**Ministry of Agriculture & Land Reclamation Agricultural Research Center**
**Central Lab for Agricultural Expert systems**

# Revised Irrigation Design Expert Systems For Grapes

# (GRAPEX)

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# Irrigation Design Expert
# Systems for Grapes

## 1. Introduction

Egypt Grapes crop is quite large and centered in the old and new land. Grapes harvest in May, Gun, Guly, Augest, September and October. Irrigation scheduling for Grapes is a planning and decision-making activity which includes applying the right amount of water at the right time to maintain economic crop production. The criteria most suitable for scheduling vary from one situation to another. Sometimes, irrigation scheduling may be utilized to minimize irrigation costs, facilities other farm operations, leaching salty soils or accommodate schedule of water delivery to the farm[A. Sharaf Eldin and A. Al-Amoud].

Irrigation water is the most limiting and most precious resource of agriculture today. Managing irrigation precisely is one of our most urgent challenges. Too little water, even for a short time, can damage a crop, cut yield and quality, and hurt a farmer's bottom line. Too much water is expensive, wasteful, and raises environmental concerns about nitrate and nutrient leaching into ground and surface water.

The purpose of irrigation scheduling is to determine the exact amount of water to apply to the field and the exact timing for application. The amount of water applied is determined by using a criterion to determine irrigation need and a strategy to prescribe how much water to apply in any situation.

The grapes irrigation system is based on earlier versions of GRAPES expert systems (TR/CLAES/30/98.3) titled with "preliminary Design of Irrigation System for Grape Expert System", (TR/CLAES/83/99.9) titled with "Irrigation Design Subsystem for Faba Bean Production Expert System(FABABEX)", and (TR/CLAES/254/2002.11) titled with "Irrigation design subsystem for Grapes Production expert system ".

This document contains six sections and one appendixes. Section one provides a description of the goal of irrigation scheduling problem. Section two provides a

Basics of Irrigation Scheduling and the approach used for solving this type of problem. The domain knowledge, inference knowledge and task knowledge for the irrigation scheduling problem are described in section three, four, and five respectively. Section six describes the irrigation interface design. Appendix A included nine cases that cover all possible reasoning paths in irrigation system.

## 2. Basics of Irrigation Scheduling

Irrigation scheduling is a method to decide how much water to apply. It sounds simple, but most of us spend too little time understanding how much water we are applying to the soil.

Weather and plants change from day to day during the growing season. Maintaining crop health and quality requires an irrigating schedule that adjusts to changing needs. Irrigators must be prepared to vary either the number of hours they irrigate in each set or the number of days between sets.

Proper scheduling must be performed in relation to the soil, crop, irrigation system, and weather. There is some unavoidable effort involved in setting up basic assumption about crop conditions. To schedule irrigation effectively, you must follow these five simple steps:

### 2.1 Evapotranspiration (ET0)

The effect of climate on crop water requirements is given by the reference crop evapotranspiration(ET0) which is defined as "*the rate of evapotranspiration from an extensive surface of 8 to 15 cm tall, green grass cover of uniform height, actively growing, completely shading the groundand not short of water*". The two methods presented, the Penman, and Pan Evaporation method. The choice of method must be based on the type of climatic data available and on accuracy required in determining water needs

Climatic data required are: mean temperature(T in 0C), mean relative humidity(RH in %), total wind run (U in Km/day at 2m heigh) and mean actual sunshine duration(n in hour/day) or mean radiation(RS or Rn equivalent evaporation in mm/day). Also measured or estimated data on mean maximum relative humidity (Rhmax in %) and mean daytime windspeed (Uday in m/sec at 2 m height) must be available.

## 2.2 EtCrop

Its goal is to determine crop evapotraspiration(Etcrop) for different crops, stages of growths, length of growing season and prevailing climatic condition To account for the effect on the crop characteristics on crop water requirements, crop coefficients(Kc) are presented to relate ET0 to crop evapotranspiration (Etcrop). Etcrop based on crop coefficients(Kc) and green cover area(Gc). The Kc value relates *to "evapotranspiration of a disease-free crop grown in large fields under optimum soil water and fertility conditions and achieving full production potential under the given growing environment".*

## 2.3 SWHC

SWHC is *the depth of water that can be stored within the root zone.*

## 2.4 Water Requirement

Water requirement gives the suitable(optimal) water to minimize crop water stress and maximize yields. It assists in controlling root zone salinity problems through controlled leaching.

## 2.5 Frequency

Correct timing of irrigation applications is of over-riding importance. Timing of irrigation should conform to soil water depletion requirements of the crop which are shown to vary considerably with evaporative demand, rooting depth and soil type as well as with stages of crop growth.

# 3.Domain Knowledge

## 3.1 Ontology

3.1.1 Plantation Ontology

```
concept plantation;
        properties :
                        planting_date : DATE,
                               SOURCE(D.B.)
                                     SINGLE
                                     NECESSARY.
```

```
area:  REAL,
    NUMBER-RANGE(1,2000),
    SOURCE(D.B.)
    SINGLE


Irrigation_system: NOMINAL,
    VALUE-LIST(غمر , رش,تنقيط )
    SOURCE(D.B.)
    SINGLE
    NECESSARY.

drainage_system: NOMINAL,
    VALUE-LIST(ردىء ,متوسط,جيد )
    SOURCE(D.B.)
    SINGLE
    NECESSARY.
```

*3.1.1.1 Soil Concept*

```
concept soil;
    properties :

        texture: NOMINAL,
                VALUE-LIST(clay, clay_loam, coarse_sand,
                    gravely, heavy_clay, loam, sand,
                    sandy_clay_loam, sandy_loam,
                    sily_clay, sily_clay_loam, sily_loam),
            SOURCE(D.B.)
            SINGLE.

        type: NOMINAL,
            VALUE-LIST(خفيفه ,متوسطه ,ثقيله),
            SOURCE(Derived[relation,soil_type]),
                SINGLE

        sp : REAL, %soil saturated percentage
            NUMBER-RANGE(0,1000),
            SOURCE(D.B.;
                Derived[table, sp_t]),
            SINGLE.

        sbd: REAL, %soil bulk density
            NUMBER-RANGE(0,1000),
            SOURCE(D.B.;
                Derived[table,sbd_t])
            SINGLE.
```

*3.1.1.2 Water Concept*

```
concept water;
          properties :
                              eciw : REAL,
                                        NUMBER-RANGE(0,3),
                                        SOURCE(D.B.)
                                        SINGLE.
```

*3.1.1.3 Climate Concept*

```
concept climate;
          properties :
                              latitude : REAL,
                                        NUMBER-RANGE(0,1000),
                                        SOURCE(D.B.)
                                        SINGLE.

                              tc_mean: REAL,
                                        NUMBER-RANGE(0,40),
                                        SOURCE(D.B.)
                                        SINGLE.
                              rh_mean: REAL,
                                        NUMBER-RANGE(0,100),
                                        SOURCE(D.B.)
                                        SINGLE.
                              actual_sun: REAL,
                                        NUMBER-RANGE(0,1000),
                                        SOURCE(D.B.)
                                        SINGLE.

                              wind_day: REAL,% average temperature
                                        NUMBER-RANGE(0,40),
                                        SOURCE(D.B.)
                                        MULTIPLE.
                              daily_tc_min: REAL,
                                        NUMBER-RANGE(0,40),
                                        SOURCE(D.B.)
                                        MULTIPLE.
                              daily_tc_max: REAL,
                                        NUMBER-RANGE(0,40),
                                        SOURCE(D.B.)
                                        MULTIPLE.
                              month : INTEGER,
                                        NUMBER-RANGE(0,12),
                                        SOURCE(Derived)
                                        SINGLE.

                              Adj_latitude : REAL,
                                        NUMBER-RANGE(0,1000),
                                        SOURCE(DERIVED, Function(Adj_latitude_f)),
                                        SINGLE.
```

```
Adj_latitude1 : REAL,
        NUMBER-RANGE(0,1000),
        SOURCE(DERIVED, Function (Adj_latitude1_f)),
        SINGLE.

solar_radiation: REAL,
        NUMBER-RANGE(0,40),
        SOURCE(Derived, Function(Solar_radiation_f))
        SINGLE.

Adjustment_solar_radiation : REAL,
        NUMBER-RANGE(0,40),
        SOURCE(DERIVED,
                Relation(Adaptive Solar Radiation)),
        SINGLE.

Adjustment_tc_mean : REAL,
        NUMBER-RANGE(0,40),
        SOURCE(DERIVED,
                Relation(Adaptive Mean Temperature)),
        SINGLE.

Adjustment_factor : REAL,
        NUMBER-RANGE(0,100),
        SOURCE(DERIVED,
                Table(adjustment_factor _t)),
        SINGLE.

radiation : REAL,
        NUMBER-RANGE(0,100),
        SOURCE(DERIVED, Table(radiation_t)),
        SINGLE.

abs_sun : REAL,
        NUMBER-RANGE(0,100),
        SOURCE(DERIVED, Table(abs_sun _t)),
        SINGLE.
Weight_factor : REAL,
        NUMBER-RANGE(0,100),
        SOURCE(DERIVED, Table(Weight_factor_t)),
        SINGLE.

ea : REAL,
        NUMBER-RANGE(0,100),
        SOURCE(DERIVED, Table(ea_t)),
        SINGLE.

function_tc : REAL,
        NUMBER-RANGE(0,100),
        SOURCE(DERIVED, Table(Function_tc_t)),
```

```
                SINGLE.

        ed : REAL,
                NUMBER-RANGE(0,100),
                SOURCE(function(ed_f)),
                SINGLE.


        adjustment_ed : REAL, %
                NUMBER-RANGE(0,100),
                SOURCE(Derived(relation, adjustment_ed),
                SINGLE.

        Function_ed : REAL,
                NUMBER-RANGE(0,100),
                SOURCE(DERIVED, Table(Function_ed_t)),
                SINGLE.

        n/N_factor : REAL,
                NUMBER-RANGE(0,100),
                SOURCE(Derived(function,n/N_factor_f),
                SINGLE.

        n/N : REAL,
                NUMBER-RANGE(0,100),
                SOURCE(Derived(function,n/N_f),
                SINGLE.

        Function_n/N : REAL,
                NUMBER-RANGE(0,100),
                SOURCE(DERIVED, Table(Function_n/N_t)),
                SINGLE.


    net_radiation: REAL,
                NUMBER-RANGE(0,40),
                SOURCE(Derived(function(Net_radiation _f))
                MULTIPLE.

    longwave_radiation: REAL,
                NUMBER-RANGE(0,40),
                SOURCE(Derived(function(longwave_radiation_f))
                MULTIPLE.

    Wind_function: REAL,
                NUMBER-RANGE(0,40),
                SOURCE(Derived(function(Wind_function_f))
                MULTIPLE.
```

*3.1.1.4 Plant Concept*

```
concept plant ;
        properties :
                        status:  NOMINAL, %حاله الاشجار حديث او مثمر
                                VALUE-LIST([حديث,غير مثمر ,مثمر]),
                                SOURCE(derived(relation(Expand plant status)
                                SINGLE
                                NECESSARY.

                        variety:  NOMINAL, %
                                VALUE-LIST([
                                        بيرليت  , كريمسون , طومسون,رومى احمر
                                        ايرلى سوبيريور , سوبيريوم , فلام ,كينج روبى   ])

                          Ece:  REAL, %درجه تحمل النبات للملوحه
                                NUMBER-RANGE(1,2000),
                                SOURCE(table(ece_t))
                                SINGLE
                          age:  REAL, %العمر بالسنه
                                NUMBER-RANGE(1,2000),
                                SOURCE(D.B.)
                                SINGLE
```

*3.1.1.5 farm Concept*

```
concept farm ;
        properties :
                type:  NOMINAL,
                        VALUE-LIS([حقل مفتوح]),
                                SOURCE(derived(relation(Farm Type))
                                SINGLE
                                NECESSARY.
                        crop: NOMINAL,
                                VALUE-LIST(عنب),
                                SOURCE(D.B.)
                                SINGLE.

                        drainage_system_factor:  Real, %معامل الترتيب الطبقى
                                SOURCE(derived(table(ds_factor_t))
                                NUMBER-RANGE(0;1000),
                                SINGLE
                                NECESSARY.
                        unit :  Real,
                                SOURCE(derived(table(unit))
                                NUMBER-RANGE(0;1000),
                                SINGLE
                                NECESSARY.
                        depression_factor :  Real,
                                SOURCE(derived(table(depression_factor _t))
                                NUMBER-RANGE(0;1000),
                                SINGLE
                                NECESSARY.
```

```
location: NOMINAL,
   VALUE-LIST ( التحرير, وجه بحرى, مصر الوسطى , مصر العليا),

         SOURCE(D.B.)
        SINGLE.
```

*3.1.1.6 Irrigation Concept*

```
concept irrigation;
        properties :
                        Irrigation_efficiency: Real;,
                                SOURCE(Derived(table(irrigation_efficiency_t)))
                                        SINGLE
                                        NECESSARY.

                        wrs: Real;, ;% نسبه مسطح البتلال
                                SOURCE(Derived(table(wrs_t)))
                                        SINGLE
                                        NECESSARY.

                                 Initialize_Leaching_requirement: Real;,
                                        SOURCE(Derived
                                                (function(Leaching_requirement_f)))
                                        SINGLE
                                        NECESSARY.

                                 Leaching_requirement: Real;,
                                        SOURCE(Derived
                                                (relation(Adapt Leaching Requirement)))
                                        SINGLE
                                        NECESSARY.


                        schedule_type : NOMINAL,
                                VALUE-LIST(each 10 days),
                                SOURCE(User).


                        Measure_type : NOMINAL,
                                VALUE-LIST(جهاز البخر,
                                        بيانات المنا خ,
                                        متوسطات قراءات بيانات المناخ على مستوى القطاع),
                                SOURCE(User).

                         irrigate_type: NOMINAL;,
                                        VALUE-LIST(ريه خفيفه ,ريه متوسطه ,ريه ثقيله)
                                        SOURCE(Derived
                                                (relation(Irrigation Type)))
                                        SINGLE
                                        NECESSARY.
```

