

# Desktop and Mobile Applications to Calculate Water Balance

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**Abstract**— The calculation of the water balance is important to determine water availability in the soil and assist in the production of certain cultures. The aim of this work is to present the development of an application for desktop and mobile devices being this last with Android. The application calculates the water balance to perennial crops for all Brazilian regions, however can be easily adapted to other cultures. The data used are from a 30-year period (1981-2010). The application was developed using the programming language Java.

**Index Terms**— Water balance, Android, Java.

## I. INTRODUCTION

The water balance represents a way to monitor the water availability in the soil. The calculation depends of some factors, just like, Precipitation and Potential Evapotranspiration (PET).

To calculate the water balance is first necessary to determine the Potential Evapotranspiration that was calculated through the methodology proposed by Thornthwaite. The evapotranspiration is defined as “The simultaneous process of water transference to the atmosphere through the evaporation of water in the soil and the transpiration of moist vegetation by plant transpiration [1].

To calculate water balance, it's required to consider the available water capacity (AWC). The AWC values are assigned by the culture. In the application are used values between 100 and 125mm, default values to perennial cultures. The process of calculating manually takes a lot of work. To solve this problem, was created a software with the purpose of automate the process. Thinking of that, and allied with the frequency of computational devices (like personal computers and smartphones), the application could be more useful.

First was developed a desktop platform, using the data from Pelotas, in Rio Grande do Sul.

The idea of developing a mobile application is given due the great rising of the platform in Brazil. Just in 2015, more than 93 million of people have access to a smartphone [2], registering an enormous rising in the app market.

The chosen language for the development was Java, because it is the language for Android development, also, due of its portability from systems. In this way, the same code can be applied to both operations without changing.

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## II. MATERIALS AND METHODS

For calculate the water balance is necessary take a consideration, the precipitation and potential evapotranspiration (PET). The evapotranspiration was calculated by methodology proposed by Thornthwaite:

$$PET = 16 * \left( \frac{10 * T_n}{I} \right)^a \quad 0 \leq T_n < 26,5^\circ C$$

or

$$PET = -415,85 + 32,24 * T_n - 0,43 * T_n^2 \quad T_n \geq 26,5^\circ C$$

After obtain the values of precipitation and potential evapotranspiration, is calculated difference between the two, keeping signal to values negative, the value of difference (P - PET). After that is calculated the accumulated deficit (ADEFIC) and the water storage (WS), which must be calculated simultaneously. While ADEFIC is negative, accumulates the value of previous month of ADEFIC with value of (P - PET) of current month, the ADEFIC will be equal to P - PET when appears a negative value after a sequence of values positive.

$$WS = AWC e^{\frac{ADEFIC}{AWC}}$$

When have P - PET positive, sum the value with WS of previous month for obtain the value of current month, the value of WS can't exceed value of AWC.

$$ADEFIC = AWC \ln \left[ \frac{WS}{AWC} \right]$$

After is necessary to calculate the alteration (ALT) which is the difference of WS between the previous month and the current month.

Next, is calculated the real evapotranspiration, which is the real value of water evaporates.

$$RET = PET, P - PET \geq 0$$

or

$$RET = P + |ALT|, ALT \leq 0$$

Finally, is calculate the deficit (DEFIC) and excess (EXC) soil water.

$$\begin{aligned} DEFIC &= PET - RET \\ EXC &= 0, WS < AWC \\ EXC &= (P - PET) - ALT, WS = AWC \end{aligned}$$

## III. JAVA PROGRAMMING LANGUAGE

In the development this work was used Java programming language, due to its portability, that is possibility to develop for various platforms, provides large number of frameworks that aim facilitate the work of developers, and a community of developers where find a vast amount of material and numerous forums to exchange information. Java is

everywhere, laptops, datacenters, console, supercomputers scientific, cellphones and Internet [3]. For accomplish the calculations, was used the data type *BigDecimal* instead of the primitive double. The control *BigDecimal* does not use point floating, and thus safer for calculations compared to double, and also with an increased precision calculated.

To display the results it was used JFreeChart framework it that provides a series of graphics options, which facilitate user understanding about behavior of the data used in application.

