Web Based Agricultural Meteorology and Crop Evapotranspiration System

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Abstract: Agrarian Service Centre plays an important role in sustainability of agriculture by ensuring the cultivation in the cultivatable land according to the acts of agricultural ministry, helping farmers in irrigation water management, guiding the cultivation program according to the annual cultivation schedule and to help farmers in obtaining loans from rural banks for agricultural production. In Agrarian Service Center in Vantharumoolai, they do not have any meteorology related system to help the farmers who are cultivating the crops in Batticaloa District. Due to this reason farmers were facing several problems related to their cultivation or agronomic practices throughout their cultivation period. Thus farmers cannot get high yield at the end of their cultivation in Batticaloa district. Therefore this web based system will provide daily and monthly updated meteorological information such as air temperature, relative humidity, rainfall pattern, evapotranspiration rate, crop water requirement. Unified Modelling Language (UML) was used to analysis and design the software. Hypertext Preprocessor (PHP) which is a server-side scripting language was used to build the system and Apache has been used as the web server, meanwhile MySQL was used to handle databases. Since this is a web based system, it could be operated in Windows environment. The web based Agro Meteorological Information was designed to fulfil the user and system requirements. The system will help to farmers to do their agronomic practices according to the information provided by this system. Therefore farmers can get high yield and high agricultural productivity.

Keywords: Agrarian Service Centre, Meteorology, Crop evapotranspiration, Crop water requirement

1 Introduction

Agro meteorology is the study and use of weather and climate information to enhance or expand agricultural crops and to increase crop production. Agro meteorology mainly involves the interaction of meteorological and hydrological factors, on one hand and agriculture, which encompasses horticulture, animal husbandry, and forestry. The crop water need (ET crop) is defined as the depth (or amount) of water needed to meet the water loss through evapotranspiration. In other words, it is the amount of water needed by the various crops to grow optimally. Therefore, in order to estimate the water requirement of a crop we first need to measure the evapotranspiration rate. Global population is expected to increase by about 30% by the year 2030, and as a result, demand for food will increase [1]. Major constrains to meet the increasing food demands of the population, irrigation water and land scarcity [2]. A possible approach to overcome constrains could be through improving performance of adopted irrigation systems or introductions of better ones. Owing to practical difficulties in obtaining accurate field measurements for ET_C prediction methods are commonly used. However, these methods often need to be applied under climatic and agronomic conditions different from those under which they were originally developed. Testing the accuracy of the methods under a new set of conditions is laborious, time consuming and costly. To overcome such difficulties, guidelines were formulated by FAO to calculate ET_C of crops under different climatic and agronomic conditions [3]. Nevertheless, to calculate ET_C, the effect of the following factors should be determined [4]. The main objective of the project is to develop a web based system to increase the agricultural production in Batticaloa district by provide the meteorological information by Agrarian Services Centre.

1.1 The effect of the crop characteristics on crop water requirements

Crop coefficient (K_C) presents the relationship between reference (ET_0) and crop evapotranspiration (ET_C). The value of crop coefficient (K_C) varies with crop type, developmental stage and prevailing weather conditions [4]. ET_C relates to ET_O and K_C as follows [5],

$$ET_C = ET_0 \times K_C \qquad \textbf{(1)}$$

The equation offers a mean value for ET_C in mm per day over a specific period of time. ET_O could be calculated from [5] version of Penman equation, known as Penman modified formula, as follows:

$$ET_0 = C\,[w.\,Rn + (1-w).\,f(u).\,(ea - ed)] \qquad \textbf{(2)}$$

Where:
ET_0 = reference crop evapotranspiration (mm/day)
C = adjustment factor
w = temperature related weighting factor
Rn = net radiation in equivalent evaporation (mm/day)
f(u) = wind related function
ea = actual vapor pressure at mean air temperature (mbar)
ed = saturation vapor pressure at mean air temperature (mbar)

2 System Analysis and Design

2.1 Outline of existing similar systems

- **A Computer program for Calculating Crop Water Requirements**

A computer program was developed for determination of crop water requirements using local meteorological and research data, and also using Visual Basic 6.0 Programming language. The program was based on using Penman equation and Penman-Monteith method. The program could offer a simple tool for planning crop water requirements for agricultural projects [6].

