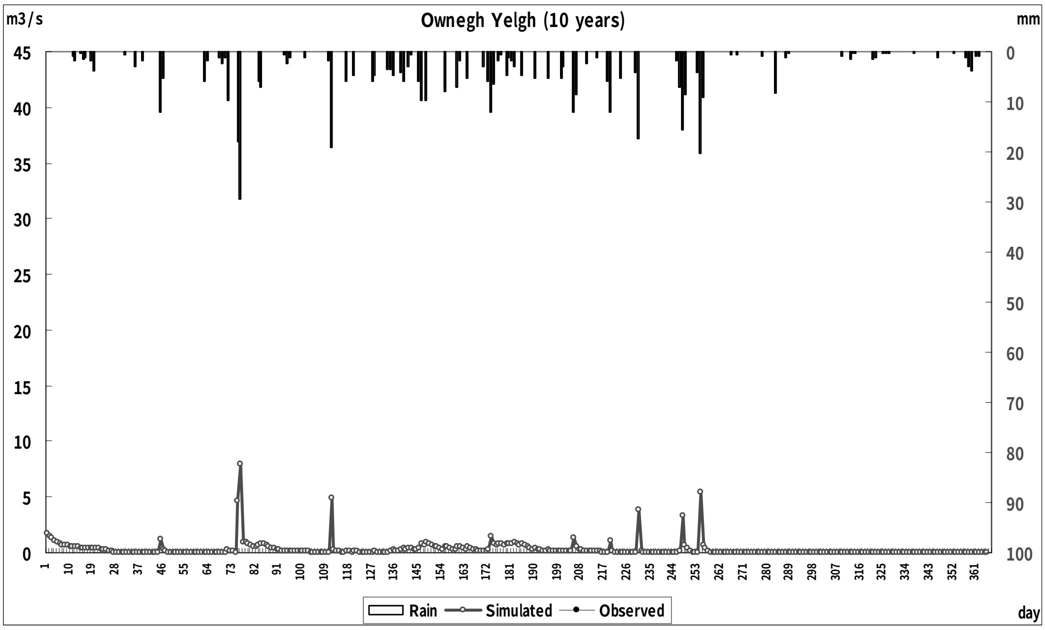
Return Period (T)	Wet Period (mm)	%	Dry Period (mm)	%
200	329.2	87.0	49.3	13.0
100	335.6	86.5	52.2	13.5
50	344.9	85.9	56.4	14.1
40	348.8	85.7	58.2	14.3
30	354.5	85.4	60.7	14.6
20	364.2	84.8	65.1	15.2
10	***387.2***	***83.7***	***75.5***	***16.3***
5	422.6	82.2	91.5	17.8
2	511.3	79.5	131.6	20.5

Obs: Wet Period (Oct-May)
Dry Period (Jun-Sep)

According to this result, the original rainfall of 1376 (1997) utilized for the model calibration was proportionally modified to generate a minimum rainfall with 10 years probability, in the same way the calibration rainfall was generated. The runoff resulted from this rainfall are as follows:

Discharge for Rain of 10 Years Return Period





The resulted values are shown in the next tables.

Seasonal Discharge Variation at Bagheh Salian (10 Years Probability Rain)

(MCM)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Monthly Volume (MCM)	0.2	2.3	2.1	4.4	6.8	7.6	5.7	8.2	0.4	0.0	0.0	1.0	38.8
% (month)	1	6	5	11	18	20	15	21	1	0	0	3	100
Season	Autumn			Winter			Spring			Summer			-
Seasonal Volume	4.6			18.9			14.3			1.0			38.8
% (Seasonal)	11.9			48.7			36.9			2.5			100

Seasonal Discharge Variation at Ownegh Yelgh (10 Years Probability Rain)

(MCM)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Monthly Volume (MCM)	0.2	2.9	0.9	1.2	1.8	1.4	0.7	1.5	0.0	0.0	0.0	0.9	11.6
% (month)	1	8	2	3	5	4	2	4	0	0	0	2	30
Season	Autumn			Winter			Spring			Summer			-
Seasonal Volume	4.1			4.4			2.2			0.9			11.6
% (Seasonal)	35.3			37.8			19.2			7.7			100

The resulted water volume was small if compared with the ordinary volume that summed about 100 MCM for both basins in 1997. But, it is necessary to restrict the project water volume to be able to guarantee enough water to the use.

So, the available water at the downstream region of Voshmgir Dam can be calculated summing the water from the Voshmgir Dam (34 MCM) and the available water form the Zaringol and Fazel Abad rivers.

A2.3.2.8 Available Water Volume

a) Actual Condition

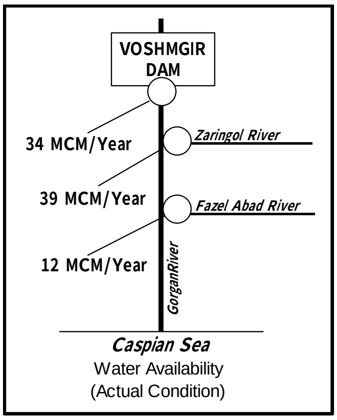
The available water volume for the study area can be resumed as follows:

Preliminar Total Available Water Volume (Voshmgir Dam Downstream)

Local	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL
Voshmgir Dam	0.8	0.6	0.4	0.4	0.7	2.2	6.0	5.8	3.6	6.4	5.1	2.0	34.0
Bagheh Salian	0.2	2.3	2.1	4.4	6.8	7.6	5.7	8.2	0.4	0.0	0.0	1.0	38.8
Ownegh Yelgh	0.2	2.9	0.9	1.2	1.8	1.4	0.7	1.5	0.0	0.0	0.0	0.9	11.6
Total	1.3	5.8	3.4	6.0	9.3	11.2	12.5	15.5	4.1	6.4	5.1	3.9	84.4

Calculating the total area that can be irrigated by this water volume, if the present average water use rate (6,300 m^3/ha) is used, we reach to an area of 13,397 ha.

The following figure shows these values in each point.



Estimated Total Available Water Volume
(Voshmgir Dam Downstream)

A2.3.2.9 Water Availability Increasing the Irrigation Efficiency

One way to increase the water availability at the Voshmgir Dam downstream is to increase the present irrigation efficiency. It is estimated that the actual irrigation efficiency in the Golestan province is about 50% with an average water necessity of 6,300 m^3/ha/year. The increase of this irrigation efficiency to 60% can decrease the average necessary water to 5,250 m^3/ha/year.

The recalculation of the water demand for the existing irrigation areas upstream of Voshmgir dam utilizing this necessary water (5,250 m^3/ha) shows the following results.

a) Irrigation Efficiency Increase by All Farmers

If all registered farmer's irrigation efficiency increases to 60%, the following water volume can be saved at the upstream area of Voshmgir Dam.

Water Save by Irrigation Efficiency Increase

Location	Area (ha)	Actual Demand (MCM)	60% IrrigationEfficiency Demand (MCM)	Saved Water (MCM)
Golestan Dam 1	10,000	51	51	0
Between Golestan 1 and Gorgan Dam	8,569	59.6	45	14.6
Voshmgir Dam	15,000	96	79	17
TOTAL	33,569	206.6	175	31.6

In this case, 31.6 MCM per year can be saved to be repassed to the Voshmgir Dam downstream. This volume can irrigate more 6,020 ha with an irrigation efficiency of 5,250 m^3/ha/year, or more 5,016 ha with an demand of 6,300 m^3/ha/year. The demand of the Golestan Dam 1 irrigation scheme remains the same because it has an demand lower than the utilized one (5,250 m^3/ha/year) that is 5,100 m^3/ha/year.

On the other hand, it can be very difficult to change the irrigation efficiency of all the farmers.

It can be said mainly for the farmers out of the irrigation schemes, that takes water direct from the river. So, the case of only the main irrigation system increasing the efficiency is shown in the next section.

b) Irrigation Efficiency Increase by the Large Irrigation Schemes

If only the main irrigation schemes situated upstream of the Voshmgir Dam increases it's irrigation efficiency to 60%, the water saved will be the 17 MCM of the Voshmgir dam irrigation scheme. This volume will allow irrigating more 3,239 ha with a demand of 5,250 m^3/ha/year or 2,698 ha with a demand of 6,300 m^3/ha/year.

A2.4 The Tazeh Abad Irrigation and Drainage Project

A2.4.1 Meteorology

(1) Climate

The Tazeh Abad Scheme is situated at the north-east part of the study area, in the area covered by the Aq Qala meteorological station, according to the division utilized in this study by the Thiessen method. The study area has the following meteorological characteristics.

Meteorological Characteristics of the Aq Qala St. (Average)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rain (mm)	41.2	44.4	46.0	34.2	40.2	12.7	9.4	12.6	22.6	38.0	47.3	52.7	401.3
Temperature (^oC)	9.9	15.7	18.3	22.3	27.3	32.0	31.2	27.5	22.4	17.1	12.5	9.2	20.5
Evaporation (mm)	58.7	72.4	97.6	137.9	196.7	227.3	213.6	179.5	114.4	87.6	60.2	53.4	1452.3
Humidity (%)	73.0	76.3	78.7	84.5	84.7	84.5	83.1	79.3	72.9	75.0	73.3	75.0	78.4

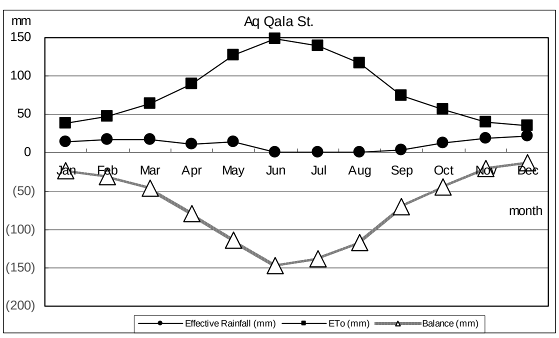
(2) ETo and Effective Rainfall

The referential evapotranspiration (ETo) and effective rainfall are shouwn in the next table.

ETo and Effective Rainfall (mm)

Station	Jan Bah	Feb Esf	Mar Far	Apr Ord	May Kor	Jun Tir	Jul Mor	Aug Sha	Sep Meh	Oct Aba	Nov Aza	Dec Dey	Annual Sum
ETo (mm)	38.1	47.0	63.5	89.6	127.9	147.8	138.9	116.7	74.4	56.9	39.1	34.7	974.6
Effective Rain (mm)	14.7	16.6	17.6	10.5	14.1	0.0	0.0	0.0	3.6	12.8	18.4	21.6	129.9

The comparison of the effective rainfall and evapotranspiration data registered at the Aq Qala St. is that the evapotranspiration exceeds the rainfall showing a negative balance during all the year. This region is the most dry area in the Study Area.