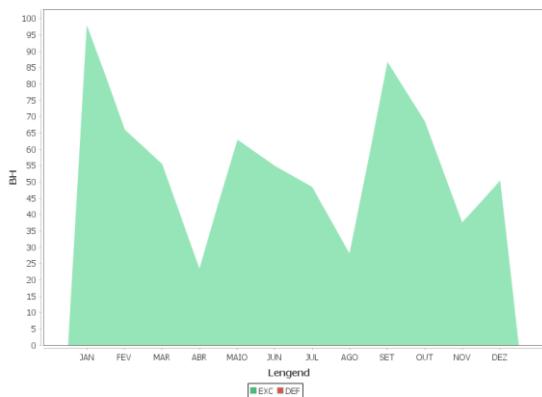


Figure 1 - Graph using JFreeChart

Figure 2 shows the diagram showing where JFreeChart is within the application. The client program receives user data and then, use standard Java and JFreeChart APIs based on requirements to generate output in the form of either a frame, which can be displayed directly inside the application or independently in the image formats such as JPEG or PNG[4].

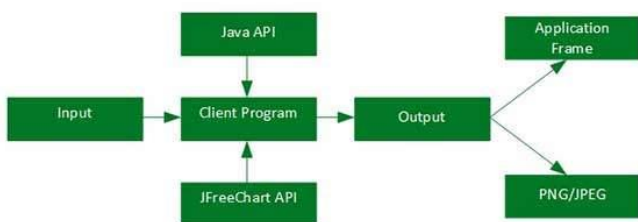


Figure 2 - JFreeChart Architecture

In mobile version was used GraphView library. Is a library for Android to programmatically create flexible and nice-looking diagrams [5]. As with JFreeChart, it can create various types charts, can meet the needs more specific.

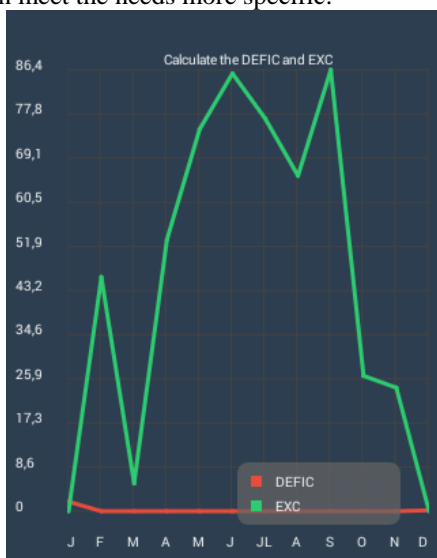


Figure 3 - Graph using GraphView

As software intends to be free, all libraries used are free.

To develop the application was using the MVC pattern of development (*Model-View-Controller*) pattern application is divided in three layers, the Model is responsible the business logic, the View is responsible for the applications screens, It is where the user can interact with the application, and finally Controller is responsible for taking events for screen (View) and turn into action. In figure 4 can be seen as MVC works, used in the application.

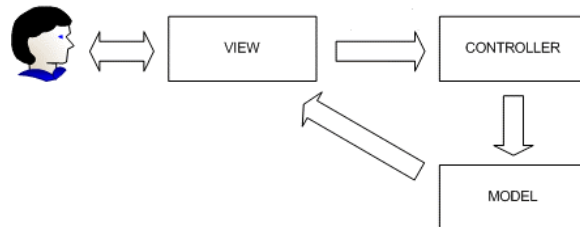


Figure 4 - Events flow and information in an MVC architecture

The advantage of using the MVC was portability like this and possible develop an application for different platforms without the need to change the business logic.

#### IV. DATABASE WITH MYSQL AND SQLITE

The database used for the desktop version is the MySQL. One of the most popular databases, with high performance and can be used for a lot of applications [6] and can be totally free for non-commercial Softwares.

First was elaborated a logical project of the database to define its structure, i.e.,the relation of tables and its respective objects, and its attributes. To create the diagram was used MySQL Workbench. In the figure 5 is the diagram of the application.

