# Study of Soil Moisture in Laba and Ghedghed Spate Irrigation Commands (Eritrea)

By Debesom Haish (B.Sc.)
Irrigation Staff of E.L.W.D. Project.
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# 1.Introduction

Spate irrigation involves pre-planting application of flood water in which plants extract the residual moisture in the soil, and this type of irrigation is very common in Shieb. The main problem in this system is the difficulty of controlling the floods. For this reason, the diversion structure is constructed by the project in Laba and Mai-ule. As a matter of fact floods could be easily managed and regulated by the farmers and the diversion and application efficiencies improved. Therefore, more water could be stored in the root zone of the soil profile or more area irrigated when compared with the traditional system of spate irrigation. In this study, soil samples were collected from the project area/Laba command and the traditional system of spate irrigation-Ghedghed and analysed and the amount of moisture we have in the root zone of the soil profile is quantified.

# 2.Objective of the study

The objective of this study is:-

1.1.To find out the water holding capacity of each profile;

1.2.To quantify the existing moisture we have in the soil profile of the two commands;

1.3.To quantify and assure if the total available moisture is enough for the full growth of the main crop;

1.4.To make a rough comparison of the two irrigation systems in relation to the moisture held in the profiles. This is because though the structure helps to control and divert more floods in to the fields, moisture storage in the profile depends on the following factors too:-

1.the type of the soil/soil texture;
2.amount of water applied;
3.the cultivation practices;
4.the soil depth and
5.salinity of the soil and others.

## 3. Methodology

3.1. Digging a profile of 1.5m. depth;
3.2. Identifying the different horizons available in each profile;
3.3. Measure and record the thickness of each horizon;
3.4. Take a soil sample from each horizon by core sampler. This is for bulk density measurement.
3.5. Take another soil sample from each horizon by using auger from a vicinity of the profile;
3.6. Each sample is sent to the laboratory of Halhale research centre for analysis of the following soil physical properties:-
   1. Texture
   2. Bulk density
   3. Field capacity moisture level
   4. Existing moisture level
3.7. Finally, the AWH capacity, the total available water and the existing moisture level are calculated by equations 2, 3 and 1 respectively.

D=Sum of (Volumetric moisture value in % *Horizon thickness)…………Eq. 1

Where, Volumetric moisture value in % = Gravimetric moisture value in % * Bulk density; or

$$\text{AWH capacity, m.m.} = \text{Sum of } \frac{(\text{F.C.} - \text{P.W.P.})}{100} * A * D \quad \text{……………………Eq. 2}$$

Where, F.C. = Field capacity moisture percent of the soil layer;
P.W.P. = Permanent wilting point moisture percent of the soil layer;
A = Bulk density of the soil layer in g/cc and
D = Depth of the soil layer in m.m.

$$\text{T.A.W.} = \text{Sum of } \frac{(\text{E.M.} - \text{P.W.P.})}{100} * A * D \quad \text{…………………………………Eq. 3}$$

Where, T.A.W. = Total available water of the soil layer;
P.W.P., A and D are explained under equation 2.

## 4.Limitation of the study

4.1.Soil sample is taken only to the depth of 1.5m.whereas roots of sorghum can extract water till the depth of 2.0m.

4.2.Wilting point and field capacity moisture levels could not be done in the laboratory of Halhale research centre due to the absence of appropriate laboratory equipments like pressure plate. To fill this gap wilting point data for each texture is taken from literatures.

4.3.Fields selected for the study were the fully irrigated ones and this selection was made based on the information received from farmers. Totally three profiles were dug in each command, one in the upstream, one in midstream and one in down stream. So, it is hardly possible to say this data is a representative of the whole command.

4.4.The available water holding capacity of the soils is not calculated, because the result obtained from estimated or approximated wilting point and field capacity moisture levels can not be reliable.

4.5.The growth stages of sorghum in GhedGhed are not clearly elaborated in this report .It needs further follow-ups. In this report it is included only to give a general idea, otherwise its crop period might be longer than that of Shieb.

