Integrated Water Resources Management for Alana Valley in Kurdistan Region - Iraq *

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Abstract

The present research has managed the water resources of Alana valley by using Water Evaluation and Planning (WEAP) software which was developed rapidly during recent drought years by Stockholm Environment Institute. The WEAP can model demand and supply and build different scenarios that may occur, and it is supported by Geographic Information System (GIS) layers, all climatic data, hydrologic data and any other data available from previous studies and models to give a clear view about Integrated Water Resources Management (IWRM).

WEAP program results shows that annual runoff in normal year was about (69.8 MCM), for Non-agricultural demands represent only 7.3% of all demands, and total demand was (8.8 MCM), about 75% of non-agricultural demands represented by Khalifan village. Even though the irrigation demands are high, but only 10% of all arable area are irrigated which is (486ha) and the rest depend on rain or are not cultivated. This area requires reservoir or system of reservoirs with capacity (5MCM) at least to satisfy all demands during summer, which now depend mostly on groundwater resources.

Keywords: Integrated Water Resources Management (IWRM), Water Evaluation and Planning (WEAP), Alana Valley, GIS, FAO, quantity and quality scenario simulations.

Introduction

Integrated water resources management (IWRM) is the process of formulating and implementing shared vision planning and management strategies for sustainable water resources development and utilization with due consideration of all spatial and temporal interdependencies among natural process, human and ecological water uses[A.Castelletti].

The demand for water in the developing world, of which the Middle East is a part, has grown significantly over the past thirty years, as the result of an accelerating population growth. In the Middle East the average annual population growth is currently 3% and, as a result, scarce water resources of the region are being severely drained since water for irrigation is competing with water needed for domestic and industrial use in the rapidly growing metropolitan areas. The result is that there is a growing gap between food production and population size in all of the countries of the Middle East. In the Tigris-Euphrates system, for example, both Turkey and Syria are engaged in enormous agricultural development in order to provide for their expanding populations. Another factor affecting water availability throughout the world in general, and in the Middle East in particular, is poor water management and the increasing politicization of agricultural policies which encourage water waste and inefficient irrigation systems [Nurit Kilot].

Life, Economic and social developments are not possible without sufficient water of right quality, The quantity of fresh water available is invariant with time, (IWRM) leads to

* Cited from M.Sc. Thesis

using water in best way, and IWRM should start at local levels (fields, farms and villages) then regional levels (catchments and river basins) [S.K.Jain].

Scope of the Work

In order to develop an integrated water resource management simulation model using Water Evaluation and Planning program (WEAP) version 21 for Alana valley, which can be a step toward understanding water resource management issues, environmental and socio-economic impacts of various water resource management practices, this is trying to develop a clear picture through linking the demands and supplies in a model by different scenarios that can help to understand the real situation in the area and the predictions due to future changes like reservoirs adding, and possibility of increasing downstream requirement.

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Field Works

Field works are done by visiting all villages and checking boundary of catchment area by GPS instrument. All official places in the area under study were checked for any statistical data available. Different kinds of people from the villages had been met and interviewed, and notes about all aspects of life in the area under study were taken. GPS instrument used to locate Demand sites, Sources of water, and track the new road to the sub-catchment (Malaccan's Valley).

Samples of water from all sources (springs, river sections and wells) has been taken to obtain (DO and BOD) tests at the sanitary laboratory of the civil engineering department. Flow measured by using section of river and current meter for main and small springs, it has been measured by other methods like stopwatch and floating object or directly collecting a volume of water in a specific time.

Model Simulation

Simulation model by WEAP software is prepared; Field data is processed to be used in WEAP. Shape files and accurate mapping by (GIS) and (MapInfo) software prepared for the catchment and sub-catchment then used in WEAP. Integrated scenarios by using WEAP program are prepared. The FAO's software (CropWat4 version 4.3) been used for obtaining reference Evapotranspration and check other crop related data. Results from WEAP scenarios are analyzed and discussed, see conceptual model Fig.(1).

Description of the area under study

Alana Valley is in Kurdistan region located in north east of Hawler(Erbil) governorate, lies between Northing N(36.4227° and 36.625°), Easting E(44.66° and 44.36°) as shown in the Fig.(2) .

Generally Alana valley is mountainous area with elevations from (650m) to more than (2200m) above mean sea level. The approximated total catchment area is about 231km² (92400 Dunams) and contains one sub-catchment of 86.3km² (34520 Dunams) and this sub-catchment called (Malaccan’s Valley). Totally there are 32 villages in the Alana valley with population about (22183 people) and number of families are (3207 families) so average family members estimated to be approximately (7) due to above data [FAO]. 72% of population clustered in Khalifan, the rest 10% distributed in 11 villages of sub-catchment and 18% in 20 villages of main catchment, the data of all villages and its population are listed in Table (1).

The slope of the lands are mostly steep slopes except some agricultural lands along the bank of the river having less slopes, from map the total length of Valley is 36km and difference in elevation is 1550m, average slope is 4.3%, generally the slope of sub-catchment area is steeper than that of the main catchment.

This area contains a lot of beautiful scenes and good recreational locations like the well known one (Fall of Gali Ali).

Alana River with two other rivers (Balak and Sedakan) compose a (Rawandwz River) and then flown in to Greater Zab, which is one of the main branches of (Tigris), and proposed Bekhma Dam lies on Greater Zab at 3km away from Alana valley.

Data process

Mean monthly and annual rainfall extrapolation were made by geo-statistical method of U. S. Weather bureau equation [Joseph] for estimating the missing data of the centre of Alana valley by using the average monthly rainfall data of neighborhood gauging stations like (Khalifan, Rawandz, Soran/Diana, Shaqlawa, and Salahaddin/Pirmam) the distances of Alana from these places taken approximately from GIS maps. Result of interpolation shown in Table (2).

Evapotranspiration from Pirmam station data obtained by (CropWat4) software which uses FAO's Penman-Monteith equation, the final results are shown in Table(3), and variation of ETo is presented in Fig.(3).

Rainfall Runoff using FAO Crop Requirement

According to WEAP software the FAO Crop requirements are calculated assuming a demand site with simplified hydrological and agro-hydrological processes such as precipitation, Evapotranspiration, and crop growth emphasizing irrigated and rainfall agriculture. Non-Agricultural land classes can be included as well. Surface runoff found by rational method also to compare results [Jack S.].