*3.1.1.7 session Concept*

```
concept session;
        properties :
                Month: integer;,
                        SOURCE(Derived)
                              SINGLE
                              NECESSARY.

                day: integer;,
                        SOURCE(Derived)
                              SINGLE
                              NECESSARY.

                range_day: nominal ;,
                        SOURCE(Derived)
                              SINGLE
                              NECESSARY.

                number_days_per_period: integer;,
                        SOURCE(Derived)
                              SINGLE
                              NECESSARY.
```

3.1.2 Et0 Ontology

***a) Et0 Concept***

```
        Concept et0;
        Properties:
                value: real,
                        NUMBER-RANGE(0;1000),
```

**relation:** compute;
% Compute Adj_latitude1_r;
**argument-1**: climate;
**argument-role**: latitude;
**argument-2**: climate;
**argument-role**: Adj_latitude1;

**relation:** compute;
% Compute Adjustment_solar_radiation _r;
**argument-1**: climate;
**argument-role**: solar_radiation;
**argument-2**: climate;
**argument-role**: Adjustment_solar_radiation;

**relation:** compute;
% Compute tc_mean_r;
**argument-1**: climate;
**argument-role**: tc_mean;
**argument-2**: climate;

**argument-role**: Adjustment_tc_mean;

**relation:** compute;
% Compute adjustment_ed _r;

**argument-1**: climate;
**argument-role**: ed;
**argument-2**: climate;
**argument-role**: adjustment_ed;

***b) Et0 Function***

**function:** Adj_latitude_f;
**argument-1**: Climate;
**argument-role**: latitude;
**argument-2**: Climate;
**argument-role**: adj_latitude;

**function:** Adj_latitude1_f;
**argument-1**: Climate;
**argument-role**: latitude;
**argument-2**: Climate;
**argument-role**: adj_latitude;

**function:** Solar_radiation_f;
**argument-1**: Climate;
**argument-role**: Actual_sun, abs_sun, radiation ;
**argument-2**: Climate;
**argument-role**: Solar_radiation;

**function:** Tc_mean_f;
**argument-1**: Climate;
**argument-role**: daily_tc_min, daily_tc_max;
**argument-2**: Climate;
**argument-role**: tc_mean;

**function:** net_radiation _f;
**argument-1**: Climate;
**argument-role**: solar_radiation, longwave_radiation;
**argument-2**: Climate;
**argument-role**: net_radiation;

**function:** n/N_factor_f;
**argument-1**: Climate;
**argument-role**: actual_sun, abs_sun;
**argument-2**: Climate;
**argument-role**: n/N_factor;

**function:** n/N_f;
**argument-1**: Climate;
**argument-role**: n/N_factor;

**argument-2**: Climate;
**argument-role**: n/N;

**function:** Ed_f;
**argument-1**: Climate;
**argument-role**: ea, rh_mean;
**argument-2**: Climate;
**argument-role**: ed;

**function:** longwave_radiation_f;
**argument-1**: Climate;
**argument-role**: function_n/N, function_tc, Function_ed;
**argument-2**: Climate;
**argument-role**: longwave_radiation;

**function:** Et0_Penman;
**argument-1**: Climate;
**argument-role**: Adjustment_factor, weight_factor, net_radiation, weight_factor, wind_function, ea, ed
**argument-2**: Climate;
**argument-role**: Et0_Penman;

**function:** Wind_function_f;
**argument-1**: Climate;
**argument-role**: wind_day ;
**argument-2**: Climate;
**argument-role**: wind;

***c) Et0 Table***

**table:** Et0_sector_t;
**argument-1**: farm, irrigation;
**argument-role**: environment ;
**argument-2**: et0;
**argument-role**: Penman method for calculate evapotranspiration($ET_0$);

**table:** Et0_ evaporator_system _t;
**argument-1**: farm,irrigation;
**argument-role**: enviroment;
**argument-2**: et0;
**argument-role**: Pan method for calculate evapotranspiration($ET_0$);

**table:** adjustment_factor _t;
**argument-1**: farm,vegetable;
**argument-role**: ;
**argument-2**: ad;
**argument-role**: adjustment factor;

**table:** radiation_t;
**argument-1**: climate ;

**argument-role**: .month,adj-latitude;
**argument-2**: climate;
**argument-role**: radiation;
**table:** abs_sun _t;
**argument-1**: climate;
**argument-role**: month,adj-latitude1;
**argument-2**: climate;
**argument-role**: abs_sun;
**table:** Weight_factor_t;
**argument-1**: climate;
**argument-role**: altitude,Adjustment_tc_mean;
**argument-2**: climate;
**argument-role**: radiation;
**table:** ea_t;
**argument-1**: climate;
**argument-role**: altitude,Adjustment_tc_mean;
**argument-2**: climate;
**argument-role**: ea;
**table:** Function_tc_t;
**argument-1**: climate;
**argument-role**: tc_mean;
**argument-2**: climate;
**argument-role**: function_tc;
**table:** Function_ed_t;
**argument-1**: climate;
**argument-role**: adjustment_ed;
**argument-2**: climate;
**argument-role**: function_ed;
**table:** Function_n/N_t;
**argument-1**: climate;
**argument-role**: n/N;
**argument-2**: climate;
**argument-role**: function_n/N;

### 3.1.3 EtCrop Ontology

a) EtCrop Concept

```
Concept EtCRop;
    Properties:
        value: real,
            NUMBER-RANGE(0;1000),
                SOURCE(Derived[relation, Adapt frequency]),

        kc: real,
            NUMBER-RANGE(0;1000),
                SOURCE(Derived[table, kc_gc_t]),
        Inialize_gc: real,
            NUMBER-RANGE(0;1000),
                SOURCE(Derived[table, kc_gc_t]),
        Growth stage: real,
            Nominal,
                SOURCE(Derived[table, growth_stage_t]),
```

gc: real,
NUMBER-RANGE(0;1000),
SOURCE(Derived[relation, Adapt Green Cover Area]),

b) EtCrop Relation

**relation:** Adapt Green Cover Area;
**argument-1**: EtCrop ;
**argument-role**: inialize_gc;
**argument-2**: EtCrop;
**argument-role**: gc;

c) EtCrop Table
**Table:** growth_stage_t;
**argument-1**: session, Plant , soil;
**argument-role**: month, day, variety, type
**argument-2**: EtCrop;
**argument-role**: growth stage;
**Table:** kc_gc_t;
**argument-1**: EtCrop, soil,Plant ;
**argument-role**: growth_stage, type, status
**argument-2**: EtCrop;
**argument-role**: kc, inialize_gc, growth stage;

d) EtCrop Function
**Function:** EtCrop_f;
**argument-1**: farm, EtCrop, et0;
**argument-role**: unit, depression_factor, kc, gc, value;
**argument-2**: EtCrop;
**argument-role**: value;

3.1.4 SWHC Ontology
a) SWHC Concept
Concept SWHC;
Properties:
value: real,
NUMBER-RANGE(0;1000),
SOURCE(Derived[function, SWHC_f]),

Concept rd;
sub_type_of: SWHC;
Properties:
value: real,
NUMBER-RANGE(0;1000),
SOURCE(Derived[table, rooting depth _t]),

Concept ad;
sub_type_of: SWHC;
Properties:
value: real,
NUMBER-RANGE(0;1000),
SOURCE(Derived[table, ad_t]),

b) SWHC Table

**table:** sbd_t;
**argument-1**: soil;
**argument-role**: type;
**argument-2**: soil
**argument-role**: spd;

**table:** sp_t;
**argument-1**: soil;
**argument-role**: type;
**argument-2**: soil
**argument-role**: sp;

**table:** ad_t;
**argument-1**: plantation;
**argument-role**: crop;
**argument-2**:ad
**argument-role**: value; %نسبة الماء المستفاد

**table:** rooting depth _t;
**argument-1**: plant, soil;
**argument-role**: Variety_type, Status, type;
**argument-2**: Rd; % rooting depth
**argument-role**: value;

c) SWHC Function
**function:** SWHC_f;
**argument-1**: Rd, ad, soil, irrigation, farm, water, plant;
**argument-role**: value, spd, sp, Irrigation_efficiency, drainage_system_factor , wsr, Eciw, Ece;
**argument-2**: SWHC;
**argument-role**: value;

3.1.5 Water Requirement Ontology
d) Water Requirement Concept

Concept Water Requirement;
Properties:
wr_m3_f_day: real,
NUMBER-RANGE(0;1000),
SOURCE(Derived(function, wr_m3_f_day_f))
wr_m3_f_period: real,
NUMBER-RANGE(0;1000),
SOURCE(Derived[function, wr_m3_f_period_f]),

e) Water Requirement Relation

**relation:** Adapt Leaching Requirement;
**argument-1**: irrigation;
**argument-role**: Initialize_Leaching_requirement;
**argument-2**: irrigation;
**argument-role**: Leaching_requirement;

**relation:** Irrigation Type;
**argument-1**: plantation, water_requirement;
**argument-role**: Irrigation_system, wr_m3_f_period;
**argument-2**: irrigation;
**argument-role**: irrigate_type;

f) Water Requirement Function

**Function:** Leaching_requirement_f;
**argument-1**: water;
**argument-role**: eciw;
**argument-2**: plant;
**argument-role**: Ece;

**Function:** wr_m3_f_day_f;
**argument-1**: EtCrop, farm ;
**argument-role**: value, drainage_system_factor;
**argument-2**: water_requirement;
**argument-role**: wr_m3_f_day.

**Function:** wr_m3_f_period_f;
**argument-1**: water_requirement, session;
**argument-role**: wr_m3_f_day, number_days_per_period;
**argument-2**: water_requirement;
**argument-role**: wr_m3_f_period.

3.1.5 Frequency Ontology

a) Frequency Concept

Concept Frequency;
Properties:
value: real,
NUMBER-RANGE(0;1000),
SOURCE(Derived[relation, Adapt frequency]),

Initialize_value: real,
NUMBER-RANGE(0;1000),
SOURCE(Derived[function, SWHC_f]),

e) Frequency Relation

**relation:** Adapt frequency;
**argument-1**: water_requirement, frequency;
**argument-role**: wr_m3_f_period, Initialize_value;
**argument-2**: frequency;
**argument-role**: value;

f) Frequency Function

**Function:** Frequency_f;
**argument-1**: water_requirement, ;
**argument-role**: wr_m3_f_period;
**argument-2**: SWHC;
**argument-role**: value;

## 3.2 Domain Models

### 3.2.1 Expansion Model

**domain-model :** Expansion Model;

**parts**: tuple(Expand case description: relation),
(irrigation_efficiency_t: table)
(ece_t:table)
(ds_factor_t:table)
(Wsr_t:table)
(unit _t : table)
(depression_factor _t :table)
(age_f:Function)
(Expand plant status: relation)

**axioms:**

a) Expansion Relation

% Soil_type
(texture of soil = "clay; clay loam; silty clay; silty clay loam"
Expand case description
type of soil = ثقيله

(texture of soil = "sandy clay; sandy clay loam; silt loam; silty loam"
Expand case description
type of soil = متوسطه

(texture of soil = "sandy loam; sand; loamy sand"

Expand case description
type of soil = خفيفه

variety of plant = عنب
Expand farm type
Variety_type of plant = حقل مفتوح

%Expand_plant_status_r

age of plant >= 1
Expand plant status
status of plant = حديث

age of plant > 1
age of plant < = 3
Expand plant status
status of plant = غير مثمر

age of plant > 3
Expand plant status
status of plant = مثمر

b) Expansion Table

irrigation_efficiency_t **table** irrigation_efficiency_t;
**Input**([Plantation.Irrigation_system])
**Output**([irrigation. Irrigation_efficiency]).

| Input | Output |
|---|---|
| Plantation. Irrigation_system | irrigation. Irrigation_efficiency |
| تنقيط | 0.95 |
| رش | 0.75 |
| غمر | 0.65 |

ece_t **table** ece_t; % درجة التحمل للملوحه dS/m
**Input**([plantation.crop])
**Output**([plant.ece]).
*Appendix A*

ds_factor_t **table** ds_factor_t;%معامل الترتيب الطبقى
**Input**([plantation.drainage_system])
**Output**([Farm.drainage_system_factor]).

| Input | Output |
|---|---|
| plantation.drainage_system | Farm.drainage_system_factor |
| ردیء | 0.5 |
| متوسط | 0.75 |
| جيد | 1 |

Wsr_t **table** wsr_t;% نسبه مسطح البتلال

**Input**([plantation.Irrigation_system])

**Output**([irrigation.Wsr]).

| Input | Output |
|---|---|
| plantation.Irrigation_system | irrigation.Wsr |
| تنقيط | 0.75 |
| رش | 1 |
| غمر | 0.9 |

unit _t **table** unit_ t

**Input**([farm.type])

**Output**([farm.unit]).

| Input | Output |
|---|---|
| Farm.type | Farm.unit |
| حقل مفتوح | 4200 |

depression_factor _t **table** depression_factor _t;

**Input**([farm.type])

**Output**([farm.depression_factor]).

| Input | Output |
|---|---|
| Farm.type | farm.depression_factor |
| حقل مفتوح | 1 |