## 5.Encountered problems

1. Much of the time was spent in negotiating with farmers to get permission of digging profiles inside their fields;
2. Auger that can reach as deep as the root depth was not found;
3. Areal coverage of the study was limited due to time and shortage of transport service;
4. Due to the absence of sufficient climate data in Shieb part of the data used for the computation of crop water requirement was taken from the climate data of Massawa tabled by Halcrow in the draft design report and
5. the bureaucracy we have in the ministry to get the samples analysed at the desired time is another problem encountered in the study.

## 6. Reference crop Evapotranspiration (ETo)

The reference crop evapotranspiration is calculated based on five years temperature data of Shieb, and humidity, wind speed and sunshine hours data of Massawa by Penman-Monteith method. But, the 2003's temperature data of Shieb will be used for the evaluation of this year's moisture in the profiles. The tables are shown below.

Table 1 : Monthly reference crop evapotranspiration calculated by Penman-Monteith method from five years record of Shieb temperature.

Country : Eritrea Station : Shieb

Altitude : 200m. above m.s.l.

Latitude : Longitude :

| Month | Max.Temp. (deg.c) | Min.Temp. (deg.c) | Humidity (%) | Wind Spd. (km/d) | Sunshine hours | Solar Rad. (MJ/m2/d) | Eto Penman (mm/d) |
|---|---|---|---|---|---|---|---|
| January | 30.1 | 20.8 | 76.0 | 190.0 | 7.3 | 16.8 | 3.9 |
| February | 32.6 | 22.6 | 77.0 | 121.0 | 6.9 | 17.9 | 4.1 |
| March | 33.6 | 23.5 | 73.0 | 164.0 | 8.6 | 22.0 | 5.3 |
| April | 37.6 | 26.4 | 74.0 | 199.0 | 10.3 | 25.4 | 6.6 |
| May | 41.2 | 28.2 | 69.0 | 173.0 | 9.9 | 24.7 | 7.0 |
| June | 43.5 | 30.8 | 56.0 | 164.0 | 10.6 | 25.4 | 7.8 |
| July | 44.2 | 33.0 | 53.0 | 164.0 | 9.2 | 23.4 | 7.6 |
| August | 43.2 | 32.5 | 56.0 | 276.0 | 9.5 | 24.0 | 8.7 |
| September | 40.6 | 30.4 | 62.0 | 216.0 | 9.9 | 24.0 | 7.4 |
| October | 37.9 | 26.8 | 65.0 | 199.0 | 9.4 | 21.7 | 6.2 |
| November | 34.8 | 24.1 | 70.0 | 173.0 | 8.9 | 19.2 | 4.9 |
| December | 33.0 | 22.6 | 75.0 | 173.0 | 8.6 | 17.9 | 4.2 |
| Year | 37.7 | 26.8 | 67.2 | 184.3 | 9.1 | 21.9 | 6.1 |

Note :- Humidity, wind speed and sunshine hours data are adapted from Halcrow's draft design report.

Table 2 : Monthly reference crop evapotranspiration calculated by Penman-Monteith method from one year (2003) record of temperature, but, November and December data are records of five years.

Country : Eritrea Station : Shieb

Altitude : 200m. above m.s.l.
Latitude : Longitude :