Precipitation intensity, catchment size and land cover are very important in determining of runoff volume. Catchment area obtained from ArcGIS9.2 software, land covers obtained from general survey work done at 2000 under the supervision of FAO, 15 villages of this area also surveyed as shown in Table (4) and this survey obtained from Ministry of Water Resources/General Directorate of Planning and researches, the data of Table (4) has been transferred to percents (%) in order to represent all Alana Valley including evacuated villages in that time, also runoff coefficients obtained for each cover type[Lmno], as shown in the Table (5).

Water Year Method in WEAP

According to WEAP software the water year method allows use of historical data in a simplified form and exploration of the effects of future changes in hydrological patterns. The water year method also can be used to test the system under historic or hypothetical drought conditions, so climate changes will be more understood and can be presented in one scenario but not used in reference scenario. Hydrologic fluctuations are entered as variations from a normal water year (The Current account year is not necessarily normal water year). The water year method requires data for defining standard types of water years (water year definitions), as well as defining the sequence of these years for a given set of scenarios (water year sequence).

A water year type characterizes the hydrological conditions over the period of one year. The five types that WEAP uses are: Normal, Very Wet, Wet, Dry, and Very Dry, as presented in Table (6).

Demands

All demands (Municipal and Irrigations) are considered separately according to available data (FAO 2002) and other field investigations, in real there are regions who share same resources of water and have nearly same social habits, because of that we modeled demand sited according to the 7 region; Malakan, Sharsina, Tarinan, Bla, Bnawi, Alana, and Khalifan. Table (7a and 7b) represent demands.

Scenario Development

The purpose behind collecting and integrating information regarding water resources by WEAP in a model was to develop different scenarios, which will help decision making.

1. Reference Scenario

In reference scenario the actual data been used and is the base scenario for other scenarios and any sub-scenarios that required. The objective of reference scenario is to help people learn what likely could occur if current trend continue and to understand the real situation better. In this study the start year is 2002 were most data available (FAO works) and 2008 is last year with data gathered from Khalifan district and villages, but for sub-models regarding future, the simulation continued to 2015 by offsetting.

2. Quality Added Scenario

DO and BOD built in WEAP models been used with temperature modeled by WEAP, and quality of demand sites been entered according to minimum requirement for each use. By this scenario we will be able to find out the impacts of water quality on the water supply. By this scenario it is possible to determine whether if water treatment plant is required and where it supposed to be added in the system. The specifications for water quality use for municipal used by Iraq specification [Maysoon], and for irrigation purposes as specified by Scofield [Maysoon].

3. Groundwater Added Scenario

There were a lot of illegal wells in the area under study, and this scenario was more helpful to find out the estimated amount of groundwater withdraw to satisfy the demands. Also by this scenario the impacts of groundwater on other supplies will be detected.

4. Reservoir Added Scenario

Gali-Bla Dam data from Ministry of Water Resource final design report been used in this scenario, and this scenario will give two possibilities, one of them is the possibility of dam existence and how it affects the management, and the other possibility is to estimate amount of water surplus to be used in increasing irrigation land and supplementary irrigation.

A Gali-Bla Dam store (0.95MCM) at elevation of (987m), total height of the dam is (27m), free board is (2m) and remained (25m) is maximum storage level height. Table (8) shows (Elevation-Area-Storage) as presented by Narin-Company.

5. Climatic Change Scenario

The reference scenario is used to generate sub-scenarios of climatic changes like used basically by WEAP as water years (Very wet, Wet, Normal, Dry and Very dry) to obtain runoff in different cases and check its results with other scenarios.

6. Advanced Irrigation Options-Scenario

Type of irrigation application and it's irrigation application efficiency will be very considerable in IWRM because most of water available goes to agricultural demands, and this scenario will simulate the irrigation by advanced irrigation options like drip and sprinkler rates of water use, and in these methods the irrigation application efficiency is very high comparing to conventional methods[G. S. Gumman], and by this scenario we can find how much more arable lands can be irrigated if such methods used.

7. Downstream Requirement Scenario

One of objectives of this study was to find the problems and probable solutions for flow decrease in Gali-AliBeg fall in recent years, which is the main downstream requirement in the area as recreational location in summer, and in this scenario the proposed Gali-Bla reservoir is also compared to find its usefulness for this fall.

Rainfall-Runoff

From water year method scenario and for different climatic sub-scenarios with monthly rain for different water year type, the runoff from precipitation for the main and sub-catchment was as shown in the Fig. (4), in normal case the main catchment runoff was 49(MCM) and sub-catchment runoff was 20.9(MCM) and normal year runoff on monthly basis shown in both Fig.(5)

The rainfall runoff relation for Alana valley was as shown in Fig.(6), equation (1) is equation of runoff , then this relation compared with another curve obtained by runoff data from Khalifan gauge station as shown in Fig.(7).

From the Fig(6) : a= 10/211 and b=6.8

$$R = \frac{10}{211} P - 6.8 \quad \text{...} (1)$$

Municipal Demands

Municipal demands were 7.3% for current account year. From the reference scenario, increase of population is rapid according to existing data and exceeds 12%, and even if this rapid increase of municipal demand continued till 2015 the water demand still not significant which it reaches 3.3MCM annually, Fig.(8) shows the curve of all municipal demands from 2002 to 2015

Irrigation Demands

The total irrigated area is (486ha) and this represents (10%) of all arable lands available in this area, and most of these lands beside the bank of river, other arable area when used depend completely on rain fed. From the reference scenario based on the irrigation rate of (16680 m^3/ha/year) the demand was 8.1MCM without losses annually, but with losses it reaches 10.133MCM and maximum requirement is 2.2MCM on August as shown in the Fig.(9), and these demands shared by all 18 canals in the area.

If the proposed Gali-Bla reservoir used the unmet demand difference will be only 510.7 thousand cubic meter on May and other months will be same as shown in Fig.(10), and that means the amount of water in this reservoir which is less than 1MCM is not enough to be used instead of groundwater with current irrigation application rate.

Calibration of the model

Half of Normal year for Khalifan rainfall data was used for calibration of the model. Data were used to calibrate the model was of years (2002 to 2005) used for calibration of runoff coefficient for the normal year.

