# WATER FOOTPRINT SIMULATION AND ANALYSIS FOR FOOD CONSUMPTION IN KRUENG ACEH WATERSHED

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**Abstract**

The concept of water footprint is total volume of water required by an individual or community to produce goods or services. One of the watersheds that play an important role in Aceh Province is the Krueng Aceh watershed. This watershed flows into two administrative areas, namely Aceh Besar District and Banda Aceh City with an area of 174,785.79 Ha. The main purpose of this research is to design software for water footprint simulation of food consumption in the Krueng Aceh watershed using Visual Basic.Net. while the data were taken from the previous studies. The procedures and methods used in this research study are as follows: analysis software requirements, software design, program code generation, and testing with validation. The result of this research is the software for analyzing the water footprintof food consumption in the Krueng Aceh watershed using Visual Basic.Net produces a windows-based program called WFcal. The WFcal is able to calculate the waterfootprint of food consumption in the Krueng Aceh watershed accordance with existing validation data. Based on the test results, the output value of the WF calculation from the WFcal software is same as the output value generated by the reference data. The functions that exist in WFcal can also run properly according to user commands.

**keywords:** *water footprint*, *software*,*simulation, food, agriculture*.
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## 1. INTRODUCTION

Water Footprint (WF) is a concept that was developed in the 2000s by Hoekstra from the University of Twente. According to him, when someone producesa product, they must involve water in it, both in terms of the process and after the product comes outas a result.This is called the water footprint, where we can track the amount of water used by a person or a community in their activities to produce a particular product or service(Chen et al., 2022). The amount of water used is calculated virtually by showing the total water which includes the green water footprint (water from rain), blue water footprint (water from the surface/underground), and gray water footprint (water used to process the waste ofa product).The industry that uses the most water during the process of producing products is the agricultural industry, especially in producing food products, both vegetables, and animals.

For example, 1 kg of wheat requires 1,500 liters of water during the process, while producing 1 kg of beef calculated from water for grass as animal feed until the slaughtering process requires 15,000 liters of water(Moni et al., 2021; Yao et al., 2022). If this situation happens continuouslywith no action in water management, it is possible that there will be a water crisis in about a third of the world's population in the future.

One of the main causes of the water crisis is the inefficient management of water resources, including in watersheds (DAS). Watershed according to government decree number 37-2017, is a land whose territory was limited by a ridge or mountain with functions to accommodate, store and drain water from rainfall to lakes or the sea naturally. In Aceh Province itself, the Krueng Aceh watershed is one of the watersheds that plays a major role for the surrounding community, this watershed flows along two administrative areas, namely the District of Aceh Besar and the City of Banda Aceh. The area of the Krueng Aceh watershed reaches 1,747.86 $km^2$ with 7 sub-watersheds in it(Ardiani et al., 2021).

To determine the value of the water footprint requires complex calculations with determining variables such as the value of *virtual water*on each food product consumed, the amount of annual consumption of people around the Krueng Aceh watershed and the total population in the Krueng Aceh watershed. To solve this problem, we need a software design that can analyze the value of the water footprint for food consumption so that the per capita and total water needs of the watershed community can be known easily by simply entering the necessary variables without having to re-calculate using the water footprint calculation formula(Ma et al., 2022; Zhang et al., 2022).

Softwareis a collection of functions that contain commands and rules that are used so that a computer device can perform tasks according to the wishes of the user, software is also a repetitive system or runs continuously (looping). One of the programming languages that can be used to design software is visual basic.NET.This software is developing applications on Windows-based computers(Chen et al., 2022; Machin Ferrero et al., 2022; Mokhtar et al., 2021). Visual basic.NET is a reengineering of visual basic so that it can be used on platformso that the results of the applications created can run on any computer system and the data retrieved can come from any type of server as long as it is installed in the .NET Framework.



As explained above, the software is needed to analyze the water footprint of food consumption in the Krueng Aceh watershed using the Visual Basic programming language.NET. It is hoped that this device will make it easier to analyze the total water consumption of people around the Krueng Aceh watershed so that it can be considered in water management policies to reduce water use in producing food commodities so that water needs can be controlled properly.