Fig. 1shows the computer program for Calculating Crop Water Requirements.

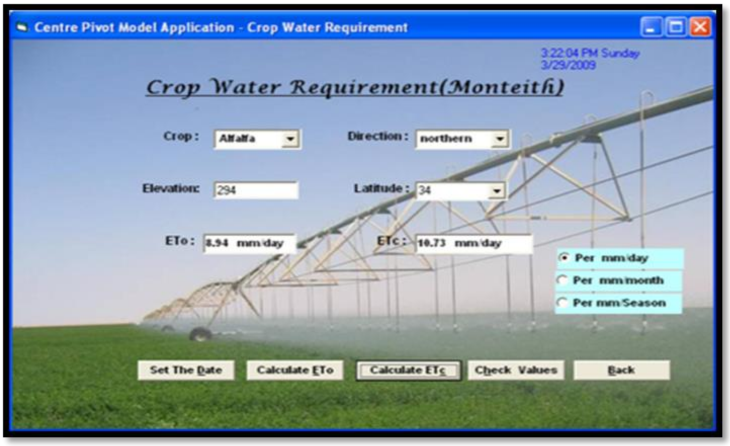

Fig. 1. Computer program for Calculating Crop Water Requirements

- **Cropwat Software**

This software (CROPWAT 8.0) uses the management of irrigation schemes, taking the user with the help of an actual data set through the different steps required to calculate evapotranspiration, crop water requirements, scheme water supply and irrigation scheduling [7].

Fig. 2 shows the Cropwat software for calculate evapotranspiration and crop water requirements.

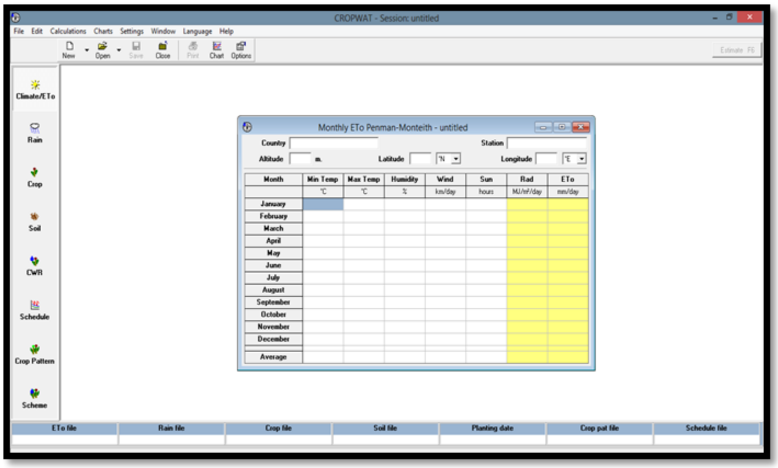

Fig. 2. Cropwat software.

- **ET_0 Calculator**

ET_O calculator software uses to determine the reference evapotranspiration from meteorological data by means of the FAO Penman-Monteith equation. This method has been selected by FAO as the reference because it closely approximates grass ET_O at the location evaluated, is physically based, and explicitly incorporates both physiological and aerodynamic parameters [8].

Fig. 3 shows the ET_O calculator software uses to determine the reference evapotranspiration.