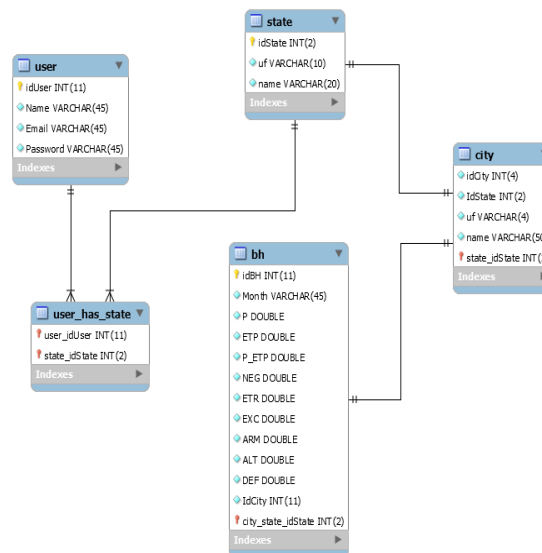


Figure 5 - Logic Project

The mobile version uses SQLite, an Android database library. Just like MySQL, it is free, but can be applied in commercial developments without having to pay for it. The SQLite code is a free domain, i.e., It's free for any purpose, being commercial purpose or private purpose [7]. It is the most used database for Android, being the native android database, this is, build to work directly in the platform. The biggest advantage of SQLite is the needlessness of a DBMS to run the database, making easier to use the library.

V. DESKTOP

The desktop and android applications can be seeing with more details on the figures below, with the intent to visualize the application, and the graphics. The section 3.1 presents the windows for the desktop version, and the section 3.2 presents the android version.

The figure 6, presents the login screen, it is the first screen. In this screen it is possible to register a new user. This way, if the user don't have an account, it's possible to register, making easier for new users.

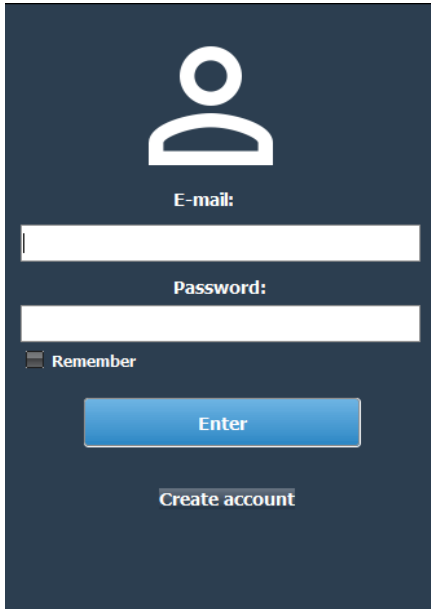


Figure 6 - Login Screen

In the register screen (figure 7), it is possible to register user, informing name, e-mail, password. Those are the requirements to control the application, mainly the email, if the user request receiving the graphics through email. This way, providing the best experience to the user.

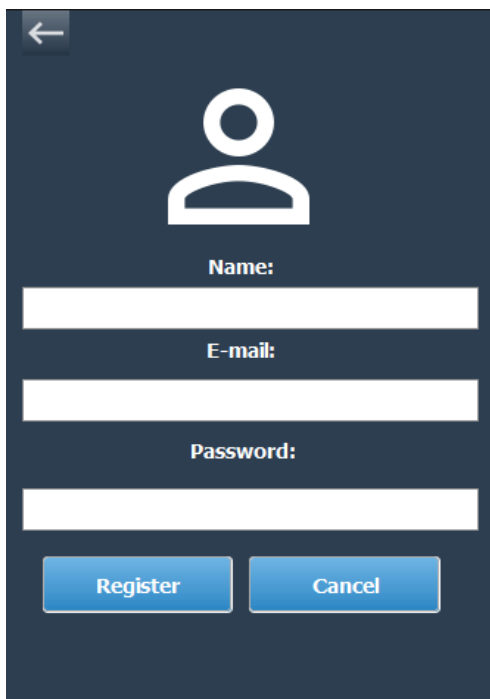


Figure 7 - User registration

In the figure 8, it is presented the main screen, it is the most important screen, mainly because of its functionality. It can show the graphics and also save in PNG, print or send through email.