4 Expansion Function

| **Function** | **Description** |
|---|---|
| Age_f | Plant.age = session.system_date – Plantation.date |

### 3.2.2 Et0 Model

**Domain_model:** EtCrop_model

**Parts:tuple :**( Adaptive latitude: relation)

(Adaptive Solar Radiation: relation)

(Adaptive Mean Temperature: relation)

(Et0_sector_t: table)

(Et0_ evaporator_system_t: table)

(adjustment_factor _t: table)

(radiation_t: table)

```
(abs_sun _t: table)
(Weight_factor_t: table)
(ea_t: table)
(Function_tc_t: table)
(ed_f: function)
(adjustment_ed_r: relation)
(Function_ed_t: table)
(n/N_factor_f: function)
(n/N_f: function)
(Function_n/N_t: table)
(Adj_latitude_f: function)
(Adj_latitude1_f: function)
(Solar_radiation_f: function)
(Tc_mean_f: function)
(Net_radiation _f: function)
(longwave_radiation_f: function)
(Et0_Penman: function)
(Wind_function_f: function)
```

a) Et0 Relation

```
% Compute Adjustment_solar_radiation _r;

  solar_radiation of  climate > 0
   solar_radiation of  climate <6
            Adaptive Solar Radiation
   Adjustment_solar_radiation of  climate =  3

 solar_radiation of  climate >= 6
   solar_radiation of  climate <9
            Adaptive Solar Radiation
   Adjustment_solar_radiation of  climate =  6

  solar_radiation of  climate > =9
   solar_radiation of  climate <12
            Adaptive Solar Radiation
   Adjustment_solar_radiation of  climate =  9

  solar_radiation of  climate > =12
            Adaptive Solar Radiation
   Adjustment_solar_radiation of  climate =  12

 % Compute tc_mean_r;

   tc_mean of  climate > 0
   Tc_mean of  climate <4
            Adaptive Mean Temperature
   Adjustment_tc_mean of  climate =  2
```

tc_mean of climate >= 4
Tc_mean of climate <6
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 4

tc_mean of climate >= 6
Tc_mean of climate <8
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 6

tc_mean of climate > = 8
Tc_mean of climate < 10
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 8

tc_mean of climate > = 10
Tc_mean of climate < 12
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 10

tc_mean of climate > = 12
Tc_mean of climate < 14
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 12

tc_mean of climate > = 14
Tc_mean of climate < 16
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 14

tc_mean of climate > = 16
Tc_mean of climate < 18
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 16

tc_mean of climate >= 18
Tc_mean of climate < 20
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 18

tc_mean of climate > = 20
Tc_mean of climate < 22
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 20

tc_mean of climate > = 22
Tc_mean of climate < 24
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 22

tc_mean of climate > = 24
Tc_mean of climate < 26
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 24

tc_mean of climate > = 26
Tc_mean of climate < 28
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 26

tc_mean of climate > 28
Tc_mean of climate < 30
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 28

tc_mean of climate > = 30
Tc_mean of climate < 32
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 30

tc_mean of climate >= 32
Tc_mean of climate < 34
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 32

tc_mean of climate > 34
Tc_mean of climate < 36
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 34

tc_mean of climate > =36
Tc_mean of climate < 38
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 36

tc_mean of climate > =38
Tc_mean of climate <40
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 38

tc_mean of climate > = 40
Adaptive Mean Temperature
Adjustment_tc_mean of climate = 40

% Compute adjustment_ed _r;

ed of climate > 0
ed of climate <8
Adjustment ed
adjustment_ed of climate = 6.0

```
ed of  climate >= 8
 ed of  climate <10
             Adjustment ed
 adjustment_ed of  climate =  8.0

ed of  climate >= 10
 ed of  climate < 12
             Adjustment ed
 adjustment_ed of  climate =  10.0

ed of  climate >= 12
 ed of  climate < 14
             Adjustment ed
 adjustment_ed of  climate =  12.0

ed of  climate >= 14
 ed of  climate < 16
             Adjustment ed
 adjustment_ed of  climate =  14.0

ed of  climate >= 16
 ed of  climate < 18
            Adjustment ed
 adjustment_ed of  climate =  16.0

ed of  climate >= 18
 ed of  climate < 20
             Adjustment ed
 adjustment_ed of  climate =  18.0

ed of  climate >= 20
 ed of  climate < 22
             Adjustment ed
 adjustment_ed of  climate =  20.0

ed of  climate >= 22
 ed of  climate < 24
             Adjustment ed
 adjustment_ed of  climate =  22.0

ed of  climate >= 24
 ed of  climate < 26
             Adjustment ed
 adjustment_ed of  climate =  24.0

ed of  climate >= 26
 ed of  climate < 28
             Adjustment ed
 adjustment_ed of  climate =  26.0
```

```
ed of  climate >= 28
 ed of  climate < 30
             Adjustment ed
 adjustment_ed of  climate =  28.0

ed of  climate >= 30
 ed of  climate < 32
             Adjustment ed
 adjustment_ed of  climate =  30.0

ed of  climate >= 32
 ed of  climate < 34
             Adjustment ed
 adjustment_ed of  climate =  32.0

ed of  climate >= 34
 ed of  climate < 36
             Adjustment ed
 adjustment_ed of  climate =  34.0

ed of  climate >= 36
 ed of  climate < 38
             Adjustment ed
 adjustment_ed of  climate =  36.0

ed of  climate >= 38
 ed of  climate < 40
             Adjustment ed
 adjustment_ed of  climate =  38.0

ed of  climate >= 40
             Adjustment ed
 adjustment_ed of  climate =  40.0
```

***b) Et0 table***

Et0_sector_t **table** Et0_sector_t;
**Input**([farm.location , session.month , session.day])
**Output**([et0.value])

| **Input** | | | **Output** |
|---|---|---|---|
| Farm.location | session.month | session.day | et0.value |
| التحرير | 1 | 10 | 2.20 |
| التحرير | 1 | 20 | 2.46 |
| التحرير | 1 | 30 | 2.70 |
| التحرير | 2 | 10 | 3.27 |
| التحرير | 2 | 20 | 3.98 |
| التحرير | 2 | 30 | 4.67 |

| | | | |
|---|---|---|---|
| التحرير | 3 | 10 | 5.63 |
| التحرير | 3 | 20 | 5.91 |
| التحرير | 3 | 30 | 6.19 |
| التحرير | 4 | 10 | 7.05 |
| التحرير | 4 | 20 | 7.30 |
| التحرير | 4 | 30 | 7.47 |
| التحرير | 5 | 10 | 8.15 |
| التحرير | 5 | 20 | 8.77 |
| التحرير | 5 | 30 | 8.91 |
| التحرير | 6 | 10 | 9.13 |
| التحرير | 6 | 20 | 9.28 |
| التحرير | 6 | 30 | 9.29 |
| التحرير | 7 | 10 | 9.35 |
| التحرير | 7 | 20 | 9.38 |
| التحرير | 7 | 30 | 9.39 |
| التحرير | 8 | 10 | 9.41 |
| التحرير | 8 | 20 | 9.28 |
| التحرير | 8 | 30 | 8.03 |
| التحرير | 9 | 10 | 6.81 |
| التحرير | 9 | 20 | 6.58 |
| التحرير | 9 | 30 | 6.47 |
| التحرير | 10 | 10 | 5.36 |
| التحرير | 10 | 20 | 5.20 |
| التحرير | 10 | 30 | 4.96 |
| التحرير | 11 | 10 | 3.97 |
| التحرير | 11 | 20 | 3.75 |
| التحرير | 11 | 30 | 3.10 |
| التحرير | 12 | 10 | 3.08 |
| التحرير | 12 | 20 | 2.96 |
| التحرير | 12 | 30 | 2.57 |
| وجه بحرى | 1 | 10 | 1.3 |
| وجه بحرى | 1 | 20 | 1.3 |
| وجه بحرى | 1 | 30 | 1.3 |
| وجه بحرى | 2 | 10 | 1.6 |
| وجه بحرى | 2 | 20 | 1.6 |
| وجه بحرى | 2 | 30 | 1.6 |
| وجه بحرى | 3 | 10 | 1.9 |
| وجه بحرى | 3 | 20 | 1.9 |
| وجه بحرى | 3 | 30 | 1.9 |
| وجه بحرى | 4 | 10 | 3.3 |
| وجه بحرى | 4 | 20 | 3.3 |
| وجه بحرى | 4 | 30 | 3.3 |
| وجه بحرى | 5 | 10 | 4.0 |
| وجه بحرى | 5 | 20 | 4.0 |
| وجه بحرى | 5 | 30 | 4.0 |
| وجه بحرى | 6 | 10 | 5.3 |
| وجه بحرى | 6 | 20 | 5.3 |
| وجه بحرى | 6 | 30 | 5.3 |

| | | | |
|---|---|---|---|
| وجه بحرى | 7 | 10 | 5.2 |
| وجه بحرى | 7 | 20 | 5.2 |
| وجه بحرى | 7 | 30 | 5.2 |
| وجه بحرى | 8 | 10 | 4.6 |
| وجه بحرى | 8 | 20 | 4.6 |
| وجه بحرى | 8 | 30 | 4.6 |
| وجه بحرى | 9 | 10 | 3.8 |
| وجه بحرى | 9 | 20 | 3.8 |
| وجه بحرى | 9 | 30 | 3.8 |
| وجه بحرى | 10 | 10 | 3.1 |
| وجه بحرى | 10 | 20 | 3.1 |
| وجه بحرى | 10 | 30 | 3.1 |
| وجه بحرى | 11 | 10 | 2.1 |
| وجه بحرى | 11 | 20 | 2.1 |
| وجه بحرى | 11 | 30 | 2.1 |
| وجه بحرى | 12 | 10 | 1.3 |
| وجه بحرى | 12 | 20 | 1.3 |
| وجه بحرى | 12 | 30 | 1.3 |
| مصر الوسطى | 1 | 10 | 1.8 |
| مصر الوسطى | 1 | 20 | 1.8 |
| مصر الوسطى | 1 | 30 | 1.8 |
| مصر الوسطى | 2 | 10 | 2.0 |
| مصر الوسطى | 2 | 20 | 2.0 |
| مصر الوسطى | 2 | 30 | 2.0 |
| مصر الوسطى | 3 | 10 | 2.9 |
| مصر الوسطى | 3 | 20 | 2.9 |
| مصر الوسطى | 3 | 30 | 2.9 |
| مصر الوسطى | 4 | 10 | 4.3 |
| مصر الوسطى | 4 | 20 | 4.3 |
| مصر الوسطى | 4 | 30 | 4.3 |
| مصر الوسطى | 5 | 10 | 5.0 |
| مصر الوسطى | 5 | 20 | 5.0 |
| مصر الوسطى | 5 | 30 | 5.0 |
| مصر الوسطى | 6 | 10 | 5.7 |
| مصر الوسطى | 6 | 20 | 5.7 |
| مصر الوسطى | 6 | 30 | 5.7 |
| مصر الوسطى | 7 | 10 | 6.8 |
| مصر الوسطى | 7 | 20 | 6.8 |
| مصر الوسطى | 7 | 30 | 6.8 |
| مصر الوسطى | 8 | 10 | 5.4 |
| مصر الوسطى | 8 | 20 | 5.4 |
| مصر الوسطى | 8 | 30 | 5.4 |
| مصر الوسطى | 9 | 10 | 5 |
| مصر الوسطى | 9 | 20 | 5 |
| مصر الوسطى | 9 | 30 | 5 |
| مصر الوسطى | 10 | 10 | 3.8 |
| مصر الوسطى | 10 | 20 | 3.8 |
| مصر الوسطى | 10 | 30 | 3.8 |

| | | | |
|---|---|---|---|
| مصر الوسطى | 11 | 10 | 2.3 |
| مصر الوسطى | 11 | 20 | 2.3 |
| مصر الوسطى | 11 | 30 | 2.3 |
| مصر الوسطى | 12 | 10 | 1.4 |
| مصر الوسطى | 12 | 20 | 1.4 |
| مصر الوسطى | 12 | 30 | 1.4 |
| مصر العليا | 1 | 10 | 1.9 |
| مصر العليا | 1 | 20 | 1.9 |
| مصر العليا | 1 | 30 | 1.9 |
| مصر العليا | 2 | 10 | 2.4 |
| مصر العليا | 2 | 20 | 2.4 |
| مصر العليا | 2 | 30 | 2.4 |
| مصر العليا | 3 | 10 | 3.1 |
| مصر العليا | 3 | 20 | 3.1 |
| مصر العليا | 3 | 30 | 3.1 |
| مصر العليا | 4 | 10 | 4.3 |
| مصر العليا | 4 | 20 | 4.3 |
| مصر العليا | 4 | 30 | 4.3 |
| مصر العليا | 5 | 10 | 5.8 |
| مصر العليا | 5 | 20 | 5.8 |
| مصر العليا | 5 | 30 | 5.8 |
| مصر العليا | 6 | 10 | 6.1 |
| مصر العليا | 6 | 20 | 6.1 |
| مصر العليا | 6 | 30 | 6.1 |
| مصر العليا | 7 | 10 | 7.9 |
| مصر العليا | 7 | 20 | 7.9 |
| مصر العليا | 7 | 30 | 7.9 |
| مصر العليا | 8 | 10 | 6.2 |
| مصر العليا | 8 | 20 | 6.2 |
| مصر العليا | 8 | 30 | 6.2 |
| مصر العليا | 9 | 10 | 5.4 |
| مصر العليا | 9 | 20 | 5.4 |
| مصر العليا | 9 | 30 | 5.4 |
| مصر العليا | 10 | 10 | 5.1 |
| مصر العليا | 10 | 20 | 5.1 |
| مصر العليا | 10 | 30 | 5.1 |
| مصر العليا | 11 | 10 | 2.5 |
| مصر العليا | 11 | 20 | 2.5 |
| مصر العليا | 11 | 30 | 2.5 |
| مصر العليا | 12 | 10 | 1.7 |
| مصر العليا | 12 | 20 | 1.7 |
| مصر العليا | 12 | 30 | 1.7 |

