



Impact of irrigation on the surface water-groundwater connections in the lacustrine plain of Lake Tana, Ethiopia

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Introduction

- surface water-groundwater interactions
- Impacts of irrigation on hydrological processes
 - ✓ infiltration
 - ✓ evapotranspiration
- If the source of irrigation water is not from groundwater pumping
 - ✓ Infiltration recharges & rises the GW level



Introduction cont.

- Evapotranspiration (ET)
 - ✓ crop roots tap water from the capillary fringe
 - ✓ at high temperature conditions, surface evaporation is high and ET rises
 - ✓ direct ET of GW also occurs in areas with shallow water tables
 - ✓ these tapping of the water table causes the water table to decline
- hence these hydrological processes (Infiltration & ET) cause the GW to fluctuate



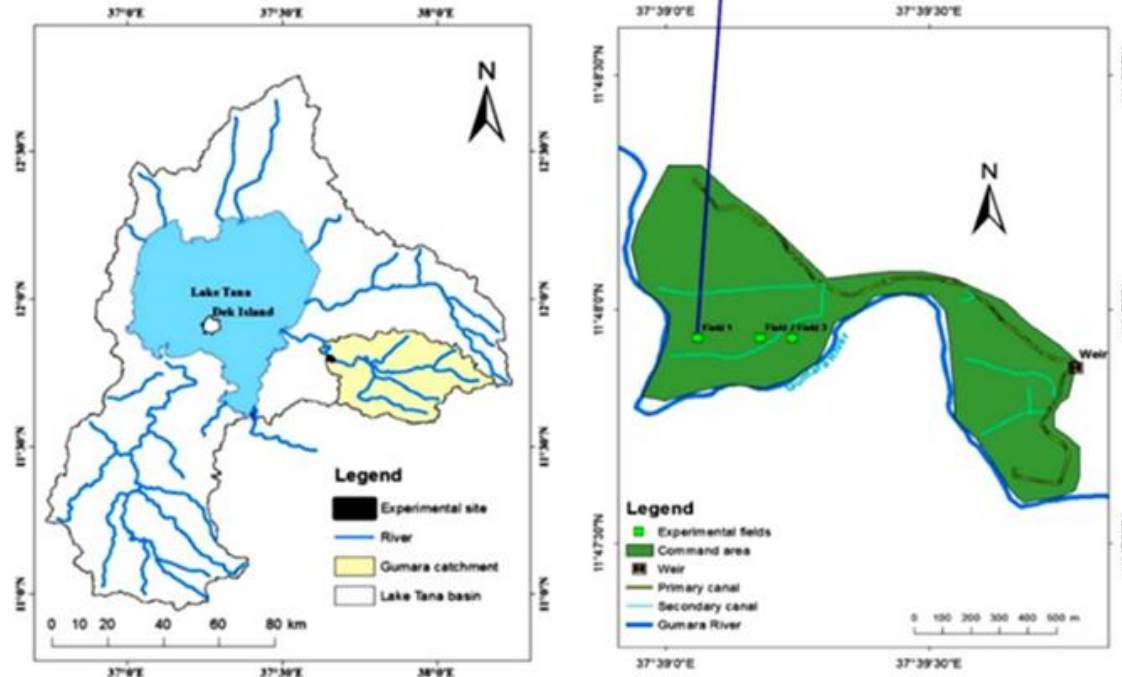
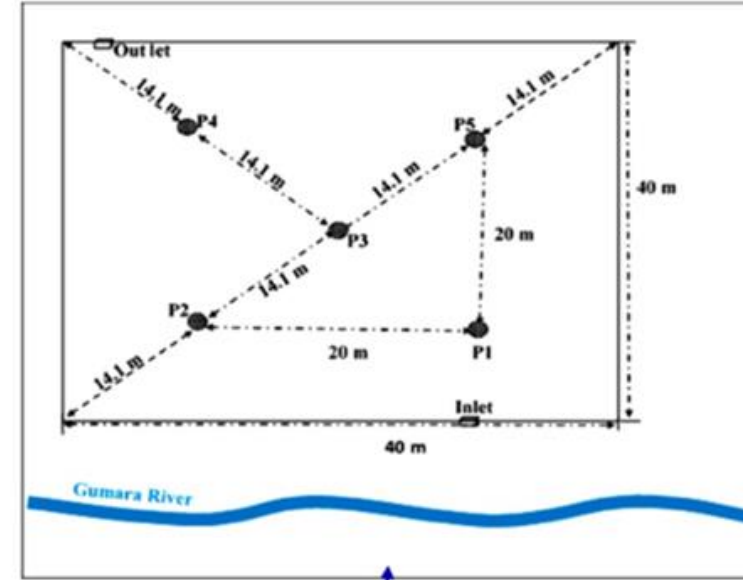
Objectives