The model was applied on the rest of Khalifan gauge data (2006-2008), Fig.(11) shows the calibration of model by gauge station data in normal year, were the annual runoff was (50 MCM) by gauge station and (47.6MCM) from the model at same location using runoff coefficient values (0.27) with correlation obtained (R=0.87). After applying the model in second part of data as shown in Fig.(12) the annual runoff was (44.5 MCM) at gauge station and by the model it was (54.43MCM)

Conclusions

1. Runoff for Alana valley in normal years was (69.8MCM), and for dry years was (41.4MCM) and these results had been used by WEAP as part of inflow to the river catchment area, and from the simulation it divided to two parts in order to separate the area of proposed dam in sub-catchment and normally the runoff was (20.9MCM) and for dry years (12.4MCM).
2. The total catchments municipal demands represent only 7.3% of demands which it was (0.6MCM) in 2002 and (1.4MCM) in 2008. It is concluded that the management of surface water will cover needs of municipal demands, but it requires water projects for the regions that suffer from drought and completely depend on ground water like villages in Sharsina region.
3. Irrigated area is (486ha) represents only 10% of all arable area available which requires more than (8MCM) of water without losses. results from advanced irrigation scenario show that irrigation area can be increased to about 3times if more efficient method of irrigation used. Most of canals are unlined and by length represent more than 70%, and total annual losses predicted to be about (2MCM).
4. Generally proposed Gali-Bla reservoir will not hold a significant amount of water and for each month of summer only (0.2MCM) should be released and this amount only can be considered with advanced methods of irrigation.

5. Gali-AliBeg fall represents the only downstream requirement as recreational place in summer. This fall cannot be improved by Gali-Bla reservoir even if ($1m^3/s$) considered as its requirement, the storage of reservoir will not be enough for June.
6. Quality constituents like DO, BOD, and TDS was considered in the quality input data of WEAP and it didn't affected the system because the intakes are from upstream of Alana region and away from point source pollutions of the villages or directly taken from springs.

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Table (1) Villages and population of Alana valley (FAO 2008)

No.	Name of Village	Coordinates		No. of Families	Average persons per family	Population	% of population	Water resources
		N	E					
1	Alana	36.5432	44.4424	126	5.35	674	3.04%	River+Deep Well
2	Bardok	36.5031	44.5306	4	9.75	39	0.18%	Spring
3	BlaUpper	36.5092	44.5213	4	9.25	37	0.17%	Spring
4	BlaLower	36.5251	44.4976	75	7.87	590	2.66%	Spring+Water Project
5	Bnawi	36.5026	44.4732	99	5.86	580	2.61%	Deep Well+Water Project
6	DashtiLoka	36.6187	44.3964	6	6.83	41	0.18%	Spring
7	Gorasher	36.4678	44.5762	9	5.11	46	0.21%	Spring
8	Harwtakawn	36.4705	44.4982	9	6.56	59	0.27%	Spring
9	Jolamerg	36.5878	44.4137	93	5.67	527	2.38%	Spring
10	Kandor	36.492	44.5342	24	8.75	210	0.95%	River
11	Khalifan	36.6104	44.4064	2164	7.34	15890	71.63%	Spring+River+ Water Projects
12	Malaccan	36.4603	44.5864	105	3.84	403	1.82%	Spring+River
13	MalaccaniSaru	36.4428	44.6131	12	5.42	65	0.29%	Spring
14	Rmawezh	36.5544	44.4294	81	5.00	405	1.83%	Deep Well
15	Sharsina	36.488	44.4822	52	6.10	317	1.43%	Deep Well
16	Sartka	36.4581	44.4973	12	7.08	85	0.38%	Small Spring
17	Sharkan	36.5756	44.4228	37	6.86	254	1.15%	Spring
18	Tarawa	36.4758	44.4785	21	8.33	175	0.79%	Spring
19	TarinaniKhwaru	36.4847	44.5503	51	6.24	318	1.43%	Spring
20	TarinaniSaru	36.4792	44.5478	60	8.35	501	2.26%	Spring
21	Tutmara	36.4819	44.4901	45	4.84	218	0.98%	River+Deep Well
22	KaniRash	36.5631	44.4237	12	5.75	69	0.31%	Spring
23	KaniPisan	36.5518	44.4858	3	8.00	24	0.11%	Spring
24	Kaniwatman	36.614	44.3791	0		0	0.00%	
25	Zelakan	36.5167	44.4809	23	4.87	112	0.50%	Spring
26	Grdkok	36.5104	44.4723	29	6.14	178	0.80%	Spring
27	Gurgar	36.5199	44.4671	13	6.92	90	0.41%	Spring
28	Khandor	36.5343	44.4724	11	7.55	83	0.37%	Spring
29	KaniNeri	36.4868	44.4418	3	7.67	23	0.10%	Spring
30	Ashokan	36.5201	44.4987	4	7.75	31	0.14%	Spring
31	Berokan	36.6093	44.3718	17	7.00	119	0.54%	Spring
32	Kutak	36.4887	44.543	3	6.67	20	0.09%	Spring
	TOTAL			**3207**	**6.92**	**22183**	**100.00%**	

Table (2) Alana Rain data obtained by U.S weather bureau equation for interpolation.

Month	pX (mm)	pP (mm)	pS (mm)	pSo (mm)	pR (mm)	pX/dX^2	pP/dP^2	pSo/dSo^2	Ps/dS^2	pR/dR^2	$\sum P/d$	***pA (mm)***
Jan	142.3	120.4	158.5	55.6	139.4	1.76	0.17	0.22	0.46	0.82	3.50	***129.32***
Feb	185.3	114.8	160.7	140.2	173.9	2.29	0.16	0.55	0.47	1.03	4.56	***169.46***
Mar	145.7	87.2	120.7	99.6	169.6	1.80	0.12	0.39	0.35	1.00	3.74	***138.25***
Apr	104.6	69.7	115.7	120.8	134.9	1.29	0.10	0.47	0.34	0.80	3.05	***113.03***
May	34.7	25.6	22.4	21.7	54.5	0.43	0.04	0.08	0.07	0.32	0.95	***35.31***
Jun	0.8	1.5	0.5	2.1	0.0	0.01	0.00	0.01	0.00	0.00	0.02	***0.78***
Jul	1.3	1.1	0.0	0.0	0.0	0.02	0.00	0.00	0.00	0.00	0.02	***0.64***
Aug	1.5	0.0	0.0	0.0	0.0	0.02	0.00	0.00	0.00	0.00	0.02	***0.68***
Sep	2.1	2.4	0.0	0.0	0.0	0.03	0.00	0.00	0.00	0.00	0.03	***1.12***
Oct	39.0	36.4	21.4	25.7	19.2	0.48	0.05	0.10	0.06	0.11	0.84	***30.50***
Nov	75.0	63.8	100.7	81.3	98.8	0.93	0.09	0.32	0.29	0.58	2.26	***83.36***
Dec	110.8	79.0	123.8	61.7	129.5	1.37	0.11	0.24	0.36	0.77	2.92	***107.37***
Annual	842.9	601.9	824.3	608.7	919.8	10.41	0.83	2.38	2.41	5.44	21.91	***809.83***

Table (3) average climate data and ETo results for Pirmam station data by CropWat4 program.