Et0_ evaporator_system_t **table** Et0_ evaporator_system _t;
**Input**([farm.location,session.month])
**Output**([et0.value])

| Concept | property | Concept | property | concept | Property |
|---|---|---|---|---|---|
| Farm | Location | session | month | Et0 | value |
| | وجه بحرى | | 1 | | 1.3 |
| | | | 2 | | 1.6 |
| | | | 3 | | 1.9 |
| | | | 4 | | 3.3 |
| | | | 5 | | 4.0 |
| | | | 6 | | 5.3 |
| | | | 7 | | 5.2 |
| | | | 8 | | 4.6 |
| | | | 9 | | 3.8 |
| | | | 10 | | 3.1 |
| | | | 11 | | 2.1 |
| | | | 12 | | 1.3 |
| | مصر الوسطى | | 1 | | 1.8 |
| | | | 2 | | 2.0 |
| | | | 3 | | 2.9 |
| | | | 4 | | 4.3 |
| | | | 5 | | 5.0 |
| | | | 6 | | 5.7 |
| | | | 7 | | 6.8 |
| | | | 8 | | 5.4 |
| | | | 9 | | 5 |
| | | | 10 | | 3.8 |
| | | | 11 | | 2.3 |
| | | | 12 | | 1.4 |
| | مصر العليا | | 1 | | 1.9 |
| | | | 2 | | 2.4 |
| | | | 3 | | 3.1 |
| | | | 4 | | 4.3 |
| | | | 5 | | 5.8 |
| | | | 6 | | 6.1 |
| | | | 7 | | 7.9 |
| | | | 8 | | 6.2 |
| | | | 9 | | 5.4 |
| | | | 10 | | 5.1 |
| | | | 11 | | 2.5 |
| | | | 12 | | 1.7 |

adjustment_factor _t

**table** adjustment_factor_t;
**Input**([farm.location,
Climate.Adjustment_solar_radiation])
**Output**([climate.Adjustment_factor]).

| Input | | | | Output | |
|---|---|---|---|---|---|
| concept | property | concept | property | concept | property |
| Farm | location | | Adjustment_solar_radiation | | Adjustment_factor |

| | | | | | |
|---|---|---|---|---|---|
| | وجه بحرى | | 3 | | 0.83 |
| | وجه بحرى | | 6 | | 0.91 |
| | وجه بحرى | | 9 | | 0.99 |
| | وجه بحرى | | 12 | | 1.05 |
| | مصر الوسطى | | 3 | | 0.83 |
| | مصر الوسطى | | 6 | | 0.91 |
| | مصر الوسطى | | 9 | | 0.99 |
| | مصر الوسطى | | 12 | | 1.05 |
| | مصر العليا | | 3 | | 0.76 |
| | مصر العليا | | 6 | | 0.83 |
| | مصر العليا | | 9 | | 0.92 |
| | مصر العليا | | 12 | | 0.98 |

radiation_t **table** radiation_t;
**Input**([climate.month,climate.adj-latitude])
**Output**([climate.radiation]).

| Input | | | | output | |
|---|---|---|---|---|---|
| concept | property | concept | property | concept | property |
| climate | Month | climate | Adj_latitude | climate | radiation |
| | 1 | | 0 | | 15 |
| | 1 | | 2 | | 14.7 |
| | 1 | | 4 | | 14.3 |
| | 1 | | 6 | | 13.9 |
| | 1 | | 8 | | 13.6 |
| | 1 | | 10 | | 13.2 |
| | 1 | | 12 | | 12.8 |
| | 1 | | 14 | | 12.4 |
| | 1 | | 16 | | 12 |
| | 1 | | 18 | | 11.6 |
| | 1 | | 20 | | 11.2 |
| | 1 | | 22 | | 10.7 |
| | 1 | | 24 | | 10.2 |
| | 1 | | 26 | | 9.8 |
| | 1 | | 28 | | 9.3 |
| | 1 | | 30 | | 8.8 |
| | 1 | | 32 | | 8.3 |

| | | | | | |
|---|---|---|---|---|---|
| | 1 | | 34 | | 7.9 |
| | 1 | | 36 | | 7.4 |
| | 1 | | 38 | | 6.9 |
| | 1 | | 40 | | 6.4 |
| | 1 | | 42 | | 5.9 |
| | 1 | | 44 | | 5.3 |
| | 1 | | 46 | | 4.9 |
| | 1 | | 48 | | 4.3 |
| | 1 | | 50 | | 3.8 |
| | 2 | | 0 | | 15.5 |
| | 2 | | 2 | | 15.3 |
| | 2 | | 4 | | 15 |
| | 2 | | 6 | | 14.8 |
| | 2 | | 8 | | 14.5 |
| | 2 | | 10 | | 14.2 |
| | 2 | | 12 | | 13.9 |
| | 2 | | 14 | | 13.6 |
| | 2 | | 16 | | 13.3 |
| | 2 | | 18 | | 13 |
| | 2 | | 20 | | 12.7 |
| | 2 | | 22 | | 11.3 |
| | 2 | | 24 | | 11.9 |
| | 2 | | 26 | | 11.5 |
| | 2 | | 28 | | 11.1 |
| | 2 | | 30 | | 10.7 |
| | 2 | | 32 | | 10.2 |
| | 2 | | 34 | | 9.8 |
| | 2 | | 36 | | 9.4 |
| | 2 | | 38 | | 9 |
| | 2 | | 40 | | 8.6 |
| | 2 | | 42 | | 8.1 |
| | 2 | | 44 | | 7.6 |
| | 2 | | 46 | | 7.1 |
| | 2 | | 48 | | 6.6 |
| | 2 | | 50 | | 6.1 |
| | 3 | | 0 | | 15.7 |
| | 3 | | 2 | | 15.6 |
| | 3 | | 4 | | 15.5 |
| | 3 | | 6 | | 15.4 |
| | 3 | | 8 | | 15.3 |
| | 3 | | 10 | | 15.3 |
| | 3 | | 12 | | 15.1 |
| | 3 | | 14 | | 14.9 |
| | 3 | | 16 | | 14.7 |
| | 3 | | 18 | | 14.6 |
| | 3 | | 20 | | 14.4 |
| | 3 | | 22 | | 14.2 |
| | 3 | | 24 | | 13.9 |

| | | | | | |
|---|---|---|---|---|---|
| | 3 | | 26 | | 13.7 |
| | 3 | | 28 | | 13.4 |
| | 3 | | 30 | | 13.1 |
| | 3 | | 32 | | 12.8 |
| | 3 | | 34 | | 12.4 |
| | 3 | | 36 | | 12.1 |
| | 3 | | 38 | | 11.8 |
| | 3 | | 40 | | 11.4 |
| | 3 | | 42 | | 11 |
| | 3 | | 44 | | 10.6 |
| | 3 | | 46 | | 10.2 |
| | 3 | | 48 | | 9.8 |
| | 3 | | 50 | | 9.4 |
| | 4 | | 0 | | 15.3 |
| | 4 | | 2 | | 15.3 |
| | 4 | | 4 | | 15.5 |
| | 4 | | 6 | | 15.4 |
| | 4 | | 8 | | 15.6 |
| | 4 | | 10 | | 15.7 |
| | 4 | | 12 | | 15.7 |
| | 4 | | 14 | | 15.7 |
| | 4 | | 16 | | 15.6 |
| | 4 | | 18 | | 15.6 |
| | 4 | | 20 | | 15.6 |
| | 4 | | 22 | | 15.5 |
| | 4 | | 24 | | 15.4 |
| | 4 | | 26 | | 15.3 |
| | 4 | | 28 | | 15.3 |
| | 4 | | 30 | | 15.2 |
| | 4 | | 32 | | 15 |
| | 4 | | 34 | | 14.8 |
| | 4 | | 36 | | 14.7 |
| | 4 | | 38 | | 14.5 |
| | 4 | | 40 | | 14.3 |
| | 4 | | 42 | | 14 |
| | 4 | | 44 | | 13.7 |
| | 4 | | 46 | | 13.3 |
| | 4 | | 48 | | 13 |
| | 4 | | 50 | | 12.7 |
| | 5 | | 0 | | 14.4 |
| | 5 | | 2 | | 14.6 |
| | 5 | | 4 | | 14.9 |
| | 5 | | 6 | | 15.1 |
| | 5 | | 8 | | 15.3 |
| | 5 | | 10 | | 15.5 |
| | 5 | | 12 | | 15.7 |
| | 5 | | 14 | | 15.8 |
| | 5 | | 16 | | 16 |

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|---|---|---|---|---|---|
| | 5 | | 18 | | 16.1 |
| | 5 | | 20 | | 16.3 |
| | 5 | | 22 | | 16.3 |
| | 5 | | 24 | | 16.4 |
| | 5 | | 26 | | 16.4 |
| | 5 | | 28 | | 16.5 |
| | 5 | | 30 | | 16.5 |
| | 5 | | 32 | | 16.5 |
| | 5 | | 34 | | 16.5 |
| | 5 | | 36 | | 16.4 |
| | 5 | | 38 | | 16.4 |
| | 5 | | 40 | | 16.4 |
| | 5 | | 42 | | 16.2 |
| | 5 | | 44 | | 16.1 |
| | 5 | | 46 | | 16 |
| | 5 | | 48 | | 15.9 |
| | 5 | | 50 | | 15.8 |
| | 6 | | 0 | | 13.9 |
| | 6 | | 2 | | 14.2 |
| | 6 | | 4 | | 14.4 |
| | 6 | | 6 | | 14.7 |
| | 6 | | 8 | | 15 |
| | 6 | | 10 | | 15.3 |
| | 6 | | 12 | | 15.5 |
| | 6 | | 14 | | 15.7 |
| | 6 | | 16 | | 15.9 |
| | 6 | | 18 | | 16.1 |
| | 6 | | 20 | | 16.4 |
| | 6 | | 22 | | 16.4 |
| | 6 | | 24 | | 16.6 |
| | 6 | | 26 | | 16.7 |
| | 6 | | 28 | | 16.8 |
| | 6 | | 30 | | 17 |
| | 6 | | 32 | | 17 |
| | 6 | | 34 | | 17.1 |
| | 6 | | 36 | | 17.2 |
| | 6 | | 38 | | 17.2 |
| | 6 | | 40 | | 17.3 |
| | 6 | | 42 | | 17.3 |
| | 6 | | 44 | | 17.2 |
| | 6 | | 46 | | 17.2 |
| | 6 | | 48 | | 17.2 |
| | 6 | | 50 | | 17.1 |
| | 7 | | 0 | | 14.1 |
| | 7 | | 2 | | 14.3 |
| | 7 | | 4 | | 14.6 |
| | 7 | | 6 | | 14.9 |
| | 7 | | 8 | | 15.1 |

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| | 7 | | 10 | | 15.3 |
| | 7 | | 12 | | 15.5 |
| | 7 | | 14 | | 15.7 |
| | 7 | | 16 | | 15.9 |
| | 7 | | 18 | | 16.1 |
| | 7 | | 20 | | 16.3 |
| | 7 | | 22 | | 16.4 |
| | 7 | | 24 | | 16.5 |
| | 7 | | 26 | | 16.6 |
| | 7 | | 28 | | 16.7 |
| | 7 | | 30 | | 16.8 |
| | 7 | | 32 | | 16.8 |
| | 7 | | 34 | | 16.8 |
| | 7 | | 36 | | 16.7 |
| | 7 | | 38 | | 16.7 |
| | 7 | | 40 | | 16.7 |
| | 7 | | 42 | | 16.7 |
| | 7 | | 44 | | 16.6 |
| | 7 | | 46 | | 16.6 |
| | 7 | | 48 | | 16.5 |
| | 7 | | 50 | | 16.4 |
| | 8 | | 0 | | 14.8 |
| | 8 | | 2 | | 14.9 |
| | 8 | | 4 | | 15.1 |
| | 8 | | 6 | | 15.2 |
| | 8 | | 8 | | 15.4 |
| | 8 | | 10 | | 15.5 |
| | 8 | | 12 | | 15.6 |
| | 8 | | 14 | | 15.7 |
| | 8 | | 16 | | 15.7 |
| | 8 | | 18 | | 15.8 |
| | 8 | | 20 | | 15.9 |
| | 8 | | 22 | | 15.8 |
| | 8 | | 24 | | 15.8 |
| | 8 | | 26 | | 15.7 |
| | 8 | | 28 | | 15.7 |
| | 8 | | 30 | | 15.7 |
| | 8 | | 32 | | 15.6 |
| | 8 | | 34 | | 15.5 |
| | 8 | | 36 | | 15.4 |
| | 8 | | 38 | | 15.3 |
| | 8 | | 40 | | 15.2 |
| | 8 | | 42 | | 15 |
| | 8 | | 44 | | 14.7 |
| | 8 | | 46 | | 14.5 |
| | 8 | | 48 | | 14.3 |
| | 8 | | 50 | | 14.1 |
| | 9 | | 0 | | 15.3 |

