Water Harvesting- Preparatory Studies

Improved Agricultural water uses Workshop

28-31 August 2017
Bari, Italy

Reduce vulnerability in Jordan in the context of water scarcity and increasing food /energy demand

Al-Ghadeer Al-Abyad watershed

National Center for Agricultural Research and Extension (NCARE)

Water Harvesting- Preparatory Studies

NCARE Project team

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PRESENTATION OUTLINE

- ✓ OBJECTIVE OF THE STUDIES
- ✓ TYPES OF THE STUDIES
- ✓ BIOPHYSICAL CHARACTERIZATIN
- ✓ HYDROLOGICAL STUDY
- ✓ LAND USE SUITABILITY AND CROPPING PATTREN (SCENARIOS) STUDY
- ✓ CONCLUSION AND RECOMENDATIONS

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Objective of the Studies:-

- **To estimate Runoff amounts for Al Gadeer alabyad watershed in Jordan.**

- **To evaluate the potential land suitability of Al Gadder Alabyad watershed for different land uses and alternatives (scenarios).**

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Types of Studies:-

1) Biophysical characterization

- Al-Ghadeer Al-Abyad watershed site was selected and characterized : Land cover/use maps, topographic/slope , contour and soil maps.

- **The Soil sampling for 20 profiles and 130 soil samples has been surveyed and analyzed.**

2) Hydrological study

Watershed/Sub-watershed maps, hydrological soil groups, calculations of run off volume, evaporation, infiltration rate data and rainfall map

3) Landuse suitability

4) Cropping pattern (scenarios) study

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Biophysical Characterization

Study Area

- The study area Al Gadeer Alabyad is located in the northeastern part of Jordan with an area of about 82 Km^2
- The annual rainfall varies from (200-250mm).

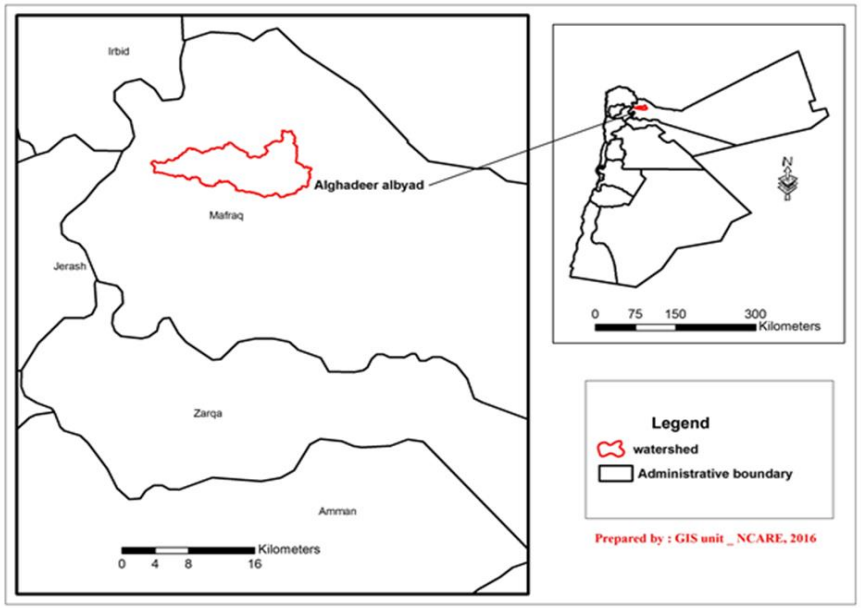
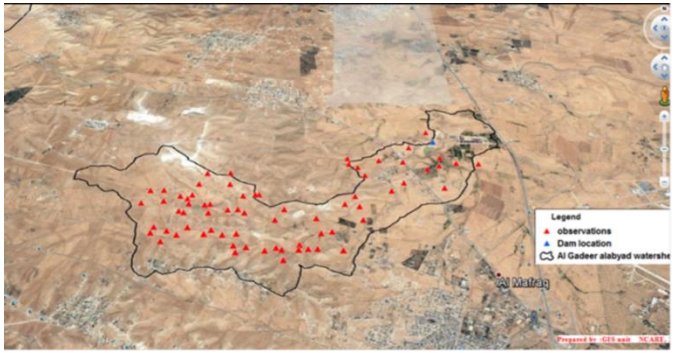


Figure (1) Location of Algadeer alabyad

Soil data collection

Twenty profiles were selected on two sub water shed, soil profiles were described and sampled according to the soil survey manual (*Soil Survey Staff, 2010*).



location of surveyed sites

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Field works (basic infiltration rate, bulk density and soil samples)

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Chemical water analysis for Al-Ghadeer Al-Abyad dam and a nearby well water samples

Lab. No.	Field No.	pH	EC (dS/m)	meq/L								
				Ca	Mg	Na	K	Cl	CO3	HCO3	SO4	Total Cation
*2017	Dam	8.06	0.26	1.31	1.75	0.31	0.03	1.56	0	0.35	6.76	8.67
*2017	Well (ground water)	8.1	1.11	3.38	5.27	0.45	0.13	4.26	0	0.90	4.63	9.79

Metrological Data

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall P50	(mm/month	34.98	30.19	31.01	6.49	0.52	0	0	0	0	3.96	11.87	26.13	145.2
Penman ETo	(mm/day)	1.57	2.23	3.33	5.1	6.9	8.25	8.29	7.43	5.83	4.09	2.63	1.67	1748
Evaporation monthly	(mm)	64	82.2	135.8	201.3	281.4	325.7	338.1	303.1	230.1	166.8	103.8	68.1	2300.4

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Soil chemical analysis for the selected field observations at ALghadeer Albaid location

Location	Extract		meq/L			Total Cat ions	Na%	SAR	ESP
	PH	EC(dS/m)	Ca	Mg	Na				
P G 1	8.1	0.97	2.40	5.60	2.19	10.19	21.45	1.09	0.34
P G 2	7.8	7.54	21.10	31.90	26.25	79.25	33.12	5.10	5.75
P G 3	8.2	1.09	5.00	3.00	3.37	11.37	29.66	1.69	1.18
P G 4	8.2	0.95	3.20	5.30	3.14	11.64	26.95	1.52	0.95
P G 5	7.8	0.85	2.80	2.70	4.43	9.93	44.64	2.67	2.55
P G 6	8.2	1.12	4.20	3.80	2.17	10.17	21.37	1.09	0.33
P G 7	8.3	0.86	2.90	3.50	1.74	8.14	21.37	0.97	0.17
P G 8	8.3	0.42	2.50	1.00	1.39	4.89	28.40	1.05	0.28
P G 9	8.2	6.89	20.00	19.00	26.09	65.09	40.08	5.91	6.78
P G 10	8.4	0.48	1.50	1.50	2.70	5.70	47.41	2.21	1.91
P G 11	8.4	0.66	1.90	1.10	3.61	6.61	54.63	2.95	2.93
P G 12	8.3	0.76	4.50	0.60	3.61	8.71	41.46	2.26	1.98
P G 13	8.4	0.57	1.50	2.50	2.66	6.66	39.95	1.88	1.46
P G 14	8.1	14.2	53.00	42.00	52.17	147.17	35.45	7.57	8.81
P G 15	8.3	0.63	2.80	1.50	2.66	6.96	38.22	1.81	1.36
P G 16	8.3	0.94	2.70	2.00	6.47	11.17	57.90	4.22	4.62
P G 17	8.3	1.20	4.30	3.10	5.99	13.39	44.73	3.11	3.15
P G 18	8.1	1.60	7.90	3.10	6.47	17.47	37.02	2.76	2.66
P G 19	7.7	6.90	19.20	18.60	36.71	74.51	49.27	8.44	9.84
P G 20	8.2	0.46	1.90	2.10	1.98	5.98	33.09	1.40	0.78