CropWat 4 Windows - [Text Editor {C:\CROPWATW\REPORTS\AVETO.TXT}]

File

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3/11/2010                                              CropWat 4 Windows Ver 4.3
********************************************************************************

                          Climate and ETo (grass) Data

********************************************************************************
Data Source: C:\CROPWATW\CLIMATE\AVETO.PEM
--------------------------------------------------------------------------------
Country : Iraq                          Station   : Pirmam
Altitude: 1088 meter(s) above M.S.L.
Latitude: 36.62 Deg. (North)            Longitude: 44.22 Deg. (East)
--------------------------------------------------------------------------------
Month       MaxTemp  MiniTemp  Humidity  Wind Spd.  SunShine   Solar Rad.    ETo
            (deg.C)  (deg.C)     (%)      (Km/d)    (Hours)    (MJ/m2/d)   (mm/d)
--------------------------------------------------------------------------------
January       8.3      1.9       71.2      181.4      7.0        10.4       1.17
February      9.4      2.3       70.9      213.4      6.9        12.7       1.63
March        14.1      6.3       64.0      241.9      8.4        17.5       2.79
April        19.5     11.1       61.0      259.2      8.8        20.9       4.10
May          26.1     16.5       45.1      234.1      9.7        23.9       5.93
June         31.7     22.0       37.1      243.6      9.8        24.5       7.33
July         36.3     25.6       35.0      213.4     10.0        24.5       7.70
August       36.5     25.2       35.7      208.2      9.4        22.3       7.13
September    31.8     27.1       36.8      197.9      8.4        18.5       5.77
October      25.4     15.5       46.7      193.5      7.8        14.6       3.73
November     15.4      8.2       60.3      184.0      6.8        10.8       1.90
December     10.3      4.5       70.5      166.8      6.7         9.4       1.12
--------------------------------------------------------------------------------
Average      22.1     13.8       52.9      211.4      8.3        17.5       4.19
--------------------------------------------------------------------------------
 Pen-Mon equation was used in ETo calculations with the following values
 for Angstrom's Coefficients:
              a = 0.25          b = 0.5
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Table (4) Alana valley villages surveying.

Village Name	Area of Village Total (km^2)	Arable (km2)	Non-Arable (km2)	Orchard (km2)	Forest (km2)	Natural Pasture (km2)	Residential (km2)
malakan	**13.75**	3.25	1.625	3	2.25	3.6	0.025
kandor	**11.5675**	2.5	2.835	0.225	2.75	3.25	0.0075
bardok	**1.9075**	0.25	1.4175	0.02	0.1375	0.075	0.0075
Harutakon	**7.25**	1.5	2.75	0.61	1.125	1.25	0.015
Bnawi	**18.28**	2.8	7.6	2.5	2.875	2.5	0.005
bla	**19.575**	2.25	12.6225	0.15	2.75	1.8	0.0025
Gurgar	**5.4**	1.155	1.545	0.675	1.25	0.75	0.025
khandol	**3.4625**	1.4	0.5625	0.1875	0.875	0.4325	0.005
Kanipisan	**2.25**	0.3875	0.9725	0.15	0.21	0.5	0.0075
Alana	**14.1525**	3.75	7.3775	0.25	1.5	1.25	0.025
Kanirash	**3.4725**	0.9	2.5	0.0075	0.0625	-	0.0025
Jolamerg	**16.6425**	5.5	7.72	0.3125	0.8475	2.2375	0.025
Tarinaa	**4.14**	0.75	2.1075	0.0575	0.45	0.75	0.025
Birokan	**3.8325**	0.925	1.3025	-	0.725	0.875	0.005
Dashtiloka	**2.98**	0.75	0.775	0.075	0.625	0.75	0.005
Total	**128.663**	**28.0675**	**53.7125**	**8.22**	**18.4325**	**20.02**	**0.1875**

Source: FAO Land survey-2000/ Ministry of Water Resources.

Table (5) Land covers and runoff coefficients.

Land cover type	Percent Area	Runoff Coefficient	Area Weighted Runoff coefficient
Arable	21.815%	0.41	8.9%
Non-Arable	41.747%	0.3	12.5%
Orchard	6.389%	0.25	1.6%
Forest	14.326%	0.32	4.6%
Natural Pasture	15.560%	0.38	5.9%
Residential	0.146%	0.75	0.1%
Total	100.000%		33.7%

Table (6) Indicating the water year method by definition factor.

Annual rain (mm)	Water year definition	the average annual rain ranges (mm)	definition factor %
Minimum= 350.4	V.Dry	350.4 to 422.35	0.55
494.6	Dry	422.36 to 566.55	0.77
638.75	Normal	566.56 to 710.8	1
782.9	Wet	710.81 to 855.00	1.23
Maximum= 927.1	V.Wet	855.01 to 927.1	1.45

Table (7a) Average water requirement per day and annually [FAO]

Item	Average Water requirement		
	l/Item/day	l/year	m^3/year
capita	100	36500	36.5
cattle (heads)	20	7300	7.3
Sheep & Goat (heads)	10	3650	3.65
horses (heads)	45	16425	16.425
birds (bird)	0.5	182.5	0.1825

Table (7b) Summary of the water duty for the existing canals in the area under study [FAO,2002]

Canal No.	Canal Condition	Length (m)	Area Irrigated (ha)	Water Duty at Head regulator (l/s/ha)	Discharge (l/s)
1	Unlined	3692	28.584	2.1393	61.15
2	Unlined	3537	34.117	2.1394	72.99
3	Unlined	2037	10.055	1.7732	17.83
4	Unlined	1077	3.463	1.4785	5.12
5	Unlined	1280	5.455	1.7727	9.67
6	Unlined	1077	6.368	1.7730	11.29
7	Unlined	1899	17.391	2.0491	35.64
8	Unlined	1063	8.857	1.8990	16.82
9	Unlined	1563	8.187	1.4560	11.92
10	Unlined	1616	6.900	1.4565	10.05
11	Lined	2950	72.622	1.5936	115.73
12	Lined	5051	67.613	1.3484	91.17
13	Unlined	7174	89.476	1.7555	157.08
14	Lined	5243	10.842	1.7580	19.06
15	Unlined	2216	31.262	2.1016	65.70
16	Unlined	4123	52.096	1.7556	91.46
17	Unlined	845	6.046	1.7959	10.86
18	Lined	2596	26.486	1.7398	46.08
	Total:		485.82		849.61

Table (8) Elevation-Area-Storage for Gali-Bla Dam.