ETo X Effective Rain

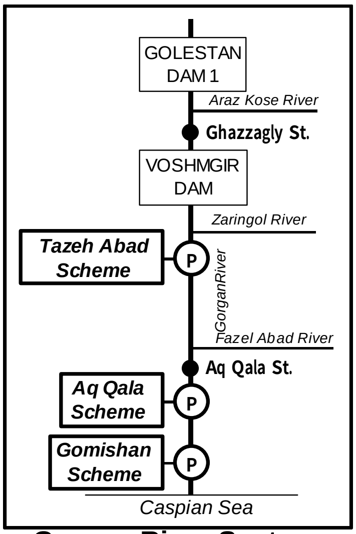
The positive and negative balance for the Study, according to the effective rainfall and evapotranspiration,can be set as follows:

Balance between ETo and Effective Rainfall

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bahm	Esfa	Farv	Ordi	Kord	Tir	Mord	Shah	Mehr	Aban	Azar	Dey
Negative											

A2.4.2 Contribution of the Existing Dams to the Water Availability

The tank model simulation was also utilized to evaluate the relation between the Golestan dam, Voshmgir dam, the tributaries of the Gorgan river with the water availability at the Tazel Abad pump station. The main purpose was to estimate the water discharged by the dams in the form of excess water (the water volume discharged over the dam storage capacity).



Gorgan River System

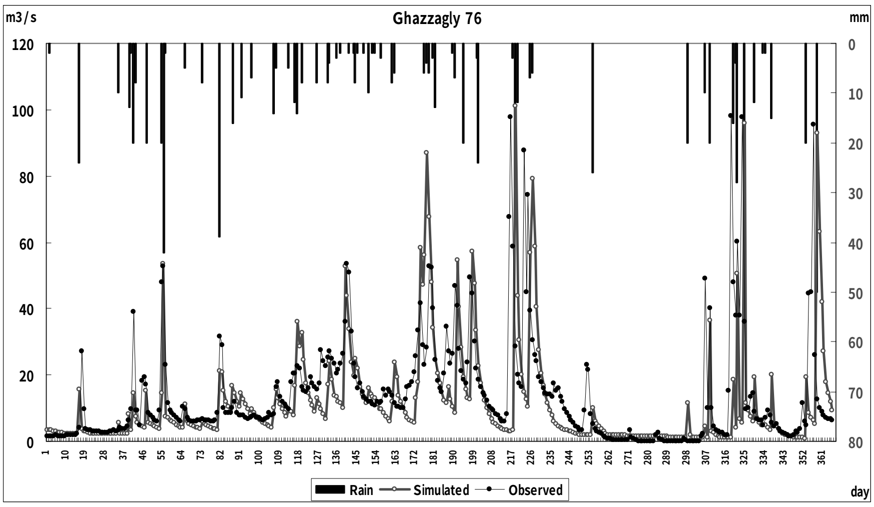
First the Golestan dam was analyzed. The Ghazzagly hydrological station's data were utilized to calibrate the model, and the result was applied to simulate the inflow volume variation in the Golestan dam considering the difference between catchment areas.

The right figure shows a schematic map of the main locations utilized in this section.

(1) Model Calibration

The tank model was calibrated using the Ghazzagly station's 1995 (1376 in Iranian callendar) data. The calibration result is shown in the following graph.

Model Calibration Result (Data of 1995)

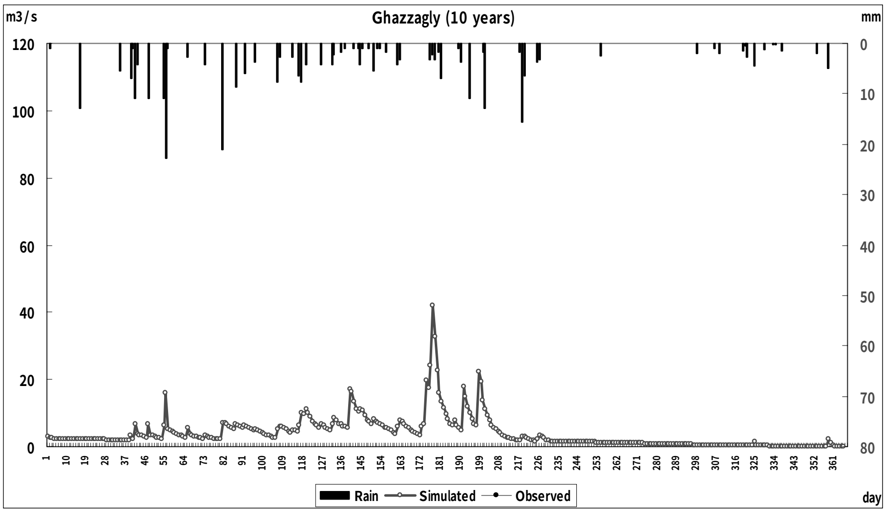


As shown in the above graph, the results of the tank model are acceptable and can be utilized for the estimation of the desired items.

(2) Simulation Result

Utilizing the tank model, the discharge was calculated for a rainfall of 10 years return period. The result is shown below.

Simulation Result for a Minimum Rainfall of 10 Years Probability



So, the estimation of the discharge in each point is shown in the following table.

Discharge Volume Variation per Month (Rain of 10 Years Return Period)

(MCM)

	Location	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL
1	Ghazzagly St.	5.9	9.8	11.2	14.9	20.0	27.7	21.8	5.3	3.1	1.8	0.8	0.4	122.7
2	Golestan Dam	3.8	6.2	7.1	9.5	12.7	17.6	13.8	3.4	2.0	1.1	0.5	0.2	78.0
3	Araz Kose River	2.2	3.6	4.1	5.4	7.3	10.1	7.9	1.9	1.1	0.7	0.3	0.1	44.8

(3) Excess Water

The excess water, the water volume flowed above the dam storage capacity, that overflows through the spillway, can be utilized by the farmers away from the 34 MCM managed by the Ministry of Energy at the Voshmgir dam. This 34 MCM/year depends on the operation of the main gate.

The Ghazzagly St. dischaged volume was utilized to calculate the Golestan 1 dam inflow volume. Considering the water use directly from the Golestan 1 and Voshmgir dam, and that they are initially empty, the storage variation for a rainfall of 10 years return period resulted in the following:

Storage Condition and Excess Water of the Golestan 1 Dam (10 Years Return Period)

(MCM)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL
Golestan Dam 1 Storage	1.1	7.1	12.3	19.7	30.5	43.9	43.8	22.7	5.4	0.0	0.0	0.0	-
% (Storage)	*1.0*	*6.2*	*10.6*	*17.0*	*26.3*	*37.8*	*37.8*	*19.6*	*4.6*	*0.0*	*0.0*	*0.0*	-
Used Water	2.7	0.2	2.0	2.0	2.0	4.2	13.9	24.5	19.3	28.4	29.3	22.3	150.7
Excess Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

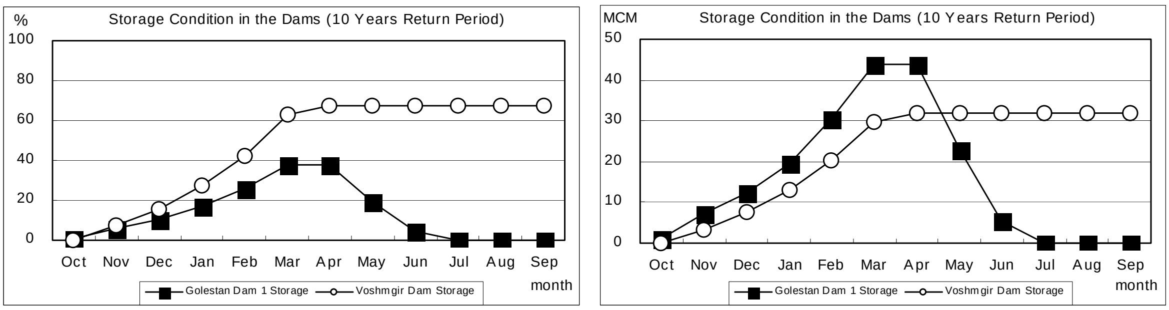
The Voshmgir dam storage condition for a 10 years return period rainfall was also analyzed. The following table shows the results:

Storage Condition and Excess Water of the Voshmgir Dam (10 Years Return Period)

(MCM)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL
Voshmgir Dam Storage	0.0	3.4	7.5	12.9	20.2	29.8	31.8	31.8	31.8	31.8	31.8	31.8	-
% (Storage)	*0.0*	*7.1*	*15.7*	*27.2*	*42.5*	*62.7*	*67.1*	*67.1*	*67.1*	*67.1*	*67.1*	*67.1*	-
Used Water	2.8	0.2	0.0	0.0	0.0	0.5	5.9	11.3	15.8	22.1	21.5	15.9	96.0
Excess Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The condition of the storage variation in a graphical image is as follows:



Storage Variation for a 10 Years Return Period Rainfall in Golestan 1 & Voshmgir Dam

As shown in the above graphs, the Golestan 1 dam reaches about 40% of its storage capacity in March and April, but becomes empty during July to October. The Voshmgir dam reaches almost 70% ot it’s capacity. Both dams storage does not exceed the total capacity, meaning that there is no excess water that overflows through the spillway.

So, it can be concluded that the Golestan 1 and Voshmgir dams do not contribute to the downstream area with excess water for a rainfall of 10 years return period. It can be said that the water coming down from the Voshmgir dam is that originated by the operation of the main gate of the dam. It is the 34 MCM/year that the Ministry of Energy allocates to the downstream agriculture.

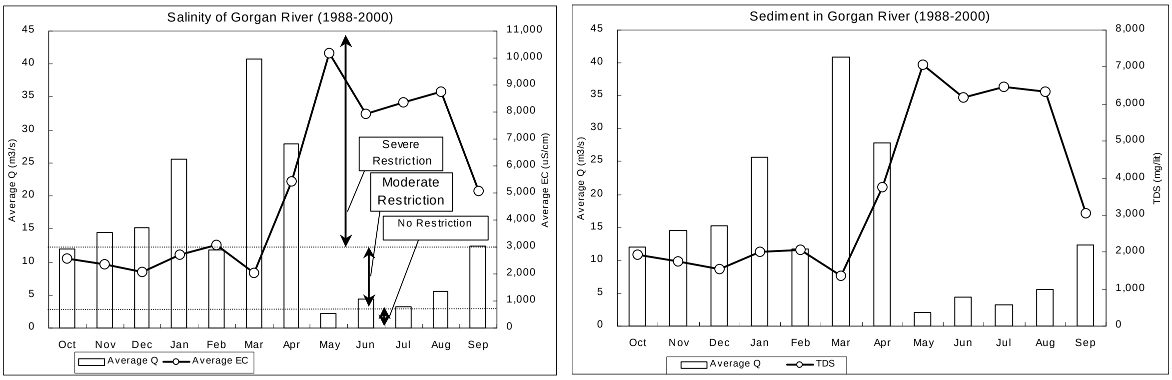
A2.4.3 Constraints and Potentials for Development

A2.4.3.1 Constraints for the Development

(1) Hydrology

One of the main restrictions in the study area is the salinity problem of the Gorgan river. The average variation (1989 to 2000) of the salinity during the year is shown in the following figure.