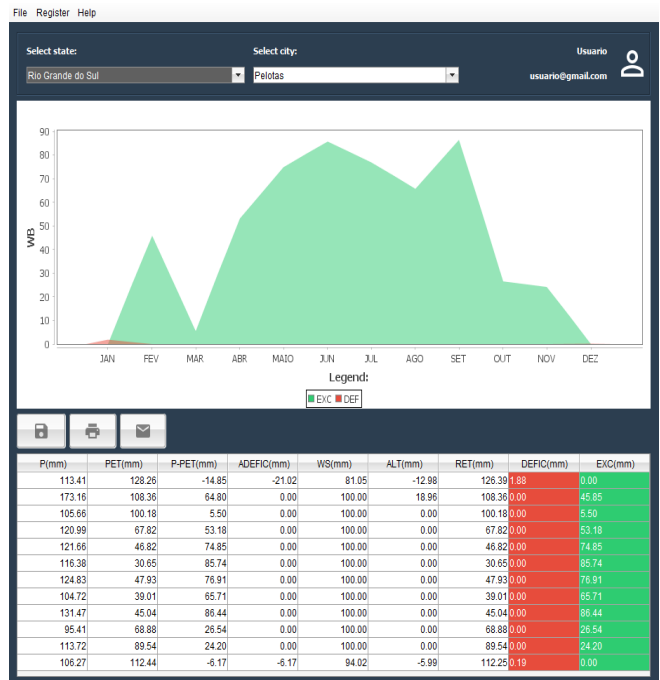


Figure 8 - Main Screen

Notice that in the bottom part of the screen it's the table that contains all the values previously calculated, in case the user need these values for admeasurement of results. In the graphic it is only displayed values of deficit and excess.

In the figure 9, the send of an email is performed. In the bottom part of the graphic, it is possible to see the progress bar, that indicates the send state. When the send is finished, pops up a notification, indicating that the sending was finished successfully.

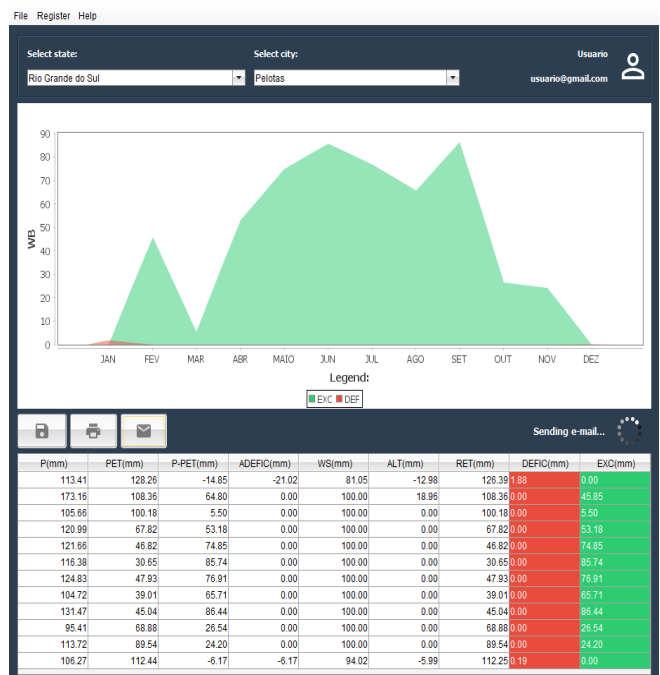


Figure 9 - Sending E-mail

Before to send the email, the user will be notified just like is presented in the figure 10, the screen confirms the email that is desired to receive the graphic.

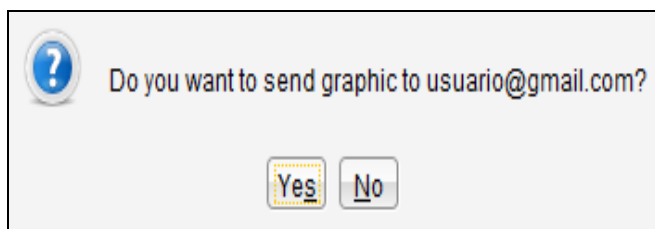


Figure 10 - E-mail confirmation

If the user do not want to receive the graphic in your email account, it is possible to send to any email that is desired. This option can be seen in the figure 11.

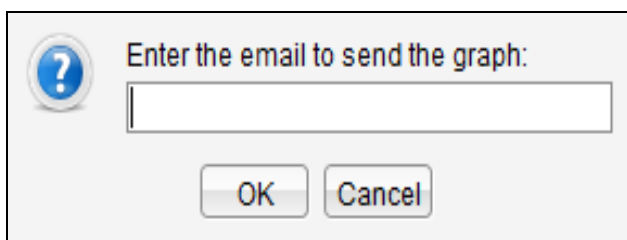


Figure 11 - Insert new e-mail

The application also allows to print the graphic directly, without having to save the image previously. The figure 12 shows the print configuration. It is possible to print through the button in the bottom of the screen, or clicking it with the right mouse button.

