# On Farm Water Management in Gash Agricultural Scheme (GAS)

## Phase II: Modelling Results

## Season 2016/2017

The analytical phase has followed intensive data collection over one completed season extending from late May 2015 to early January 2016 which has been carried out in two pilot farms one in Kassala Block (Mesga 1, 1300 Feddans) and the second one in Hadalya Block (Mesga 16, 300 Feddans) in GAS. Based on results obtained from close assessment of the current irrigation practice, a newly irrigation scheduling practice would be tested in a pilot farm during the growing season of year 2017.

In this phase, results on certain issues were obtained. One of them is determination of available water for Sorghum under the investigated farm condition besides the water balance in the root zone and all relevant components on seasonal basis. The other theme deals with simulating the farm condition using WinSRFR software to study efficiency of spate water distribution on farm level and consequently to find out the optimum irrigation scheduling. AquaCrop software is also used to provide information on biomass production in GAS.

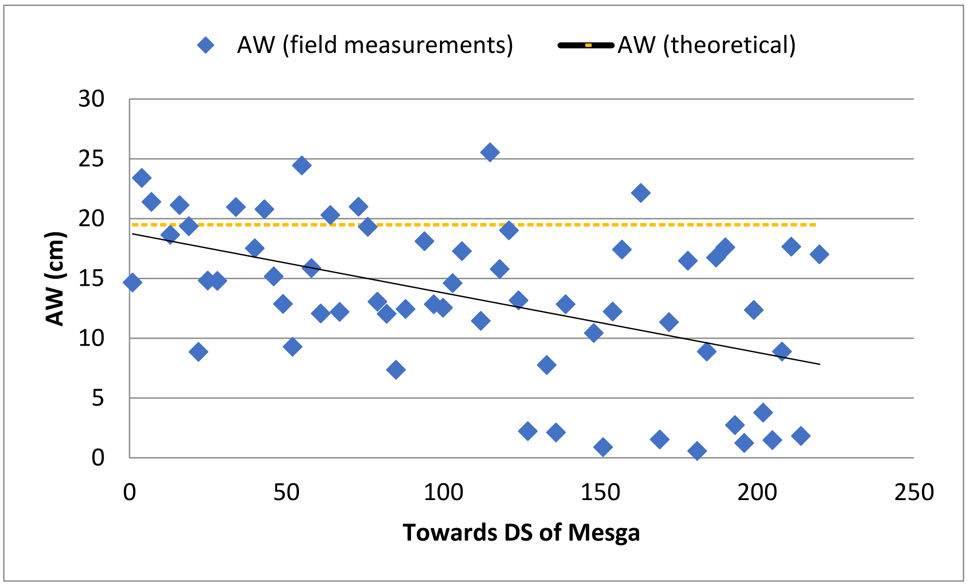
- **Determination of AW in Mesga 1 & Mesga 16**

Initial soil moisture content data ranged from 0.8 to 18.5% and form 2.8 to 11.6% for Kassala and Hadalya soils respectively. In general, soil moisture content for all samples, except for few ones, increases with the increase of soil depth in the two sites.

To determine the available water (AW) for Sorghum all through the growing season, soil moisture measurements in around 74 points scattered within the Mesga area in Kassala Block were analysed. Here it was assumed that soil moisture of soil samplings after flood water has ceased to represent the field capacity (FC) condition and those taken during the harvesting period to represent the permanent wilting point (PWP) condition. Hence, the AW is calculated as indicated below:

$$\mathbf{AW = FC - PWP}$$

It is to be noted that the bulk density of 1.1 $gm/cm^3$ is adopted as calculated from field measurements to convert the gravimetric soil moisture into volumetric soil moisture contents. The figure below shows the available water in each profile towards downstream of Mesga versus the theoretical available water.