| Month | Max.Temp. (deg.c) | Min.Temp. (deg.c) | Humidity (%) | Wind Spd. (km/d) | Sunshine hours | Solar Rad. (MJ/m2/d) | Eto Penman (mm/d) |
|---|---|---|---|---|---|---|---|
| January | 32.7 | 21.3 | 76.0 | 190.0 | 7.3 | 16.8 | 4.2 |
| February | 30.9 | 20.7 | 77.0 | 121.0 | 6.9 | 17.9 | 3.9 |
| March | 33.9 | 23.2 | 73.0 | 164.0 | 8.6 | 22.0 | 5.3 |
| April | 40.0 | 24.7 | 74.0 | 199.0 | 10.3 | 25.4 | 6.7 |
| May | 45.0 | 29.0 | 69.0 | 173.0 | 9.9 | 24.7 | 7.6 |
| June | 45.2 | 31.0 | 56.0 | 164.0 | 10.6 | 25.4 | 8.0 |
| July | 45.3 | 29.8 | 53.0 | 164.0 | 9.2 | 23.4 | 7.7 |
| August | 45.1 | 31.3 | 56.0 | 276.0 | 9.5 | 24.0 | 9.0 |
| September | 42.9 | 30.4 | 62.0 | 216.0 | 9.9 | 24.0 | 7.7 |
| October | 39.0 | 26.8 | 65.0 | 199.0 | 9.4 | 21.7 | 6.3 |
| November | 34.8 | 24.1 | 70.0 | 173.0 | 8.9 | 19.2 | 4.9 |
| December | 33.0 | 22.6 | 75.0 | 173.0 | 8.6 | 17.9 | 4.2 |
| Year | 39.0 | 26.2 | 67.2 | 184.3 | 9.1 | 21.9 | 6.3 |

Note :- Humidity, wind speed and sunshine hours data are adapted from Halcrow's draft design report.

## 6.Effective Rainfall

Ten years rainfall data is collected from MoA's office in Shieb and the effective amount is computed by USDA's S.C. method for 2003's rainfall data as well. The tables are shown below.

Table 3 : Effective rain fall from ten years monthly rain fall data of Shieb.
Effective rain method : USDA S.C. method.

| Month | Rain fall in m.m. /month | Effective rain fall in m.m. /month |
|---|---|---|
| January | 6.6 | 6.5 |
| February | 1.8 | 1.8 |
| March | 10.5 | 10.4 |
| April | 5.6 | 5.6 |
| May | 3.3 | 3.3 |
| June | 2.4 | 2.4 |
| July | 21.6 | 20.9 |
| August | 17.8 | 17.3 |
| September | 8.6 | 8.3 |
| October | 22.8 | 22.0 |
| November | 14.3 | 13.9 |
| December | 8.2 | 8.1 |
| Total | 123.5 | 120.5 |

Table 4 : Effective rain fall from Shieb's monthly rain fall data of 2003.
Effective rain method : USDA S.C. method.

| Month | Rain fall in m.m. /month | Effective rain fall in m.m. /month |
|---|---|---|
| January | 3.0 | 3.0 |
| February | 10.8 | 10.6 |
| March | 0.0 | 0.0 |
| April | 3.1 | 3.1 |
| May | 0.0 | 0.0 |
| June | 2.6 | 2.6 |
| July | 25.0 | 24.0 |
| August | 5.0 | 5.0 |
| September | 0.0 | 0.0 |
| October | 0.0 | 0.0 |
| November | 0.0 | 0.0 |
| December | 11.0 | 10.80 |
| Total | 60.5 | 59.1 |

## 7.Crop Evapotranspiration/Crop Water Requirment

The crop evapotranspiration which is equivalent to the crop water requirment is calculated as follows:-

$$ETc = Eto * Kc$$

Where, Etc = crop evapotranspiration;
Eto = Reference crop evapotranspiration and
Kc = Crop factor

But, the procedure requires the completion of the following steps. They are:-

1.Identifying the crop growth stages, determining their lengths, selecting the corresponding Kc values and adjusting for variation of climate;

1.1.The growth stages of sorghum as of any crop, which is harvested at the end of its maturation stage, are initial, development, mid and late. Their lengths are 21, 41, 20 to 30 and 26 days respectively which totals to 108 to 118. As moisture and other environmental stresses usually accelerate the rate of crop maturation, the absence of rain in the crop period (September to now) in this year is expected to make the mid and late season growing periods shorter. As is shown in the research made on Shieb's Spate irrigation, 1997-2000 by Dr. Mehreteab, the total crop period for the 1998 sorghum was 108 days. Since harvest of this year's crop is expected by the end of December and planting date was 10th of September, the total crop peried of this year's sorghum will be 113 days which is 21 for initial, 41 for development, 25 for mid and 26 days for late stage.