- to examine the impact of current irrigation practice on surface water - groundwater connections
- to characterize the water table fluctuations following irrigation

Methodology

- Field experimentation and measurements with 3 experimental fields (each approx.. 40 m x 40 m)
- the crop grown was onion (from Dec to April 2014/5)

Location map of the study area and experimental field





Methodology cont..

- GW level was measured manually by installing piezometers
- GW recharge determined by water table fluctuation method (WTFM)

$$R_e = S_y \times \Delta h \quad (1)$$

where, R_e is recharge (mm), S_y is the soil specific yield (-), Δh is the change in water table height (mm)

- based on porosity & specific retention relationships the specific yield (S_y) is given as

$$S_y = \phi - S_{FC} \quad (2)$$

$$\phi = \frac{\rho_G - \rho_B}{\rho_G} \quad (3)$$

where, ϕ is porosity (-), S_{FC} is the soil moisture content at field capacity (-), ρ_G and ρ_B are the particle and bulk densities respectively (kg m^{-3}).

Methodology cont..

- alternatively we used the soil percent sand, clay and silt to determine the value of S_y based on Johnson (1967) textural triangle



Piezometer measurement



Methodology cont..

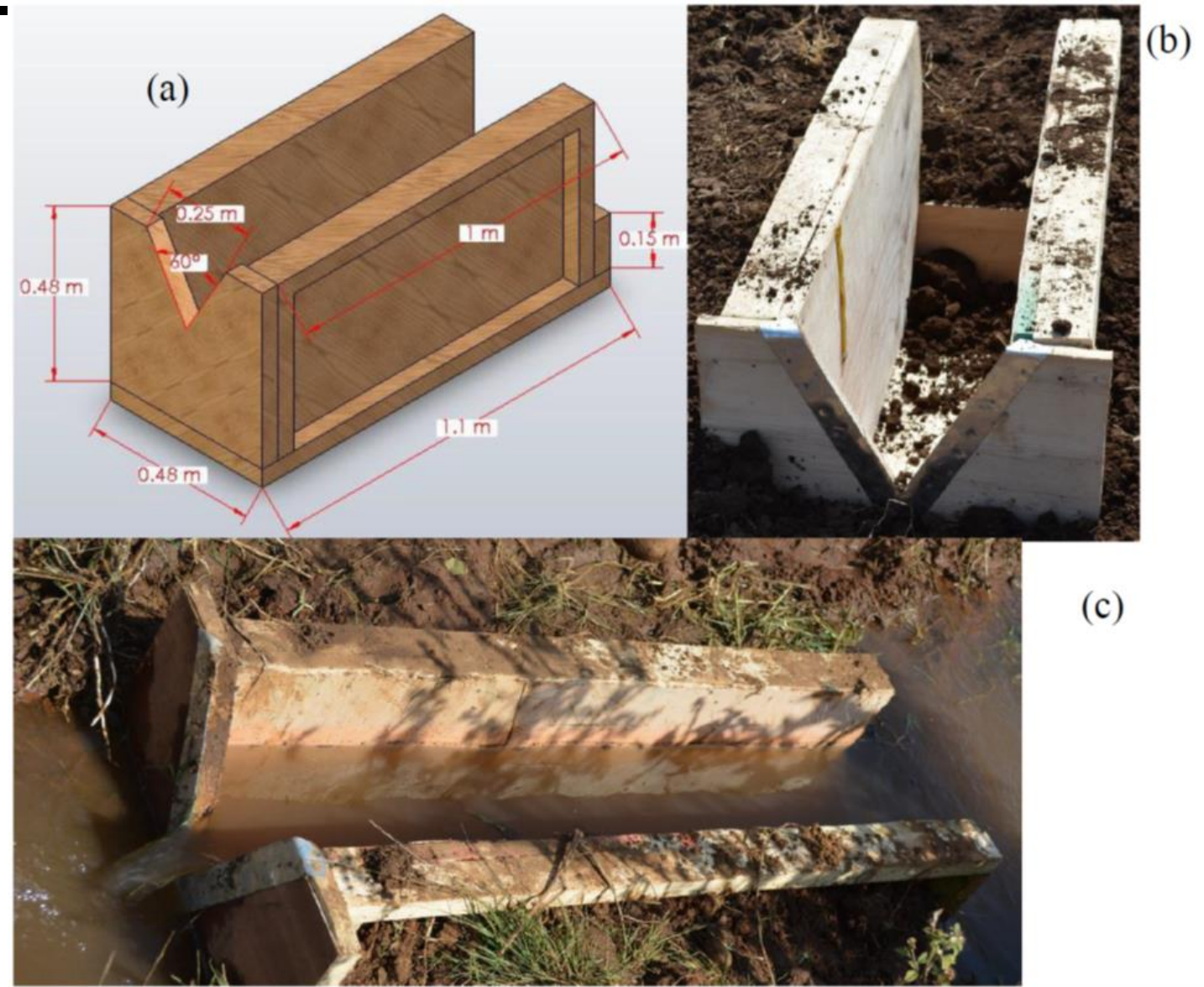
➤ field water measurement using 60° V-notches