Elevation (m)	Area (m^2)	Storage (m^3)
961	0	0
963	97	36
965	1667	1689
967	5471	8595
969	11881	26008
971	18012	56652
973	27030	102150
975	37598	168073
977	47648	254160
979	58785	361989
981	71377	492888
983	85612	651613
985	101247	840018
987	115974	1059293
989	129266	13073.7
991	140519	1580169
993	151387	1875399

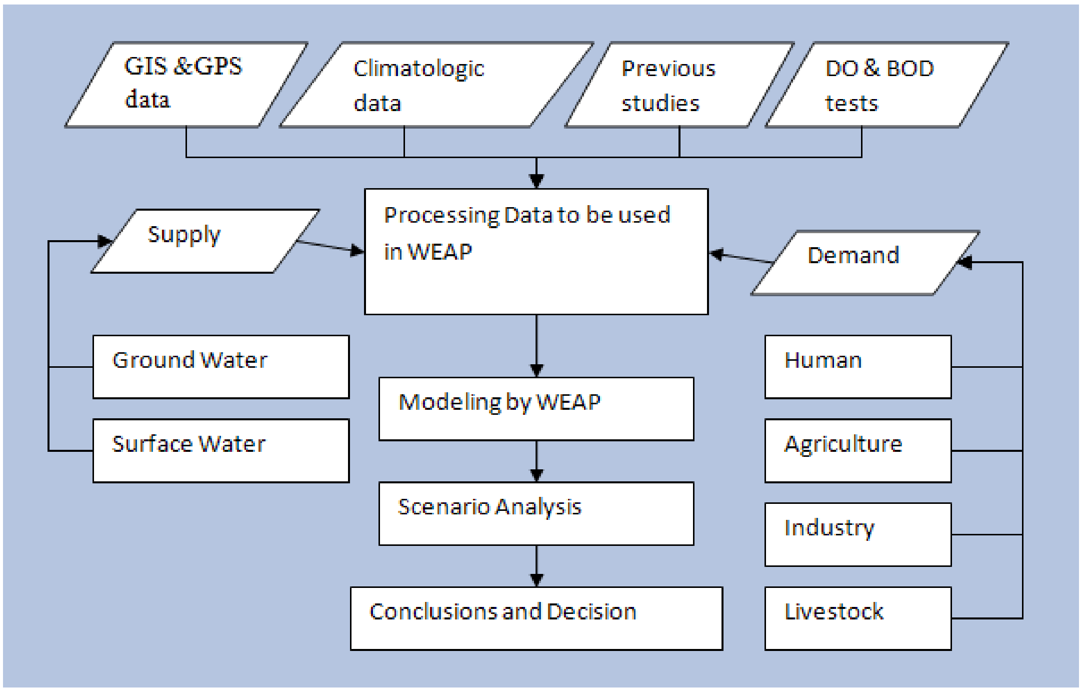

Fig. 1 Basic Conceptual Model of IWRM for Alana Valley

Fig. 2 Alana Valley General Map.

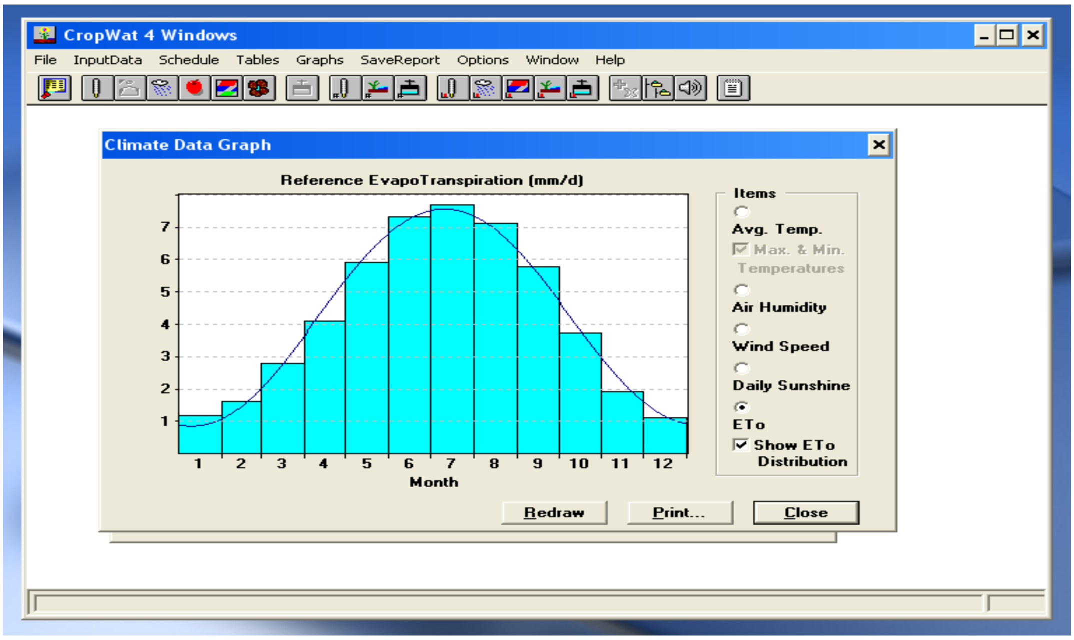

Fig. 3 Variation of ETo by CropWat4 software.

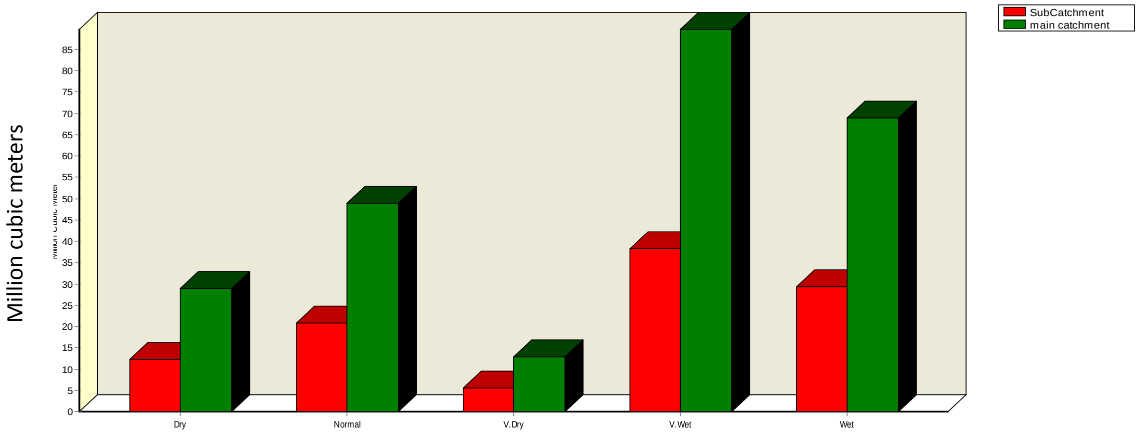

Fig. 4 Runoff from precipitation by WEAP for different year types.