Salinity and Sediment Variation in Gorgan River (Aq Qala)

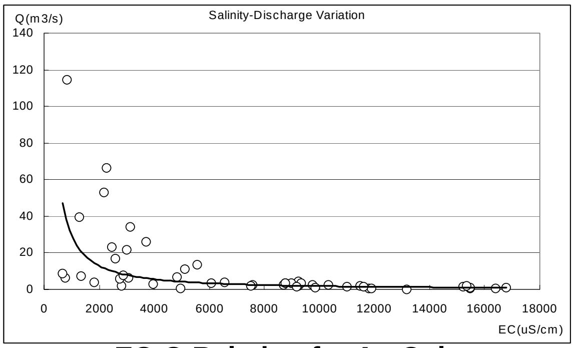


According to the figure, the salinity and sediment concentration in the Gorgan river vary in similar form. The river's water salinity remains in the moderate restriction band for irrigation use from October to March, but after April this value reaches the severe restriction band. The worst months concentrate between May and August, when the EC values reach more than 7,000 μS/cm.

This phenomena has it's origin in the Voshmgir dam operation. During February to April, the Voshmgir dam is storing water. So, the only water coming from the dam is the excess water and the water volume managed by the Ministry of Energy. In this period, the rainy season, the Zaringol river and Fazel Abad rivers have enough discharge, being the EC value in the moderate restriction band.

On the other hand, after May, beginning of the dry period, the only water coming from the Voshimgir dam is also the one managed by the Ministry of Energy. But during this period, the base discharge of the river, that comes from the Zaringol and Fazel Abad rivers, are small and includes the drainage water of the agriculture fields. This drainage water includes fertilizers, chemical products, etc. of the farms. That's why the salinity increases to high values.

The folowing graphic shows the relation of the discharge and EC for the sampling data. As shown, the high EC values are found when the discharge is low. In other words, it is estimated that the high values are found when the base flow comes from the Zaringol and Fazel Abad rivers during the dry season, and was collected when the discharge was low.



EC-Q Relation for Aq Qala (Apr-Sep)

A2.4.3.2 Potentials for Development

(1) Water Resources

Let's revise the potential of the water resources in the area. The main water sources at the Voshmgir dam downstream are the Voshmgir dam itself, Zaringol river and Fazel Abad river. As shown in the previous report, the available water volume from these sources are as follow:

Available Water for 10 Years Return Period Rainfall

(MCM)

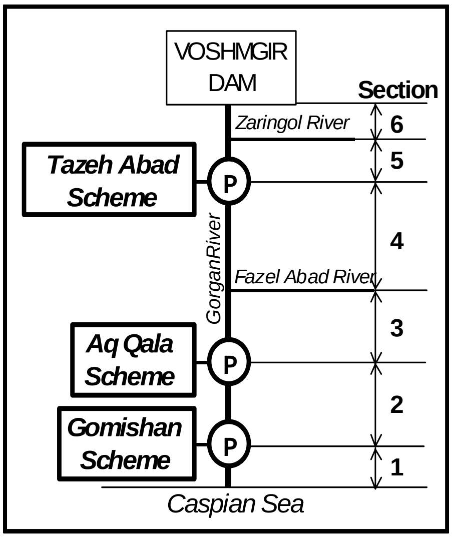
Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Voshmgir Dam	0.8	0.6	0.4	0.4	0.7	2.2	6.0	5.8	3.6	6.4	5.1	2.0	34.0
Zaringol River	0.2	2.3	2.1	4.4	6.8	7.6	5.7	8.2	0.4	0.0	0.0	1.0	38.8
Fazel Abad River	0.2	2.9	0.9	1.2	1.8	1.4	0.7	1.5	0.0	0.0	0.0	0.9	11.6

The actual estimated available discharge is 34 MCM/year from the Voshmgir dam, 38.8 MCM/year from the Zaringol river and 11.6 MCM/year from the Fazel-Abad river for a rainfall of 10 years return period.

The Gorgan river was divided in 6 sections (right figure) to analize it's potential. The sections were set as follows:

Settled Sections for the Study

Section	Location
1	Caspian Sea - Gomishan Pump St.
2	Gomishan Pump St. – Aq Qala Pump St.
3	Aq Qala Pump St. – Fazel-Abad River
4	Fazel-Abad River – Tazeh-Abad Pump St.
5	Tazeh-Abad Pump St. - Zaringol River
6	Zaringol River – Voshmgir Dam



Settled Sections for the Study

The estimated water demand of the irrigation is 20.4 MCM/year, 26.4 MCM/year, 5.4 MCM/year, 3.6 MCM/year, 15.0 MCM/year and 11.4 MCM/year respectively for the section

1 to 6. This demand includes the actual irrigation area of 2,000 ha for Tazeh Abad, 300 ha for Aq Qala and 300 ha for Gomishan.

In the next step, two conditions were studied: not considering and considering the salt problem in the Gorgan river's water.

a) Not Considering the Water Salt Problem

If the salt problem is not considered, all the estimated available water can be utilized in the agriculture. So, the total available water is estimated in 34 MCM/year from the Voshmgir dam, 38.8 MCM/year from the Zaringol river and 11.6 MCM/year from the Fazel-Abad river.

a-1) Irrigation Potential for the Actual Condition (Fig. A2.4.3.2a)

According to this, the water balance estimated for the Voshmgir dam downstream. shows that there is no water shortage. It means that all *actual* irrigation area can be irrigated by this volume of water.

Let's analyze the situation of an increase in irrigation surface at the Voshmgir dam downstream region. The area increase is only considered for the 3 existing irrigation schemes. All the other agricultural lands are considered to be constant. The available water volume was maintained as the estimated one.

a-2) Irrigation Potential for Area Increase with the Actual Water Volume (Fig. A2.4.3.2a)

If the 3 schemes increase the irrigation area from the actual irrigated area to 100% of the irrigable lands, it is expected a water shortage in the sections 1, 2, 4 and 5. It means that the actual water volume, even considering the utilization of the water in the months that the salt concentration is high, will be not sufficient to support an increase in the irrigation surface. In other words, the existing schemes can not irrigate all of its lands.

a-3) Potential for Irrigation Efficiency Increase (Fig. A2.4.3.2b)

The increase of the irrigation efficiency at the Voshmgir dam upstream was considered here. As shown in the previous report, the increase in the irrigation efficiency, from 50% to 60% at the Voshmgir dam upstream irrigation schemes, will make available an adittional water volume of 31.6 MCM/year from the Voshmgir dam to it's downstream area. It means that 65.6 MCM/year will be available to the downstream part. Three situations are going to be analysed:

- Irrigation of the actual irrigated area;
- Irrigation of 100% of the irrigation schemes;
- Irrigation of 100% of Tazeh-Abad scheme, 50% of Aq Qala and Gomishan schemes.

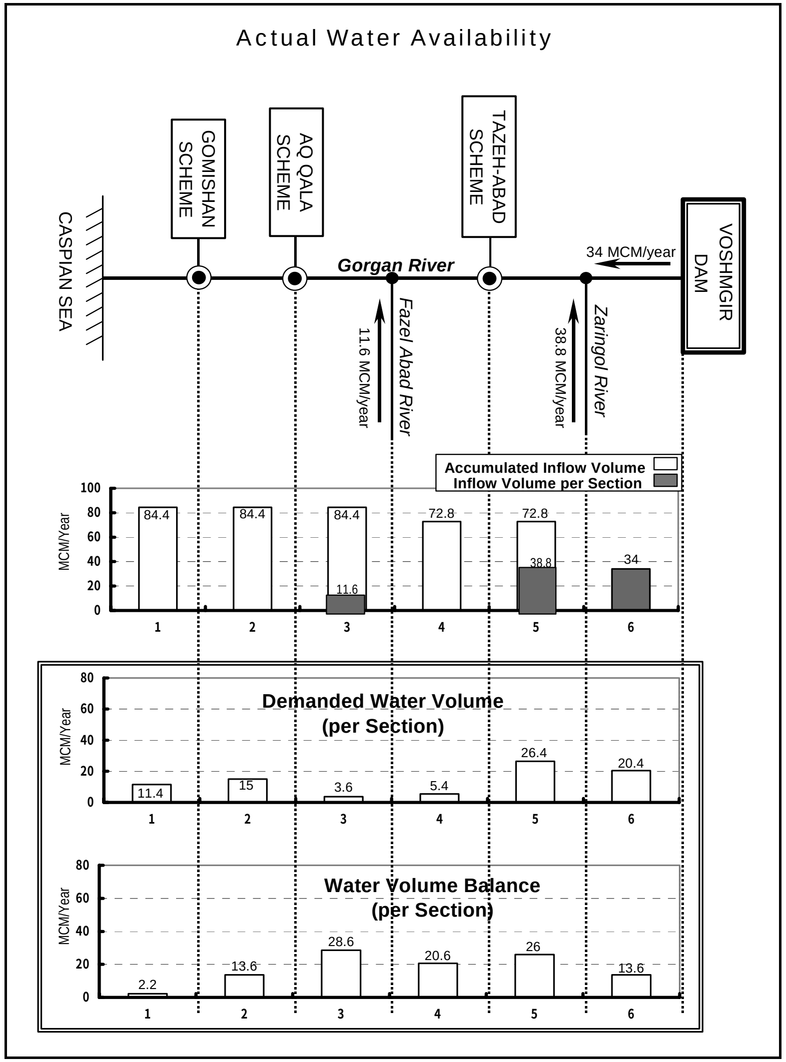
The first scenario, actual water demand, carries to an excess water of 33.8 MCM, that is quite the same volume of the water saved by the efficiency increase.