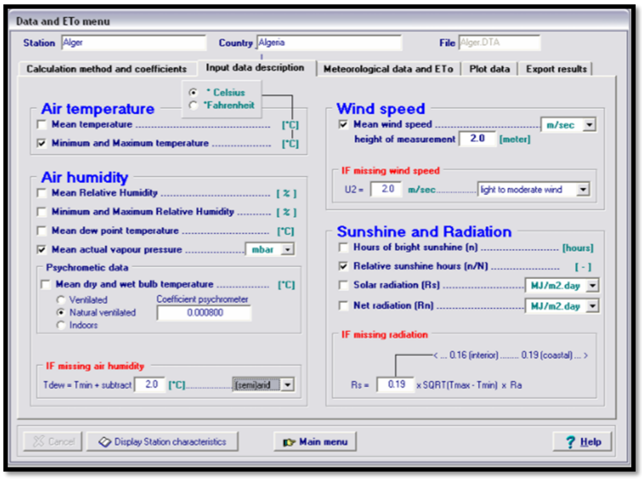

Fig. 3. ET_0 Calculator.

According to above existing systems, documentation, some of reference books and websites related with system scope, this system was developed.

2.2 Feasibility study

Feasibility study is one of the stages in analysis phase. Feasibility studies, aim to objectively and rationally uncover the strengths and weaknesses of an existing or proposed system, opportunities and threats present in the environment, the resources required to carry through, and ultimately the prospects for success. So, it allows the developer to understand the feasibility level of the proposed system. Following feasibility studies;

- **Legal Feasibility:** The proposed system has been analyzed to ensure that it is under law of Sri Lanka.
- **Technical Feasibility:** The proposed system has been analyzed to ensure that the developer has all resources or technologies and skill needed to carry out the development.
- **Operational Feasibility:** This feasibility study has been carried out to measure how the proposed system will solve the problems and how it will satisfy the user requirements.
- **Economic Feasibility:** The proposed system has been analyzed to determine the positive economic benefits to the organization.

2.3 Fact Gathering Techniques

Multiple techniques were employed here to capture requirements from different stakeholder perspectives. The main methods used for fact finding process were interview and document review. Meteorological data were collected from the Meteorological Department, Sri Lanka.

2.4 Functional Requirements

- System shall provide the meteorological information such as Temperature, Relative Humidity and other weather information.
- System shall provide the meteorological information patterns (Rainfall Pattern) for particular period (Weekly or Monthly) by graph or chart.
- System shall calculate the Crop water requirement in Batticaloa district farmers' fields.

2.5 Non-Functional Requirements

- **Accuracy:** These are very important non-functional requirements that should be considered when getting the meteorological details and calculating the evapotranspiration.
- **Consistency:** The requirement does not contradict any other requirement and is fully consistent with all authoritative external documentation.
- **Security:** System security should be highly secure to prevent unauthorized modification and access
- **Reliability:** This is one of the non-functional requirements from the user's perspective. There should be trustworthiness between the user and system.
- **User friendly:** The system should provide a user friendly environment to work with including flexible interfaces, where proper links and menus to be placed in suitable locations.
- **Performance:** Performance of the system, including response time and processing time should be less.

2.6 Methodology for the proposed system

Among all other software development methodologies, the waterfall model was selected as the process model by considering a lot of advantages it consists. Such as:

- This model is simple and easy to understand and use.
- It is easy to manage due to the rigidity of the model – each phase has specific deliverables and a review process.
- In this model phases are processed and completed one at a time. Phases do not overlap.
- Waterfall model works well for smaller projects where requirements are very well understood.

2.7 Selection of web based system

There are reasons to choose the web based system. The main reason is frequently updating of weather data is necessary to measure and estimate the meteorological information and Crop water requirement. A great advantage that a web based system can bring to organization is that they only require an up to date browser such as Internet Explorer, Google Chrome or Mozilla Firefox and are not bound by the restrictions of the businesses operating system. Web based applications can dramatically lower costs due to reduced support and maintenance, lower requirements on the end user system and simplified architecture. Therefore web based system was selected to complete the project.

2.8 Design Techniques

Design techniques are the methods used to model the solution domain. Among that Object Oriented design technique was chosen out of them for the main design concepts. Unified Modelling Language (UML) plays an important role in Object Orientation.

- **Use-Case diagrams**: shows what the system needs to do.
- **Class diagrams**: shows the needed objects and relationships between them.
- **Sequence diagrams**: shows how the objects interact overtime.
- **Activity diagrams**: shows object states at a specific timeline.
- **Database diagram**: shows the links or relations between the tables.