1.2.The Kc values for non stressed and well managed sorghum in subhumid

climates is given in table 12 of FAO Irrigation and Drainage paper, 24. This is adjusted for variation in climates of mean relative humidity and wind speed which differ from 45% and 2m/s respectively and is finalized as shown below.
Kc ini. = 0.25, Kc mid = 1.1 and Kc end = 0.52

2.Calculating Etc based on the crop coefficient curve. See the following tables, please.

Table 5- Etc for Eto obtained from mean climate data

| **Crop Growth Stages** | **Crop Growth Period** | **No. of Days** | **Eto in m.m./d** | **Kc Value** | **Etc in m.m./d** | **Etc in m.m.** |
|---|---|---|---|---|---|---|
| **Initial** | 10 to 30 Sept. | 21 | 7.4 | 0.25 | 1.85 | 39 |
| **Development** | 01 to 31 Oct. | 31 | 6.2 | 0.57 | 3.53 | 109 |
| | 01 to 10 Nov. | 10 | 4.9 | 1.00 | 4.90 | 49 |
| **Mid** | 11 to 30 Nov. | 20 | 4.9 | 1.10 | 5.39 | 108 |
| | 01 to 05 Dec. | 05 | 4.2 | 1.10 | 4.62 | 23 |
| **Late** | 06 to 31 Dec. | 26 | 4.2 | 0.81 | 3.40 | 88 |
| **Total** | 10Sept. to 31 Dec. | 113 | 31.8 | | 23.69 | 416 |

Table 6- Etc for Eto obtained from climate data of 2003

| **Crop Growth Stages** | **Crop Growth Period** | **No. of Days** | **Eto in m.m./d** | **Kc Value** | **Etc in m.m./d** | **Etc in m.m.** |
|---|---|---|---|---|---|---|
| **Initial** | 10 to 30 Sept. | 21 | 7.7 | 0.25 | 1.93 | 41 |
| **Development** | 01 to 31 Oct. | 31 | 6.3 | 0.57 | 3.59 | 111 |
| | 01 to 10 Nov. | 10 | 4.9 | 1.00 | 4.90 | 49 |
| **Mid** | 11 to 30 Nov. | 20 | 4.9 | 1.10 | 5.39 | 108 |
| | 01 to 05 Dec. | 05 | 4.2 | 1.10 | 4.62 | 23 |
| **Late** | 06 to 31 Dec. | 26 | 4.2 | 0.81 | 3.40 | 88 |
| **Total** | 10Sept. to 31 Dec. | 113 | 32.2 | | | 420 |

## 8.Available Water Holding Capacity and Existing Moisture

The available water is the soil water held between the field capacity and the permanent wilting point. So, the existing moisture in this context is meant the soil moisture within the above range which is available to the plant roots. For the calculated values, refer the following tables.

Table 7 :- Total available moisture/water of each horizon in the upstream command of Laba calculated by using equation 3.

| Profile depth (c.m.) | Horizon | Horizon thickness (c.m.) | Soil texture | Existing moisture (v/v) | Water content at wilting | Total available water in |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | point (v/v) | m.m |
| 0-25 | LUS-1 | 25 | Sandy loam | 0.16 | 0.06 | 25.0 |
| 26-50 | LUS-2 | 25 | Silt loam | 0.44 | 0.09 | 87.5 |
| 51-68 | LUS-3 | 18 | Sandy loam | 0.26 | 0.06 | 36.0 |
| 69-75 | LUS-4 | 7 | Sandy loam | 0.20 | 0.06 | 9.8 |
| 76-102 | LUS-5 | 27 | Sandy loam | 0.17 | 0.06 | 29.7 |
| 103-132 | LUS-6 | 30 | Sandy loam | 0.21 | 0.06 | 45.0 |
| 133-145 | LUS-7 | 13 | Loamy sand | 0.08 | 0.03 | 6.5 |
| Total | Profile | 145 | | | | 239.5 |

Note :- v/v = Volumetric ratio.

