**A proposal to earn MSc degree in the field of water harvesting**

**I)Title of the Proposal**:

**Evaluation of different water harvesting techniques at two different rainfall zones of the semiarid climate of Erbil province**.

**II) Overview and Justification:**

Water shortage is the major limiting factor for agricultural development and rangeland improvement throughout arid and semi-arid regions. Therefore, water harvesting techniques have long been utilized as a way to increase soil water storage and reduce soil erosion (Xiao-yan and others 2004). Water harvesting can be defined as the process of concentrating rainfall as runoff from a large catchment area to be used in a smaller target area (Oweis and others 1999). WHT consists of two components: the catchment area, where runoff is collected, and the cultivated area, where the runoff is concentrated (Critchley and siegert 1991).

Rainfed agriculture is the predominant farming system in Iraqi Kurdistan region, but aridity and climatic uncertainty are chief challenges faced by farmers who rely on rainfed farming ( Adham et al., 2016). Rainfall is the most important natural resource in dry environments. In arid and semiarid regions, precipitation is generally lower than potential evaporation and non-uniform in distribution, resulting in frequent drought periods during the crop growing season, and usually comes in intense showers, resulting in surface runoff and uncontrolled rill and gully erosion (Oweis and Hachum 2009).

Despite its scarcity, rainfall is generally poorly managed with much of it lost through runoff and evaporation. Capturing rainwater and making effective use of it is crucial for any integrated research and development project( Yazar and Ali, 2016).

Any attempt to improve agriculture theretore must tackle moisture constraint, but knowledge of appropriate techniques is surprisingly poor (Gowing et al., 1999).

To increase the availability of water for crop and livestock production, inhabitants of dry areas have constructed and developed several techniques for harvesting rainwater ( Adham et al., 2016). Water harvesting is based on the principle of preventing a part of the land, which is usually small and non-productive, from getting the share of rain and adding it to the share of another part. Run-off water is usually applied to an adjacent agricultural area, where it is both stored in the root zone and used directly by plants, or stored in a small reservoir for later use (Surucu et al., 2014).

In water-scared areas, water, not land, is the primary limiting factor to improving agricultural production. Rainwater harvesting (RWH) is one of the promising ways of supplementing the surface and underground scarce water resources in areas where existing water supply system is inadequate to meet demand (Aladenola and Adeboye, 2010). Water harvesting can substantially increase rainwater productivity in the drier marginal environments (Oweis and Hachum, 2006).

According to Critchley and Siegert (1991), generally, two runoff farming water harvesting groups are generally recognized, rainwater harvesting and floodwater harvesting. Rainwater harvesting can be further divided into microcatchment, and macrocatchment runoff farming types.

Microcatchment runoff farming takes various forms such as Negarin, pitting , contour ridge, Meskat type, contour bench terraces, etc. (Prinz 1996). On-farm research has shown that stone lines are efficient in increasing soil water status and in reducing soil erosion and downward particle transport ( Van Duijn et al., 1994)

Microcatchment water harvesting (MCWH) is a method of collecting surface runoff from a small catchment area and storing it in the root zone of an adjacent infiltration basin with the plant. This cultivated area may be planted with annual crops or with a single tree or bush (Boers and Ben-Asher, 1982). The higher the aridity of an area, the larger is the required catchment area in relation to the cropping area for the same water yield (Prinz2002). The most suitable areas for runoff farming are those with an average annual rainfall of 300 - 600 mm and with rainfalls during few but relatively intensive rainstorms (Esser 1999).

The most important criteria for the selection of suitable sites for RWH were slope, land use/cover, soil type, rainfall, distance to settlements/streams, and cost. The success rate of RWH projects tended to increase when these criteria were considered, but an objective evaluation of these selection methods is still lacking ( Adham et al., 2016).

However, pertinent and reliable information on the advantages of runoff farmimg is lacking in the region. Therefore this study addresses the effect of ----on runoff and soil loss in comparison to the conventional ploughing system.

The lines are constructed by making a shallow foundation trench along the contour. Larger stones are then put on the downslope side of the trench. Smaller stones are used to build the rest of the bund. The stone lines can be reinforced with earth, or crop residues to make them more stable. When it rains, soil will start to build up on the upslope side of the stoneline, and over time a natural terrace is formed. The stone lines are spaced 15-30 m apart, a shorter distance being used for the steeper slopes(Duveskog, 2003).

Therefore the current study will be proposed with the main aim of improving rainwater productivity in the drier marginal environments via targeting the specific objectives in the incoming sections.