2.9 Overall use-case of the proposed system

Fig. 4 shows the overall use case diagram of this system. It is consists of three actors such as Server, Operator and Admin.

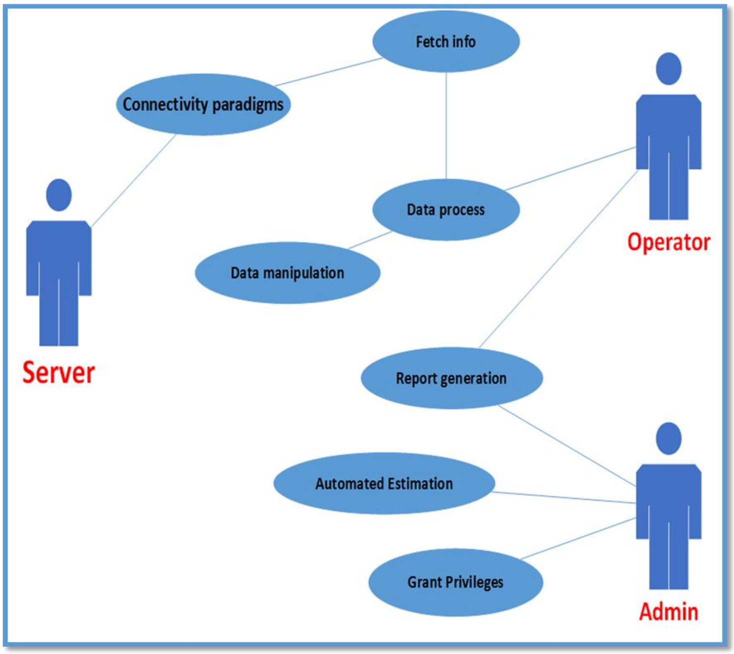

Fig. 4. Overall Use case diagram.

2.10 Database diagrams

Fig. 5 shows the Database diagram of this system.