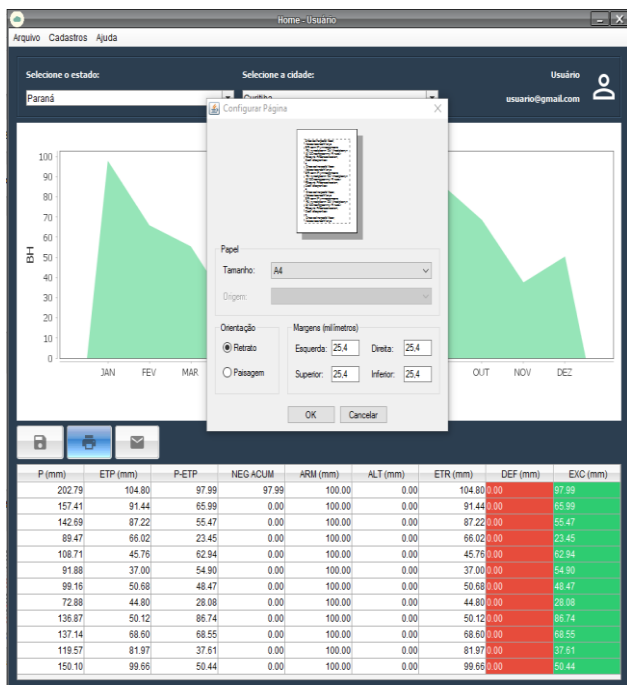


Figure 12 - Print graph

The figure 13 shows the option to save the graphic, the allowed format to save is PNG. Just like to print, it can be done through clicking in the bottom icon or clicking with the right button of the mouse.