$$Q = C \frac{8}{15} \sqrt{2g} \tan \frac{\theta}{2} h^{\frac{5}{2}} \quad (4)$$

$$C = \frac{0.585}{\left(\tan \frac{\theta}{2}\right)^{0.004} h^{0.03}} \quad (5)$$

where, Q is discharge ($\text{m}^3 \text{s}^{-1}$), C is coefficient of discharge, g is acceleration due to gravity (m s^{-2}), θ is angle included between the sides of the notch (degrees) and h is the head of water measured at the vertex of the notch (m)

Methodology cont..



Triangular-notch, thin-plate weir for farm water measurement (a) design, (b) installed and (c) measuring



Methodology cont..

- the field - water application efficiency (E_a)

$$E_a = \frac{D_r}{D_f} \times 100 \quad (6)$$

Where, D_r is depth of water retained in the root zone and D_f is depth of water applied to the field (mm)

- ✓ The depth of water retained to the root zone: measuring the soil moisture content before and after irrigation events at 0.3 m and 0.6 m depths of the soil
- Analysis of meteorology data in relation to recharge & calculation of ET_o using CropWat 8.0

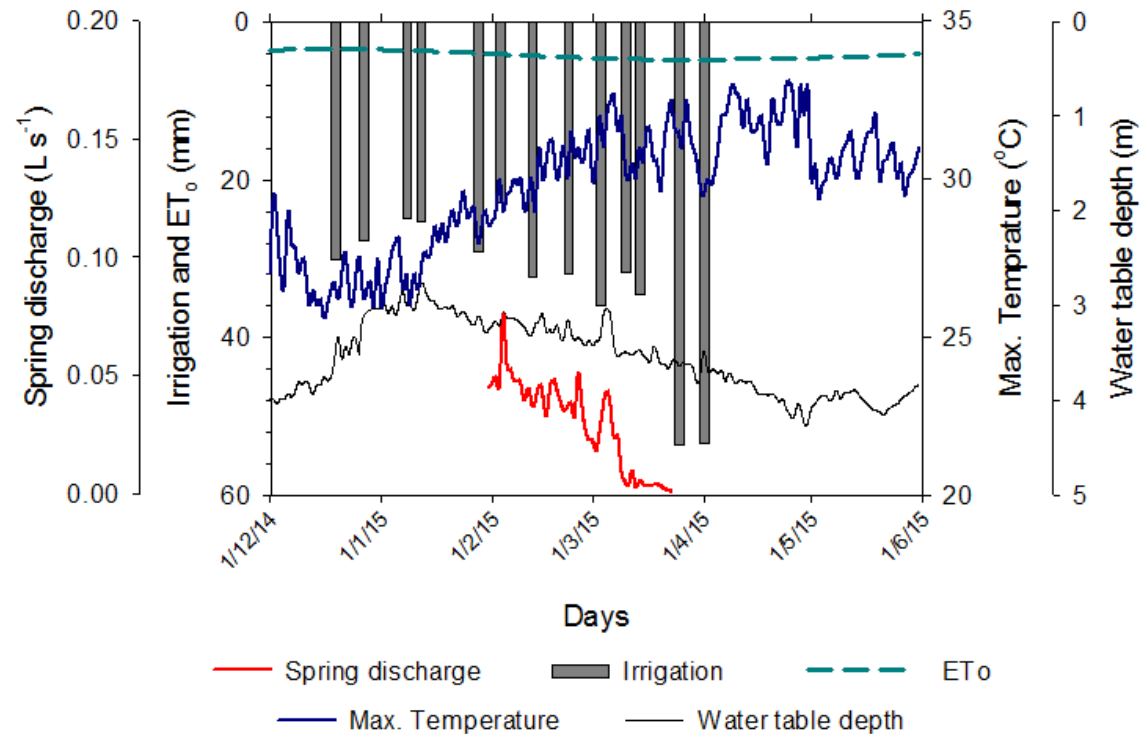


Results and discussion

Water Level Response to irrigation

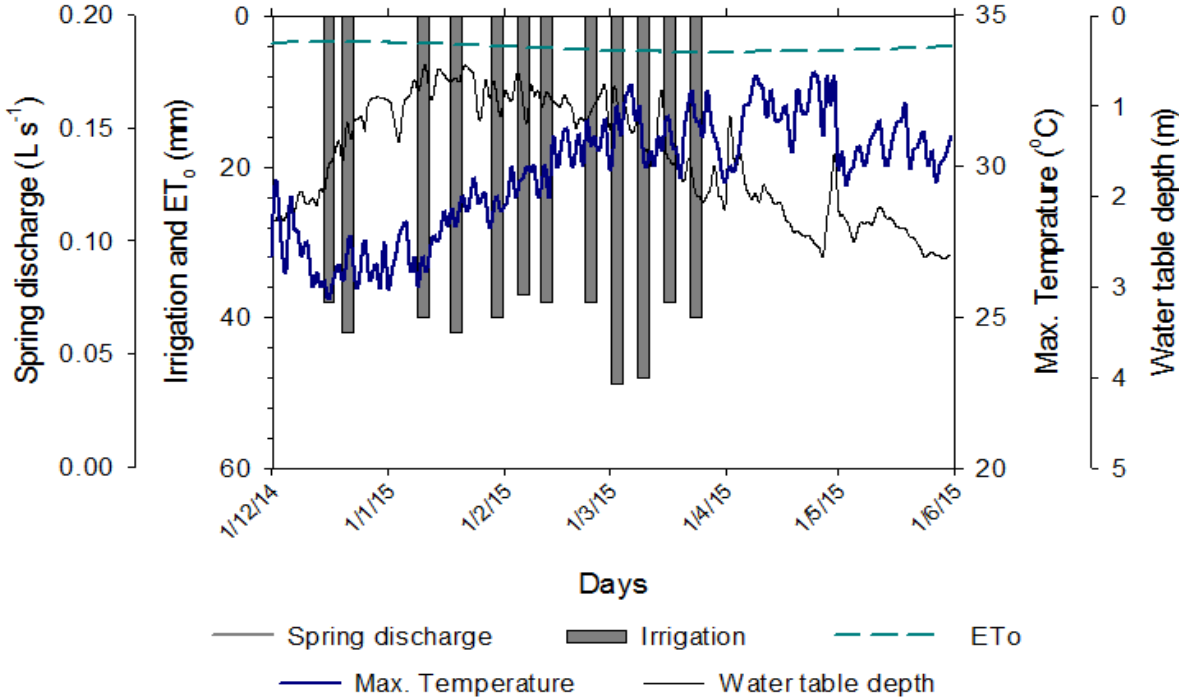
- water level rise occurred in all the three fields following every irrigation event
- The highest water level rise (0.56 m) was observed in field 3 on 9 Dec, 2014 and 15 march, 2015
- The second highest water level rise (0.46 m) was observed on 10 Apr, 2015 in field 2
- water level rise showed a decreasing trend starting from third week of February
 - ✓ high temperature during the period
 - ✓ high crop water demand during the mid stage