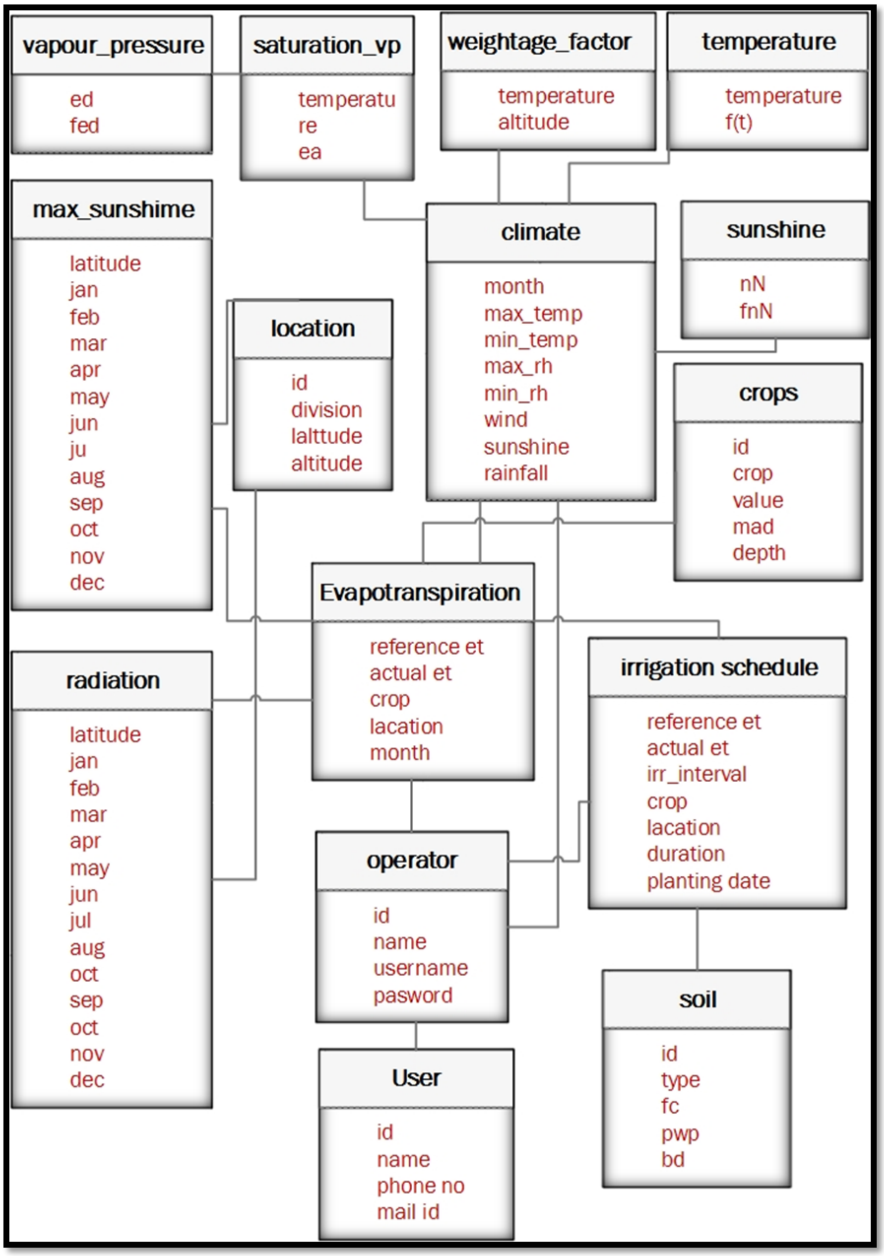

Fig. 5. Database diagram.

2.11 Crop Evapotranspiration calculator form (Default form)

Fig. 6 represents the crop evapotranspiration calculator form which has three selection boxes such as month, station and crop. This form is used calculating the daily crop water requirement when farmers do not know the values of monthly average climate.

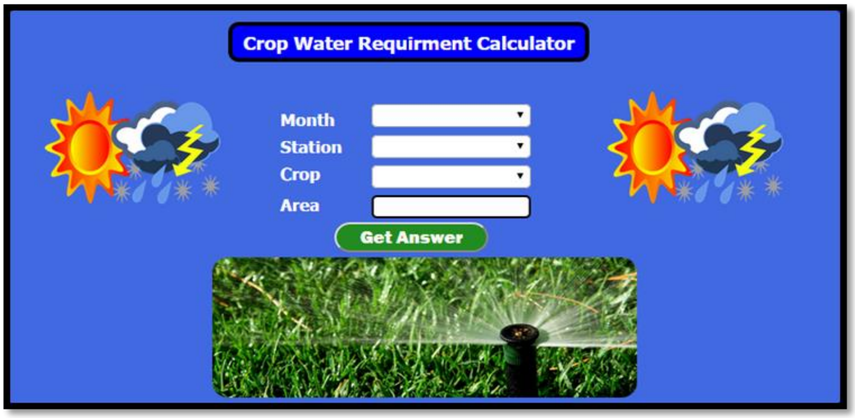

Fig. 6. Crop evapotranspiration calculator form (Default form).

2.12 Crop Evapotranspiration calculator form (Known value)

Fig. 7 represents the crop evapotranspiration calculator form which has three selection boxes such as month, station and crop with six fields. This form is used calculating the daily crop water requirement when farmers know the values of monthly average climate.