Table 8 :- Total available moisture/water of each horizon in the midstream command of Laba calculated by using equation 3.

| Profile depth (c.m.) | Horizon | Horizon thickness (c.m.) | Soil texture | Existing moisture (v/v) | Water content at wilting point (v/v) | Total available water in m.m |
|---|---|---|---|---|---|---|
| 0-48 | LMS-1 | 48 | Silt clay loam | 0.30 | 0.17 | 62.4 |
| 49-68 | LMS-2 | 20 | Silt clay loam | 0.30 | 0.17 | 26.0 |
| 69-112 | LMS-3 | 44 | Clay loam | 0.35 | 0.13 | 96.8 |
| 113-127 | LMS-4 | 15 | Clay loam | 0.27 | 0.13 | 21.0 |
| 128-150 | LMS-5 | 23 | Silt loam | 0.21 | 0.09 | 27.6 |
| Total | | 150 | | | | 233.8 |

Table 9 :- Total available moisture/water of each horizon in the downstream command of Laba calculated by using equation 3.

| Profile | Horizon | Horizon | Soil | Existing | Water | Total |
|---|---|---|---|---|---|---|

| depth (c.m.) | | thickness (c.m.) | texture | moisture (v/v) | content at wilting point (v/v) | available water in m.m |
|---|---|---|---|---|---|---|
| 0-30 | LDS-1 | 30 | Silt clay loam | 0.38 | 0.17 | 63.0 |
| 31-48 | LDS-2 | 18 | Silt clay loam | 0.45 | 0.17 | 50.4 |
| 49-60 | LDS-3 | 12 | Silt loam | 0.26 | 0.09 | 20.4 |
| 61-96 | LDS-4 | 36 | Silt loam | 0.33 | 0.09 | 86.4 |
| 97-143 | LDS-5 | 47 | Silt clay loam | 0.37 | 0.17 | 94.0 |
| 144-150 | LDS-6 | 7 | Silt loam | 0.33 | 0.09 | 16.8 |
| Total | | 150 | | | | 331.0 |

Table 10 :- Total available moisture/water of each horizon in the upstream command of Ghedghed calculated by using equation 3.

| Profile depth (c.m.) | Horizon | Horizon thickness (c.m.) | Soil texture | Existing moisture (v/v) | Water content at wilting point (v/v) | Total available water in m.m |
|---|---|---|---|---|---|---|
| 0-33 | GUS-1 | 33 | Silt loam | 0.07 | 0.09 | - |
| 34-48 | GUS-2 | 15 | Sandy loam | 0.07 | 0.06 | 1.5 |
| 49-66 | GUS-3 | 18 | Silt loam | 0.20 | 0.09 | 19.8 |
| 67-77 | GUS-4 | 11 | Silt loam | 0.16 | 0.09 | 7.7 |
| 78-94 | GUS-5 | 17 | Silt loam | 0.13 | 0.09 | 6.8 |
| 95-105 | GUS-6 | 11 | Sandy loam | 0.11 | 0.06 | 5.5 |
| 106-113 | GUS-7 | 8 | Silt loam | 0.26 | 0.09 | 13.6 |
| 114-132 | GUS-8 | 19 | Silt loam | 0.33 | 0.09 | 45.6 |
| 133-145 | GUS-9 | 13 | Loam | 0.19 | 0.07 | 15.6 |
| 146-150 | GUS-10 | 5 | Loam | 0.16 | 0.07 | 4.5 |
| Total | | 150 | | | | 120.6 |

Table 11 :- Total available moisture/water of each horizon in the midstream command of Ghedghed calculated by using equation 3.