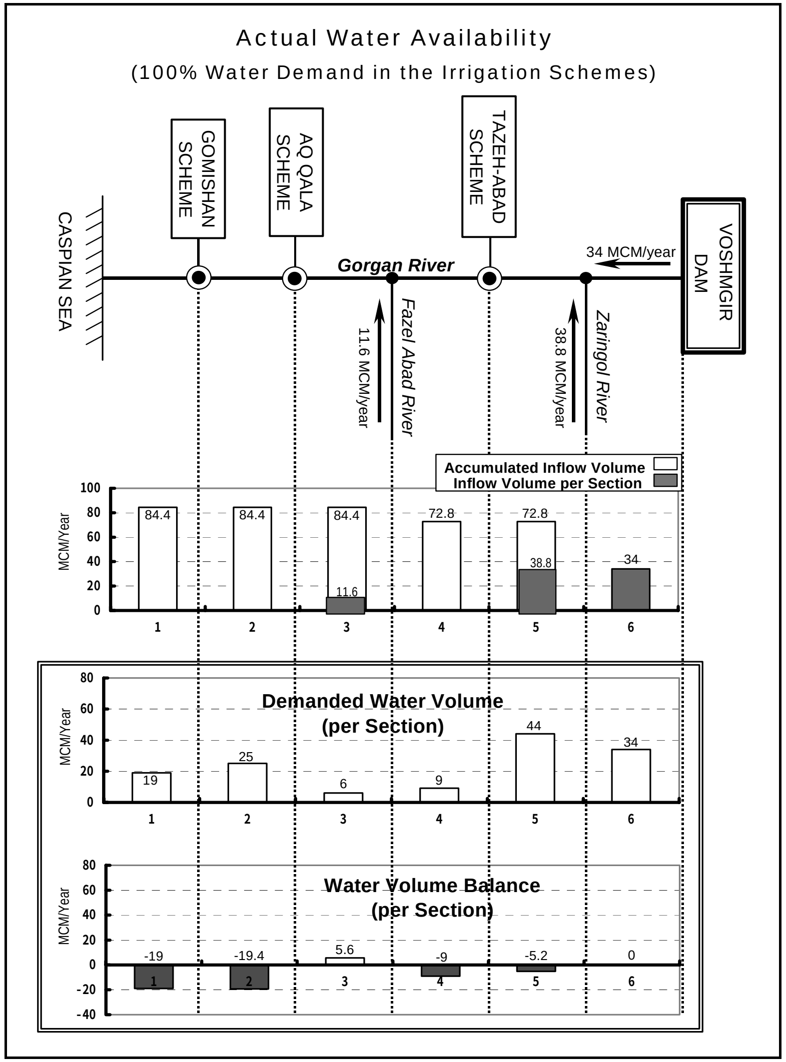
The second scenario, increasing the irrigated surface to 100% in the schemes, carries to a water shortage in Gomishan scheme (section 2) and downstream of Gomishan scheme (section 1). But it can be said that almost all Gomishan scheme can be irrigated by this volume of water.

The last scenario, irrigating 100% of Tazeh Abad scheme, 50% of Aq Qala and Gomishan schemes, indicated that the whole *existing* Voshmgir dam downstream irrigation area can be irrigated.

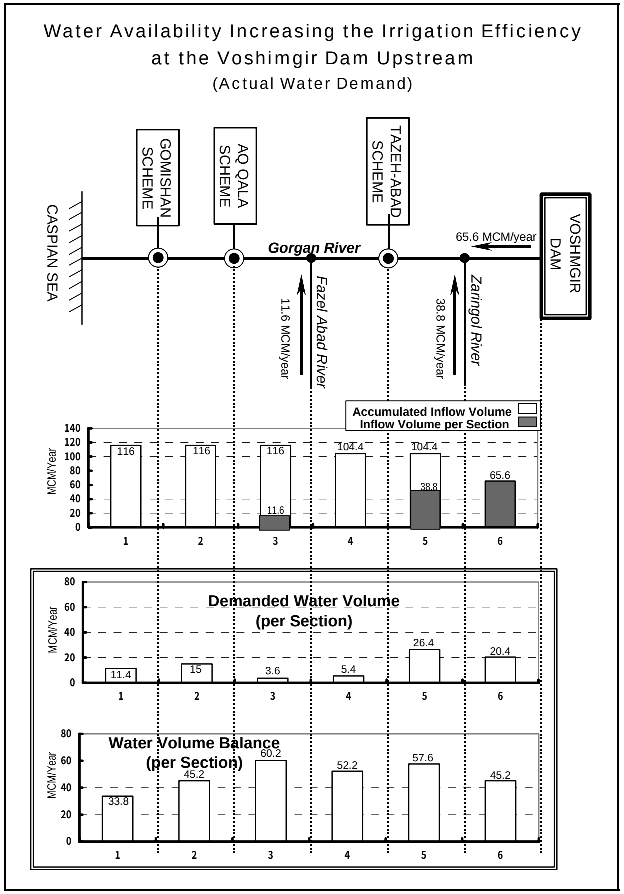
It must be emphasized here that the water considered in this analysis includes the period that the Gorgan river has salinity problems.

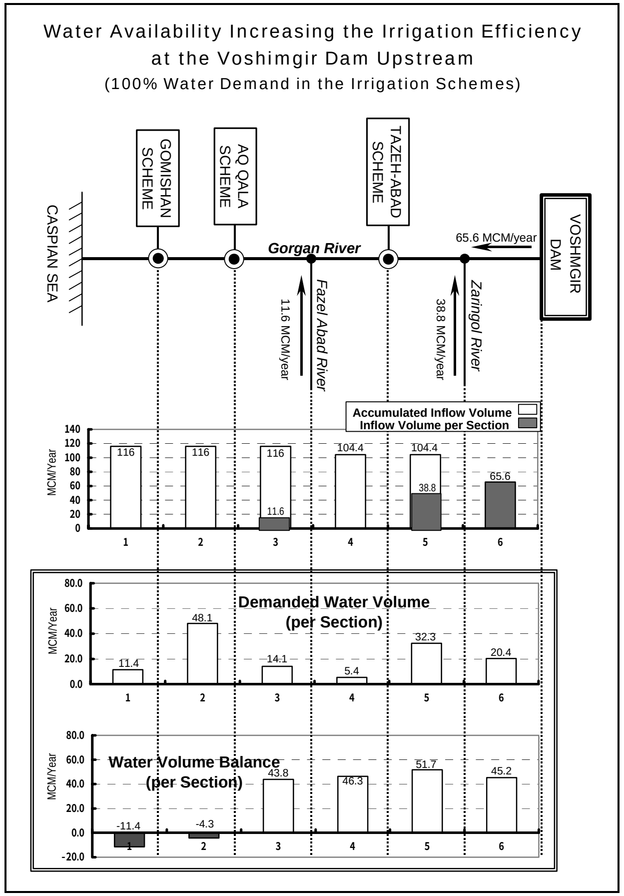
Graph A2.4.3.2a: Water Resource Potential Not Considering the Water Salt Problems

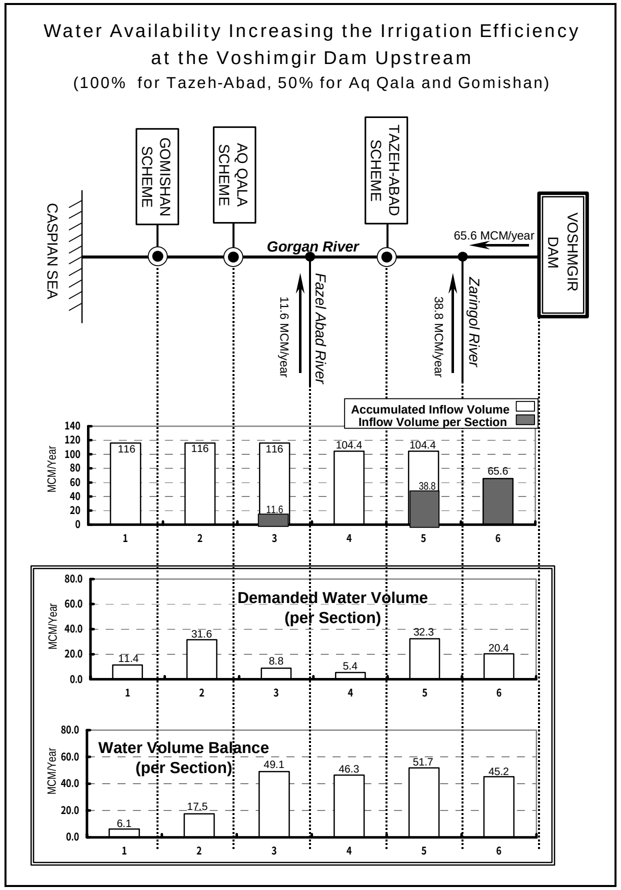




Graph A2.4.3.2b: Water Resource Potential Not Considering the Water Salt Problems







b) Considering the Water Salt Problem

The months that the water salinity increases to a severe restriction range is from April to September. But as shown in the 12 years average, the most dangerous period is from May to August. So, the water this period was not considered to be available for the irrigation in this analysis.

Another item is that the water salt sources come mainly from the Zaringol and Fazel Abad rivers. It is estimated that the Voshmgir dam water has not too much influence in the water salinization problem. So, the above period was not considered only for the water in Zaringol and Fazel Abad rivers. It means that the base flow of the Gorgan river (coming from Zaringl and Fazel Abad rivers) is not utilized for irrigation, and the water for irrigation is only utilized when the Voshmgir dam opens it’s gate to discharge the allocated irrigation water.

So, the available water volume can be resumed as follows:

Available Water Considering the Salt Problem in Gorgan River

(MCM)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Voshmgir Dam	0.8	0.6	0.4	0.4	0.7	2.2	6.0	5.8	3.6	6.4	5.1	2.0	34.0
Zaringol River	0.2	2.3	2.1	4.4	6.8	7.6	5.7	0.0	0.0	0.0	0.0	1.0	30.1
Fazel Abad River	0.2	2.9	0.9	1.2	1.8	1.4	0.7	0.0	0.0	0.0	0.0	0.9	10.1

The water from the Voshmgir dam was set untouched.

b-1) Actual Water Availability (Fig. A2.4.3.2c)

The actual water availability and demand, not considering that from May to August, will carry to a water shortage in the section 1. If the irrigation surface of the schemes are set to 100%, there will be a water shortage in the sections 1, 2, 4 and 5.

b-2) Irrigation Efficiency Increase (Fig. A2.4.3.2d)

The increase in the irrigation efficiency at the Voshmgir dam upstream was also considered in this scenario. The same three patterns were studied as follows:

- Irrigation of the actual irrigated area;
- Irrigation of 100% of the irrigation schemes;
- Irrigation of 100% of Tazeh-Abad scheme, 50% of Aq Qala and Gomishan schemes.