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PG1 Profiles Description

Horizon	Depth/cm	Descriptions
Ap	0 - 19	Reddish yellow (7.5YR 7/6) dry; strong brown (7.5 YR 4/6) moist; clay loam; moderately medium sub-angular blocky; slightly hard; firm; moderately sticky; moderately plastic; many fine spherical pores (<2mm); many fine roots (1-2mm); strong reaction to HCl; 3% sur-rounded to angular lime stone gravels (2-20mm); clear smooth boundary to:
Bw_1	19 - 33	Reddish yellow (7.5YR 6/6) dry; strong brown (7.5 YR 4/6) moist; clay loam; moderately medium angular blocky; moderately hard; firm; very sticky; moderately plastic; many fine spherical pores (<2mm); many fine roots (1-2mm); strong reaction to HCl; 3% sur-rounded to angular lime stone gravels (2-20mm); clear smooth boundary to:
Bw_2	33 - 76	Reddish yellow (7.5YR 6/6) dry; strong brown (7.5 YR 4/6) moist; clay; moderately medium angular blocky; slightly hard to hard; firm; very sticky; very plastic; many fine spherical pores (<2mm); few fine roots (1-2mm); strong reaction to HCl; <2 soft calcareous concretions(< 5mm); 5% sur-rounded to angular lime stone gravels (2-20mm); clear smooth boundary to:
Bw_3K_1	76 - 110	Reddish yellow (7.5YR 6/6) dry; strong brown (7.5 YR 4/6) moist; clay; moderately medium angular blocky; hard to very hard; very firm; very sticky; very plastic; common fine spherical pores (<2mm); strong reaction to HCl; <10 moderate to soft calcareous concretions(< 5mm); 2% sur-rounded to angular lime stone gravels (2-20mm); common dark coatings (1mm); clear smooth boundary to:
Bw_4K_2	110 - 115	Reddish yellow (7.5YR 6/6) dry; strong brown (7.5 YR 4/6) moist; clay; moderately medium angular blocky; hard to very hard; very firm; very sticky; very plastic; few fine spherical pores (<2mm); violent reaction to HCl; 15% moderate to soft calcareous concretions(< 5mm); 1% sur-rounded to angular lime stone gravels (< 20mm); common dark coatings (1mm).

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PG1 Profiles Description

Soil classification (USDA, 2010)	Fine; Mixed; Thermic; Calcic Haploxerepts.
Location	0.6 km South of Dam.
Coordinates	E 36.20809 N 32.38899
Elevation	656 m.
Aspect	North.
Physiography	Mid slope.
Parent material	Colluvium – derived from Limestone associated with chert.
Vegetation	Tree crops (Olives) under drip irrigation.
Land use	Tree crops
Soil Surface conditions	Dry / soft.
Surface cover	20 % gravels and stones on the surface (limestone with chert).
Date of Sampling	5/10/2016.
Author	Majed Bsoul.

Existing land use

The land use / land cover map was prepared by Data from the Royal Jordanian Geographic Center (RJGC) that represents year 2011

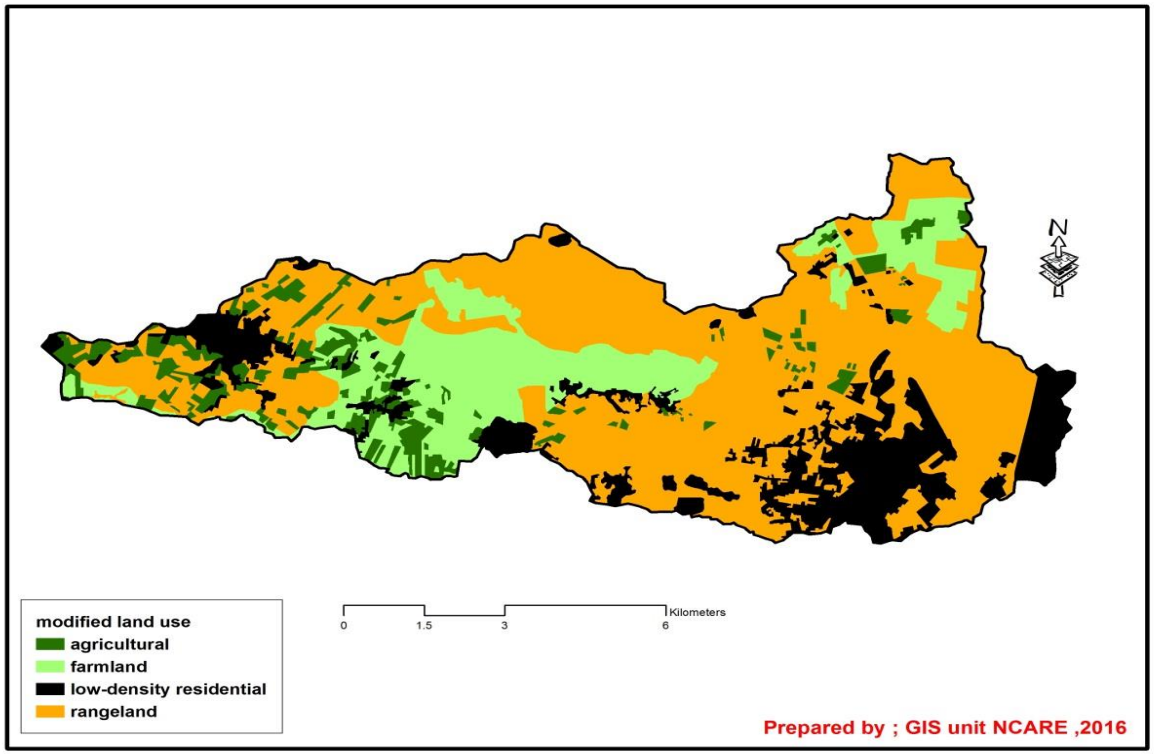


Figure (2) The modified land use /land cover map.

Slope & Rainfall maps

- **Slope** map was derived for the watershed using the DEM received from the RJGC. This map was classified into 3 classes: (0-2 %, 2-6%, > 6%) as shown in fig (3).
- **Rainfall** isohyets map was used in the calculation of runoff see fig (4). Two annual rainfall isohyets pass through Algadeer alabyad watershed (200,250 mm).