| Profile depth (c.m.) | Horizon | Horizon thickness (c.m.) | Soil texture | Existing moisture (v/v) | Water content at wilting point (v/v) | Total available water in m.m |
|---|---|---|---|---|---|---|
| 0-46 | GMS-1 | 46 | Silt loam | 0.29 | 0.09 | 92.0 |
| 47-53 | GMS-2 | 7 | Silt loam | 0.27 | 0.09 | 12.6 |
| 54-84 | GMS-3 | 31 | Silt loam | 0.22 | 0.09 | 40.3 |
| 85-103 | GMS-4 | 19 | Loam | 0.28 | 0.07 | 39.9 |
| 104-123 | GMS-5 | 20 | Sandy loam | 0.19 | 0.06 | 26.0 |
| 124-133 | GMS-6 | 10 | Sandy loam | 0.13 | 0.06 | 7.0 |
| 134-150 | GMS-7 | 17 | Sandy loam | 0.13 | 0.06 | 11.9 |
| Total | | 150 | | | | 229.7 |

Table 12 :- Total available moisture/water of each horizon in the downstream command of Ghedghed calculated by using equation 3.

| Profile depth (c.m.) | Horizon | Horizon thickness (c.m.) | Soil texture | Existing moisture (v/v) | Water content at wilting point (v/v) | Total available water in m.m |
|---|---|---|---|---|---|---|
| 0-46 | GDS-1 | 46 | Clay loam | 0.26 | 0.13 | 59.8 |
| 47-62 | GDS-2 | 16 | Silt loam | 0.31 | 0.09 | 35.2 |
| 63-118 | GDS-3 | 56 | Silt clay loam | 0.42 | 0.17 | 140 |
| 119-134 | GDS-4 | 16 | Clay loam | 0.50 | 0.13 | 59.2 |
| 135-150 | GDS-5 | 16 | Silt clay loam | 0.51 | 0.17 | 54.4 |
| Total | | 150 | | | | 348.6 |

Table 13 :- Existing moisture in each horizon in the upstreastream command of Laba calculated by using equation 1.

| Profile depth (c.m.) | Horizon | Horizon thickness (c.m.) | Soil texture | Bulk density (g/c.c.) | Existing moisture level (%) | Existing moisture (c.m./m.) | Existing moisture (m.m.) |
|---|---|---|---|---|---|---|---|
| 0-25 | LUS-1 | 25 | Sandy loam | 1.22 | 13.34 | 16.27 | 40.8 |
| 26-50 | LUS-2 | 25 | Silt loam | 1.11 | 39.55 | 43.9 | 109.8 |
| 51-68 | LUS-3 | 18 | Sandy loam | 1.27 | 20.44 | 25.96 | 46.7 |
| 69-75 | LUS-4 | 7 | Sandy loam | 1.15 | 17.6 | 20.24 | 14.2 |
| 76-102 | LUS-5 | 27 | Sandy loam | 1.35 | 12.55 | 16.94 | 45.7 |
| 103-132 | LUS-6 | 30 | Sandy loam | 1.20 | 17.65 | 21.18 | 63.5 |
| 133-145 | LUS-7 | 13 | loamy Sand | 1.10 | 7.24 | 7.96 | 10.3 |
| Total | | 145 | | | | | 331 |

Table 14 :- Existing moisture in each horizon in the midstream command of Laba calculated by using equation 1.

| Profile depth (c.m.) | Horizon | Horizon thickness (c.m.) | Soil texture | Bulk density (g/c.c.) | Existing moisture level (%) | Existing moisture (c.m./m.) | Existing moisture (m.m.) |
|---|---|---|---|---|---|---|---|
| 0-48 | LMS-1 | 48 | Silt clay loam | 1.16 | 25.68 | 29.79 | 143 |
| 49-68 | LMS-2 | 20 | Silt clay loam | 1.16 | 26.21 | 30.40 | 60.8 |
| 69-112 | LMS-3 | 44 | Clay loam | 1.20 | 28.91 | 34.69 | 152.6 |
| 113-127 | LMS-4 | 15 | Clay loam | 1.37 | 19.35 | 26.51 | 39.8 |
| 128-150 | LMS-5 | 23 | Silt loam | 1.28 | 16.13 | 20.65 | 47.5 |
| Total | | 150 | | | | | 443.7 |