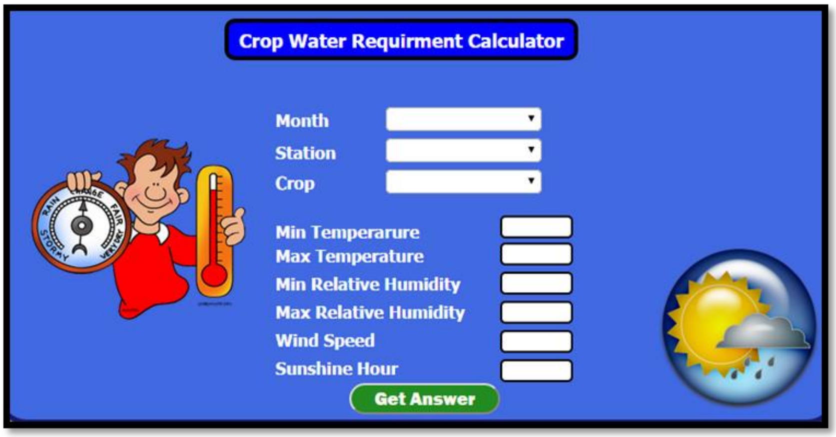

Fig. 7. Crop Evapotranspiration Calculator form (Known value).

2.13 Crop Evapotranspiration answer screen

Fig. 8 represent the crop evapotranspiration answer screen which display the particular month, station and crop with monthly climate data and which display the daily reference crop evapotranspiration as well as actual crop evapotranspiration for particular month, station and crop.

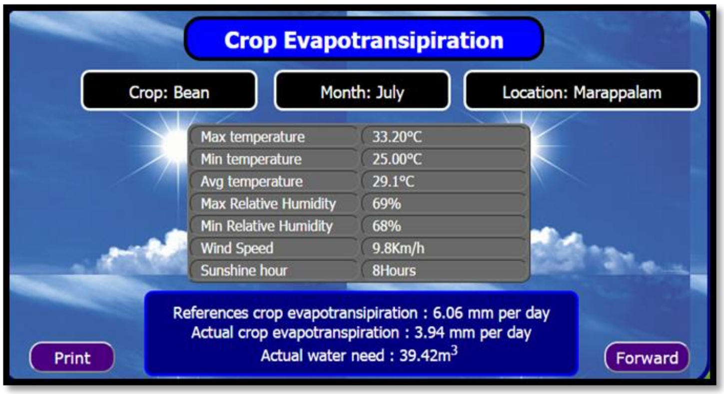

Fig. 8. Crop Evapotranspiration Answer screen.

3 Implementation and Testing

3.1 Hardware and Software Requirements

Software: Microsoft Windows 7 or 8 Operating System

Web Browser (Google Chrome)
WAMP server 2.4 (PHP, MYSQL database, Apache server)
Notepad ++ (Editor)

Hardware: Internet connection
Medium Configuration PC or laptop (Core i5 Processer, 500GB Hard Disk with 4GB RAM or up)

3.2 Development Tools and Technologies

- **PHP** (Hypertext Pre Processor) was the main development language used to develop the main system and its functionalities.
- **MySQL** was used to handle all the development related to the database.
- **CSS** was used to make the plain **HTML** interfaces more attractive and user friendly, which also decided the look and feel of the system.

- **JavaScript** was used to code all the client-side validation and creating some interactive dropdown menus and popup menus.
- **J-Query** which is based on JavaScript was used to implement the pre-coded functionalities such as home page slide show images in the home page.
- Two weather **widgets** were used in home page and weather page in the system.