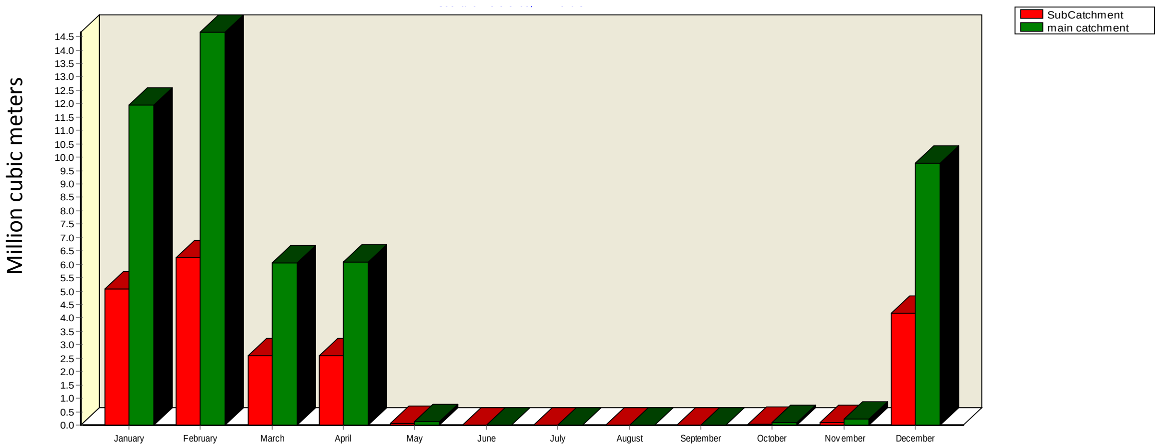

Fig. 5 Monthly runoff for normal year type.

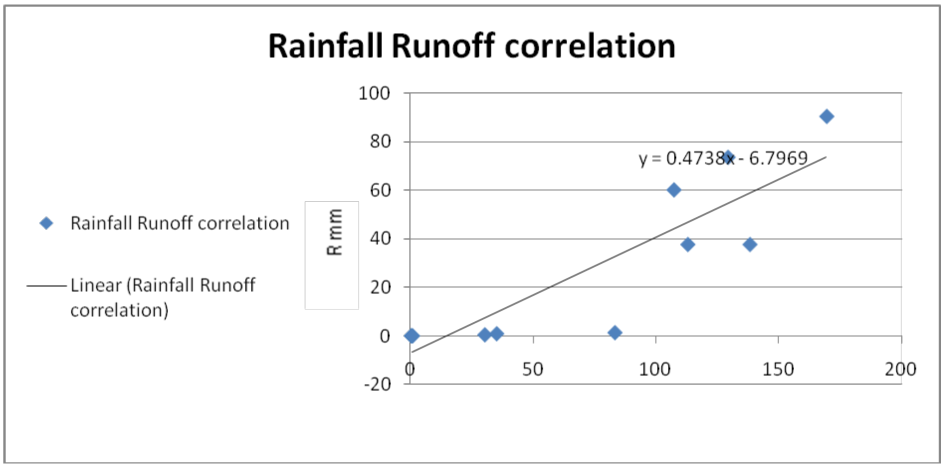

Fig.6 Rainfall /runoff correlation for Alana valley.

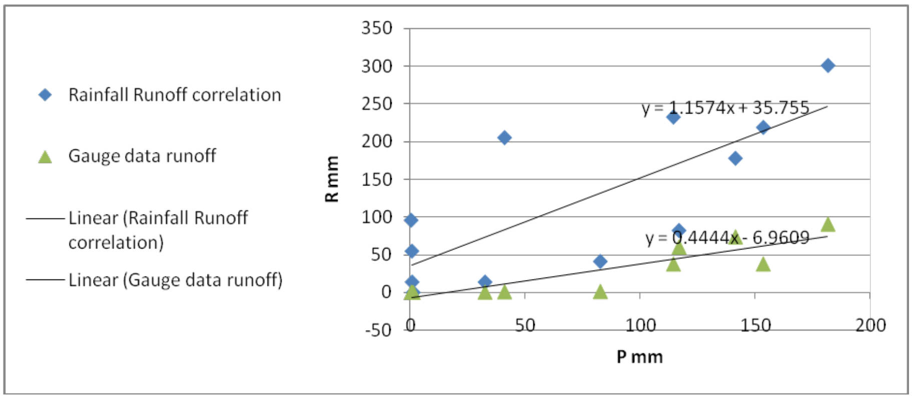

Fig.7 Rainfall /runoff correlation by WEAP and Khalifan Gauge station

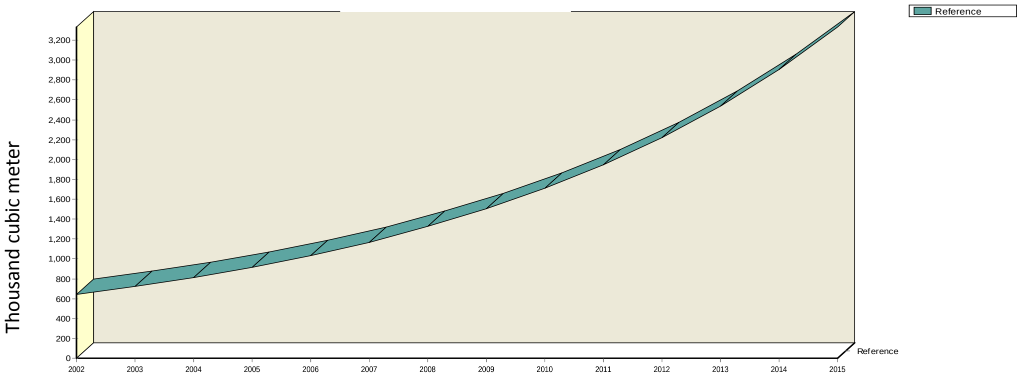

Fig.8 Municipal water demands increase in reference data.