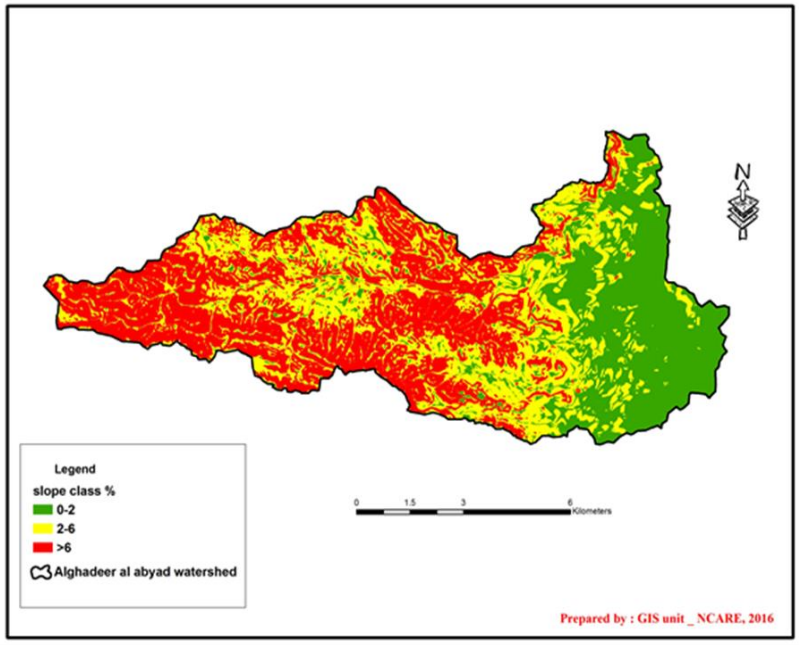


Figure (3) Slope map

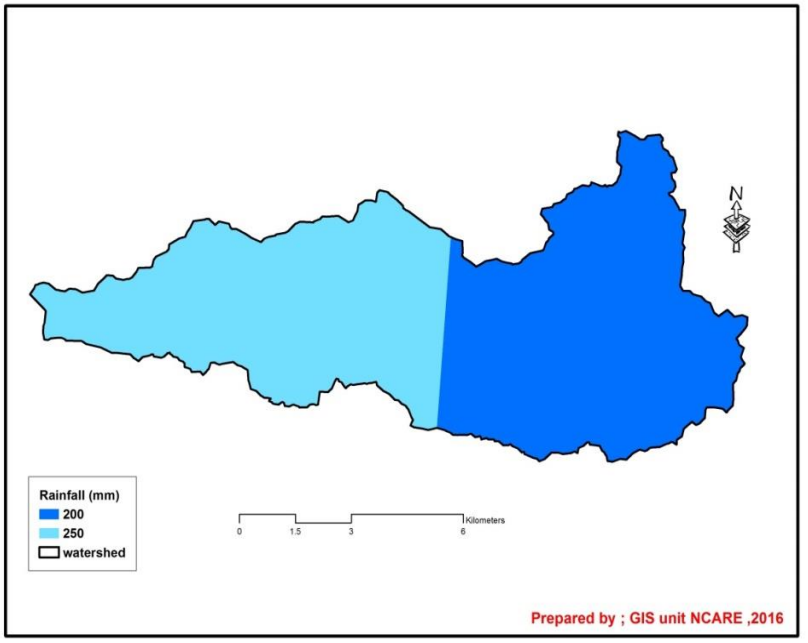
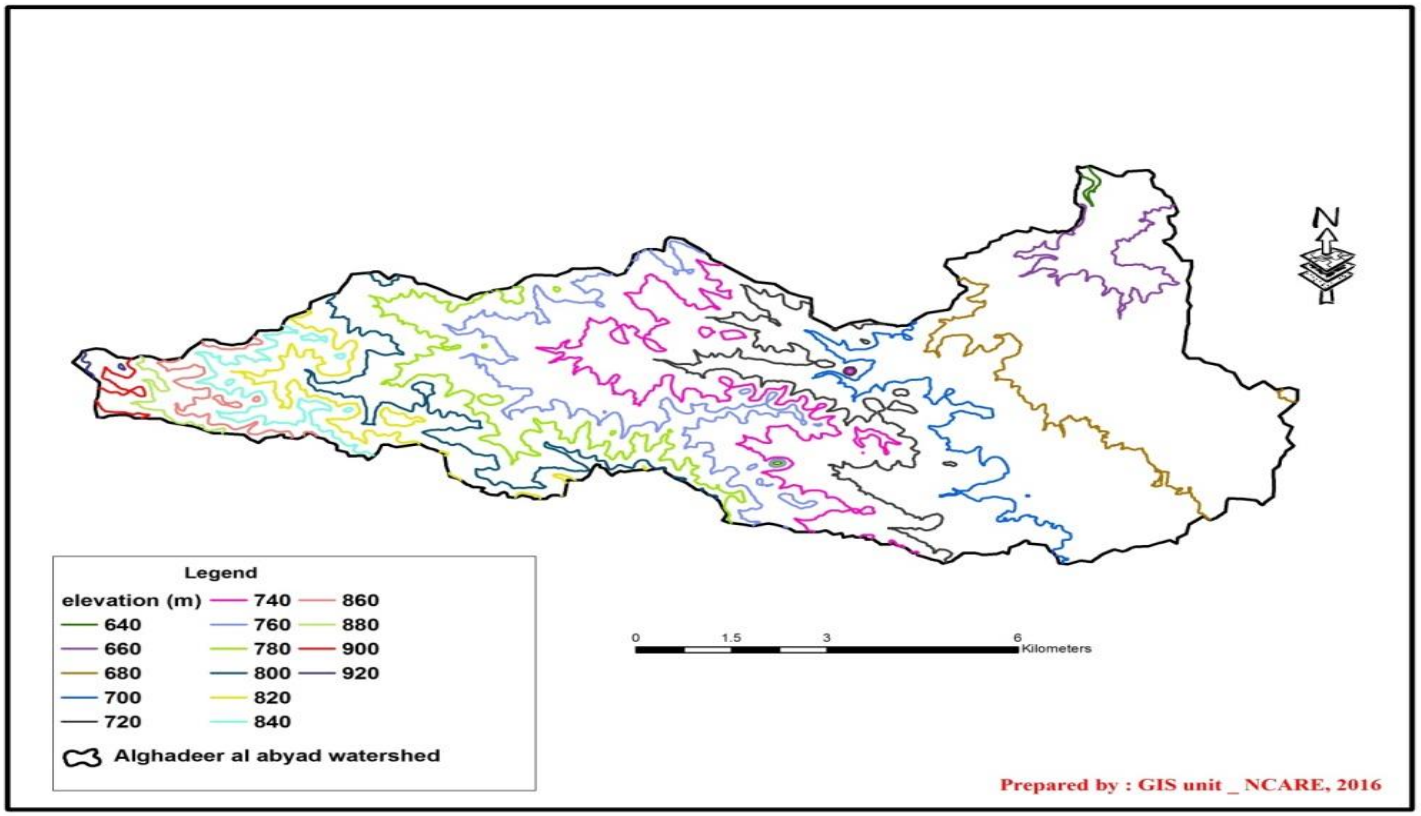


Figure (4) Rainfall isohyets map

Contour map with interval of 20 meters was derived from DEM as elevation ranges (640m- 920 m)



Figure(5) Contour map

Hydrological study - Runoff estimation amounts

- **Data collection and processing:**

- Watershed delineation and area calculation using hydrological module in GIS.

- Landuse: The map is classified into seven classes. The classes of land use have been modified into four classes to meet the runoff coefficient table.

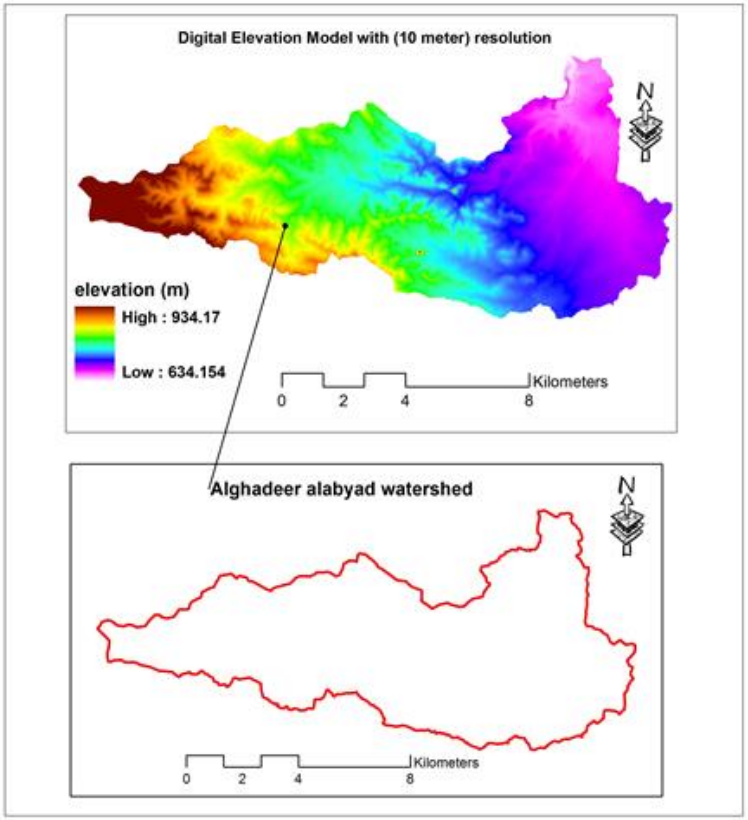
-Slope :Slope steepness is one of the most important factor for selecting the runoff coefficient necessary for the hydrological study.