3.3 Program codes

Code for crop evapotranspiration and irrigation schedule modules

```
<?php

mysql_connect("localhost","root","") or die(mysql_error());
mysql_select_db("agro    meteorological    inticator")    or
die(mysql_error());

$date="";
$station="";
$crops="";

$date = $_GET['date'];
$station = $_GET['locate'];
$crops = $_GET['crops'];
$crop = $_GET['crops'];

$max_temp=$_GET['max_temp'];
$min_temp=$_GET['min_temp'];
$max_rh=$_GET['max_rh'];
$min_rh=$_GET['min_rh'];
$wind=$_GET['wind'];
$sunshine=$_GET['sunshine'];

$rainfall="";
$latitude="";
$radiation="";
$max_sunshine="";
$Weightage_factor="";
$vapour_pressure_effect="";
$ed="";
$fed="";
$sunshine_ratio="";
$nN="";
$fnN="";
/*   (If farmers don not know the weather data:activate the
coding below in the comments)
$query_first  =  "select  *  from  climate  where  month='".
$date."'";
$result = mysql_query($query_first);
```

```
while($row=mysql_fetch_array($result))
{
    $max_temp = $row['max temp'];
    $min_temp = $row['min temp'];s
    $max_rh = $row['max rh'];
    $min_rh = $row['min rh'];
    $wind = $row['wind'];s
    $sunshine = $row['sunshine'];
    $rainfall = $row['rainfall'];
}*/

$query_second = "select latitude from location where
id='".$station."'";
$result = mysql_query($query_second);
while($row=mysql_fetch_array($result))
{
    $latitude = $row['latitude']; //get latitude from
location table
}

$query_third = "select * from radiation where
latitude='".$latitude."'";

$result = mysql_query($query_third);
while($row=mysql_fetch_array($result))
{
    $radiation = $row[$date];     //get radiation from
radiation table
}

$query_forth = "select * from max_sunshine where
latitude='".$latitude."'";

$result = mysql_query($query_forth);
while($row=mysql_fetch_array($result))
{
    $max_sunshine = $row[$date];   //get maximum sunshine
from max_sunshine table
}

$query_fivth = "select value from crops where
id='".$crops."'";

$result = mysql_query($query_fivth);
while($row=mysql_fetch_array($result))
{
    $crops = $row['value'];  //get value station from crops
table
}
$avgtmp="";
```

```
$avgtmp = ($min_temp+$max_temp)/2;
echo "<br>Average temperature is ".$avgtmp;

$avgtmpp = number_format($avgtmp , 2);
echo "<br>Average temperature is ".$avgtmpp;
$ed = ($Saturation_vapour_pressure *$max_rh)/100;
echo "<br>ed is ".round($ed, 1);
$rs = (0.25 + 0.5 * $sunshine_ratio)* $radiation ;
echo "<br>Rs is ".$rs;
$rnl     =($effect_temperature     *     $effect_vapour     *
$effect_sunshine);
echo "<br> Rnl is ".$rnl;
$rn=(0.75 * $rs ) - $rnl;
echo "<br> Rn is ".$rn;
$fu = (0.27 * (1+ $wind/100));
echo "<br> Function of wind is ".$fu;

$ans              =              ($Weightage_factor*$rn)+(1-
$Weightage_factor)*$fu*($Saturation_vapour_pressure-$ed);
echo "<br> References crop evapotransipiration is  ".round
($ans , 2)." mm per day";

$actual_et = ($ans * $crops);
echo  "<br>  Actual  crop  evapotransipiration  is   ".round
($actual_et , 2)." mm per day";

mysql_close();
?>
```

3.4 Testing

Software testing is performed to verify that the completed software package functions according to the expectations defined by the requirements/specifications. The overall objective to not to find every software bug that exists, but to uncover situations that could negatively impact the customer, usability and/or maintainability.
In general, these properties indicate the extent to which the component or system under test:

- Meets the requirements that guided its design and development
- Responds correctly to all kinds of inputs
- Performs its functions within an acceptable time
- Sufficiently usable

Types of Testing

- Unit testing
- Integrated testing
- Validation testing
- Output testing
- User acceptance testing
- Unit testing

4 Conclusion

Along the various stages of this project, whatever work done, was checked along with the client requirements to make sure that those requirements have been addressed during those phases. This constant checking with the requirements made sure that the developed system met the goals and objectives that were devised at the beginning of the project. By reviewing the functional and non-functional requirements that were discovered during the analysis phase and checking back with the functionalities implemented in the developed system, it can be said that all the requirements of the user have been satisfied. The simple and intuitive user interface that was designed and developed was easy to learn and use proved to be satisfactory for the user. Furthermore working on the project helped to improve technical skills as well as intellectual skills by collaborating with many individuals from collective fields. The system could in the future be connected to all Agrarian Service Centres with additional functional and non-functional requirements. In future application can be sent online with agricultural people, this will be more effective and efficient method for getting good agricultural productivity to farmers.