**III. Objectives:**

The aim of this study is to evaluate the improvements in crops yield through the application of some water harvesting techniques in low rainfall zones. The specific objectives are: (1) identification of suitable sites for rainwater harvesting within the outskirts of Erbil city based on some selected criteria such as slope, land use/cover, soil type, rainfall, distance to settlements/streams, and cost; (2) evaluating the effect of some water harvesting techniques on soil water conservation; 3) evaluating of the effect of land slope and annual rainfall on water harvesting performance (ratio between catchment area and cropping area) under runoff farming; (3) determining the impact of some water harvesting techniques on crops growth and yield of cereal and fodder crops.

**IV. Hypothesis**

The hypothesis is: the practices that retain soil water during times of drought and reduce soil erosion/degradation during times of heavy rainfall will increase the winter cropping performance in the area under study.

**V. Brief outlines**

1. **Determination annual rainfall of design**

The analysis of design rainfall depth consists of :

1. Collecting the historical data over a sufficient number of years
2. Ranking the data in descending order, assigning rank( m=1) to the highest value and assigning ( m=N) , where N = number of observations to the lowest value
3. Determining the probability of exceedance (P) using the Weibull formula:

 ; ; where Tr = return period (Year)

1. The rainfall depth will be plotted on ordinate versus propobabilty on a probability paper
2. The design rainf(all depth can be determined after fitting the data points to a straight line.
3. Two sites with different rainfall zones( 250 mm and 500 mm ) will be selected within the area surrounding Erbil city

**B) Calculation of the overall suitability for each site for rainfall water harvesting:**



where: S: suitability; W: weight of criteria i; X: score of criteria i; i, n: number of criteria

Different sets of criteria ( guidelines ) will be selected including biophysical(IMSD, 1995) and socioeconomic criteria(Oweis et al., 1998).

They encompass: rainfall, drainage system, slope, land use / land cover, soil texture (soil type), Socioeconomic ( land tenure).

The overall suitability will be classified also from 1 to 5, namely, 5 (very high suitability), 4 (high suitability), 3 (medium suitability), 2 (low suitability) and 1 (very low suitability)(Adham et al., 2016).

**C) Theoretical Determination of catchment: cultivated area ration ( C/CA):**

The calculation will be based on the principle of : water harvested = Extra water required as follows:



Where:

DR= Design annual rainfall(mm)

CWR = Crop water requirement (mm)

K =Runoff coefficient (0.1 – 0.5)

EFF = Efficiency factor( 0.5 -0.75)

The calculation of CWR will be based on determination of ETo from Penman-Monteith Model and crop coefficient (Kc) over the growing season.

The Penman-Monteith formula that recommended by the Food and Agriculture Organization of The United Nations (FAO-56-PM) was used to calculate potential evapotranspiration over the study area.



where: ETo=potential evapotranspiration (mm day -1); Δ=slope of vapour pressure curve (kPaoC-1); Rn=net radiation (MJm-2day-1); G=heat flux density(MJm-2day­-1); γ=the psychometric constant (kPaoC-1); T=Mean daily air temperature at 2 m height (oC); U2=wind speed at 2 m height(ms-1) and (es-ea) = vapour pressure

**D) Field Experiments**

1. **Runoff Strip Experiment**

The catchment fields for conducting the field experiments will be selected on two slopes at each rainfall zone ( 3% and 10%) but the cultivated areas will be plain bed with bund on its edges. The catchment will be rectangular in shape laid out across the contour lines. The three sides of the catchment will be surrounded by soil bunds of height 25 cm to prevent

water to flow across the bunds. However, the lower width (3 m) that borders the cultivated area will be bunded. Each microcatchment had an adjacent cultivated area of 9 m2 at its lower position. The dimensions of the microcatchments will be: 3m x 0 m, 3m x 3 m , 3m x 6 m, 3 m x 9m and 3m x 12 m to produce catchment area to cultivated area ratio of 0, 1, 2, 3 and 4

1. The layout of the experiment at each site will be factorial with CRBD. The first factor is slope ( s) with two levels

S1 = 3%

S2 = 10%

While the second factor will be catchment area cultivated area ratio with the following levels:

R1= 0; R2 = 1; R3=2; R4 = 3; R5 = 4

Each combination treatment will be replicated three times

1. The cultivated area will be cropped with wheat.

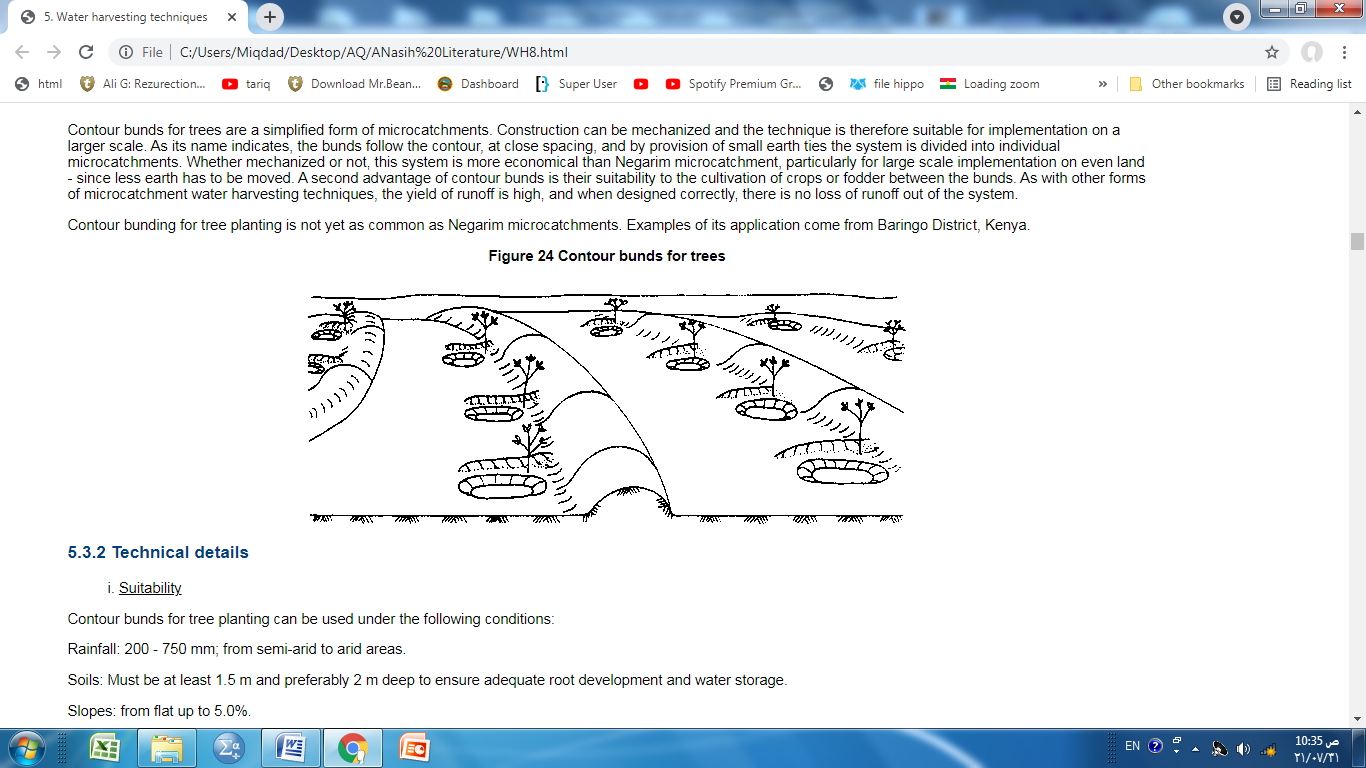
Diversion channel

Fig.1. Layout of the field experiment

( Rep 1 at site one )

Slope Direction

1. **Contour bund experiment**
2. Establishment of furrows with top width of 0.5 m across the slope and approximately on the contours. The side slope will depend on type of soil
3. Leaving a catchment area uncultivated and clear of vegetation to maximize runoff.
4. Planting cyprus seedlings on the lower side of the furrow at recommended spacing.
5. Putting the bund spacing at distances of 3, 6, 9 and 12 m
6. Measuring the seedling growth( plant height, number of branches, survival etc)
7. Monthly measuring the soil water content
8. The experiment will be conducted over two land slopes ( 5% and 10%) within a given site
9. Each treatment will be replicated 3 times and the layout of the experiment will be factorial in RCBD.
10. The experiment will be conducted at two sites with two different annual rainfall.
11. The study factors are :
12. Bund spacing: B1= control, B2 = 3m, B3 = 6m, B4 = 9m, B5 = 12m,
13. Land Slope: S1= 5%, S2 = 10%
14. The number of replicates = 3. The total number of experimental unit at each site = 5 x 2 x 3 = 30 experimental units



1. **Stone line experiment**

This experiment will be similar contour bund experiment in all aspects except that the bunds are replaced by stone lines.

**VI. Requirements**

1. Parcels of land
2. Shovel for preparing cultivated area
3. Grader for leveling cultivated strips
4. Razor wires and pegs for fencing
5. Wheat seeds or Cyprus seedlings
6. Tractor for plowing
7. NPK fertilizer +Herbicides
8. Stones for making stone lines
9. Level and staff for measuring slopes
10. Pickup for transportation

**VII. Allocated money**

Seven million I.D. to cover all the expanses

Proposed by

Nasih Hassan Aziz Dr. Tariq H. Karim

M.Sc. student The supervisor