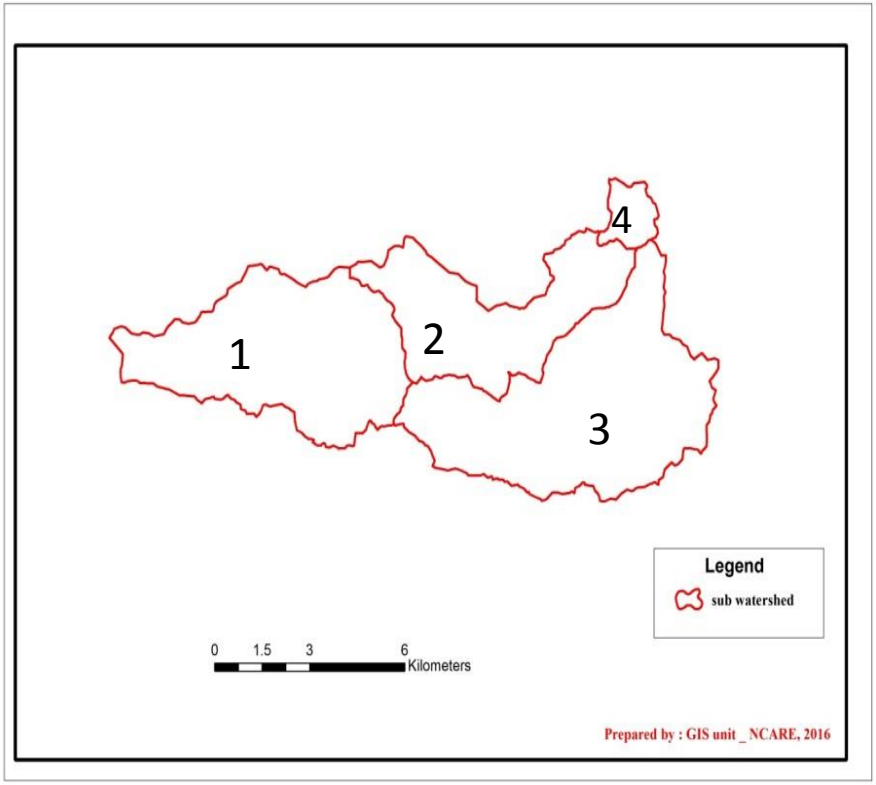
- Soil: the soil texture was required to find the hydrological soil groups (HSG).

- Rainfall: Rainfall isohyets map was used in the calculation of runoff.

Delineation of the watershed

The watershed was delineated based on DEM with a 10 meter resolution.





Figure(6) Watershed al Gadeer Alabyad was sub-divided into four sub-watersheds fig (8) using hydrological tool in the GIS

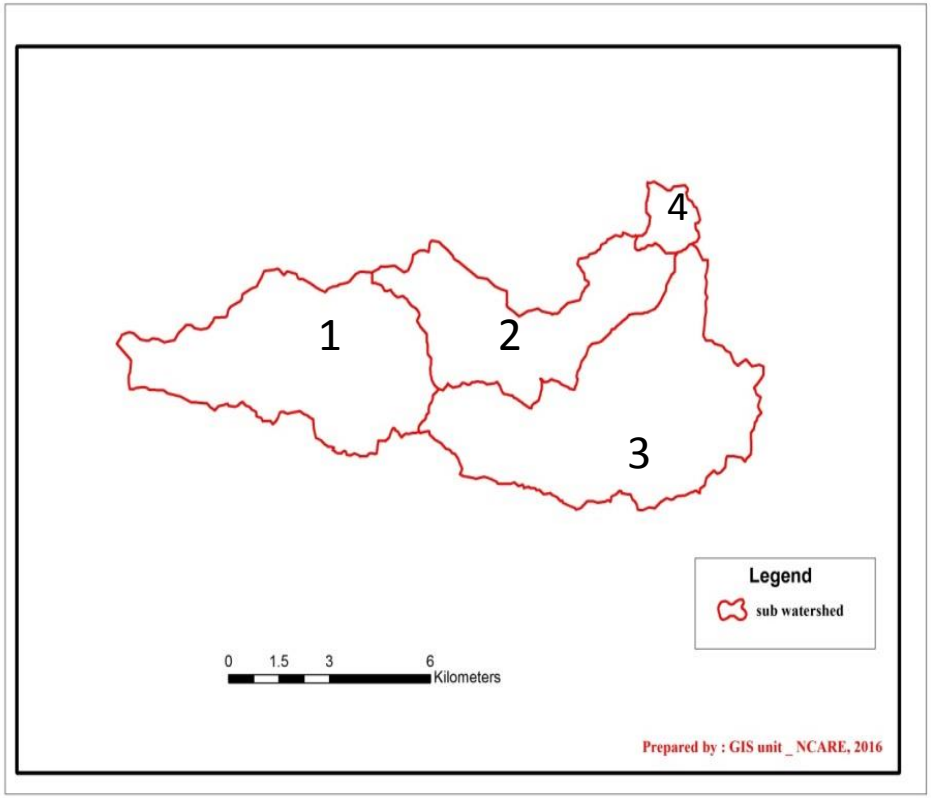
Runoff Estimation

The Rational Formula was applied as the most commonly used method of determining runoff volume for medium to large watersheds.
The Rational Formula is expressed as:

Runoff volume (m^3) = catchment area (m^2)* annual rainfall (m) * annual runoff coefficient %

The runoff coefficients were extracted from tables according to slope, land use, HSG

The area of the sub-watersheds



The area of all sub-watersheds was calculated

Sub water shed number	area(km²)
1	27.19
2	18.74
3	33.84
4	2.39
total	82.16

Figure (7) hydrological tool in GIS was used to derive four sub-watersheds

Effective runoff coefficient

✓The runoff coefficients were extracted from tables according to slope, land use, HSG

✓Effective composite Runoff coefficient (CRC) :

- For each sub-watershed the composite Runoff coefficient was modified according to specific features existing in the sub-watershed like:
urban areas (reduce the Runoff coefficient 50%.),
and roads intersection with streams (reduces the Runoff coefficient 1.5%.)
that affect the runoff collected at the outlet.

Table(3): Effective runoff coefficient for the four sub-watersheds

sub watershed No.	effective runoff coefficient
1	0.036
2	0.1
3	0.022
4	0.098

Runoff Estimation

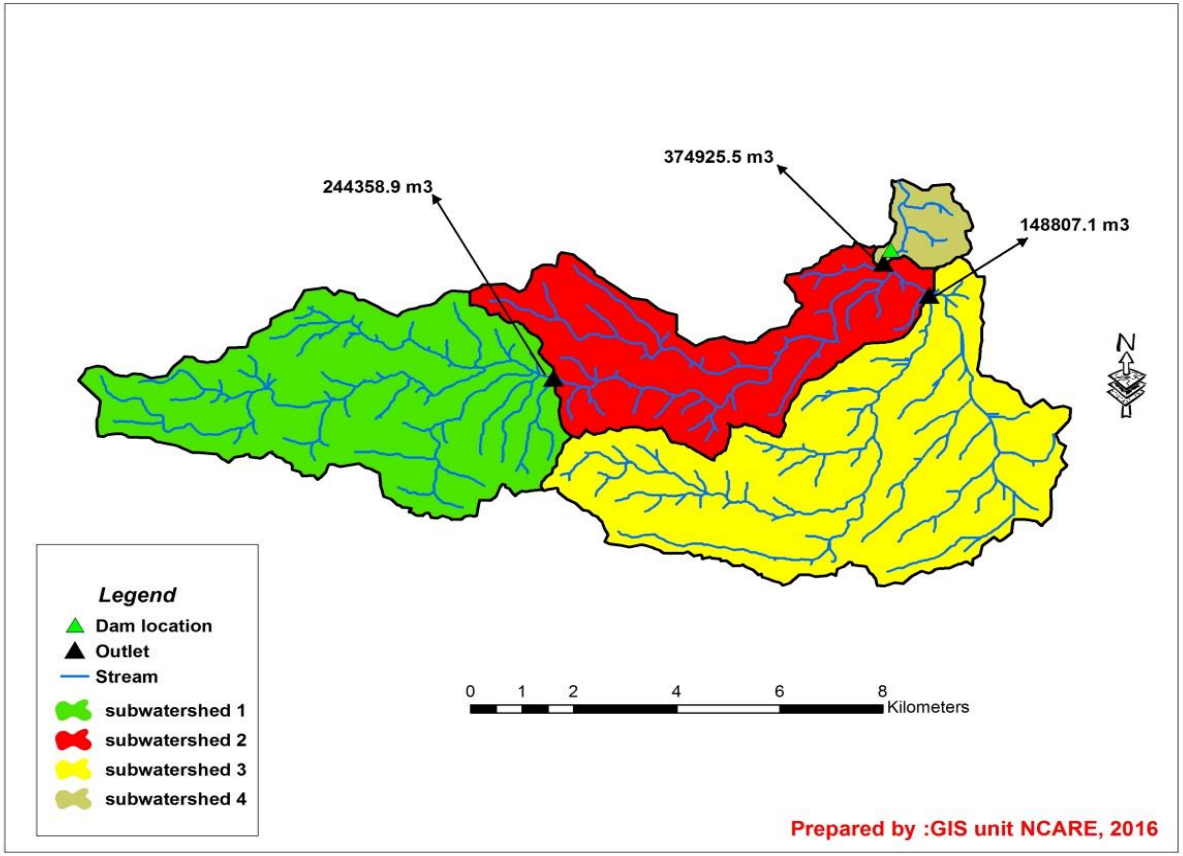


Figure (8) Runoff volume for all sub watersheds and the total at the outlet.