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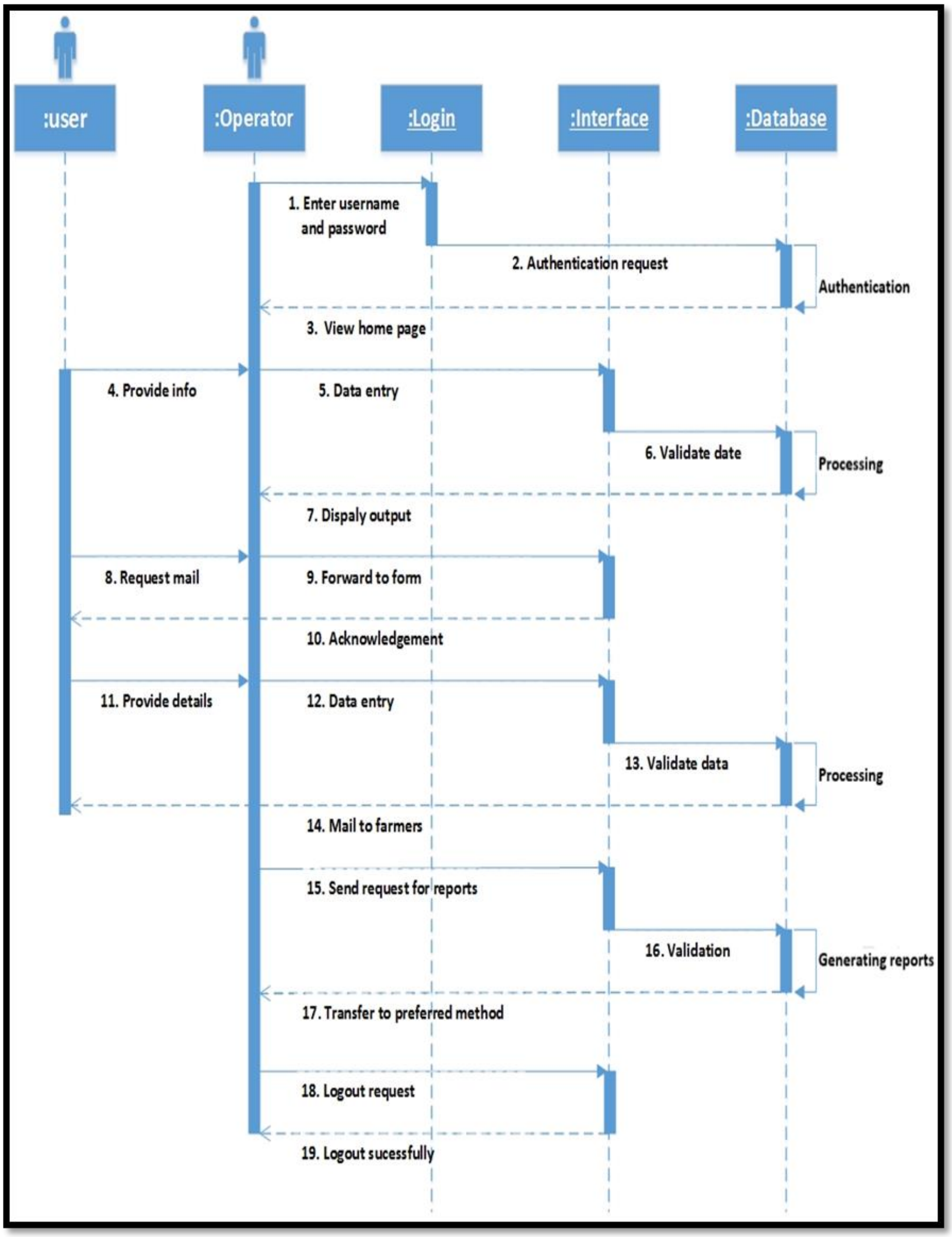
Appendix

A. Sequence Diagrams

System function



B. Activity diagram

Operator and user interaction activities