➤ Water table response, irrigation amount, temperature and ET_0
 (a) Field 1

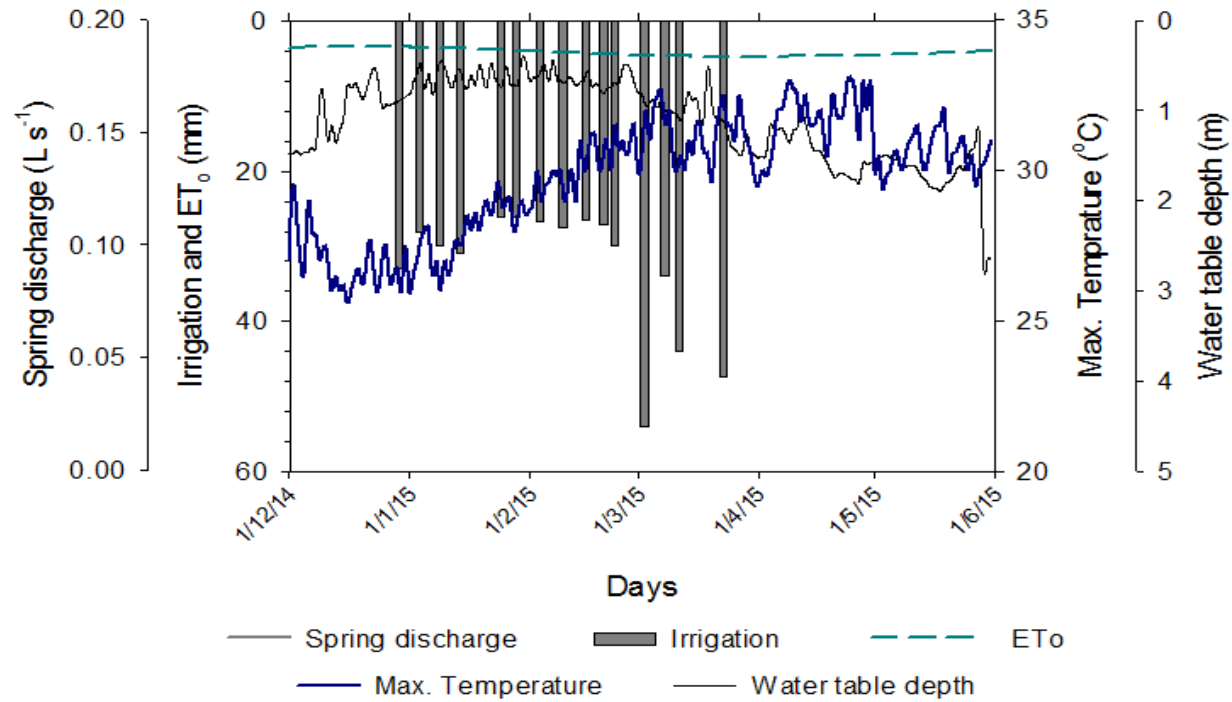




(b) Field 2



(c) Field 3





Seasonal groundwater recharge

Specific yield values based on porosity and Johnson 1967 textural class

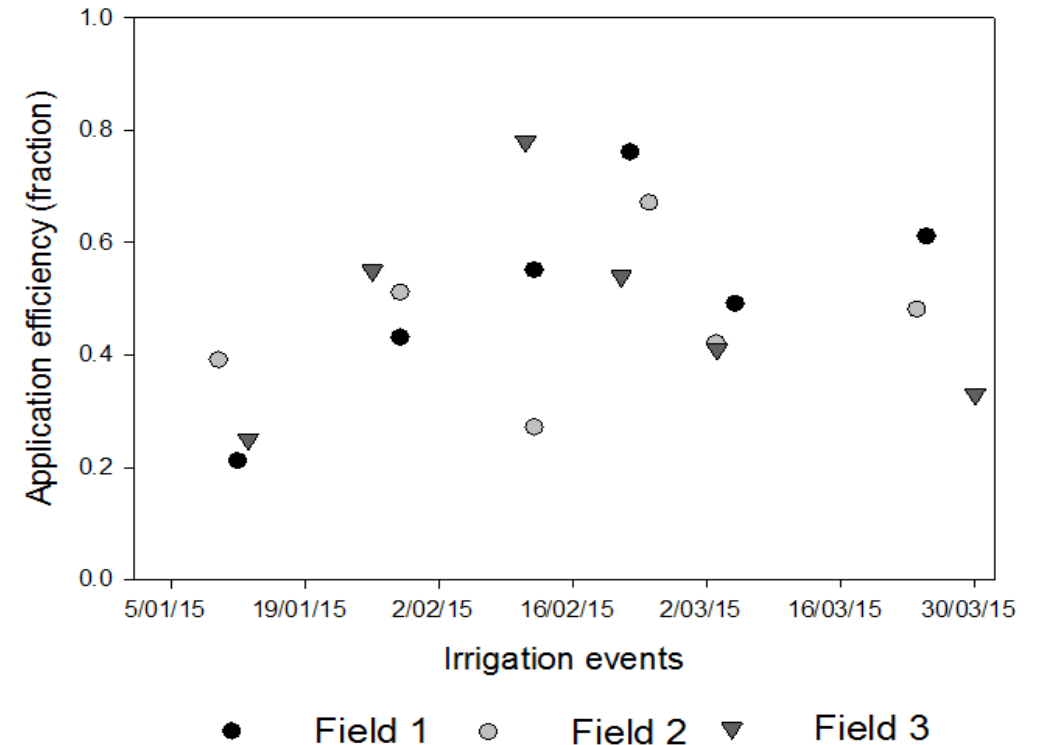
	Field 1	Field 2	Field 3
S_y based on Johnson 1967	0.027	0.015	0.017
$S_y = \phi - S_{FC}$	0.031	0.039	0.062

- Higher GW recharge was observed in fields 3 (65 mm) than field 1 (54 mm) & field 2 (55 mm) for irrigation applications of 432 mm, 490 mm and 467 mm respectively
 - ✓ the soil is shallow (2 m) in this field than field 1 (4 m) and field 2 (3 m)
- this recharge estimation was calculated using the S_y based on the soil texture
- This recharge could increase by 20 to 70 % if we were applying the value of the specific yield according to porosity & specific retention

➤ Field irrigation application efficiency



application efficiency varies from 20% to 80% and the average values (%) for fields 1, 2 and 3 are 51 (± 0.17), 46 (± 0.12) and 48 (± 0.17) respectively



Field irrigation Application Efficiency for fields measured at 6 irrigation events



- losses from field occurred as deep percolation
- there was no any runoff observed throughout the season
- the applied irrigation for our case is either deep percolated to the GW or stored in the root zone for plants use
- the ratio of water stored in the root zone to applied water (referred to as field application efficiency) is low, this implies that the amount of deep percolation is higher



Emerging of spring at edge of river bank as result of rise of water table recharge from irrigation (see field 1 a)

- the spring discharge was initially higher (0.06 l s^{-1} on 5 Feb.) decreased gradually (0.002 l s^{-1} on 21 Mar.) & finally dried following the decrease of recharge by end of March
- This indicates that the source of the spring was deep percolated irrigation water



Conclusions

- this experimental study shows that irrigation can be a significant source of GW recharge
- the GW response from irrigation deep percolation was influenced by irrigation amount, soil depth, seasonal climate variations & crop growth stages
- the amount of recharge estimation using WTFM highly depends on the specific yield value
- The field water application efficiency suggests that there is much room for improvement of efficiency
- The study evidences that in the study area the hydrological regime is strongly affected by irrigation



Thank you for
your attention!!!