Land suitability mapping For Different Land Use and crop pattern

Data collection and processing:

- The field observations layer shown in figure (9) was the basic one for running the suitability analysis.
- Therefore, Data required for suitability analysis were collected through field survey and samples were analyzed.

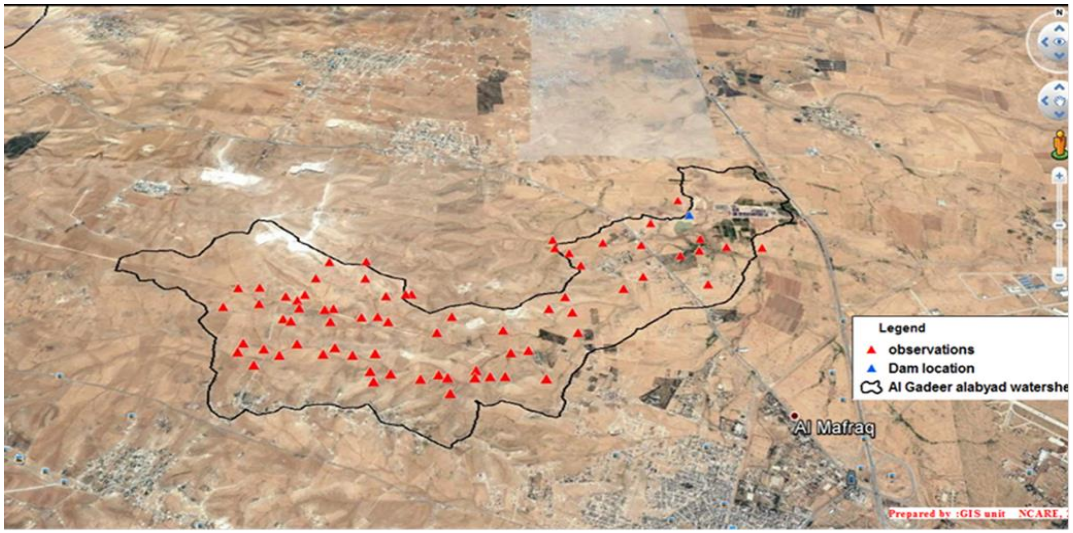


Figure (9): location of surveyed sites in AL Gadeer Alabyad watershed

Suitability for rainfed field crops

❖ The evaluation of land suitability deals with the ranking, or classification, of land into distinctly different categories, each one corresponding with a different potential for a particular use.

Categories commonly used are:

- Highly suitable (S1)
- Moderately suitable (S2)
- Marginally suitable (S3)
- Not suitable (NS)

Rainfed (field crops)	area (km2)	area %
S2	1.0	4.8
S3	16.6	78.9
NS	3.4	16.3
total	21.0	100.

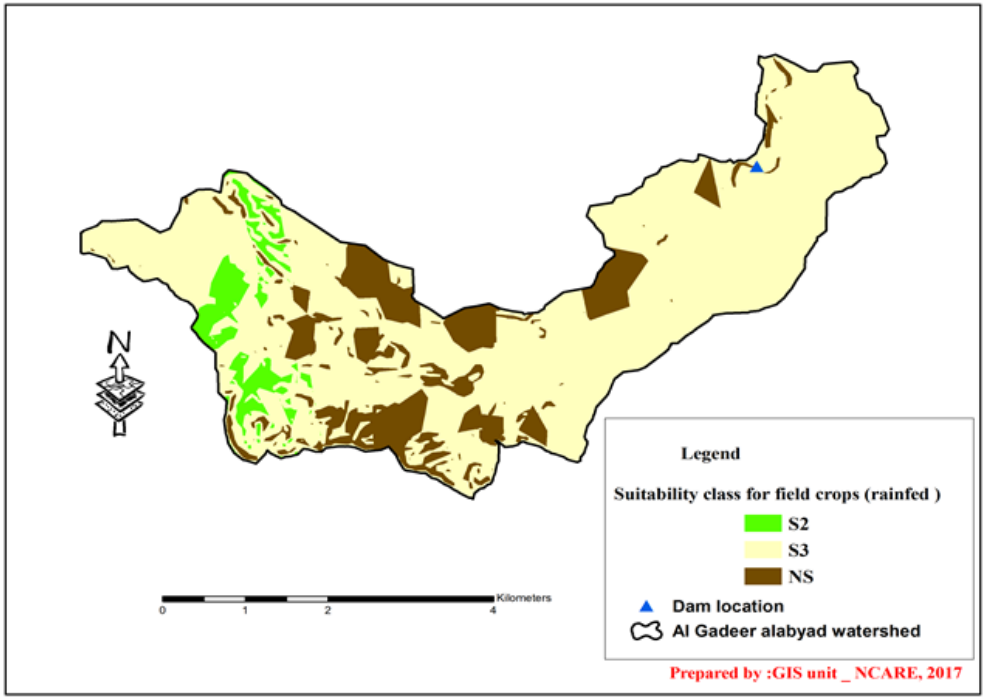


Figure (10) General land suitability for rainfed field crops

Land suitability for rainfed perennials

Low precipitation is a very severe climatic constraint that limits the suitability class which makes this land use to be not good choice for farmers.

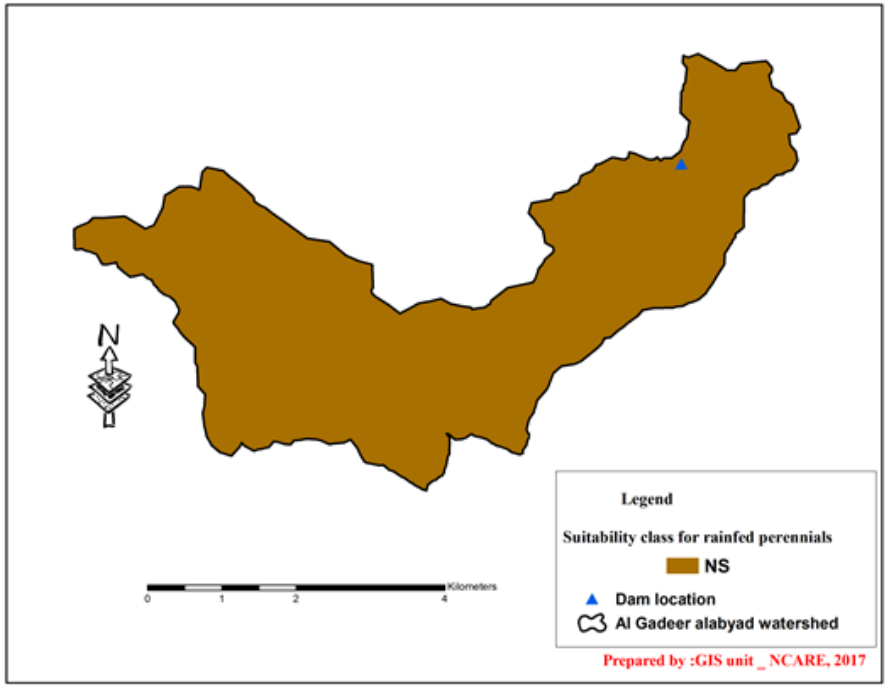
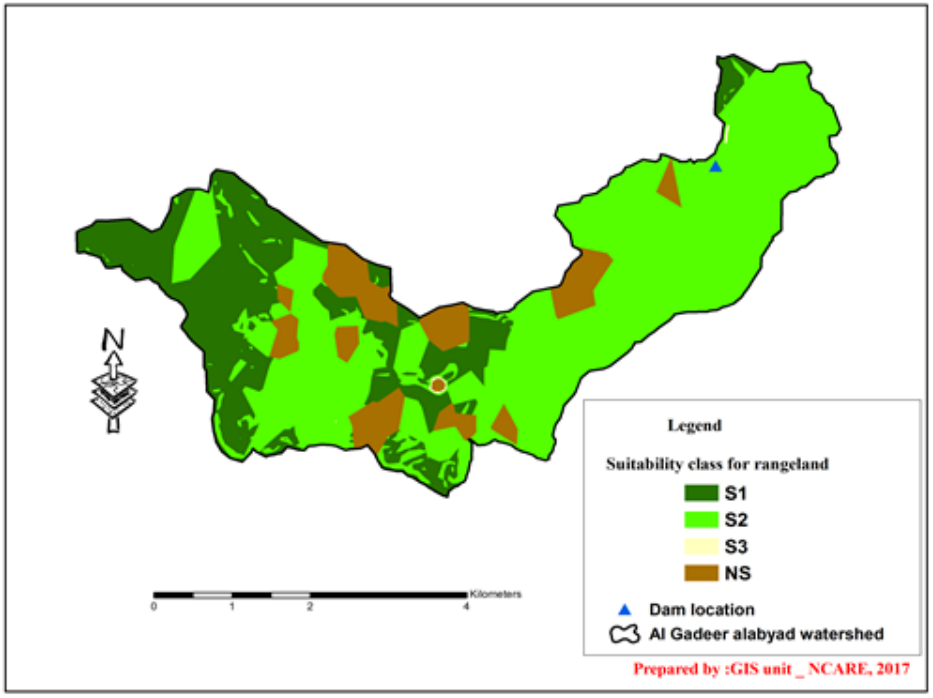