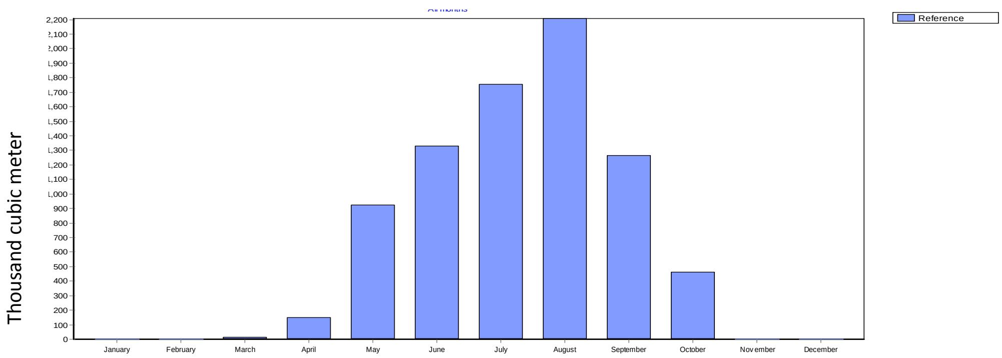

Fig.9 Monthly irrigation demand.

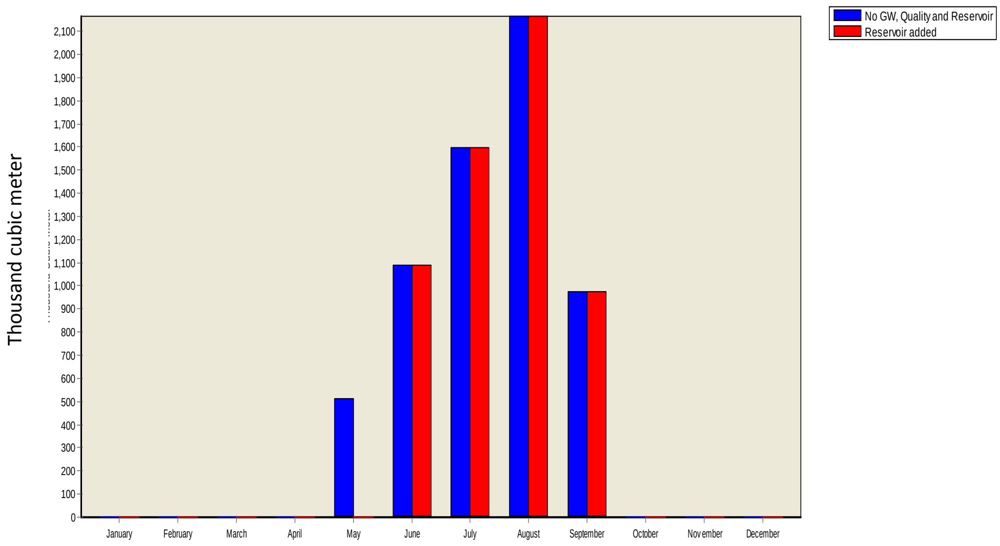

Figure (5.11): Unmet demand when reservoir exist or not exist.

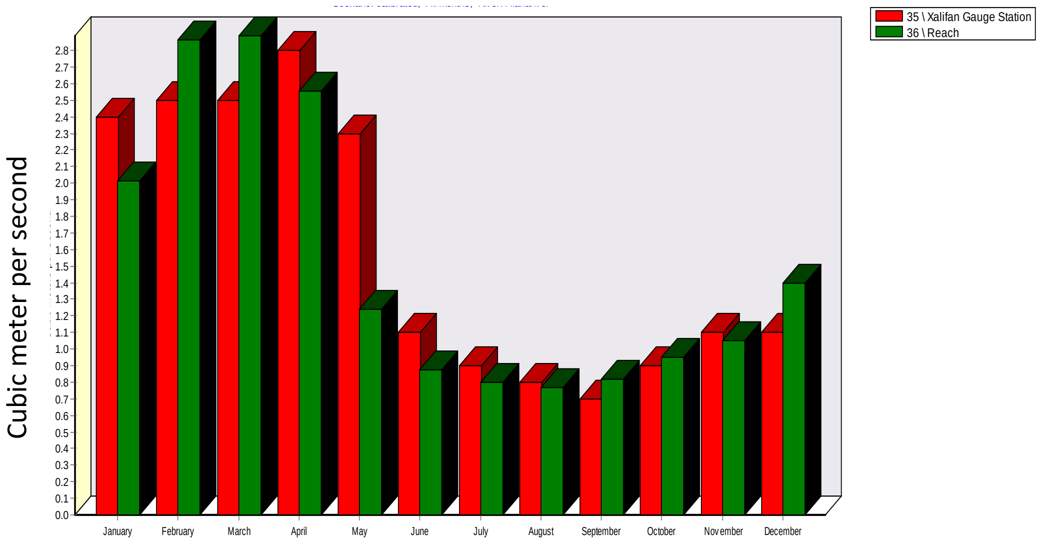

Figure (5.17): Calibration of the model by Khalifan gauge station (2002-2005).

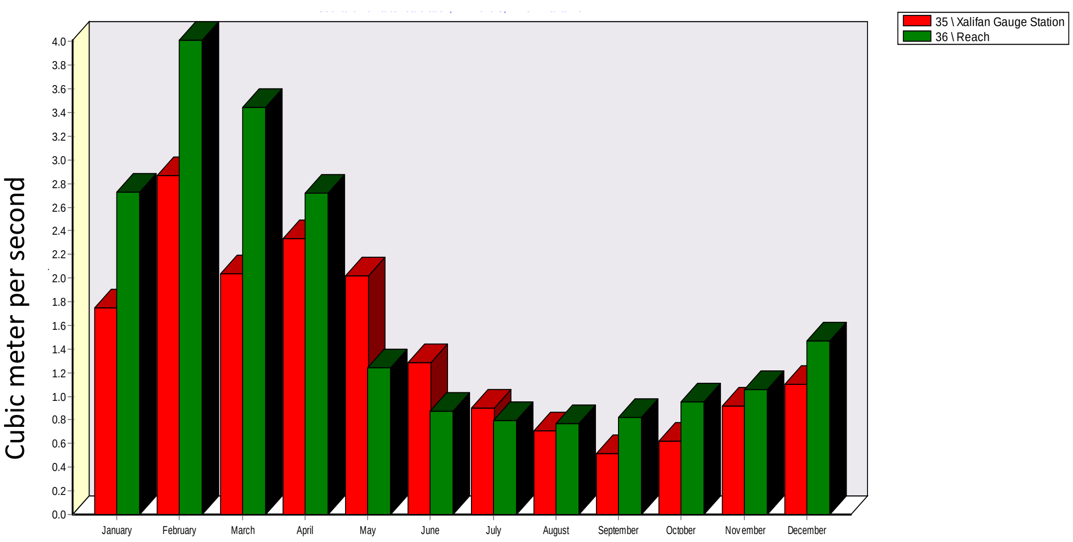

Figure (5.18): The comparison between modeled and gauge station after calibration (2006-2008).