| | | | | | |
|---|---|---|---|---|---|
| | 9 | | 2 | | 15.3 |
| | 9 | | 4 | | 15.3 |
| | 9 | | 6 | | 15.3 |
| | 9 | | 8 | | 15.3 |
| | 9 | | 10 | | 15.3 |
| | 9 | | 12 | | 15.2 |
| | 9 | | 14 | | 15.1 |
| | 9 | | 16 | | 15 |
| | 9 | | 18 | | 14.9 |
| | 9 | | 20 | | 14.8 |
| | 9 | | 22 | | 14.6 |
| | 9 | | 24 | | 14.5 |
| | 9 | | 26 | | 14.3 |
| | 9 | | 28 | | 14.1 |
| | 9 | | 30 | | 13.9 |
| | 9 | | 32 | | 13.6 |
| | 9 | | 34 | | 13.4 |
| | 9 | | 36 | | 13.1 |
| | 9 | | 38 | | 12.8 |
| | 9 | | 40 | | 12.5 |
| | 9 | | 42 | | 12.2 |
| | 9 | | 44 | | 11.9 |
| | 9 | | 46 | | 11.5 |
| | 9 | | 48 | | 11.2 |
| | 9 | | 50 | | 10.9 |
| | 10 | | 0 | | 15.4 |
| | 10 | | 2 | | 15.3 |
| | 10 | | 4 | | 15.1 |
| | 10 | | 6 | | 15 |
| | 10 | | 8 | | 14.8 |
| | 10 | | 10 | | 14.7 |
| | 10 | | 12 | | 14.4 |
| | 10 | | 14 | | 14.1 |
| | 10 | | 16 | | 13.9 |
| | 10 | | 18 | | 13.6 |
| | 10 | | 20 | | 13.3 |
| | 10 | | 22 | | 13 |
| | 10 | | 24 | | 12.6 |
| | 10 | | 26 | | 12.3 |
| | 10 | | 28 | | 12 |
| | 10 | | 30 | | 11.6 |
| | 10 | | 32 | | 11.2 |
| | 10 | | 34 | | 10.8 |
| | 10 | | 36 | | 10.6 |
| | 10 | | 38 | | 10 |
| | 10 | | 40 | | 9.6 |
| | 10 | | 42 | | 9.1 |
| | 10 | | 44 | | 8.7 |

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|---|---|---|---|---|---|
| | 10 | | 46 | | 8.3 |
| | 10 | | 48 | | 7.8 |
| | 10 | | 50 | | 7.4 |
| | 11 | | 0 | | 15.1 |
| | 11 | | 2 | | 14.8 |
| | 11 | | 4 | | 14.5 |
| | 11 | | 6 | | 14.2 |
| | 11 | | 8 | | 13.9 |
| | 11 | | 10 | | 13.6 |
| | 11 | | 12 | | 13.3 |
| | 11 | | 14 | | 12.8 |
| | 11 | | 16 | | 12.4 |
| | 11 | | 18 | | 12 |
| | 11 | | 20 | | 11.6 |
| | 11 | | 22 | | 11.1 |
| | 11 | | 24 | | 10.7 |
| | 11 | | 26 | | 10.3 |
| | 11 | | 28 | | 9.9 |
| | 11 | | 30 | | 9.5 |
| | 11 | | 32 | | 9 |
| | 11 | | 34 | | 8.5 |
| | 11 | | 36 | | 8 |
| | 11 | | 38 | | 7.5 |
| | 11 | | 40 | | 7 |
| | 11 | | 42 | | 6.5 |
| | 11 | | 44 | | 6 |
| | 11 | | 46 | | 5.5 |
| | 11 | | 48 | | 5 |
| | 11 | | 50 | | 4.5 |
| | 12 | | 0 | | 14.8 |
| | 12 | | 2 | | 14.4 |
| | 12 | | 4 | | 14.1 |
| | 12 | | 6 | | 13.7 |
| | 12 | | 8 | | 13.3 |
| | 12 | | 10 | | 12.9 |
| | 12 | | 12 | | 12.5 |
| | 12 | | 14 | | 12 |
| | 12 | | 16 | | 11.6 |
| | 12 | | 18 | | 11.1 |
| | 12 | | 20 | | 10.7 |
| | 12 | | 22 | | 10.2 |
| | 12 | | 24 | | 9.7 |
| | 12 | | 26 | | 9.3 |
| | 12 | | 28 | | 8.8 |
| | 12 | | 30 | | 8.3 |
| | 12 | | 32 | | 7.8 |
| | 12 | | 34 | | 7.2 |
| | 12 | | 36 | | 6.6 |

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|---|---|---|---|---|---|
| | 12 | | 38 | | 6.1 |
| | 12 | | 40 | | 5.7 |
| | 12 | | 42 | | 5.2 |
| | 12 | | 44 | | 4.7 |
| | 12 | | 46 | | 4.3 |
| | 12 | | 48 | | 3.7 |
| | 12 | | 50 | | 3.2 |

abs_sun _t **table** abs_sun _t;
**Input**([climate.month,climate.adj-latitude1])
**Output**([climate.abs_sun]).

| Input | | | | output | |
|---|---|---|---|---|---|
| concept | property | concept | property | concept | property |
| climate | month | climate | Adj_latitude1 | climate | Abs_sun |
| | 1 | | 0 | | 12 |
| | 1 | | 5 | | 11.8 |
| | 1 | | 10 | | 11.6 |
| | 1 | | 15 | | 11.3 |
| | 1 | | 20 | | 11 |
| | 1 | | 25 | | 10.7 |
| | 1 | | 30 | | 10.4 |
| | 1 | | 35 | | 10.1 |
| | 1 | | 40 | | 9.6 |
| | 1 | | 42 | | 9.4 |
| | 1 | | 44 | | 9.3 |
| | 1 | | 46 | | 9.1 |
| | 1 | | 48 | | 8.8 |
| | 1 | | 50 | | 8.5 |
| | 2 | | 0 | | 12 |
| | 2 | | 5 | | 11.9 |
| | 2 | | 10 | | 11.8 |
| | 2 | | 15 | | 11.6 |
| | 2 | | 20 | | 11.5 |
| | 2 | | 25 | | 11.3 |
| | 2 | | 30 | | 11.1 |
| | 2 | | 35 | | 11 |
| | 2 | | 40 | | 10.7 |
| | 2 | | 42 | | 10.6 |
| | 2 | | 44 | | 10.5 |
| | 2 | | 46 | | 10.4 |
| | 2 | | 48 | | 10.2 |
| | 2 | | 50 | | 10.1 |
| | 3 | | 0 | | 12 |
| | 3 | | 5 | | 12 |
| | 3 | | 10 | | 12 |
| | 3 | | 15 | | 12 |
| | 3 | | 20 | | 12 |

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|---|---|---|---|---|---|
| | 3 | | 25 | | 12 |
| | 3 | | 30 | | 12 |
| | 3 | | 35 | | 11.9 |
| | 3 | | 40 | | 11.9 |
| | 3 | | 42 | | 11.9 |
| | 3 | | 44 | | 11.9 |
| | 3 | | 46 | | 11.9 |
| | 3 | | 48 | | 11.8 |
| | 3 | | 50 | | 11.8 |
| | 4 | | 0 | | 12 |
| | 4 | | 5 | | 12.2 |
| | 4 | | 10 | | 12.3 |
| | 4 | | 15 | | 12.5 |
| | 4 | | 20 | | 12.6 |
| | 4 | | 25 | | 12.7 |
| | 4 | | 30 | | 12.9 |
| | 4 | | 35 | | 13.1 |
| | 4 | | 40 | | 13.3 |
| | 4 | | 42 | | 13.4 |
| | 4 | | 44 | | 13.4 |
| | 4 | | 46 | | 13.5 |
| | 4 | | 48 | | 13.6 |
| | 4 | | 50 | | 13.8 |
| | 5 | | 0 | | 12 |
| | 5 | | 5 | | 12.3 |
| | 5 | | 10 | | 12.6 |
| | 5 | | 15 | | 12.8 |
| | 5 | | 20 | | 13.1 |
| | 5 | | 25 | | 13.3 |
| | 5 | | 30 | | 13.6 |
| | 5 | | 35 | | 14 |
| | 5 | | 40 | | 14.4 |
| | 5 | | 42 | | 14.6 |
| | 5 | | 44 | | 14.7 |
| | 5 | | 46 | | 14.9 |
| | 5 | | 48 | | 15.2 |
| | 5 | | 50 | | 15.4 |
| | 6 | | 0 | | 12 |
| | 6 | | 5 | | 12.4 |
| | 6 | | 10 | | 12.7 |
| | 6 | | 15 | | 13 |
| | 6 | | 20 | | 13.3 |
| | 6 | | 25 | | 13.7 |
| | 6 | | 30 | | 14 |
| | 6 | | 35 | | 14.5 |
| | 6 | | 40 | | 15 |
| | 6 | | 42 | | 15.2 |
| | 6 | | 44 | | 15.4 |

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|---|---|---|---|---|---|
| | 6 | | 46 | | 15.7 |
| | 6 | | 48 | | 16 |
| | 6 | | 50 | | 16.3 |
| | 7 | | 0 | | 12 |
| | 7 | | 5 | | 12.3 |
| | 7 | | 10 | | 12.6 |
| | 7 | | 15 | | 12.9 |
| | 7 | | 20 | | 13.2 |
| | 7 | | 25 | | 13.5 |
| | 7 | | 30 | | 13.9 |
| | 7 | | 35 | | 14.3 |
| | 7 | | 40 | | 14.7 |
| | 7 | | 42 | | 14.9 |
| | 7 | | 44 | | 15.21 |
| | 7 | | 46 | | 15.4 |
| | 7 | | 48 | | 15.6 |
| | 7 | | 50 | | 15.9 |
| | 8 | | 0 | | 12 |
| | 8 | | 5 | | 12.3 |
| | 8 | | 10 | | 12.4 |
| | 8 | | 15 | | 12.6 |
| | 8 | | 20 | | 12.8 |
| | 8 | | 25 | | 13 |
| | 8 | | 30 | | 13.2 |
| | 8 | | 35 | | 13.5 |
| | 8 | | 40 | | 13.7 |
| | 8 | | 42 | | 13.9 |
| | 8 | | 44 | | 14 |
| | 8 | | 46 | | 14.2 |
| | 8 | | 48 | | 14.3 |
| | 8 | | 50 | | 14.5 |
| | 9 | | 0 | | 12 |
| | 9 | | 5 | | 12.1 |
| | 9 | | 10 | | 12.1 |
| | 9 | | 15 | | 12.2 |
| | 9 | | 20 | | 12.3 |
| | 9 | | 25 | | 12.3 |
| | 9 | | 30 | | 12.4 |
| | 9 | | 35 | | 12.4 |
| | 9 | | 40 | | 12.5 |
| | 9 | | 42 | | 12.6 |
| | 9 | | 44 | | 12.6 |
| | 9 | | 46 | | 12.6 |
| | 9 | | 48 | | 12.6 |
| | 9 | | 50 | | 12.7 |
| | 10 | | 0 | | 12 |
| | 10 | | 5 | | 12 |
| | 10 | | 10 | | 11.8 |

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|---|---|---|---|---|---|
| | 10 | | 15 | | 11.8 |
| | 10 | | 20 | | 11.7 |
| | 10 | | 25 | | 11.6 |
| | 10 | | 30 | | 11.5 |
| | 10 | | 35 | | 11.3 |
| | 10 | | 40 | | 11.2 |
| | 10 | | 42 | | 11.1 |
| | 10 | | 44 | | 11 |
| | 10 | | 46 | | 10.9 |
| | 10 | | 48 | | 10.9 |
| | 10 | | 50 | | 10.8 |
| | 11 | | 0 | | 12 |
| | 11 | | 5 | | 11.9 |
| | 11 | | 10 | | 11.6 |
| | 11 | | 15 | | 11.4 |
| | 11 | | 20 | | 11.2 |
| | 11 | | 25 | | 10.9 |
| | 11 | | 30 | | 10.6 |
| | 11 | | 35 | | 10.3 |
| | 11 | | 40 | | 10 |
| | 11 | | 42 | | 9.8 |
| | 11 | | 44 | | 9.7 |
| | 11 | | 46 | | 9.5 |
| | 11 | | 48 | | 9.3 |
| | 11 | | 50 | | 9.1 |
| | 12 | | 0 | | 12 |
| | 12 | | 5 | | 11.8 |
| | 12 | | 10 | | 11.5 |
| | 12 | | 15 | | 11.2 |
| | 12 | | 20 | | 10.9 |
| | 12 | | 25 | | 10.6 |
| | 12 | | 30 | | 10.2 |
| | 12 | | 35 | | 9.8 |
| | 12 | | 40 | | 9.3 |
| | 12 | | 42 | | 9.1 |
| | 12 | | 44 | | 8.9 |
| | 12 | | 46 | | 8.7 |
| | 12 | | 48 | | 8.3 |
| | 12 | | 50 | | 8.1 |