Figure (11) General land suitability for rainfed perennials

Land suitability for Rangeland

The combination of evaluated soil characteristics (AWHC, depth, salinity, erosion, rockiness, stoniness and slopes) is relatively favorable for rangeland, and results into a much better soil potential for rangeland in comparison with annual field crops and



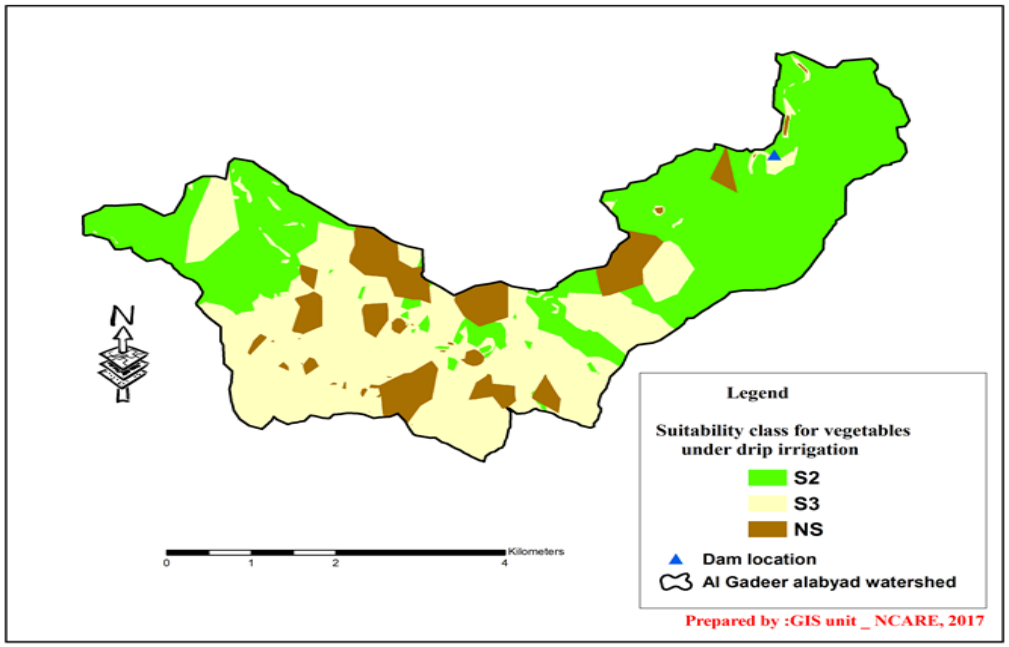
The area percentage of the suitability classes for rangeland

Rangeland	Area km2	Area%
S1	5.6	26.7
S2	13.1	62.4
S3	0.02	0.10
NS	2.3	10.9
total	21.06	100.00

Figure (12) general land suitability for rangeland

Land suitability for vegetables under drip –irrigation

47% of the total area is classified as moderately suitable for vegetables under drip irrigation



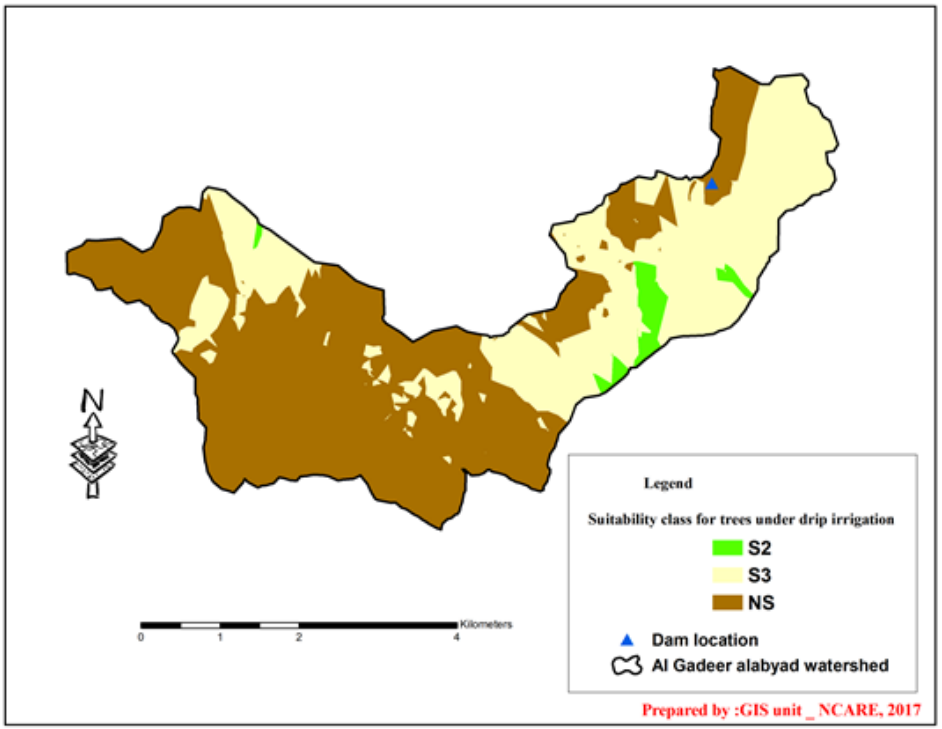
The area percentage of the suitability classes for vegetables under drip – irrigation

vegetables under drip irrigation	Area (km2)	Area %
S2	9.9	46.9
S3	8.7	41.5
NS	2.4	11.5

Figure (13) General land suitability for vegetables under drip – irrigation

Land suitability for trees under drip irrigation

The majority of the watershed (60%) is not suitable for trees under drip irrigation