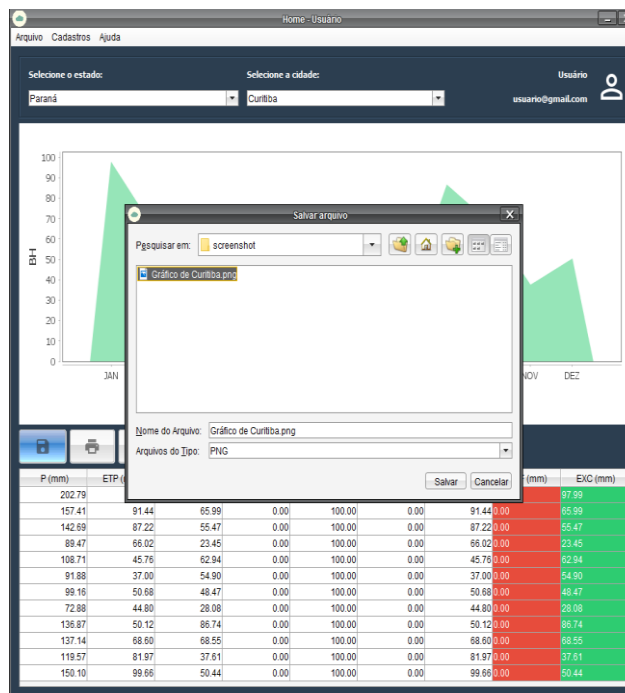


Figure 13 - Save graph

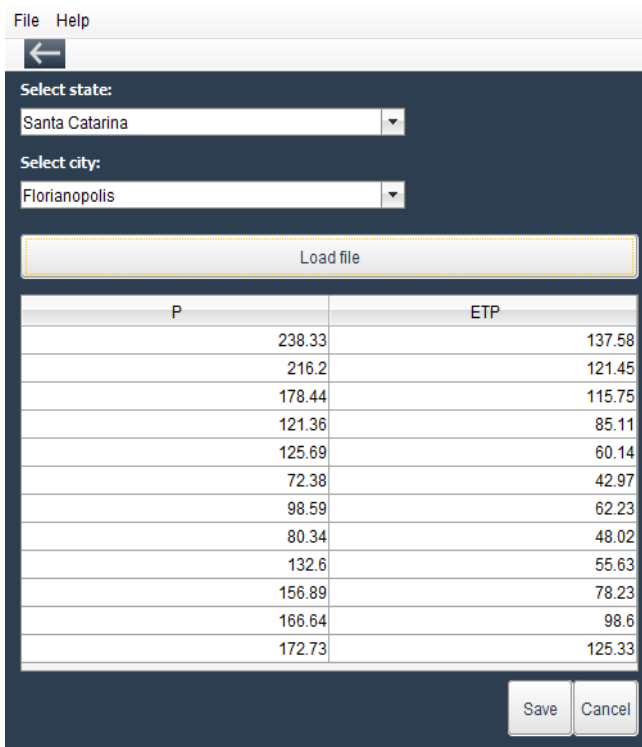


Figure 14 - City registration

The figure 14 shows how the cities are registered. In the figure, was registered the city of Florianópolis. To realize the register, first the user needs to select the desired city to register. In the application, is only allowed to register Brazilian cities. After the city selection, the user must to load a file with all values of precipitation and potential evapotranspiration. To load the file into the application, it's necessary xls/x format (default format for Microsoft Excel).

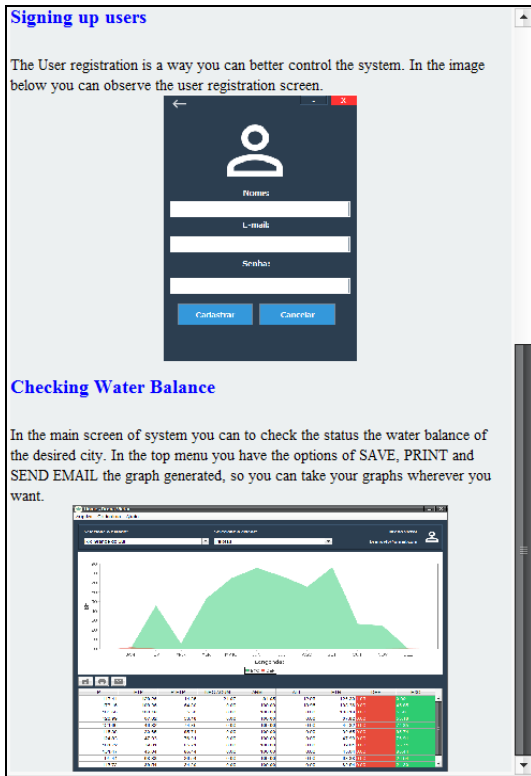


Figure 15 - Help screen

The figure 15 shows the help screen. This helps the user to use the application. In this screen, it is described how works the user register, city register and the main screen.

#### VI. ANDROID

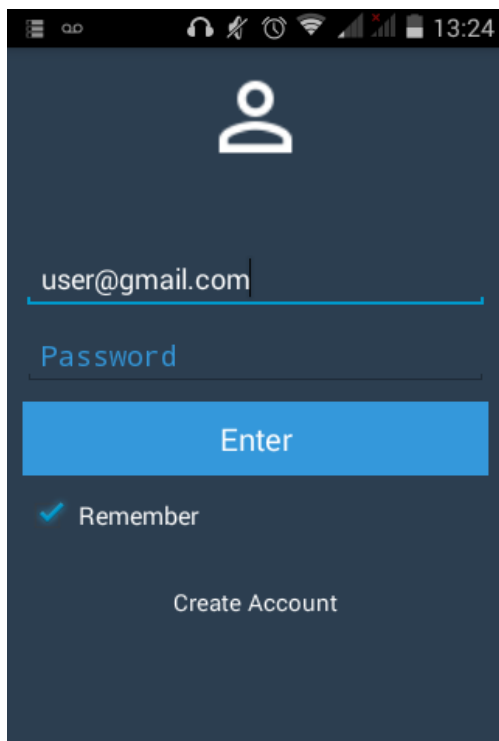


Figure 16 - Login screen

Figure 16 shows the login screen, where the user can access the application. In the screen bottom the user can make the register, case does not have an account.

Figure 17 shows the user registration screen, for a new

registration is necessary provide name, email and password. The data for the registration are the same as described earlier in the desktop version.