Table 15 :- Existing moisture in each horizon in the downstream command of Laba calculated by using equation 1.

| Profile depth (c.m.) | Horizon | Horizon thickness (c.m.) | Soil texture | Bulk density (g/c.c.) | Existing moisture level (%) | Existing moisture (c.m./m.) | Existing moisture (m.m.) |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0-30 | LDS-1 | 30 | Silt clay loam | 1.2 | 31.57 | 37.88 | 113.6 |
| 31-48 | LDS-2 | 18 | Silt clay loam | 1.34 | 33.49 | 44.88 | 80.8 |
| 49-60 | LDS-3 | 12 | Silt loam | 1.17 | 22.16 | 25.93 | 31.1 |
| 61-96 | LDS-4 | 36 | Silt loam | 1.23 | 27.22 | 33.48 | 120.5 |
| 97-143 | LDS-5 | 47 | Silt clay loam | 1.13 | 32.87 | 37.14 | 174.6 |
| 144-150 | LDS-6 | 7 | Silt loam | 1.18 | 28.11 | 33.17 | 23.2 |
| Total | | 150 | | | | | 543.8 |

Table 16 :- Existing moisture in each horizon in the upstreastream command of Ghedghed calculated by using equation 1.

| Profile depth (c.m.) | Horizon | Horizon thickness (c.m.) | Soil texture | Bulk density (g/c.c.) | Existing moisture level (%) | Existing moisture (c.m./m.) | Existing moisture (m.m.) |
|---|---|---|---|---|---|---|---|
| 0-33 | GUS-1 | 33 | Silt loam | 1.14 | 6.39 | 7.28 | 24 |
| 34-48 | GUS-2 | 15 | Sandy loam | 1.48 | 5.05 | 7.47 | 11.2 |
| 49-66 | GUS-3 | 18 | Silt loam | 1.08 | 18.81 | 20.31 | 36.6 |
| 67-77 | GUS-4 | 11 | Silt loam | 1.28 | 12.56 | 16.08 | 17.7 |
| 78-94 | GUS-5 | 17 | Silt loam | 1.17 | 10.96 | 12.82 | 21.8 |
| 95-105 | GUS-6 | 11 | Sandy loam | 1.34 | 7.85 | 10.52 | 11.57 |
| 106-113 | GUS-7 | 8 | Silt loam | 1.17 | 21.93 | 25.66 | 20.5 |
| 114-132 | GUS-8 | 19 | Silt loam | 1.23 | 26.90 | 33.09 | 62.9 |
| 133-145 | GUS-9 | 13 | Loam | 1.22 | 15.42 | 18.81 | 24.5 |
| 146-150 | GUS-10 | 5 | Loam | 1.28 | 12.30 | 15.74 | 7.9 |
| Total | | 150 | | | | | 238.8 |

Table 17 :- Existing moisture in each horizon in the midstream command of Ghedghed calculated by using equation 1.

| Profile depth (c.m.) | Horizon | Horizon thickness (c.m.) | Soil texture | Bulk density (g/c.c.) | Existing moisture level | Existing moisture (c.m./m.) | Existing moisture (m.m.) |
|---|---|---|---|---|---|---|---|

| | | | | | (%) | | |
|---|---|---|---|---|---|---|---|
| 0-46 | GMS-1 | 46 | Silt loam | 1.3 | 22.47 | 29.21 | 134.4 |
| 47-53 | GMS-2 | 7 | Silt loam | 1.1 | 24.15 | 26.57 | 18.6 |
| 54-84 | GMS-3 | 31 | Silt loam | 1.2 | 18.70 | 22.44 | 69.6 |
| 85-103 | GMS-4 | 19 | Loam | 1.23 | 22.68 | 27.90 | 53.0 |
| 104-123 | GMS-5 | 20 | Sandy loam | 1.47 | 13.03 | 19.15 | 38.3 |
| 124-133 | GMS-6 | 10 | Sandy loam | 1.42 | 8.83 | 12.54 | 12.5 |
| 134-150 | GMS-7 | 17 | Sandy loam | 1.40 | 9.18 | 12.85 | 21.8 |
| Total | | 150 | | | | | 348.2 |