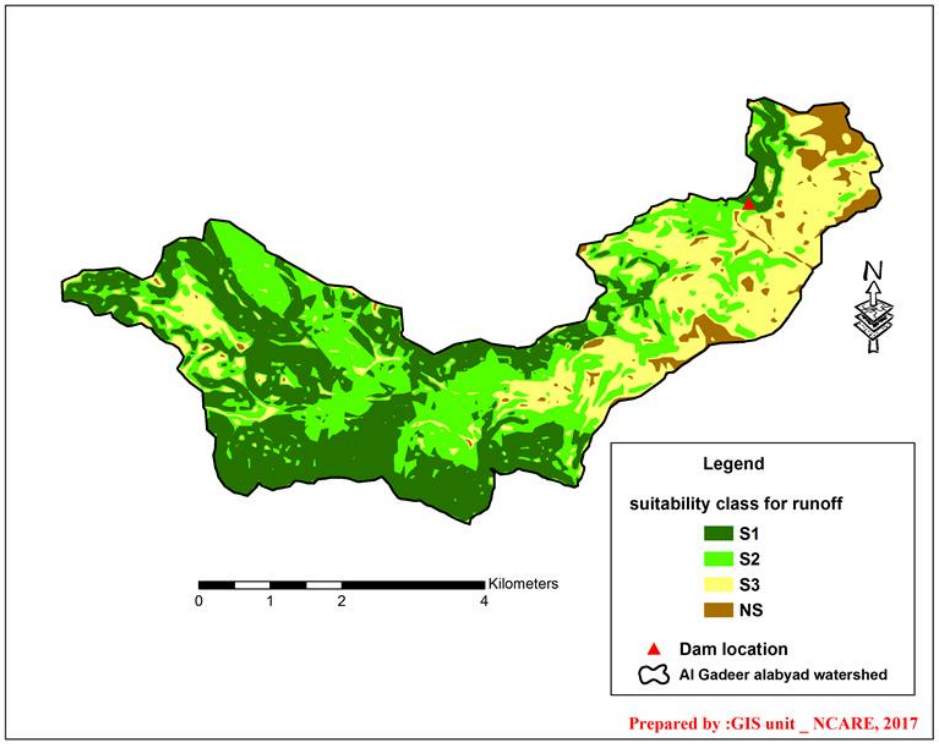
The area percentage of the suitability classes for trees under drip irrigation

trees under drip irrigation	area	Area%
S2	0.5	2.4
S3	8.1	38.3
NS	12.5	59.3
total	21.05	100

Figure (14) Land suitability for trees under drip irrigation

Land suitability for runoff

About 70% of the total area is potentially suitable (S1+S2) for runoff generation

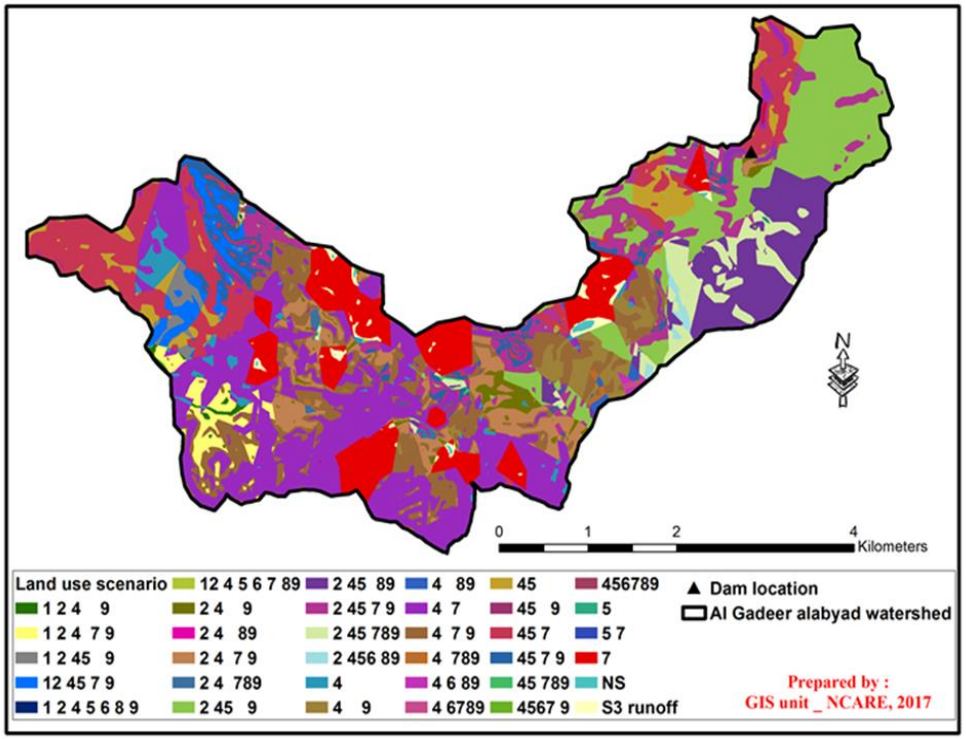


The area percentage of the suitability classes for runoff

runoff	area	Area%
S1	7.8	37.1
S2	6.8	32.5
S3	5.4	25.5
NS	1.0	4.9
total	21.0	100.0

Figure (15) General land suitability for runoff

Optimum landuse scenarios



index table explains the legend linked with the figure 16

legend	land use
1	rainfed agriculture
2	irrigated agriculture
3	rainfed trees
4	rangeland
5	vegetables under drip irrigation
6	trees under drip irrigation
7	runoff
8	trees / WH
9	Rangeland / WH
NS	not suitable
S3 runoff	marginally suitable for run off

Figure (16): landuse scenarios formulated for optimum landuse

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Suitable areas for different landuse alternatives

✓It is concluded that 89% (18710.5 dunum) of the area could be used for rangeland .Generally, The results show that 55 % of the total area has high potential for irrigation which will support the agricultural practices in some areas. About 54% of The study area is potentially suitable to apply water harvesting techniques for both trees and rangeland. It is obvious that 71% of the total area could be utilized for runoff generation

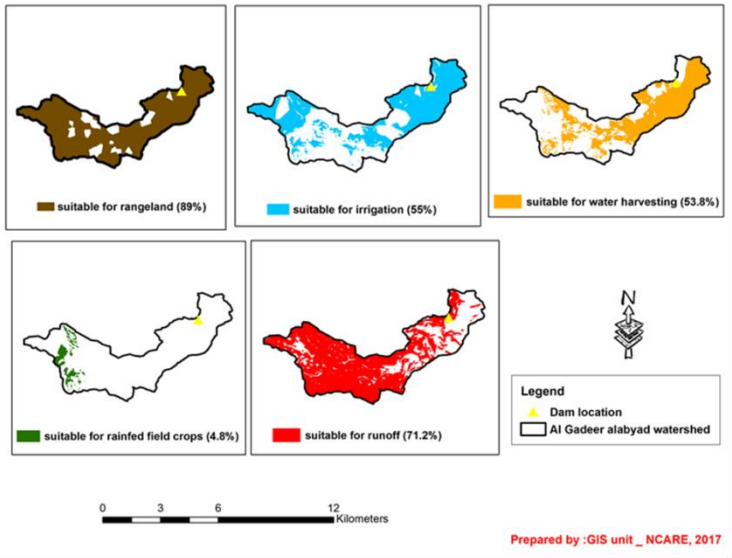

Figure (17): suitable areas for different landuse alternatives

Legend (refer to table)	land use	area dunum	area%
1	rainfed agriculture (field crops)	1000.5	4.8
2 , 5 ,6	irrigation	11566.0	55.0
3	rainfed trees	0.0	0.0
4	rangeland	18710.5	89.0
7	runoff	14966.7	71.2
8,9	WH	11307.8	53.8
NS	not suitable	31350.5	0.1

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Two plots were selected by FAO team for future activities