Weight_factor_t **table** weight_factor _t;
**Input**([climate.altitude,climate. Adjustment_tc_mean])
**Output**([climate.weight_factor]).
**Remark :**values of weight factor (W) for the effect of radiation on Et0

at different temperatures and Altitudes

| Input | | | | output | |
|---|---|---|---|---|---|
| concept | property | concept | property | concept | property |
| climate | altitude | climate | Adjustment_tc_mean | climate | Weight_factor |
| | 0 | | 2 | | 0.43 |
| | 0 | | 4 | | 0.46 |
| | 0 | | 6 | | 0.49 |
| | 0 | | 8 | | 0.52 |
| | 0 | | 10 | | 0.55 |
| | 0 | | 12 | | 0.58 |
| | 0 | | 14 | | 0.61 |
| | 0 | | 16 | | 0.64 |
| | 0 | | 18 | | 0.66 |
| | 0 | | 20 | | 0.69 |
| | 0 | | 22 | | 0.71 |
| | 0 | | 24 | | 0.73 |
| | 0 | | 26 | | 0.75 |
| | 0 | | 28 | | 0.77 |
| | 0 | | 30 | | 0.78 |
| | 0 | | 32 | | 0.80 |
| | 0 | | 34 | | 0.82 |
| | 0 | | 36 | | 0.83 |
| | 0 | | 38 | | 0.84 |
| | 0 | | 40 | | 0.85 |
| | 500 | | 2 | | 0.44 |
| | 500 | | 4 | | 0.48 |
| | 500 | | 6 | | 0.51 |
| | 500 | | 8 | | 0.54 |
| | 500 | | 10 | | 0.57 |
| | 500 | | 12 | | 0.60 |
| | 500 | | 14 | | 0.62 |
| | 500 | | 16 | | 0.65 |
| | 500 | | 18 | | 0.67 |
| | 500 | | 20 | | 0.70 |
| | 500 | | 22 | | 0.72 |
| | 500 | | 24 | | 0.74 |
| | 500 | | 26 | | 0.76 |
| | 500 | | 28 | | 0.78 |
| | 500 | | 30 | | 0.79 |
| | 500 | | 32 | | 0.81 |
| | 500 | | 34 | | 0.82 |
| | 500 | | 36 | | 0.84 |
| | 500 | | 38 | | 0.85 |
| | 500 | | 40 | | 0.86 |
| | 1000 | | 2 | | 0.46 |
| | 1000 | | 4 | | 0.49 |
| | 1000 | | 6 | | 0.52 |

| | | | | | |
|---|---|---|---|---|---|
| | 1000 | | 8 | | 0.55 |
| | 1000 | | 10 | | 0.58 |
| | 1000 | | 12 | | 0.61 |
| | 1000 | | 14 | | 0.64 |
| | 1000 | | 16 | | 0.66 |
| | 1000 | | 18 | | 0.69 |
| | 1000 | | 20 | | 0.71 |
| | 1000 | | 22 | | 0.73 |
| | 1000 | | 24 | | 0.75 |
| | 1000 | | 26 | | 0.77 |
| | 1000 | | 28 | | 0.79 |
| | 1000 | | 30 | | 0.80 |
| | 1000 | | 32 | | 0.82 |
| | 1000 | | 34 | | 0.83 |
| | 1000 | | 36 | | 0.85 |
| | 1000 | | 38 | | 0.86 |
| | 1000 | | 40 | | 0.87 |
| | 2000 | | 2 | | 0.49 |
| | 2000 | | 4 | | 0.82 |
| | 2000 | | 6 | | 0.55 |
| | 2000 | | 8 | | 0.58 |
| | 2000 | | 10 | | 0.61 |
| | 2000 | | 12 | | 0.64 |
| | 2000 | | 14 | | 0.66 |
| | 2000 | | 16 | | 0.69 |
| | 2000 | | 18 | | 0.71 |
| | 2000 | | 20 | | 0.73 |
| | 2000 | | 22 | | 0.75 |
| | 2000 | | 24 | | 0.77 |
| | 2000 | | 26 | | 0.79 |
| | 2000 | | 28 | | 0.81 |
| | 2000 | | 30 | | 0.82 |
| | 2000 | | 32 | | 0.84 |
| | 2000 | | 34 | | 0.85 |
| | 2000 | | 36 | | 0.86 |
| | 2000 | | 38 | | 0.87 |
| | 2000 | | 40 | | 0.88 |
| | 3000 | | 2 | | 0.52 |
| | 3000 | | 4 | | 0.55 |
| | 3000 | | 6 | | 0.58 |
| | 3000 | | 8 | | 0.61 |
| | 3000 | | 10 | | 0.64 |
| | 3000 | | 12 | | 0.66 |
| | 3000 | | 14 | | 0.69 |
| | 3000 | | 16 | | 0.71 |
| | 3000 | | 18 | | 0.73 |
| | 3000 | | 20 | | 0.75 |
| | 3000 | | 22 | | 0.77 |

| | | | | | |
|---|---|---|---|---|---|
| | 3000 | | 24 | | 0.79 |
| | 3000 | | 26 | | 0.81 |
| | 3000 | | 28 | | 0.82 |
| | 3000 | | 30 | | 0.84 |
| | 3000 | | 32 | | 0.85 |
| | 3000 | | 34 | | 0.86 |
| | 3000 | | 36 | | 0.87 |
| | 3000 | | 38 | | 0.88 |
| | 3000 | | 40 | | 0.89 |
| | 4000 | | 2 | | 0.54 |
| | 4000 | | 4 | | 0.58 |
| | 4000 | | 6 | | 0.61 |
| | 4000 | | 8 | | 0.64 |
| | 4000 | | 10 | | 0.66 |
| | 4000 | | 12 | | 0.9 |
| | 4000 | | 14 | | 0.71 |
| | 4000 | | 16 | | 0.73 |
| | 4000 | | 18 | | 0.75 |
| | 4000 | | 20 | | 0.77 |
| | 4000 | | 22 | | 0.79 |
| | 4000 | | 24 | | 0.81 |
| | 4000 | | 26 | | 0.82 |
| | 4000 | | 28 | | 0.84 |
| | 4000 | | 30 | | 0.85 |
| | 4000 | | 32 | | 0.86 |
| | 4000 | | 34 | | 0.87 |
| | 4000 | | 36 | | 0.89 |
| | 4000 | | 38 | | 0.90 |
| | 4000 | | 40 | | 0.90 |

ea_t

**table** ea_t;
**Input**([climate. tc_mean])
**Output**([climate.ea).
**Remark** saturation vapour pressure (ea) in mbar as
Function on Mean
Air Temperature(T) in $^{0}$c

| input | | Output | |
|---|---|---|---|
| concept | property | concept | property |
| climate | Int(Tc_mean) | climate | ea |
| | 0 | | 6.1 |
| | 1 | | 6.6 |
| | 2 | | 7.1 |
| | 3 | | 7.6 |
| | 4 | | 8.1 |
| | 5 | | 8.7 |

| | | | |
|---|---|---|---|
| | 6 | | 9.3 |
| | 7 | | 40 |
| | 8 | | 10.7 |
| | 9 | | 11.5 |
| | 10 | | 12.3 |
| | 11 | | 13.1 |
| | 12 | | 14 |
| | 13 | | 15 |
| | 14 | | 16.1 |
| | 15 | | 17 |
| | 16 | | 18.2 |
| | 17 | | 19.4 |
| | 18 | | 20.6 |
| | 19 | | 22 |
| | 20 | | 23.4 |
| | 21 | | 24.9 |
| | 22 | | 26.4 |
| | 23 | | 28.1 |
| | 24 | | 29.8 |
| | 25 | | 31.7 |
| | 26 | | 33.6 |
| | 27 | | 35.7 |
| | 28 | | 37.8 |
| | 29 | | 40.1 |
| | 30 | | 42.1 |
| | 31 | | 44.9 |
| | 32 | | 47.6 |
| | 33 | | 50.3 |
| | 34 | | 53.2 |
| | 35 | | 56.2 |
| | 36 | | 59.4 |
| | 37 | | 62.8 |
| | 38 | | 66.3 |
| | 39 | | 69.9 |

Function_tc_t

**table** function_tc_t;
**Input**([climate.tc_mean)
**Output**([climate.function_tc]).

| input | | Output | |
|---|---|---|---|
| concept | property | concept | property |
| climate | Tc_mean | climate | Function_tc |
| | 0 | | 11 |
| | 2 | | 11.4 |
| | 4 | | 11.7 |
| | 6 | | 12 |
| | 8 | | 12.4 |

| | | | |
|---|---|---|---|
| | 10 | | 12.7 |
| | 12 | | 13.1 |
| | 14 | | 13.5 |
| | 16 | | 13.8 |
| | 18 | | 14.2 |
| | 20 | | 14.6 |
| | 22 | | 15 |
| | 24 | | 15.4 |
| | 26 | | 15.9 |
| | 28 | | 16.3 |
| | 30 | | 16.7 |
| | 32 | | 17.2 |
| | 34 | | 17.7 |
| | 36 | | 18.1 |

Function_ed_t

**table** function_ed_t;
**Input**([climate.adjustment_ed])
**Output**([climate.function_ed]).

| Input | | Output | |
|---|---|---|---|
| concept | property | concept | Property |
| climate | adjustment_ed | climate | Function_ed |
| | 6 | | 0.23 |
| | 8 | | 0.22 |
| | 10 | | 0.20 |
| | 12 | | 0.19 |
| | 14 | | 0.18 |
| | 16 | | 0.16 |
| | 18 | | 0.15 |
| | 20 | | 0.14 |
| | 22 | | 0.13 |
| | 24 | | 0.12 |
| | 26 | | 0.12 |
| | 28 | | 0.11 |
| | 30 | | 0.10 |
| | 32 | | 0.09 |
| | 34 | | 0.08 |
| | 36 | | 0.08 |
| | 38 | | 0.07 |
| | 40 | | 0.06 |

Function_n/N_t

**table** function_n/N_t;
**Input**([climate.n/N])
**Output**([climate.function_n/N]).

| input | | Output | |
|---|---|---|---|
| concept | property | concept | Property |
| climate | n/N | climate | Function_n/N |
| | 0 | | 0.10 |
| | 0.05 | | 0.15 |
| | 0.1 | | 0.19 |
| | 0.15 | | 0.24 |
| | 0.2 | | 0.28 |
| | 0.25 | | 0.33 |
| | 0.3 | | 0.37 |
| | 0.35 | | 0.42 |
| | 0.4 | | 0.46 |
| | 0.45 | | 0.51 |
| | 0.5 | | 0.55 |
| | 0.55 | | 0.60 |
| | 0.6 | | 0.64 |
| | 0.65 | | 0.69 |
| | 0.7 | | 0.73 |
| | 0.75 | | 0.78 |
| | 0.8 | | 0.82 |
| | 0.85 | | 0.87 |
| | 0.9 | | 0.91 |
| | 0.95 | | 0.96 |
| | 0.10 | | 1.0 |

c) Et0 Function

| Function | Description |
|---|---|
| Adj_latitude_f | Climate.adj_latitude = int((climate,latitude+1)/2)*2) |
| Adj_latitude1_f | Climate.adj_latitude1 = int((climate,latitude+2.5)/5)*) |
| Solar_radiation_f | Climate.Solar_radiation = (0.25+(0.5*(climateActual_sun/climate.abs_sun)))*climate..radiation |
| Tc_mean_f | Climate.tc_mean = (climate.daily_tc_min + climate.daily_tc_max)/2 |
| Net_radiation _f | Climate. net_radiation = (climate.solar_radiation*0.75)-climate.longwave_radiation |
| longwave_radiation_f | Climate. longwave_radiation = function_n/N*function_tc*Function_ed |
| n/N_factor_f | Climate. n/N_factor = round(((climate.actual_sun / climate.abs_sun) +0.05)/0.05)) |
| n/N _f | Climate. n/N = round((climate.n/N -1)*5)/100) |
| Ed_f | Climate. ed = climate.ea *climate.rh_mean /100) |
| Et0_Penman | Et0.value=Adjustment_factor*[climate.weight_factor*climate.net_radiation+(1- weight_factor)*climate.wind_function*( climate.ea-climate.Function_ed)]<br><br>**Net_radiation** net radiation in equivalent evaporation in mm/day<br>**Weight_factor** temperature – related weight factor |

| Function | Description |
|---|---|
| | **Adjustment_factor** adjustment factor to compensate for the effect of day and night weather conditions.<br>**(ea – ed)** difference between the saturation vapor pressure at mean air temperature and the mean actual vapour pressure of the air, both in mbar |
| Wind_function_f | climate.wind_function =0.27(1+climate.wind_day/100) |

### 3.2.4 EtCrop Model

**Domain_model:** EtCrop_model

**Parts:tuple :**

*% (unit_t: table) Expansion model*
*% (depression_factor _t: table) Expansion model*
( growth_stage_t: table)
( kc_gc_t: table)
(Adapt Green Cover Area: relation)
(EtCrop_f: function)

***a) EtCrop Relation***

EtCrop.inialize_gc = Gc
(Gc/100)>=0.5
Adapt Green Cover Area
EtCrop..gc = (EtCrop.inialize_gc /100)+0.5*(1-( EtCrop.inialize_gc /100))

EtCrop.inialize_gc = GC
(Gc/100) < 0.5
Adapt Green Cover Area
EtCrop.gc = (EtCrop.inialize_gc /100)

***b) EtCrop Table***

growth_stage_t

**table** growth_stage_t;
**Input**([session.month, session.day,
Plant.variety, soil.type,plant.status])
**Output**([EtCrop. Growth stage]).
***See Appendix A***

kc_gc_t

**table** kc_gc_t;
**Input**([EtCrop. Growth stage, soil.type, Plant.status])
**Output**([EtCrop.kc, EtCrop. Inialize_gc]).
***See Appendix A***

***c)EtCrop function***

| Function | Description |
|---|---|
| EtCrop_f | EtCrop.value= ( farm.unit /1000) * farm.depression_factor*et0.value * EtCrop.kc *( EtCrop.gc) |

### 3.2.4 SWHC Model ( m3/f الماء الميسر)

**Domain_model:** water_requirement_model
**Parts:tuple** %(ece_t :table) *Expansion model*
% (irrigation_efficiency_t :table) *Expansion model*
% (ds_factor_t :table) *Expansion model*
% (wrs_t :table) *Expansion model*
(sbd_t: table)
(Sp_t: table)
(ad_t: table)
(rooting depth _t: table)
(SWHC_f: function)