ادارمليارمه ائيملك الى ليادهة اللاهد الى م كزنشاه الع زاك

من ألومى اوهى وادزمن اهم الق يا على ملع لصز , و التحديثات ادارمليارمه ائي جكن اه تياجه أو تبرزأمن من قى صغيره اومن واده (كيادة ألاهد) الدره يغ ى (٢٣١ كم مزبع) والدره دري هرا البحث من خلأمن ف انحسابي بأسم (WEAP) أه (تقيم و تخطيط مليارمه ائي) و الدره بزنمج وبحيرمن قبل معهد ستيكهيلم البيئي) خلأمن التغيرات من اخي للاخيره , وهرا البرنامج قادر على جمع عص اد ومتطلبات البياده سين اسيهات نجلفي هي بملب , وهيم زعيد من قبل مملي بهاتي الجغزافي (GIS) وجمع البيانات من اخى و لهى زروليجي و غيره امن البيانات تصلى من نتائج البحث الى ابقى وهرايع ى صيره واجحى حيم ادارمليارمه ائيملك الى (IWRM).

خرائطمن قى و البيانات (GIS) اد زتمع تبيت الخزود عن بجزنيق برنامج (GIS-9.2), يم استعمل (GPS) لبيت أكر من صحى مجزائك و الخزود, بزأت للاعم الحقلى باستخدام (GPS) لبيت أكر من النق ا ق الخزودبي لبياده و تخر زمياقعص لموى او و استخدامه انقا , ومن يم تم جمع يم ازج من هر وص اد لاجزائ ألحيات (DO) و (BOD) لتقييم جيدمى او , و اخيرا تم ق اشص زيفمه ائلين ليع . يم التعامل نغجمع البيانات التى تم جمعها بالاجزاى ابه البيانات الحقليى لكيهه قابلى للاستخدام انزايل صحيح برنامج (WEAP), مملا, كل بجيق ات مجزائك اه (GIS) و النقاط الحقلى اجتاج ابه التغير ابه (WGS84) ومليحق الأم sh. للعن بجزنيق البرنامج (MAPINFO), استعمل برنامج (CropWat4) الحص يم تفى (ETo) من البيانات الحيي . يج ز ك يين الوين ابيد للسلى يم أجاى ستسين ابيهات اخزاء لبل من : نيعى جيده ملي او ملي او الحيفى , أمجساب تماه ائي ماتقزحى , ألتعيومن اخى , بجزك للزوانمليق زى ومتطلبات ملهيب الدهزه.

خلأمن البزى للاوممن الداكه ا لم يزج , بيت النتائج الزئيسيي لمجع زمه البزنيه ابجريده الى ى صل ابه (٦٩,٨) على يهن ٣ , للاستعمالات الغير زراعيي لا نميل سيء (٧,٣٪) من الخابي الكلي , وكانت اقل من (١) على يهن ٣ وحيالى (٧٥٪) من هر و للاستعمالات الغير زراعيي نميلها امن قى وادزه وهى (هيف اه) , الدلب الكلى لهى لوصل ابه (٨,٨) على يهن ٣ , رغم انه للاستعمالات الزراعيي مزقعى ولكن قكت (١٠٪) من الاراضي الى الحلى لبسراعى تزوء تمس لحى (٤٨٦) هيكتار , اما الزيى البالقى فك يهه اموتم زه على اللاه لر قكت او نميل اراضى غير مسروعي . قدرز كبير مهاى لوملى تيسى جملته لخى همن خلأمن اسه له ك أه الدزه ملقي ابيهيه ائي و ين انائ الى زود و تقليل اجي ارومن القن يات عن بجرنيق تب لي القن يات يح يد باقع لي ياده وملهيب .

بالنيبه مزيع الدهز , كانت نيعيته ابحابيى , من حيث (الدغم, الزاغي , الويهد, DO و BOD), ولكن عن زوصيمه ائل ياده و حتى الدهايبي فيق ز مؤشرملينف ات بربب إق انائ الف يات ومى او الس زقاص عن هه وبعتبر هرا حمن الخزودهابر يح صرمب ننتائج البحث .

للاوفى للاخيره اقترح ابن ائستزبيعي اقل من فى يهمتزطيب (كم ا القين درايى الحزوء لحاجى هرا الى ز قريى (ابعد الهزلى), سليك يهفى زا لهى اخى و للاستعمالات غير السراعي , ولكن لاجطئ نهه تقرى الخابات السراعي , و أيه الى يتطئ من تق يهي شلأمه (كرى على بك), لأكثر من شه زوادز ضل الصيف , لاههرا البياده يتلب غساله اوليلي غسالات لا تقل سعته اعن (٥) على يهن ٣ لتى لبيى حوى ملمتطلبات خلأمه ضل الصيف , وهي للاههتم زنزليل ولسع فى ميليرمى او الحيفى .

[illegible] (IWRM).

[illegible] 231 كم² [illegible] (SEI), [illegible] (WEAP) [illegible] (GIS) [illegible]

[illegible] (ArcGIS-9.2) [illegible] (GIS) [illegible] (GPS) [illegible] (GPS) [illegible] (DO) [illegible] (BOD) [illegible]

[illegible] (GIS) [illegible] (WEAP) [illegible] (CropWat4) [illegible] (MapInfo) [illegible] (.shp) [illegible] (WGS84) [illegible] (ETo) [illegible]

[illegible] (69.8MCM) [illegible] (1MCM) [illegible] 7.3٪ [illegible] 75٪ [illegible] (8.8MCM) [illegible] 10٪ [illegible] 486 [illegible]

[illegible] (BOD، DO) [illegible]

[illegible] (1MCM) [illegible] (5MCM) [illegible]