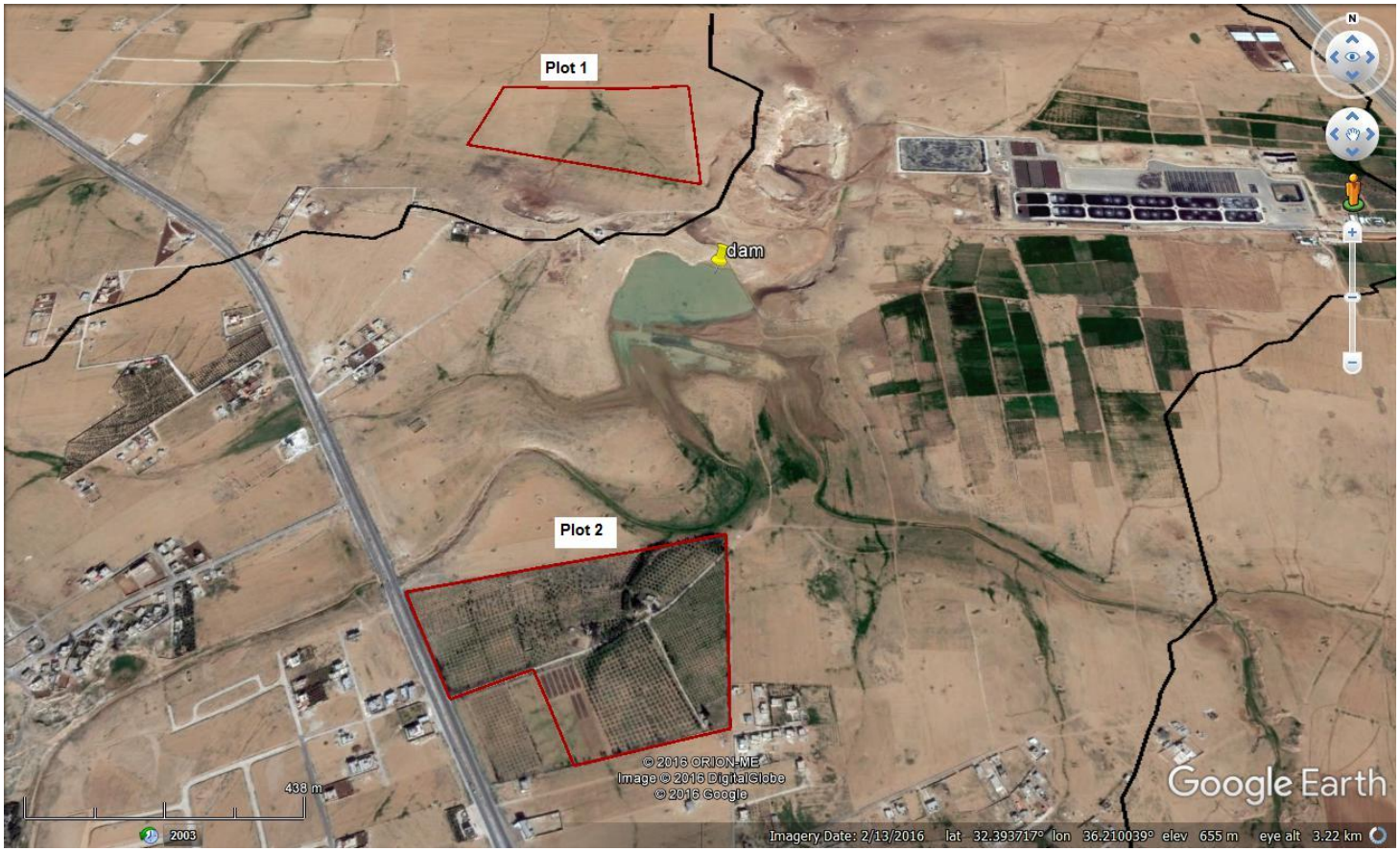
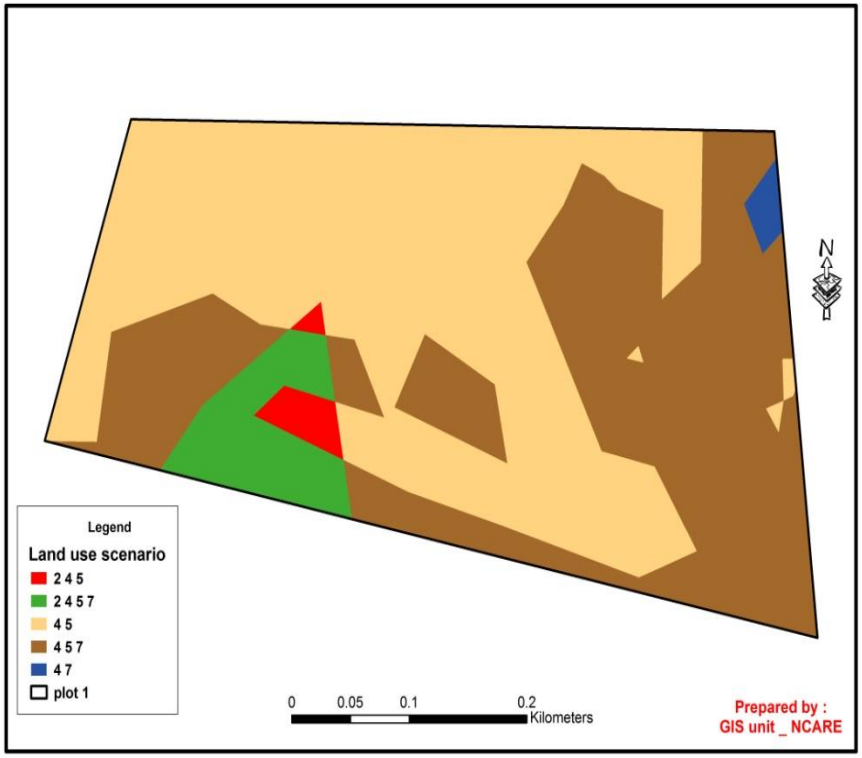


Figure (18): Location of Plot 1& plot 2

Landuse scenarios formulated for optimum landuse (plot1)

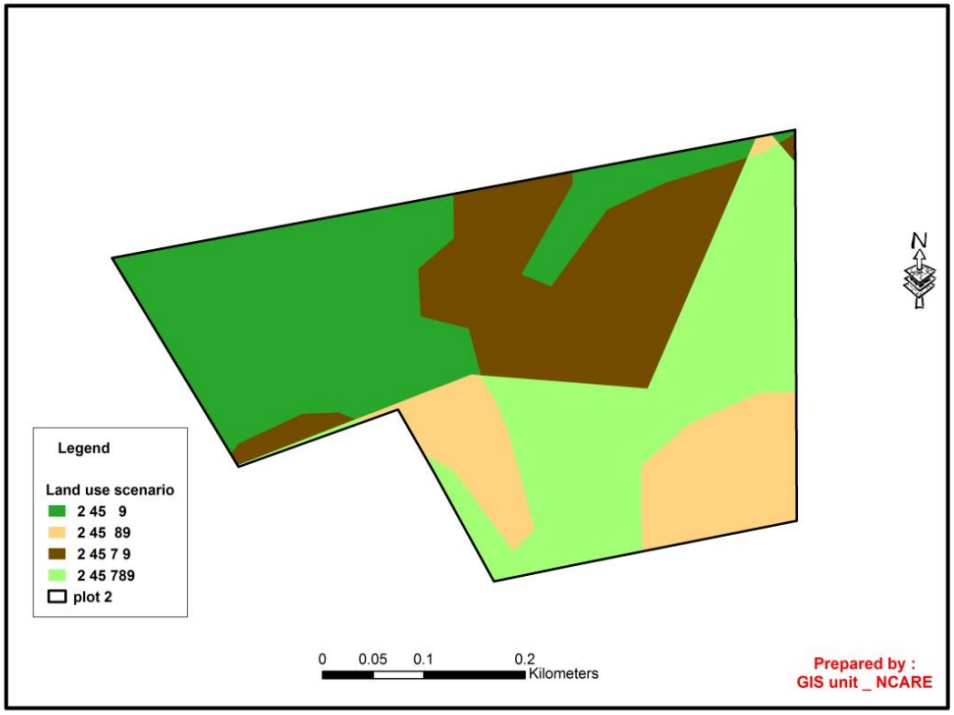


Index table explains the legend linked with the figure 19

legend	land use
2	irrigated agriculture
4	rangeland
5	vegetables under drip irrigation
7	runoff

Figure (19): landuse scenarios formulated for optimum landuse (plot 1)

Landuse scenarios formulated for optimum landuse (plot2)



Index table explains the legend linked with the figure 20

legend	land use
2	irrigated agriculture
4	rangeland
5	vegetables under drip irrigation
7	runoff
8	trees / WH
9	Rangeland / WH

Figure (20): landuse scenarios formulated for optimum landuse (plot2)

Conclusions and Recommendations

- The study area has a promising potential to be exploited into many land use alternatives taking into consideration sustainable production and farmer existing practices.
- Areas which are around the dam could be utilized for agricultural production (vegetables and trees) using drip irrigation provided that the water in the dam is the main source for irrigation.
- Trees production under rainfed condition is not supported to be successful because of rainfall scarcity which is considered as the main limitations.
- Soil conservation practices are recommended in some parts of the area to stop or decrease the erosion hazard in the area to protect the soil and conserve it from further deterioration .
- Application of water harvesting techniques in the area far from the dam will promote agricultural production of trees and improved rangeland .
- Areas with high potential for runoff generation could be used to feed water in the existing dam.

Conclusions and Recommendations

- this study provides guidance for land managers, decision makers and farmers, for the sustainable agricultural use of land.

- The results show that the area is highly dependable on extra source of water rather than rainfall to improve agricultural production.

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Thank you for your attention