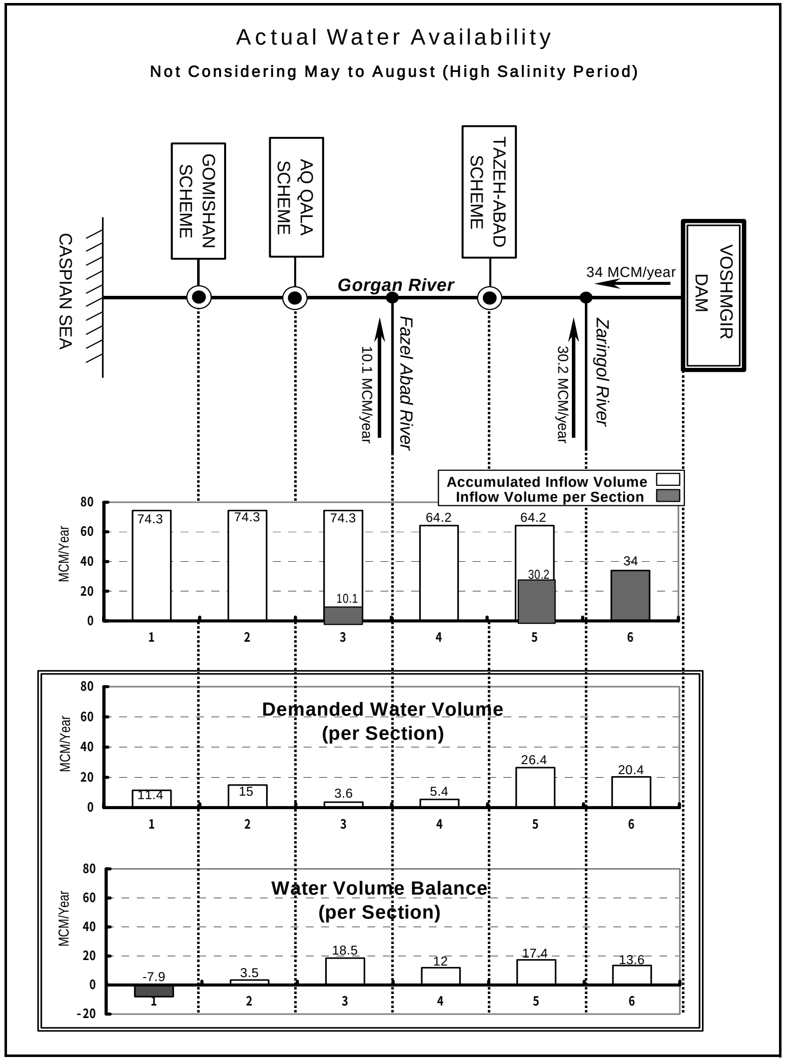
If the actual water demand is considered, it is estimated that there will not be water shortage.

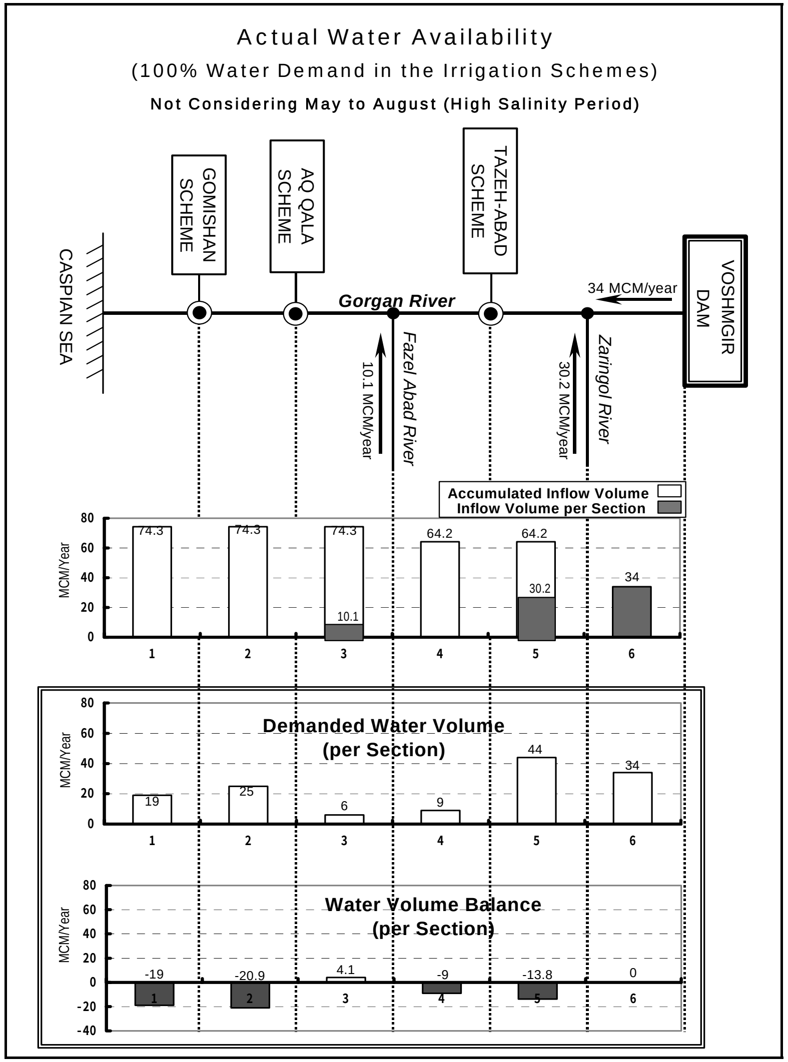
The increase in the irrigation surface to 100% in the existing three schemes will carry to a water shortage in sections 1 and 2. In other words, the Gomishan scheme will have a shortage of water.

The irrigation of 100% of Tazeh Abad scheme and 50% of Aq Qala and Gomishan schemes will carry to a small water shortage in the section 1.

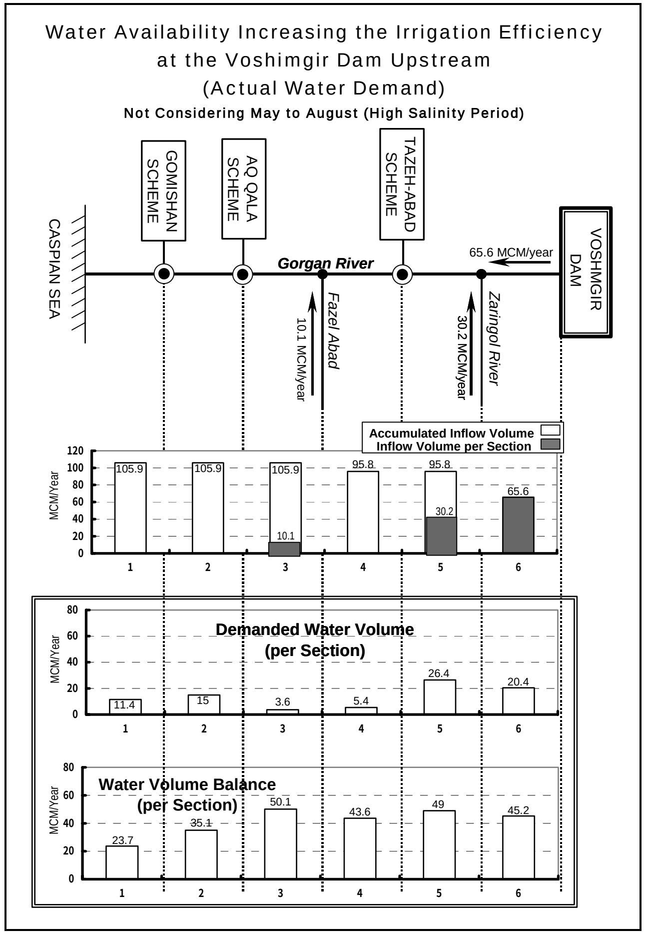
So, considering the water convey to the downstream part of the region, emphasizing the Tazeh Abad scheme, only 50% of the Aq Qala and Gomishan schemes can be irrigated even with an increase of the irrigation efficiency if the salty water is not considered.

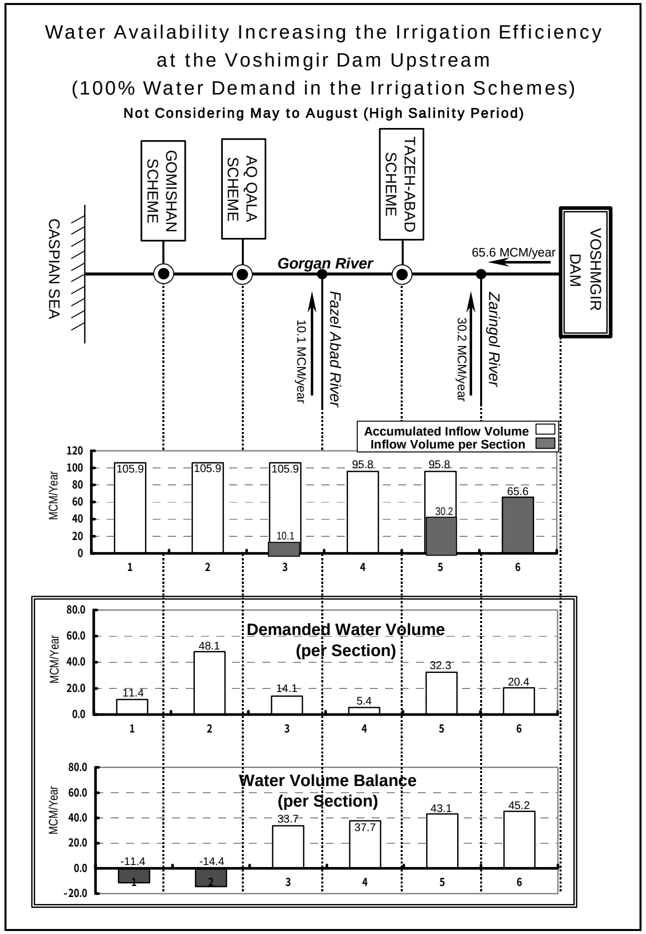
Graph A2.4.3.2c: Water Resource Potential Considering the Water Salt Problems