***a) SWHC Table***

sbd_t

**table** sbd_t %soil bulk density;
**Input**([soil.type])
**Output**([soil.spd]).

| Input | Output |
|---|---|
| soil.type | soil.spd |
| خفيفه | 1.58 |
| متوسطه | 1.39 |
| ثقيله | 1.23 |

Sp_t

**table** sp_t; %soil saturated percentage
**Input**([soil.type])
**Output**([soil.sp]).

| Input | Output |
|---|---|
| soil.type | soil.sp |
| خفيفه | 20 |
| متوسطه | 30 |
| ثقيله | 40 |

ad_t

**table** ad_t; %نسبة الماء المستفاد
**Input**([plantation.crop])
**Output**([ad.value]).
***See Appendix A***

rooting depth _t

**table** rd_t; %rooting depth per meter
**Input**([plant.Variety_type, Plant.Status, soil.type])
**Output**([rooting depth.value]).
***See Appendix A***

***b) SWHC Function***

| Function | Description |
|---|---|
| SWHC_f | SWHC.value= (4200*Rd.value* soil.SPd *( soil.SP /(3*100))* Ad.value * (1/ irrigation. Irrigation_efficiency)* farm.drainage_system_factor * irrigation.Wsr *( water.Eciw / plant.Ece +1))) |

### 3.2.5 Water Requirement Model

**Domain_model:** water_requirement_model

**Parts:tuple** <u>%(ece_t :table) *Expansion model*</u>
<u>% (irrigation_efficiency_t :table) *Expansion model*</u>
<u>% (ds_factor_t :table) *Expansion model*</u>
(Leaching_requirement_f: function)
(Adapt Leaching Requirement: relation)
(wr_m3_f_day_f: function)
(wr_m3_f_period_f: function)
(Irrigation Type: relation)

***a)*** Water Requirement ***Relation***

irrigation.Initialize_Leaching_requirement = LR
LR < 25
Adapt Leaching Requirement
irrigation.Leaching_requirement = LR/100

irrigation.Initialize_Leaching_requirement = LR
LR >=25
Adapt Leaching Requirement
irrigation.Leaching_requirement = 25/100

plantation. Irrigation_system = غمر
water_requirement.wr_m3_f_period >= 150
water_requirement.wr_m3_f_period <= 200
Irrigation Type
Irrigation.irrigate_type = "ريه خفيفه"

plantation. Irrigation_system = غمر
water_requirement.wr_m3_f_period > 200
water_requirement.wr_m3_f_period <= 300
Irrigation Type
Irrigation.irrigate_type = "ريه متوسطه"

water_requirement.wr_m3_f_period > 300
Irrigation Type
Irrigation.irrigate_type = "ريه ثقيله"

b) Water Requirement ***Function***

| Function | Description |
|---|---|
| Leaching_requirement_f | Irrigation. Initialize_Leaching_requirement =(water.eciw*100/ plant.Ece) |
| wr_m3_f_day_f | water_requirement.wr_m3_f_day =EtCrop.value* farm.drainage_system_factor * (1+ irrigation.Leaching_requirement) /irrigation. |

| | |
|---|---|
| | irrigation_efficiency |
| wr_m3_f_period_f | water_requirement.wr_m3_f_period = water_requirement.wr_m3_f_day * session. number_days_per_period |

### 3.2.6 Frequency Model

**Domain_model:** frequency_model

**Parts:tuple**(Frequency_f : function)

(Adapt frequency: relation)

***a) Frequency Relation***

water_requirement.wr_m3_f_period = WR
WR = 0
    Adapt frequency
frequency.value = 0

frequency. Initialize_value = Frequency
Frequency > 0
Frequency < 1
    Adapt frequency
frequency.value = 1

frequency. Initialize_value = Frequency
Frequency > 1
Frequency < 2
    Adapt frequency
frequency.value = 2

frequency. Initialize_value = Frequency
Frequency > 2
Frequency < 3
    Adapt frequency
frequency.value = 3

frequency. Initialize_value = Frequency
Frequency > 3
Frequency < 4
    Adapt frequency
frequency.value = 4

frequency. Initialize_value = Frequency
Frequency > 4
Frequency < 5
    Adapt frequency
frequency.value = 5

frequency. Initialize_value = Frequency
Frequency > 5

session.number_days_per_period = Number_days_per_period
Adapt frequency
frequency.value = Number_days_per_period

b)***Frequency Function***

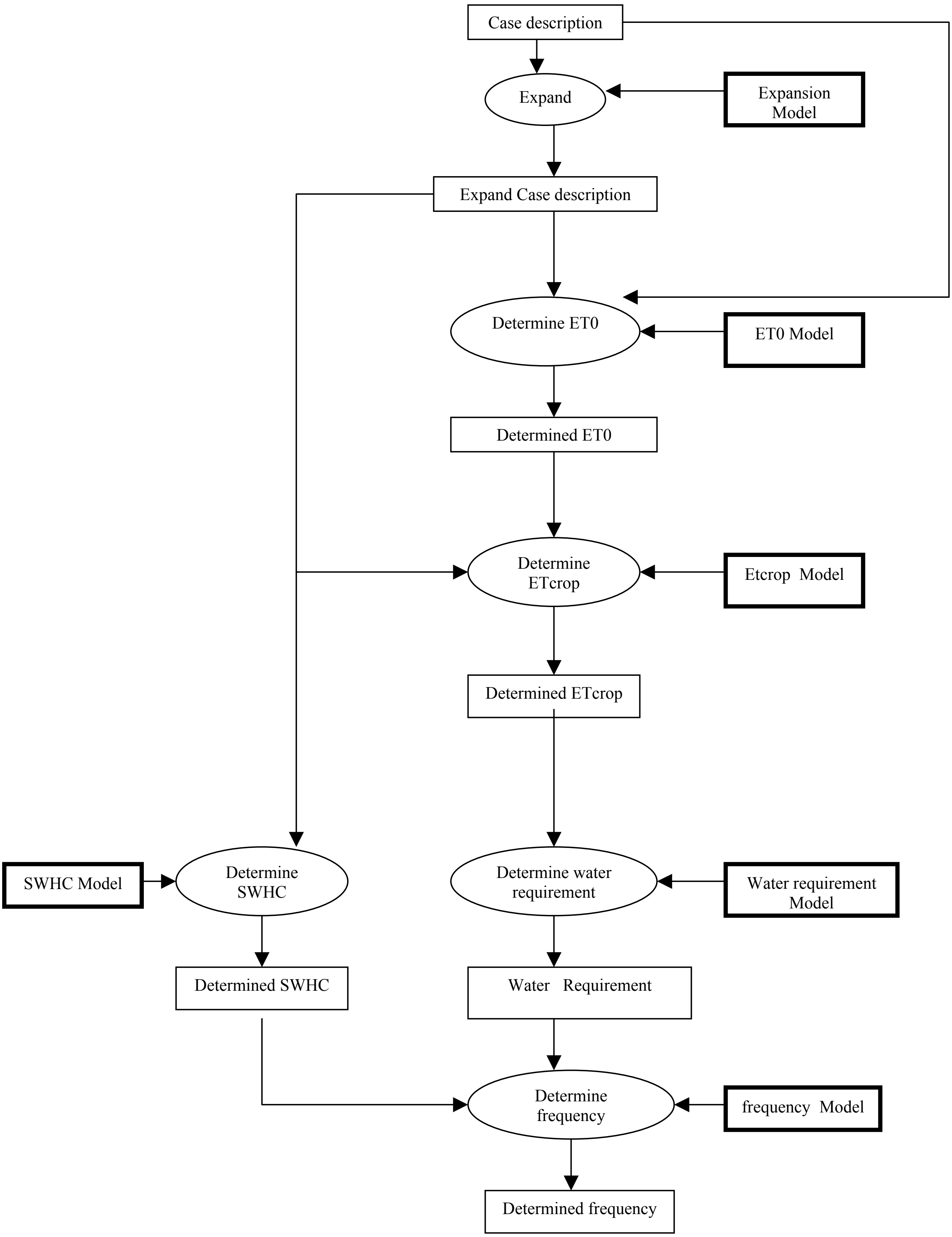
| Function | Description |
|---|---|
| Frequency_f | Frequency. Initialize_value = water_requirement.wr_m3_f_period/ SWHC.value |

# 4. Inference Knowledge

The design of inference knowledge consists of two main parts namely: inference structure and inference specification. The following paragraphs explain them in much more details.

## *4.1 Inference Structure*

As shown in the following figure the inference structure includes six inference steps. The objective of the *expand* inference is to use known data to derive new ones using a set of relations that forms the *expansion model*. The goal of Et0 irrigation schedule is to get the results of the expand inference step and use the *evapotranspiration(Et0)* model to generate a *evapotranspiration*. The goal of EtCrop is to get the results of the expand and Et0 inference step and use the EtCrop model to generate a *EtCrop.* The goal of SWHC is to get the results of the expand and SWHC inference step and use the SWHC model to generate a SWHC. The goal of Frequency is to get the results of the expand and Frequency inference step and use the Frequency model to generate a Frequency The goal of Water Requirement is to get the results of the expand and Water Requirement inference step and use the Water Requirement model to generate a Water Requirement



Case description
Expand
Expansion Model
Expand Case description
Determine ET0
ET0 Model
Determined ET0
Determine ETcrop
Etcrop Model
Determined ETcrop
SWHC Model
Determine SWHC
Determine water requirement
Water requirement Model
Determined SWHC
Water Requirement
Determine frequency
frequency Model
Determined frequency

### *4.2 Inference specification*

Names of inferences represent the role that these inferences play in solving the problem. Inference names are thus goal-oriented. For each role, a mapping is specified to the domain knowledge. For instance, static roles indicate which domain model should be accessed. Dynamic roles, on the other hand, are supposed to be part of the overall working memory of the problem solver and are thus not directly linked to specific domain model. Two inference steps from the irrigation application are given in figure 2.

| | |
|---|---|
| **Name** : | Expand |
| **Goal:** | Expand case description |
| **Static Role :** | Expansion model |
| **Input Role:** | Case Description |
| **Output Role:** | Expand case description |
| **Spec:** | Expand case description: Relation,<br>irrigation_efficiency_t: table<br>ece_t: table<br>ds_factor_t: table<br>Wsr_t: table<br>unit _t : table<br>depression_factor _t :table<br>age_f: Function<br><br>Expand plant status: relation |
| **Name :** | Determine ET0 |
| **Goal:** | Compute Evapotranspiration (ET0) |
| **Static Role :** | Evapotranspiration model |
| **Input Role:** | Case Description |
| **Output Role:** | Evapotranspiration (ET0) |
| **Spec:** | */* calculate the evaporation Et0*/*<br><br>**if** (irrigation.measure_type=’ بيانات المنا خ **Then**<br>Et0_Penman<br><br>**else if** (irrigation.measure_type=’جهاز البخر ’ **Then**<br>Et0_pan_t : table<br>**else if** (irrigation.measure_type=’ متوسطات قراءات بيانات المناخ على مستوى القطاع **Then**<br>Et0_sector_t : table<br>**EndIf**<br>**EndIf** |

**EndIf**

*/*Et0 Penman equation */*

**Et0_Penman:-**

**Begin**

*/*adj_latitude*/*

**If** (climate.latitude <40) **Then**

*%Adj_latitude1_f([climate,latitude],[Climate.adj_latitude])*

Adj_latitude1_f: Function

**Else**

*%Adj_latitude_f([climate,latitude],[Climate.adj_latitude])*

Adj_latitude_f: Function

**EndIf**

*/*tc_mean*/*

**If** known((climate.daily_max_tc) AND known(climate.daily_min_tc)) **Then**

*%Tc_mean_f([climate.daily_max_tc, climate.daily_min_tc], [climate. tc_mean])*

Tc_mean_f:Function

**Else**

climate. tc_mean = climate.tc

**EndIf**

*/*Adjustment_tc_mean */*

*%Adjustment_tc_mean_r([climate.tc_mean], [climate.Adjustment_tc_mean])*

Adjustment_tc_mean_r: Relation

/* Ea*/

*%ea_t([climate.altitude,climate. Adjustment_tc_mean], [climate.ea])*

ea_t: Table

/*Ed*/

*%ed_f([climate.ea,climate.rhmean],[climate.ed])*

ed_f : Function

/* adjustment_ed _r */

% adjustment_ed _r(climate.ed, climate. adjustment_ed)

adjustment_ed _r : Relation

/* n/N_factor*/

*%* n/N_factor_f *([climate.* actual_sun, abs_sun*], [climate. n/N_factor]).*

| | |
|---|---|
| | n/N_factor_f: Function<br><br>/* n/N*/<br>*% n/N_f ([climate.n/N_factor], [climate.n/N]).*<br>n/N_f : Function<br><br>/*Function_n/N*/<br>*%Function_n/N_t ([climate.n/N], [climate.function_n/N]).*<br>Function_n/N_t : Table<br><br>/*Function_tc*/<br>*%Function_tc_t ([climate.tc_mean], [climate.function_tc]).*<br>Function_tc_t : Table<br><br>/*Function_ed*/<br>*%Function_ed_t([climate.adjustment_ed], [climate.function_ed]).*<br>Function_ed_t: Table<br><br>/*longwave_radiation*/<br>*%longwave_radiation_f([function_n/N, function_tc, Function_ed],[Climate. longwave_radiation])*<br>longwave_radiation_f: Function<br><br>*/*net_radiation:*/*<br>*%net_radiation_f([climate.solar_radiation, climate.longwave_radiation]*<br>*,[Climate. net_radiation])*<br>net_radiation_f: Function<br><br>*/*abs_sun*/*<br>*%abs_sun _t;([climate.month,climate.adj-latitude], [climate.abs_sun]).*<br>abs_sun _t:Table<br><br>*/*radiation*/*<br>*%radiation_t([climate.month,climate.adj-latitude], [climate.radiation]).*<br>radiation_t:Table<br><br>*/*Solar_radiation */*<br>*%solar_radiation_f([climateActual_sun,climate.abs_sun,climate..radiati*<br>*on] ,*<br>*[ Climate. Solar_radiation])*<br>solar_radiation_f:Function<br>*/*Adjustment_solar_radiation*/*<br>*%Adjustment_solar_radiation_r ([climate.solar_radiation],*<br>*[Adjustment_solar_radiation])*<br>Adjustment_solar_radiation_r :Relation<br>*/* Adjustment_factor:*/*<br>*%adjustment_factor _t ([plantation.sector* |