Table 18 :- Existing moisture in each horizon in the downstream command of Ghedghed calculated by using equation 1.

| Profile depth (c.m.) | Horizon | Horizon thickness (c.m.) | Soil texture | Bulk density (g/c.c.) | Existing moisture level (%) | Existing moisture (c.m./m.) | Existing moisture (m.m) |
|---|---|---|---|---|---|---|---|
| 0-46 | GDS-1 | 46 | Clay loam | 1.11 | 23.53 | 26.12 | 120.2 |
| 47-62 | GDS-2 | 16 | Silt loam | 1.41 | 22.23 | 31.34 | 50.1 |
| 63-118 | GDS-3 | 56 | Silt clay loam | 1.19 | 35.24 | 41.94 | 234.9 |
| 119-134 | GDS-4 | 16 | Clay loam | 1.28 | 38.73 | 49.57 | 79.3 |
| 135-150 | GDS-5 | 16 | Silt clay loam | 1.21 | 41.92 | 50.72 | 81.2 |
| Total | | 150 | | | | | 565.7 |

## 9. Discussions

Table 19 :- Summary of tables 7 to 18.

| No. | Profile | Command |
|---|---|---|

| | | Laba | | Ghedghed | |
|---|---|---|---|---|---|
| | | Existing Moisture (m.m.) | Total Available water/moisture (m.m.) | Existing Moisture (m.m.) | Total Available water/moisture (m.m.) |
| 1. | Upstream | 331.0 | 239.5 | 238.8 | 120.6 |
| 2. | Midstream | 443.7 | 233.8 | 348.2 | 229.7 |
| 3. | Down stream | 543.8 | 331.0 | 565.7 | 348.6 |

As can be seen from the table the soil profiles in the two commands, especially the mid and downstream profiles, have the capacity to hold the total moisture required for the full growth of the crop. As is calculated and shown in tables no. 5 and 6 the crop water requirement for sorghum growing in Shieb is 420 m.m. This figure is very close to the Etc calculated by Dr. Mehreteab in the study for his PhD paper. i.e. 465 and 411 m.m. for the 1998 and 1999 sorghum grown in Shieb. Therefore, there is no doubt the profile has the capacity of holding enough moisture up to the final root depth of sorghum,i.e. 2.0m. This coud have been very clear if we were able to know the field capacity and the wilting point moisture levels. But, the problem is, not all the moisture held in the profile is available to the roots of the crop. So, one can say the crop has faced moisture stress in this year. This problem is again aggravated by the scarcity of rain. Though the fields have got relatively good flood in comparison to the previous years only 60.5m.m. of rain is recorded in Menshieb out of which only 59.1m.m. is effective. For further information refer table 4.

## 10. <u>Conclusion</u>

1. In comparison to the crop water requirement of sorghum grown in Shieb i.e. 420m.m.,the total available water in both cammands is not sufficient up to the 1.5m. depth from which soil sample is taken. Only the downstream profiles may have sufficient available water upto the final root depth of sorghum i.e. 2.0m.
2. It is very difficult to compare the two commands with respect to moisture held in the profiles.As is already mentioned under the objective of this study moisture held in the profiles depends on many factors.
3. The soils in the two commands are more of clay type. But, clay soil though it is a good moisture holder(has more pore spaces than other soil textures) it is very weak in making the moisture available to roots of crops(more of its pore spaces are micro pores). So, some management aspects are required to improve its capacity of making the soil moisture available to roots of crops. For example, application of organic manure.

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