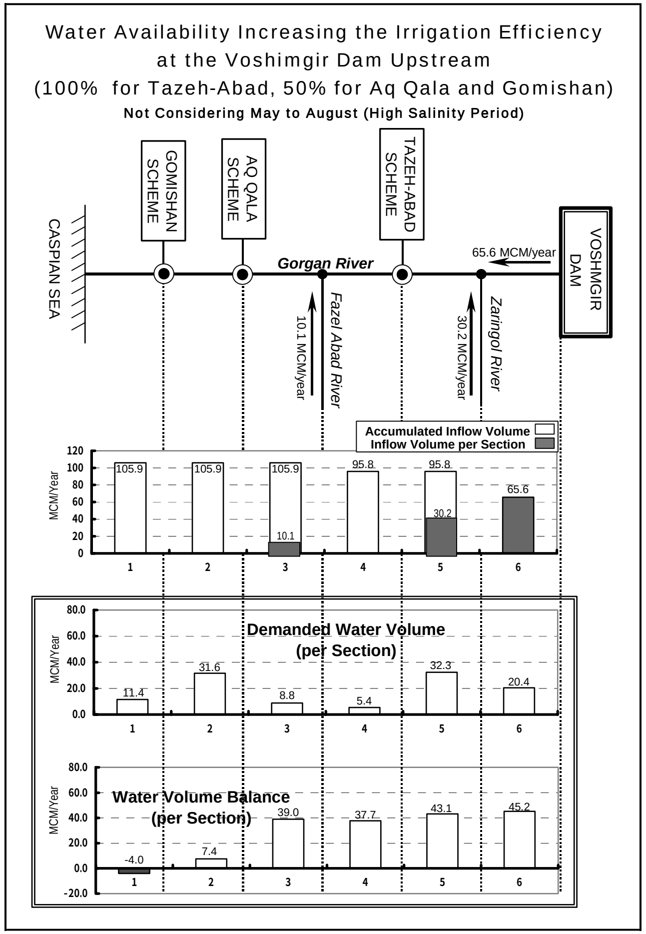




Graph A2.4.3.2d: Water Resource Potential Considering the Water Salt Problems







c) Resume

So, it can be resumed that the following water volume is estimated to be available for the *actual* condition of considering and not considering the salty water during May to August coming from Zaringol and Fazel Abad rivers.

- **Including the Salty Water (1)**

Available Water Volume Including the Salty Water

(MCM)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Voshmgir Dam	0.8	0.6	0.4	0.4	0.7	2.2	6.0	5.8	3.6	6.4	5.1	2.0	34.0
Zaringol River	0.2	2.3	2.1	4.4	6.8	7.6	5.7	8.2	0.4	0.0	0.0	1.0	38.8
Fazel Abad River	0.2	2.9	0.9	1.2	1.8	1.4	0.7	1.5	0.0	0.0	0.0	0.9	11.6

- **Not Including the Salty Water (2)**

Available Water Volume NOT Including the Salty Water

(MCM)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Voshmgir Dam	0.8	0.6	0.4	0.4	0.7	2.2	6.0	5.8	3.6	6.4	5.1	2.0	34.0
Zaringol River	0.2	2.3	2.1	4.4	6.8	7.6	5.7	0.0	0.0	0.0	0.0	1.0	30.1
Fazel Abad River	0.2	2.9	0.9	1.2	1.8	1.4	0.7	0.0	0.0	0.0	0.0	0.9	10.1

A2.5 The Case Study Area CHELDIN

A2.5.1 Meteorology and Hydrology

a) Climate Conditions

The case study area is situated at the south-west part, in the Gorgan Central Office meteorological station area, according to the division utilized in this study by the Thiessen method. The study area has the following meteorological characteristics.

Meteorological Characteristics of the Gorgan Central Office St. (Average)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rain (mm)	44.6	53.7	59.7	49.0	50.6	21.0	18.0	25.9	31.5	52.6	58.0	57.5	522.1
Temperature (^oC)	8.3	10.5	15.5	20.2	25.2	27.2	26.6	24.3	18.9	13.7	8.7	7.1	17.2
Evaporation (mm)	30.8	40.4	63.2	106.1	147.5	182.8	190.7	182.4	118.4	85.7	47.2	37.9	1,133.7
Humidity (%)	73.7	73.0	78.7	92.7	85.7	92.7	90.4	72.7	74.0	72.1	70.7	79.3	79.6

b) ETo and Effective Rainfall

The referential evapotranspiration, to be utilized in the calculation of the necessary irrigation water are as follows:

ETo (mm)

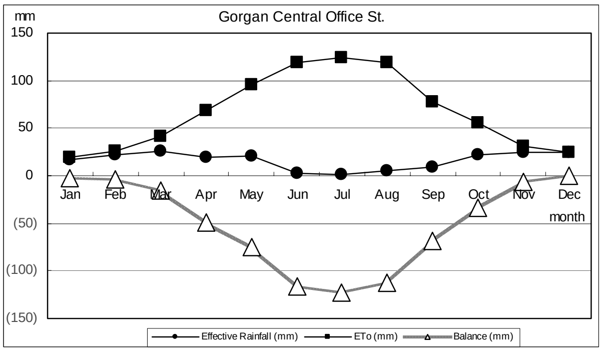
Station	Jan Bah	Feb Esf	Mar Far	Apr Ord	May Kor	Jun Tir	Jul Mor	Aug Sha	Sep Meh	Oct Aba	Nov Aza	Dec Dey	Annual Sum
Gorgan Central Off.	20.0	26.3	41.1	69.0	95.9	118.9	124.0	118.6	77.0	55.7	30.7	24.6	801.8

Effective Rainfall (mm)

Station	Jan Bah	Feb Esf	Mar Far	Apr Ord	May Kor	Jun Tir	Jul Mor	Aug Sha	Sep Meh	Oct Aba	Nov Aza	Dec Dey	Annual Sum
Gorgan Central Off.	16.8	22.2	25.8	19.4	20.4	2.6	0.8	5.5	8.9	21.6	24.8	24.5	193.3

The comparison of the ETo and Effective Rainfall shows the right figure's characteristics.

The following graph shows the positive and negative balance periods set in this study for the Case Study Area.



Balance ETo & Effective Rain

ETo and Effective Rain Balance

Jan Bahm	Feb Esfa	Mar Farv	Apr Ordi	May Kord	Jun Tir	Jul Mord	Aug Shah	Sep Mehr	Oct Aban	Nov Azar	Dec Dey
Positive			Negative							Positive	

c) Wells

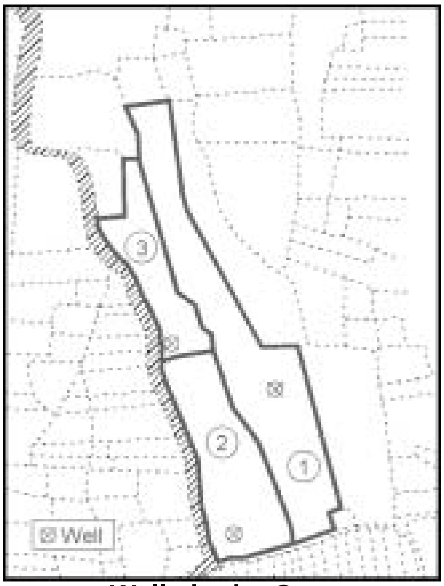
The actual most important water source in the area is the groundwater, explored in the form of well. The well in a property must be registered and an operation permit shall be issued by the Ministry of Energy. This permission is for one year, so it must be renewed every year.

The following table shows the registered wells information in the Case Study Area.

Well Information in the Case Study Area

Item	Area Number		
	1	2	3
Land Area (ha)	10	7	7
Well Depth (m)	145	130	160
Type	Artesian		
Settlement Year	1998	1994	1992
Well Pipe Size (inch)	12	12	12
Water Pipe Size (inch)	3	3	3
Qmax (lit/s)	8.0	5.0	5.5
Pump Power (hp)	65	18	18
Setting Depth (m)	45	57	
Max Working Time (hr/year)	2,200	2,200	2,200

source: Ministry of Agriculture (Golestan)



Wells in the Case Study Area

Only the wells are utilized as water source for the agriculture in the Case Study Area.

A2.5.2 Constraints for the Development

(1) Meteorology and Hydrology

The drainage conditions of the area is the main constraint. The area has two main drainage canals (one is the Shast Khola river) that drain the water to the Gharasu river. But the smooth slope of the Gharasu river and the canals, as the deposition of sediment and improper vegetation in the canal creates difficulties to the drainage process.

The following picture shows the main drainage system around the Case Study Area.