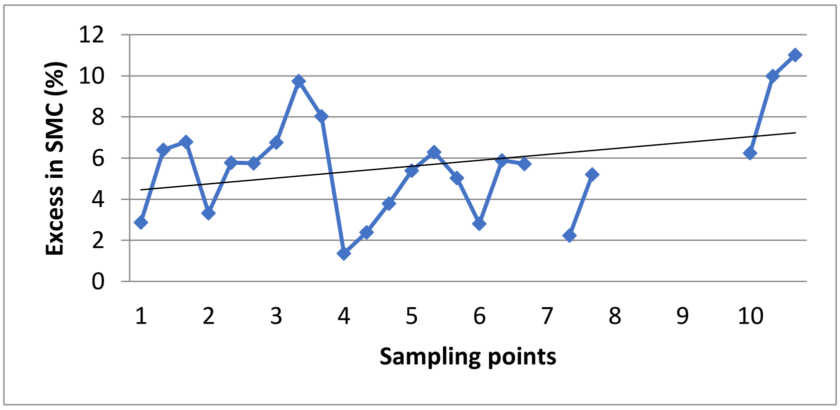



*Available water in each soil profile in Mesga 1 versus theoretical AW*

Theoretically, Silty clay is of a total available water amounts to 19.5 cm per 90 cm soil depth, it can clearly be concluded that AW in Mesga 1 with an overall depth of 13 cm is far below the theoretical AW. It was also observed that soil moisture decreases towards the end of the farm and the availability of soil moisture fluctuates obviously due to the topography of the Mesga.

The status of the soil moisture content in Kassala Block by the end of the season shows that at harvesting time in November 2015 soil moisture was more or less the same as the condition in preseason in June 2015. The overall average of water depth was 7 cm (preseason) while that at harvesting time was 6 cm.

For Mesga 16 in Hadalya Block, where more water has been applied to the farm than the crop water requirements by 32%, considerable percentage of soil moisture was available all through the farm by harvesting time. On the other hand, available water is estimated at 15 cm versus 16.5 cm theoretical record.



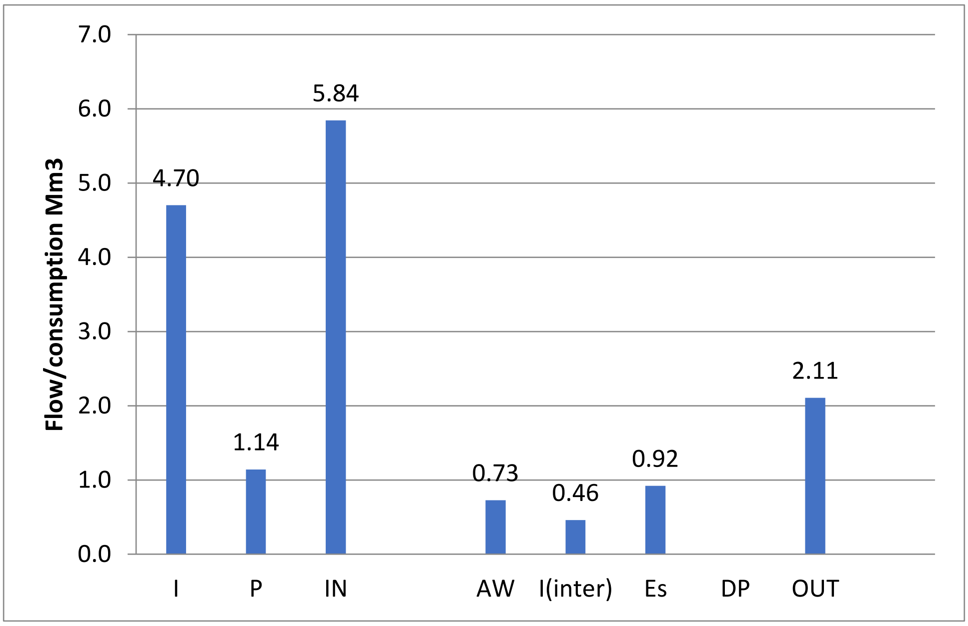

*Excess in soil moisture by end of growing season in Mesga 16*

- **Overall water balance results**

This section presents the quantification of the different water balance components and gives results of root zone water balance over the whole season for Mesga 1. By arranging the water balance equation as below, it can be seen that deep percolation is the only missed parameter and it could be estimated at 3.73 $Mm^3$ which ensures the high infiltration rates of the experimental soil.

$$\mathbf{I + P = (AW+D) + E_s + I_{interception}}$$

On the other side, it can clearly be stated that total crop water requirements in order of 2.184 $Mm^3$ was partially supplemented by upward flow contribution.




*Calculations of water balance parameters*

- **WinSRFR'S results**

WinSRFR software is used to investigate many scenarios and to give insights on the appropriate irrigation scheduling to be adopted for irrigation in GAS without deficit or overuse of water.