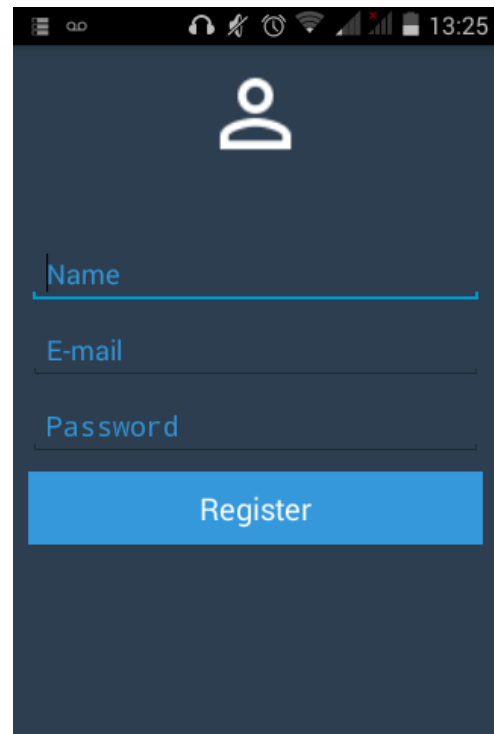


Figure 17 - User registration

Figure 18 shows the main screen application, which shows the graph. Initially the user selects the state and city, which want to make the query and then can view the chart.

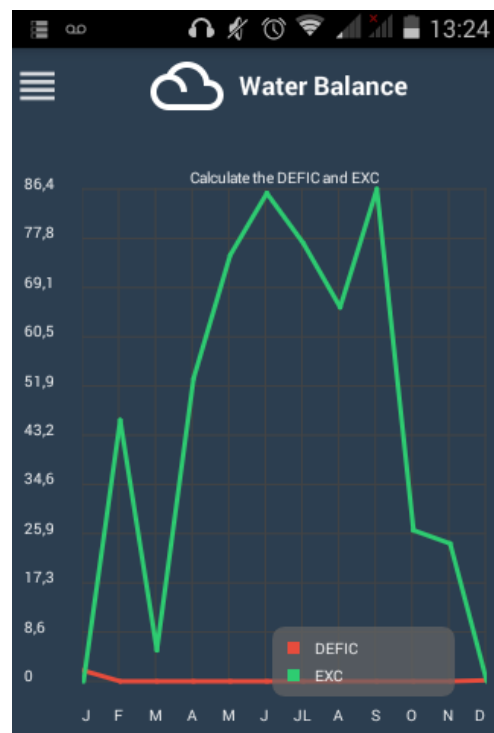


Figure 18 - Main screen

Figure 19 shows the menu options. It is also possible consult user profile, view information about the application and exit.

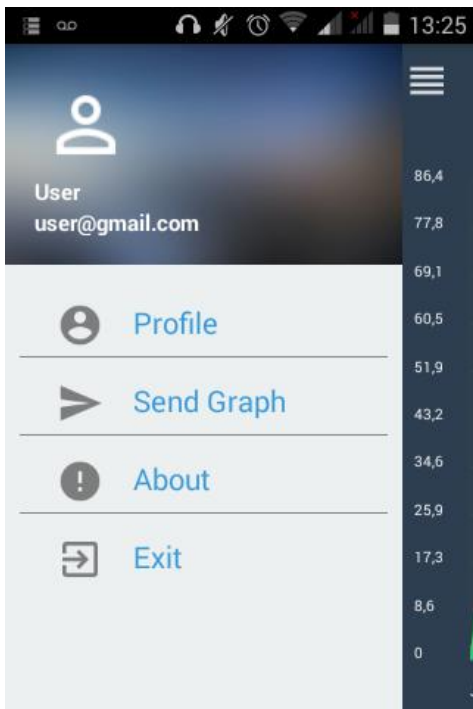


Figure 19 - Menu options

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## VII. CONCLUSION

The present paper shows the development of an application, available in Desktop and Mobile (Android) versions, which calculates the water balance by method proposed by Thornthwaite.

This application aims to optimize the process involved for the calculation of water balance.

The development of two versions of application is justified by for practicality and mobility, because the user can use it on devices with Android operating system, but not limited to a computer or laptop.

The technologies used in the development of these applications are free.

The application, in both versions, offers many features to user, allowing the insertion of new data to other cities in Brazil. The data needs to be in a spreadsheet Microsoft Excel (xlsx) for the application can load and then perform all the calculations needed. The users, can also print results, send by email or even save in image format (png).

As future work we intend to develop an application for Web, which will calculate the water balance using the Potential Evapotranspiration calculated by Thornthwaite, Priestley-Taylor and Penman-Monteith methods.

After developing the application for these three methods, a job to be explored is to achieve a climate classification.

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