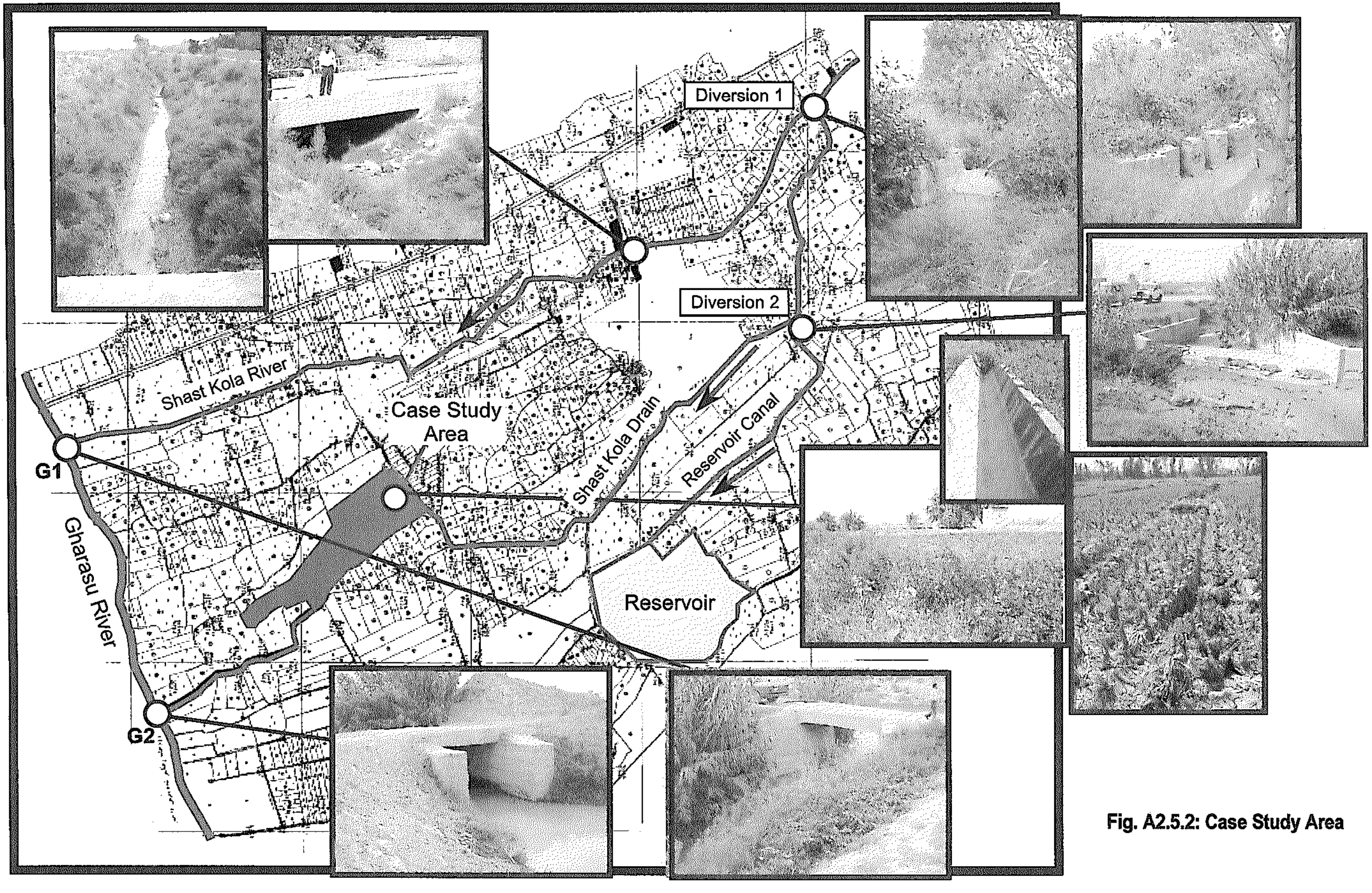


Fig. A2.5.2: Case Study Area

As the picture shows, there are two diversion structures that divide the water to three canals. The first canal is the original Shast Kola river. The second is the Reservoir canal, designed to convey water to the reservoir. The third is the Shast Kola drain, that was designed to divide the water of the reservoir canal that was superior to the capacity of the reservoir.

The two diversion structures need to be restored. The gates set in the diversion 2 were out of function and the division 1 was completely destroyed by the erosion. The three canals need to be cleaned. There are too much vegetation and sediment in the canal, that obstructes the water passage.

Other necessary structures are gates in the G1 and G2 points,where the Shast Kola river and drain connect with the Gharasu river.

In the following part it is presented the necessary measurements to be taken to improve the drainage condition of the canals in the area.

- Necessary Drainage Improvements

The diversification of the agricultural products will need a improvement of the drainage system in the area. There are places that are easily inundated and the Case Study Area is included in one of this areas.

There are points that the groundwater level can be seem in a depth of 40 cm, being the water table very high in the area. So, the drainage improvement will be a decisive factor for the agricultural development that includes a crop diversification.

The right picture shows the mark of a tractor tyre after entering in the wet field in the Case Study Area. The on field works are very difficult due to the high groundwater level and poor drainage condition. The farmers say that it is quite impossible to realize machine works during the rainy days.

It was analysed the drainage condition of the existing canals to know the necessary improvement to be realized.

The existing drains surrounding the Case Study Area were analyzed. The following table shows the Shast Kola river discharge estimation for several return period.

- **Discharge for Several Return Periods**

Shast Kola River Q by Return Period

(m3/s)

River	Area (km^2)	Return Period (year)						
		2	5	10	25	50	100	200
Shast Kola	204.00	5.24	12.30	18.70	28.70	42.90	63.10	83.10

$Q_{T2} = 3.488 + 0.009A$ r = 0.968 n = 5

$Q_{T5} = 10.34 + 0.010A$ r = 0.996 n = 4

$Q_{T10} = 16.79 + 0.009A$ r = 0.989 n = 4

$Q_{T25} = 27.12 + 0.008A$ r = 0.796 n = 4

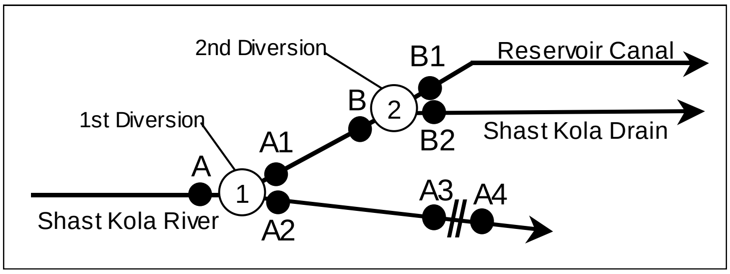
$Q_{T50} = 42.52 + 0.002A$ r = 0.476 n = 3

$Q_{T100} = 19.12 + 0.215A$ r = 0.758 n = 3

$Q_{T200} = 15.65 + 0.331A$ r = 0.800 n = 3

The following figure shows a schematic view of the existing drains.

Schematic View of the Drain System



Dimension of the Canals

Point	Bottom (m)	Top (m)	Depth (m)	A (m^2)
A	4	8	2.7	16.2
A1	3	7	2.8	14
A2	4	7.5	3	17.25
A3	2	10	3.5	21
A4	2.5	10	3.4	21.25
B	2	6.5	2.7	11.475
B1	1.5	6	1.8	6.75
B2	4	9	2.2	14.3

The velocity was calculated from existing topographical data. According to this, the following equation was derived:

$$V = 0.8 + 0.027Q \qquad r = 0.76$$

Q: m3/s; v=m/s

So, it is estimated the following conditions for a discharge of 10 years return period:

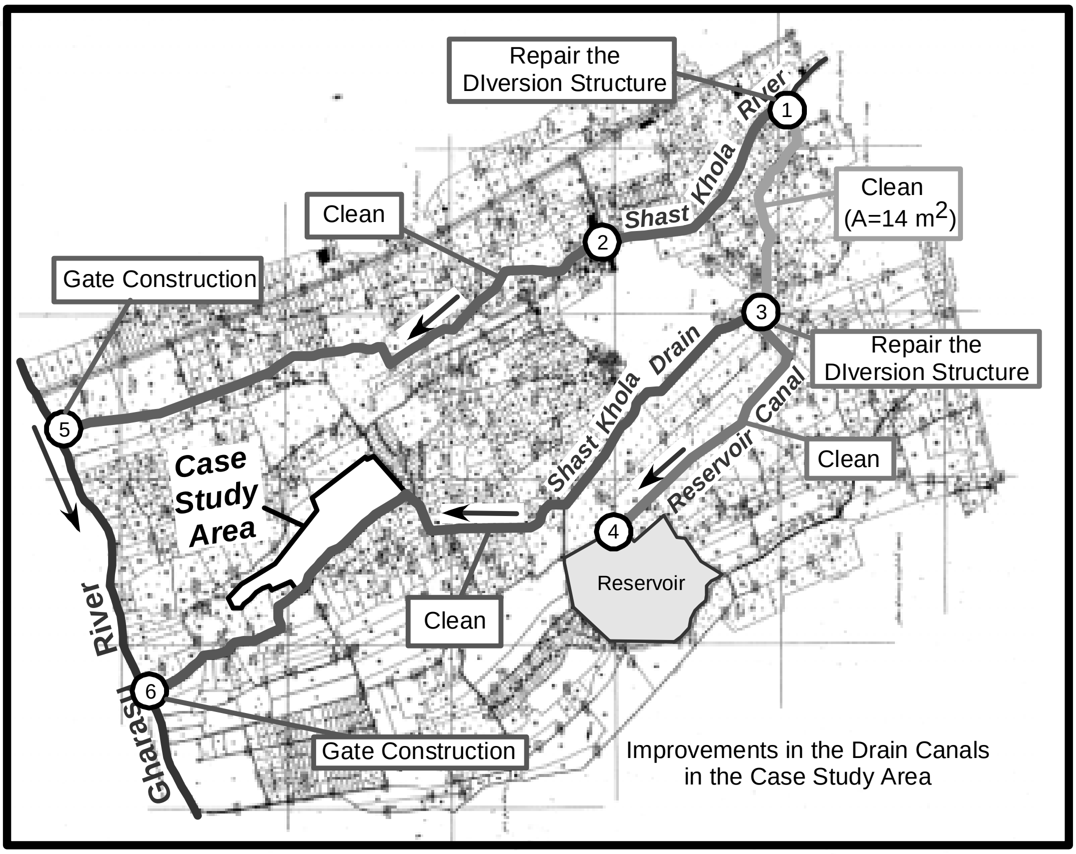
10 Years Return Period (18.7 m^3/s)

Section	A (m^2)	Q (m^3/s)	V (m/s)
A	16.2	18.7	1.15
A1	14	8.415	0.6
A2	17.25	10.29	0.6
B	11.475	8.415	0.73
B1	6.75	2.69	0.4
B2	14.3	5.72	0.4

There are no flood problems for these return period according to the existing topographical data.

- **Improvements in Case Study Drain System**

The following figure shows the necessary improvements in the actual drain system of the Case Study Area.



Recommended Improvements in the Drainage System

The improvements necessary in the area are:

- The diversion structures in points 1 and 3 are totally damaged. So they must be repaired to permit controlling the discharge in the canal;

- All canals should be cleaned because they have parts with sediments and vegetation in the canal, obstructing the water flow;
- Gates should be constructed in the points 5 and 6 to avoid the back flow of the Gharasu river's water into the area;
- If possible, the section between the points 1 and 3 should be unified to 14 m^2 because it tapers off from 14 to 11.475 m^2.

A2.5.3 Potentials for the Development

(1) Water Resources

The relative abundant groundwater of the area is one of the potential for development. But new wells must be avoided and replaced by the surface water. The water coming from the mountains are clean and is more qualified to be used as irrigation water (in respect to the water salinity) than the Gorgan river's one. Another aspect to avoid the well utilization is the high cost of it's construction. The initial investment for the well carries to the production of crops with high valued products, that has high water demand as the rice, to pay the initial investment.

Other important item is to maintain the forest in the mountains and surrounding the water source to protect them. The intense destruction of the vegetation can carry to the decrease of the water sources, and at the end destruct all water cycle in the area. So, the conservation works shall be very important to maintain the actual water source potencial in the Gharasu basin. The forestation of the Gharasu river's margins shall be a good protection for erosion that carries every year great volume of sediments to the Gharasu river's downstream.

The monthly average discharge of the Shast Kola river, that flows beside the Case Study Area, and Gharasu river, where the Shast Kola river discharges it's water, are as follows.

Monthly Average Discharge

(m3/s)

Local	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
	Aba	Aza	Dey	Bah	Esf	Far	Ord	Kor	Tir	Mor	Sha	Meh	
Shast Kola River	0.39	0.41	0.43	0.51	0.72	1.04	1.14	0.86	0.61	0.47	0.40	0.41	0.61
Gharasu (Seah Ab)	0.95	1.93	2.67	2.79	3.64	4.43	3.75	2.24	0.51	0.10	0.10	0.70	1.98

The basin of the Gharasu river is about 10 times smaller than the Gorgan river. The average discharge at Basir Abad St. (near the Gorgan river mouth) and Seah Ab St. (near the Gharasu river mouth) also reaches to a difference of 10 times. The Basir Abad discharge reaches almost to an monthly average of 40 m^3/s when the Seah Ab only reaches to 4 m^3/s.