| | |
|---|---|
| | *Adjustment_solar_radiation], [Adjustment_factor]),*<br>adjustment_factor _t : Table<br>*/* Adjustment_tc_mean */*<br>*%Adjustment_tc_mean_r([climate.tc_mean], [Adjustment_tc_mean])*<br>Adjustment_tc_mean_r:Relation<br>*/*weight_factor:*/*<br>*%Weight_factor_t([climate.altitude,climate. Adjustment_tc_mean], [climate.weight_factor]).*<br>Weight_factor_t:Table<br>/*Adjustment_tc_mean */<br>*%Adjustment_tc_mean_f(climate.daily_tcMin+climate.daily_tcmax)/2*<br>Adjustment_tc_mean_f:Function<br>*%Adjustment_tc_mean Adjustment_tc_mean_r([climate.tc_mean], [Adjustment_tc_mean])*<br>Adjustment_tc_mean Adjustment_tc_mean_r: Relation<br>*/*wind_function */*<br>*%wind_function_f([climate.wind_day],[climate.wind_function])*<br>wind_function_f: Function<br>*/*Et0_Penman*/*<br>*%Et0_Penman_f([Adjustment_factor, weight_factor, net_radiation, weight_factor,*<br>*wind_function, ea, ed] , [ Et0_Penman])*<br>Et0_Penman_f: Function<br>**End.** |
| **Name :** | Determine Etcrop |
| **Goal:** | Compute EtCrop |
| **Static Role :** | Etcrop model |
| **Input Role:** | Case Description |
| **Output Role:** | Etcrop |
| **Spec:** | Growth_stage_t : Table<br>kc_gc_t : Table<br>Adapt Green Cover Area: Relation<br>EtCrop_f : Function |
| **Name :** | Determine SWHC reference |
| **Goal:** | Compute SWHC |

| | |
|---|---|
| **Static Role :** | SWHC model |
| **Input Role:** | Case Description<br>Expand Case Description |
| **Output Role:** | SWHC |
| **Spec:** | sbd_t : Table<br>sp_t: Table<br>ad_t: Table<br>rooting depth _t: Table<br>SWHC_f: Function |

| | |
|---|---|
| **Name :** | Determine water requirement |
| **Goal:** | Compute water requirement |
| **Static Role :** | Water Requirement model |
| **Input Role:** | Etcrop |
| **Output Role:** | Water requirement |
| **Spec:** | Leaching_requirement_f : function<br>Adapt Leaching Requirement: relation<br>wr_m3_f_day_f : function<br>wr_m3_f_period_f: function |

| | |
|---|---|
| **Name :** | Determine frequency |
| **Goal:** | Compute frequency |
| **Static Role :** | frequency model |
| **Input Role:** | Water requirement<br>SWHC |
| **Output Role:** | frequency |
| **Spec:** | Frequency_f : function<br>Adapt frequency : relation |

## 5. Task Knowledge

The task definition describes the main goal of irrigation schedule as well as the input, and the output roles. The task body describes the control over these sub-tasks.

**task:** Irrigation schedule ,
**task-definition:**
**goal:** the main goal of the irrigation is to determine the water requirement during cultivation.

**input:** case-description

**output:** irrigation schedule
**task_body**
**type:** Composite
**sub_tasks:** Propose mathematic irrigation schedule
**control_structure:**
Propose mathematic irrigation schedule.

**task:** Propose mathematic irrigation schedule
**task-definition:**
**goal:** Generating an propose irrigation schedule

**input:** case-description

**output:** Propose irrigation schedule
**task_body**
**type:** Composite
**sub_tasks:** Compute propose irrigation schedule
**primitive_tasks:** Initialize irrigation parameters
**transfer_tasks:** Display irrigation schedule
**control_structure:**
(case description, expansion model -> expanded case description ),
Initialize irrigation parameters,
Compute propose irrigation schedule,
Display irrigation schedule.

**task:** Compute propose irrigation schedule
**task-definition:**
**goal:** Its compute the propose irrigation schedule.

**input:** Case description,

Expand case description

**output:** Propose irrigation schedule
**task_body**
**type:** Composite
**sub_tasks:**,

Evapotranspiration (ET0),
Etcrop,
Water requirement,
SWHC,
frequency,

**primitive_tasks:** Adjustment irrigation parameters

**control_structure:**

```
While session.month < 13 do
 Begin
   While session.day < 31 do
    Begin
       (Climatic data, ET0 model ----> Determined Evapotranspiration (ET0)),
        Case Description, Determined ET0, Etcrop model ------> Etcrop,

        ((Determined Etcrop, Water requirement model)) ------>
                                 Determined Water requirement)
        Case Description , SWHC model ---> Determined SWHC,

        frequency model, Climatic data -----> Determined frequency,

        Get (session.month(Month)),
        Get (session.range_day (Range_day)),
        Get (water_requirement.value (Wr)),
        Get (frequency.value(Frequency)),
        Get (irrigation. Irrigate_type(Irr_type)),
         Get (EtCrop. Growth stage (Growth_Stage)),

      Assert_irr_db(Month,  Range_day, Wr, Frequency, Irr_type,
                    Growth_Stage)
        Adjustment irrigation parameters.
    End{While}
 End{While}
```

**task:** Initialize irrigation parameters
**task_body**
**type:**
**control_structure:**
session.month = 1,
climate.month = 1,
session.day = 10,
session. number_days_per_period =10.

**task:** Adjustment irrigation parameters
**task_body**
**type:** Primitive Task
**control_structure:**
session.month = session.month + 1,
climate.month = climate.month + 1,

```
 If (session.day >30 ) Then
    session.day = 10
Else
   session.day = session.day +10.
Endif
Case session.day
 10: session.range_day="1-10"
      session. number_days_per_period =10
 20: session.range_day="11-20"
      session. number_days_per_period =10
 30: If (session.month=1;3;5;7;8;10;12) Then
           session.range_day="21-31"
           session. number_days_per_period =11
           Else If (session.month=4;6;9;11) Then
                session.range_day="21-30"
                session. number_days_per_period =10
                If (session.month=2) Then
                   session.range_day="21-28"
                   session. number_days_per_period =8
                EndIf
             EndIf
       EndIf
```

**task:** Display irrigation schedule.
**task_body**
**type:** Primitive Task
**control_structure:**

```
Get_value( plantation.irrigation_system (Irrigation_system))

Case Irrigation_system

تنقيط :

  display ("الشهر     عدد أيام الشهر     معدل الرى م3/ف-فتره     عدد مرات الرى للفتره
 ").

غمر :

     display ("الشهر     عدد أيام الشهر     معدل الرى م3/ف-فتره     عدد مرات
 الرى للفتره   نوع الريه        ").

EndCase

get list irr_schedule from Assert_irr_db
while(not empty list irr_schedule)
 Begin
   Assert_irr_db(Month,  Range_day, Wr, Frequency, Irr_type,
                Growth_Stage)

   If (  Month >1 & Previous_growth_stage \== Growth_Stage) Then
      Background different colour
```

```
      Separate table
   EndIf
   Write(Month)

   Write(Range_day)
   Write(Wr)
   Write(Frequency)
    Get_value( plantation.irrigation_system (Irrigation_system))
    If(Irrigation_system = غمر ) Then
      Write(Irrigate)
   EndIf
  Previous_growth_stage = Growth_Stage
End{while}
```

## 6. User Interface

Transfer tasks are used to handle system transaction. Two types of transaction are designed input transaction in which the user can enter his/her data into the system where as output transaction are used to display the result obtain from using the system.

There are two output screens for displaying the irrigation schedule concerning the drip and sprinkler irrigation in a each 10 days bases mode and flooding irrigation in a each 10 days bases mode.

***a) Drip_sprinkler irrigatiom screen***

| عدد مرات الرى للفتره<br>مره/خلال الفترة | معدل الرى للفتره<br>م3/فدان خلال الفترة | عدد ايام الشهر<br>يوم/شهر | الشهر |
|---|---|---|---|
| 0 | 0 | 1-10 | 1 |
| 0 | 0 | 11-20 | 1 |
| 0 | 0 | 21-31 | 1 |
| 0 | 0 | 1-10 | 2 |
| 0 | 0 | 11-20 | 2 |
| 0 | 0 | 21-28 | 2 |
| 0 | 0 | 1-10 | 3 |
| 1 | 26 | 11-20 | |
| 1 | 30 | 21-31 | 3 |
| 1 | 32 | 1-10 | 4 |
| 1 | 33 | | 4 |
| 1 | 33 | 21-30 | 4 |
| 1 | 36 | 1-10 | 5 |
| 1 | | 11-20 | 5 |
| 1 | 44 | 21-31 | 5 |
| 1 | 41 | 1-10 | |
| 1 | 42 | 11-20 | 6 |
| | 42 | 21-30 | 6 |
| 1 | 42 | 1-10 | 7 |
| 1 | | 11-20 | 7 |

| | | | |
|---|---|---|---|
| 2 | 46 | 21-31 | 7 |
| 1 | 42 | 1-10 | |
| 1 | 42 | 11-20 | 8 |
| 1 | 40 | 21-31 | 8 |
| 1 | 30 | 1-10 | 9 |
| 1 | 29 | 11-20 | 9 |
| 1 | 29 | 21-30 | 9 |
| 1 | 8 | 1-10 | 10 |
| 1 | 8 | 11-20 | 10 |
| 1 | 8 | 21-31 | 10 |
| 1 | 6 | 1-10 | 11 |
| 1 | 6 | 11-20 | 11 |
| 1 | 5 | 21-30 | 11 |
| 1 | 5 | 1-10 | 12 |
| 1 | 4 | 11-20 | 12 |
| 1 | 4 | 21-31 | 12 |

نمو خضرى     فترة سكون

*a)Flooding irrigatiom screen*

| نوع الرية | عدد مرات الرى للفتره مره/خلال الفترة | معدل الرى للفتره م3/فدان خلال الفترة | عدد ايام الشهر يوم/شهر | الشهر |
|---|---|---|---|---|
| ريه خفيفه | 1 | 7 | 1-10 | 1 |
| ريه خفيفه | 1 | 8 | 11-20 | 1 |
| ريه خفيفه | 1 | 10 | 21-31 | 1 |
| ريه خفيفه | 1 | 11 | 1-10 | 2 |
| ريه خفيفه | 2 | 69 | 11-20 | 2 |
| ريه خفيفه | 2 | 92 | 21-28 | 2 |
| ريه خفيفه | 3 | 138 | 1-10 | 3 |
| ريه خفيفه | 3 | 145 | 11-20 | 3 |
| ريه خفيفه | | 178 | 21-31 | 3 |
| ريه متوسطه | 5 | | 1-10 | |
| ريه متوسطه | 5 | 237 | 11-20 | 4 |
| ريه متوسطه | 5 | 242 | 21-30 | |
| ريه متوسطه | 5 | 280 | 1-10 | 5 |
| ريه ثقيله | 5 | 301 | 11-20 | |
| ريه ثقيله | 11 | 337 | 21-31 | 5 |
| ريه ثقيله | 10 | 331 | | 6 |
| ريه ثقيله | 10 | 336 | 11-20 | 6 |
| ريه ثقيله | | 337 | 21-30 | 6 |
| ريه ثقيله | 10 | 339 | 1-10 | 7 |
| ريه ثقيله | 10 | 340 | 11-20 | 7 |
| ريه ثقيله | 11 | 374 | 21-31 | 7 |
| ريه ثقيله | 10 | | 1-10 | 8 |
| ريه ثقيله | 10 | 336 | 11-20 | 8 |
| ريه ثقيله | 11 | 320 | 21-31 | |
| ريه متوسطه | 5 | 247 | 1-10 | 9 |
| ريه متوسطه | 5 | 239 | 11-20 | 9 |
| ريه متوسطه | 5 | 235 | 21-30 | 9 |
| ريه خفيفه | 1 | 18 | 1-10 | 10 |
| ريه خفيفه | 1 | 17 | 11-20 | 10 |
| ريه خفيفه | 1 | 18 | 21-31 | 10 |
| ريه خفيفه | 1 | 13 | 1-10 | 11 |
| ريه خفيفه | 1 | 12 | 11-20 | 11 |
| ريه خفيفه | 1 | 10 | 21-30 | 11 |

| | | | | |
|---|---|---|---|---|
| ريه خفيفه | 1 | 10 | 1-10 | 12 |
| ريه خفيفه | 1 | 10 | 11-20 | 12 |
| ريه خفيفه | 1 | 9 | 21-31 | 12 |

اثمار وعقد — نمو خضرى — بدايه تفتح البراعم — نمو خضرى

ما بعد الحصاد — النضج والحصاد — نمو ثمرى