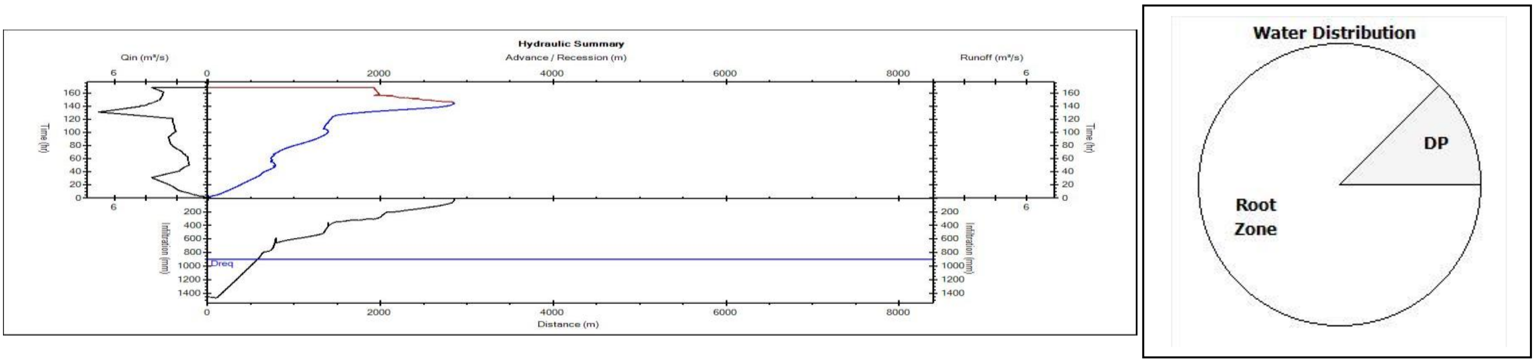
### *Mesga 1, Kassala Block*

For the current situation of Mesga 1 i.e. applying irrigation water for 25 days, simulation results have shown that more than half of the farm could not be irrigated. Some of the most important calculated performance indicators are as follows:

**Efficiency & Uniformity Indicators**

AE = 86 %

| | |
|---|---|
| DUmin = 0 | DUlq = 0 |
| ADmin = 0 | ADlq = 0 |




*Results of the current condition in Mesga 1*

Shortfall in water distribution can be attributed to:

1- The Mesga area is big in comparison with the amount of water.

2- Failure in early preparation on field level.

3- Lack in water distribution and uniformity across the field (levelling problems).

### *Mesga 16, Hadalya Block*

By the end of the flood season, a total amount of irrigation water in order of 1.29 $Mm^3$ has entered the Mesga. An applied depth of 1.03 m was estimated and it was observed that excess water has formed ponds at downstream the field. Excess of water is due to the following reasons:

1- The Mesga is relatively small in comparison with the amount of water.

2- Regular slope.

3- High flood waves were occurred at the end season, when most of Mesgas in GAS were blocked.

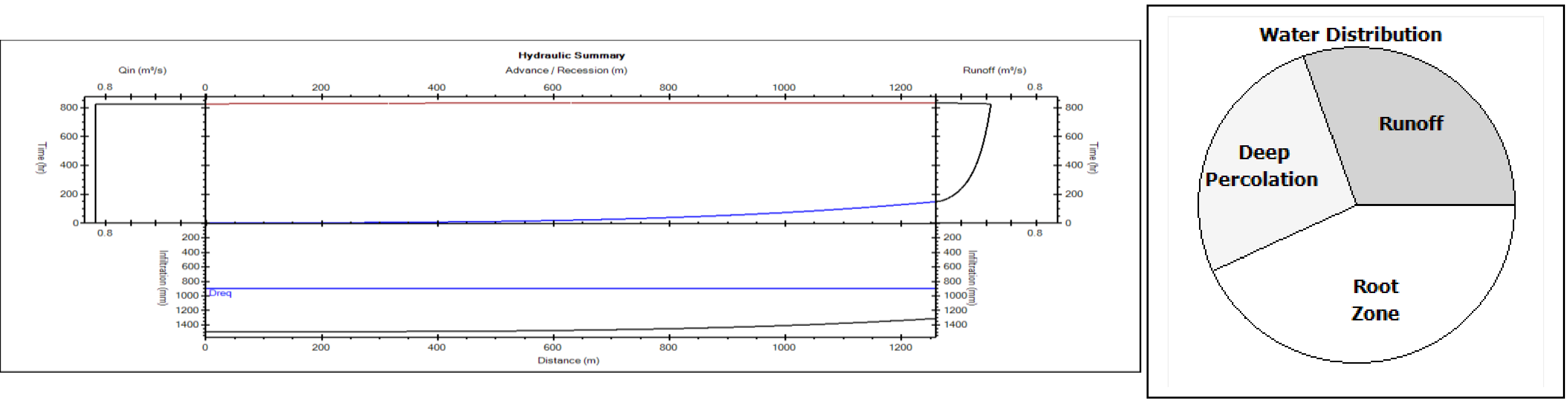
The current situation is simulated as in the figure below. Some of the most important calculated performance indicators are as follows:

**Efficiency & Uniformity Indicators**

AE = 44 %

DUmin = 0.9    DUlq = 0.95

ADmin = 1.46    ADlq = 1.53




*Results of the current condition in Mesga 16*

Certain solutions were proposed to be investigated through the following scenarios in order to improve the irrigation efficiency, which were as follows:

1- Dividing Mesga into two parts vertically.
2- Dividing Mesga into two parts horizontally.
3- Dividing Mesga into four parts.

Consequently 32 scenarios have been investigated to find out the most practical scenarios that can be applied on farm level. The table below illustrates the scenarios results for Mesga 1 in Kassala Block.

*Summary of the scenarios results as obtained from WinSRFR*

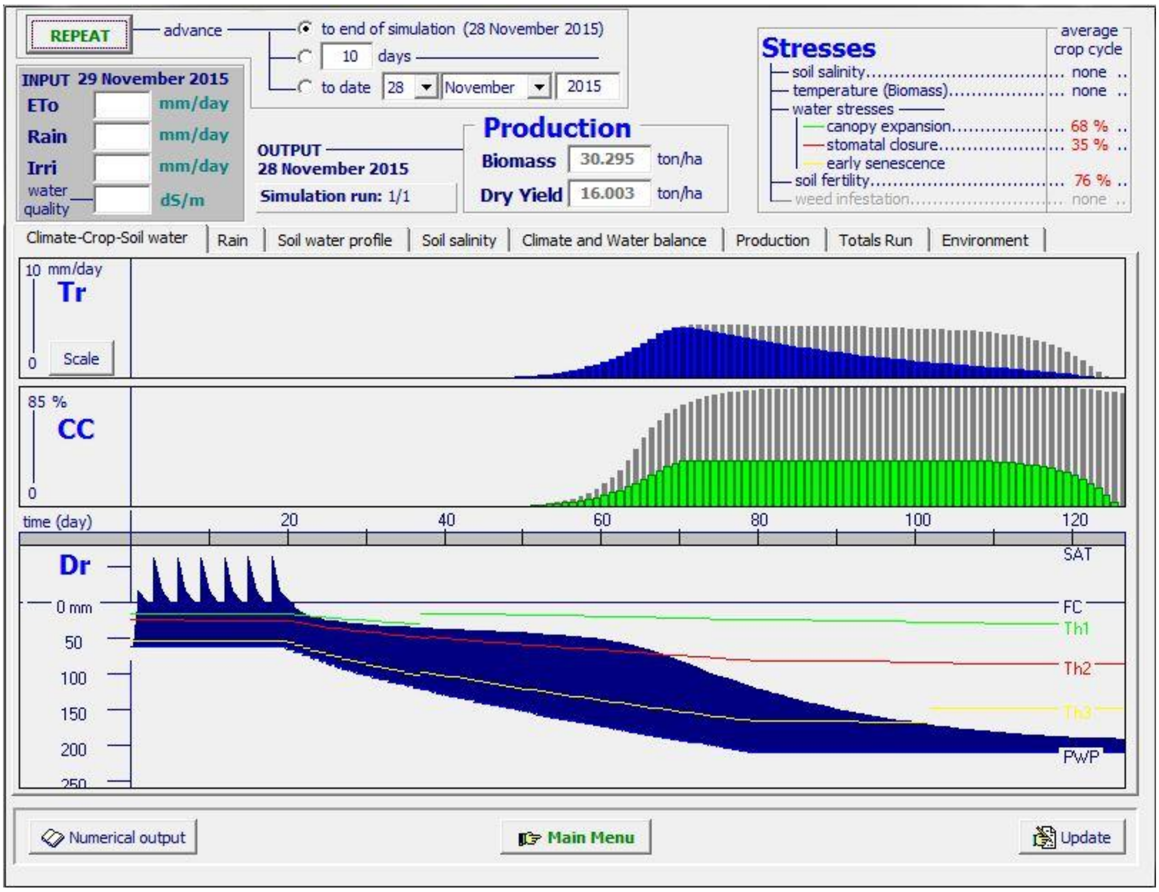
| Scenario NO. | Parameters | Irrigation Scheduling | Field situation | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | C.S | 2 V | 2 H | 3H | 4 Parts | | | |
| | | | | | | | Q(1,1) | Q(1,2) | Q(2,1) | Q(2,2) |
| Sc1 | AE% | 25 | 40% | 40% | 40% | 40% | 32% | 32% | 32% | 32% |
| | DUmin | | 0 | 0 | 0 | 0 | 0.82 | 0.81 | 0.79 | 0.81 |
| | DUlq | | 0 | 0 | 0 | 0.54 | 0.91 | 0.91 | 0.89 | 0.91 |
| | ADmin | | 0 | 0 | 0 | 0 | 2.27 | 2.2 | 2.17 | 2.2 |
| | ADlq | | 0 | 0 | 0 | 1.28 | 2.54 | 2.48 | 2.44 | 2.48 |
| Sc2 | AE% | 20 | 48% | 48% | 48% | 48% | 40% | 40% | 40% | 40% |
| | DUmin | | 0 | 0 | 0 | 0 | 0.74 | 0.76 | 0.74 | 0.76 |