The Gharasu river's discharge is not constant. Most of time between June to September, the Gharasu river presents a discharge of zero or near zero. The tributaries of Gharasu river, like

Shast Kola and Naharkoran rivers, have a very small discharge.

So, future development of the water surface can use the potential of those tributaries to collect and conduct the water to areas where the agricultural lands concentrates. It means, utilize the combined potential of those small rivers. But the project shall be deeply studied to avoid future environmental problems. Before this study, the existing wells can be used as water source.

The priority, if the agriculture production is going to be diversified, shall be the improvement of the drainage condition in the area.

A2.6 Water Resources Development Study

As stated in the scenario of agricultural development, it is highly important to secure stable and sufficient water resources to realize a sustainable agricultural development in the Gorgan Plain. Studies such as 'Integrated Water Resources Management Study in the Gorgan Plain' shall be carried out to clarify availability of usable water resources. A brief description of the Study is given below.

(1) Necessity of the Study

A study of the water resources in the area was carried out in 1972. But the conditions of the water resources utilization have been changed due to several changes in the basin, such as the construction of actual dams. Hence, it is necessary to revise the water use condition to permit an efficient and optimal utilization of water resource.

(2) Effects of the Study

The study shall recognize the exact water circulation in the whole area, evaluating at the same time an effective water distribution for the use. It will allow an efficient water use in future for the regional development, based on the availability of water resources. It will also recognize the water availability in both the basins, creating the basic conditions to succeed projects such as 'Water Supply from the Mazandaran Province'.

(3) Contents of the Study

The Study mentioned here shall be realized for the basins of Gorgan and Gharasu rivers, clarifying the actual water use condition and water demand in the area. The usable water resources shall be studied, pointing out the water shortage by area in the basin.

This study shall also re-evaluate the actual management structure of the dams and water resources, including the present information transmission system. The improvement of the information transmission system includes the transmission of information from the dams and meteo-hydrological measurement stations. In the present system, the data is digitalized and stored in the Sari office of Mazandaran province. Whenever any information is needed one must have to go Sari to get the information. The data should be readily available for all the institutions concerned. It can be said that not only for the institutions in the province, but also between the provinces.

The same thing can be said to the dam operation structure. The data (including the dam's storage condition) should be available for the involved institutions in and out of the province to permit an effective water use. The instantaneous availability of information such as water shortage and surplus will permit an efficient water use in the basin. The water supply from the Mazandaran Province to the Gorgan Plain will also require an efficient communication system. Hence, the present system shall be improved to permit a more flexible decision to manage the water use according to each condition.

The improvement plan shall include the following aspects, but the detailed evaluation shall be carried out in the study.

(Improvement Plan)

First the Gorgan plain can be divided in 2 basins: Gorgan and Gharasu. All dams will be connected to the Golestan Central Office. Each dam will be connected to the dams in the same basin to permit the communication between them. The climatological and hydrological stations will be linked to the dams to make possible the prediction of the dam operation. Also all irrigation schemes shall be linked to the responsible dam. The Golestan Central Office shall be linked to the Mazandaran Central Office to permit an efficient management of the water supply between both provinces in the future.

The final form of this system shall be an on a line network. The possibility to share detailed information will make it possible to control the water use considering the general condition of the basin, allowing an efficient water use.

So, the hard component is very important, but the soft component must also be sufficiently considered to elevate the possibility to succeed the results of the development project. It can be said mainly for the soft component that needs a longer time to be executed.

Considering the above aspects the Terms of Reference (TOR) for the Proposed Study is prepared as mentioned below.

(4) Objectives of the Study

1) To update the conditions of the water resources potential, estimating the present and future water demand and realizing water balance in the Gorgan Plain;
2) To formulate a well-balanced integrated water resources management, including inter-basin and inner-basin water transfer, considering natural and social environment in each river basin as well as in the neighboring river basins;

(5) Study Area

The Study Area covers the basins of the Gorgan river (11,480 km^2) and Gharasu rivers (1,720 km^2).

(6) Phases of the Study

The Study shall be divided into two phases.

Phase I: Evaluation of the Existing Water Resources

In the Phase I, the present conditions of water resources and related problems will be evaluated in terms of water resources potential, water demand and water balance. Furthermore, the related items such as national and regional development plan, landuse, social and natural environment, institution and organization, financial situation and other problems for the water resources management will be studied. Additionally, a water resources simulation model (especially for the Gorgan and Gharasu river basins) as well as a database for Geographic Information System (GIS) will be developed.

Phase II: Elaboration of the Integrated Water Resources Management Plan

A plan for the water resources management in the Study Area will be formulated in the Phase II. This phase will be divided into two sub-phases. The Phase II-1: Alternative Study for the Integrated Water Resources Management Plan and the Phase II-2: Formulation of the Integrated Water Resources Management Plan.

Phase II-1: Alternative Study for the Integrated Water Resources Management Plan

Alternatives for the water resources management plan will be studied setting the target year and planning criteria in the Phase II-1. The major items to be considered here shall be the future socio-economic framework, water resources potential under controlled condition, future water demand and water balance, cost estimation for the necessary remedial works and project evaluation for the alternatives from technical, economical and social/natural environmental point of views.

Phase II-2: Formulation of the Integrated Water Resources Management Plan

The plan for an integrated water resources management in the Study Area will be formulated in the Phase II-2. The major items in this phase are formulation of the optimum plan, operation/maintenance plan for the hydraulic structures, landuse plan, agronomical plan, conservation plan, water distribution plan, institutional and organization plan, financial plan and implementation plan. An improvement plan for the water utilization to solve the salinization problems will be formulated. Finally, the priority projects for the urgent implementation of the water resources management in the region will be identified.

(7) Scope of Work of the Study

1) Phase I: Evaluation of Present Water Resources

1. Data Collection

- Topography, geology and soil
- Meteo-hydrology
- Hydrogeology
- Socio-economy including national and regional development plans
- Landuse
- Water consumption (Irrigation, Domestic, Industrial, etc.)
- Existing hydraulic structures (Dams, Irrigation Systems, Headworks, etc.)
- Surface water and groundwater quality
- Social and natural environment
- Operation / Maintenance of the existing hydraulic structures
- Existing institutional and organization for water resources management
- Financial condition for water resources management

2. Field Investigation and Survey

- Longitudinal and cross sectional survey for the major rivers
- Hydrological survey for the river discharge
- Water usage survey including irrigation water intake
- Water quality survey for surface water and groundwater
- Conditions in the farmland (irrigation, cultivation, etc.)

3. Study of the Socio-Economical Conditions
4. Study of the National and Regional Development Plans
5. Study on Landuse Condition
6. Development of Water Resources Simulation Model
7. Development of GIS Database
8. Estimation of Present Water Resources Potential

- Natural surface water resources potential
- Groundwater resources potential

9. Estimation of the Present Water Demand (Irrigation, Domestic, Industrial, etc.)

10. Estimation of Water Balance (Present and Future)

11. Study on the Conditions of the Surface Water and Groundwater Quality

12. Study on the Social and Natural Environment

13. Study on Institution and Organization for the Water Resources Management

- Existing structure of institution and organization
- Existing staffs and capability for water resources management
- Management tools (monitoring networks, database and others)
- Inter-institutional relation related to the water use management

14. Study on Financial Situation for the Water Resources Management

2) Phase II: Study on a Master Plan for Water Resources Management

2.1 Phase II-1: Alternative Study for the Water Resources Management Plan

1. Setting up a Target Year and Criteria for the Master Plan
2. Setting up Socio-economic Framework and Future Landuse
3. Estimation of Future Water Demand in the Target Year
4. Setting up Alternatives for Water Resources Control
    - Water supply for agriculture
    - Water supply for domestic water
    - Water supply for industrial water
    - Water supply for other use
5. Estimation of Future Water Resources and Water Balance for the Alternatives
6. Study on the Water Quality Improvement
7. Planning Necessary Remedial Works for Hydraulic Structures
    - Intakes
    - Reservoirs
    - Inter-basin and inner-basin water transfer facilities
    - Others
8. Cost Estimation for the Alternatives
9. Project Evaluation for the Alternatives
    - Technical Evaluation
    - Economic Evaluation
    - Social and Environmental Evaluation including Initial Environmental Examination (IEE)

2.2 Phase II-2: Formulation of the Integrated Water Resources Management Plan

1. Formulation of the Optimum Plan for the Water Resources Management
    - Structural measures including remedial works for the hydraulic structures
    - Non-structural measures composed of operation of water facilities, strengthening of monitoring networks and related database system, conservation and protection area, necessary regulation and others

2. Formulation of an Operation / Maintenance Plan for the Hydraulic Structures

- Dams/Reservoirs
- Water Intake Structures
- Inter-basin and inner-basin water transfer facilities
- Other facilities

3. Formulation of a Landuse Plan
4. Formulation of an Environmental Conservation and Protection Plan for Water Resources
5. Formulation of a Preliminary Water Quality Improvement Plan
6. Formulation of an Institution and Organization Plan
7. Formulation of a Financial and Implementation Plan
8. Identification of the Priority Projects for the Urgent Implementation
9. Formulation of an Agricultural Water Use Plan

- Irrigation Techniques
- Agronomical Methods
- Land Reform

(8) Study Schedule

The total period for the Study will be 14 months. The period for each phase is as follows:

Phase I: 6 months

Phase II: 8 months (Phase II-1: 4 months and Phase II-2: 4 months)

Study Schedule

Phase	Phase I: Evaluation of the Present Water Resources						Phase II: Master Plan Study							
							Alternative Study				M/P Formulation			
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Schedule	■	■	■	■	■	■								
							■	■	■	■				
											■	■	■	■

(9) Expertise Required

1) Team Leader (Regional Development Planner)
2) Water Resources Management Engineer
3) Hydrologist (Including Modeling)
4) Hydrogeologist
5) Irrigation/Drainage Engineer
6) Agronomist

7) Environmental Management Engineer
8) Water Supply Engineer (Including Water Quality)
9) Institutional and Organization Planner
10) Socio-economist and Financial Planner
11) GIS Specialist

(10) Implementing Agency

The Ministry of Energy and Water Resources shall be the implementing agency and also acts as the coordinating organism in relation with other government and non-government organization for the smooth and appropriate implementation of the Study.