| | DUlq | | 0 | 0 | 0 | 0.42 | 0.86 | 0.89 | 0.86 | 0.89 |
| | ADmin | | 0 | 0 | 0 | 0 | 1.66 | 1.75 | 1.66 | 1.75 |
| | ADlq | | 0 | 0 | 0 | 0.8 | 1.95 | 2.04 | 1.95 | 2.04 |
| Sc3 | AE% | 15 | 59% | 59% | 59% | 60% | 53% | 53% | 53% | 53% |
| | DUmin | | 0 | 0 | 0 | 0 | 0.64 | 0.66 | 0.64 | 0.66 |
| | DUlq | | 0 | 0 | 0 | 0.27 | 0.81 | 0.85 | 0.81 | 0.85 |
| | ADmin | | 0 | 0 | 0 | 0 | 1.13 | 1.17 | 1.13 | 1.17 |
| | ADlq | | 0 | 0 | 0 | 0.38 | 1.45 | 1.52 | 1.45 | 1.52 |
| Sc4 | AE% | 10 | 80% | 79% | 80% | 80% | 77% | 78% | 77% | 78% |
| | DUmin | | 0 | 0 | 0 | 0 | 0.46 | 0.46 | 0.46 | 0.46 |
| | DUlq | | 0 | 0 | 0 | 0.08 | 0.75 | 0.75 | 0.75 | 0.75 |
| | ADmin | | 0 | 0 | 0 | 0 | 0.56 | 0.57 | 0.56 | 0.57 |
| | ADlq | | 0 | 0 | 0 | 0.09 | 0.93 | 0.94 | 0.93 | 0.94 |

**Best Scenarios**

- **AquaCrop results for Mesga 1**

AquaCrop shows that the Dry Yield production reaches 16 ton/ha, Biomass production is estimated at about 30.3 ton/ha, and ET Water Productivity approximately 7.43 $kg/m^3$, see the figure below. Also, the water balance computations have shown resultant as follows:

| INFLOW | RAIN | CR | Storage WC | EVAPORATION | TRANSPIRATION | Deep percolation | RUNOFF | DRAIN | WATER BALANCE |
|---|---|---|---|---|---|---|---|---|---|
| 4.7 | 0.952224 | 0 | 0 | 1.671852 | 0.755664 | 1.500954 | 0.047502 | 1.093092 | 0.58316 |
| Remaining Water% | 10.31735 | | | | | | | | |




*AquaCrop results for Mesga 1*