## 2. MATERIALS AND METHODS

Data used in this study are secondary data obtained from our previous research covers all basic requirements for water footprint analysis, including: data on the population of the Krueng Aceh watershed, population data of Aceh Besar Regency and Banda Aceh, food consumption and virtual water dataset.

### 2.1 Simulation requirements analysis

At this stage all processes needed tocomplete and specify software requirements are collected so that the software can later be easily understood according to the command and needs of the user.

### 2.2 Simulation softwaredesign

Software design is a process that has many steps and focuses on the design of software program designs which include data structures, software architecture, *interface*, and coding procedures.

**2.3 Mathematical models**

The design that has been made must be translated into a software program. Making the program code will produce a design that is in accordance with the program. In this study, the actions performed on existing data structure variables can be seen in the equation below(Fu et al., 2022; Sreekumar et al., 2021; Tomaz et al., 2021).

**Water footprint of food consumption per capita**

$$WF_{(p)Kap\,(desa)} = \sum_{i}^{n} KP\,(i)x\,VWP\,(i)$$

$$WF_{(p)Kap\,(kota)} = \sum_{i}^{n} KP\,(i)x\,VWP\,(i)$$

Where:

$WF_{(p)Kap\,(desa)}$ = Water footprint on food product consumption per capita in rural areas in the watershed ($m^3$)

$WF_{(p)Kap\,(kota)}$ = Water footprint on food product consumption per capita in urban areas in the watershed ($m^3$)

$\sum_{i}^{N} KP\,(i)$ =Quantity of product consumption (kg/year)

VWP = Virtual *water* product/virtual water contained in the product consumed (m3/ton)

**Water footprint of food consumption in the Krueng Aceh watershed**

$$WF_{(p)DAS\,(desa)} = \sum_{i}^{n} WF_{(p)Kap}\,x \text{ urban population in the watershed}$$

$$WF_{(p)Kap\,(kota)} = \sum_{i}^{n} WF_{(p)Kap}\,x \text{ villagers population in the watershed}$$

$WF_{(p)DAS\,KA} = WF_{(p)DAS,Kota} + WF_{(p)DAS,desa}$

Where:

$WF_{(p)\mathrm{DAS\,KA}}$ = Water footprint on food product consumption in the Krueng Aceh watershed ($m^3$)

$WF_{Kap(kota/desa)DAS\ KA}$ = Water footprint on product consumption per capita in rural or urban areas in the watershed ($m^3$)

**2.4 Software testing**

Testing of the program is carried out by entering various types of combinations of data. In this case, data from previous studies are used. When the value of the test results is the same as the analysis value obtained, then the software has been successfully run. Tests are also carried out on various computer models to try whether the program will run properly or not.

**3. RESULTS AND DISCUSSION**



The Krueng Aceh watershed is span two administrative areas, namely Banda Aceh City and Aceh Besar District, this watershed is the main water source for the community around the Krueng Aceh watershed to meet their needs. daily water, both domestic and industrial and agriculture, the large of Krueng Aceh watershed is 174,785.79 Ha with 7 sub-watersheds, namely the Krueng Aceh Hilir sub-watershed, the Krueng Jreue sub-watershed, the Keumireu sub-watershed, the Krueng Inong sub-watershed, the Seulimum sub-watershed, and the Seulimum sub-watershed. Krueng Khea and Krueng Aneuk Sub-watershed.

*Water Footprint* of food consumption in the Krueng Aceh Watershed is an illustration of the total water consumption needed by the community around the watershed to produce a food product. The water footprint is calculated and determined based on two variables, namely the number of residents in the Krueng Aceh watershed and the food consumption pattern that is consumed by the watershed population. Validation and data for software design in this study refer to previous research. The validation data for the software are 32 food commodities which are the consumption patterns of the people in the Krueng Aceh watershed area. The 32 food commodities are divided into 25 vegetable food commodities and 6 animal food commodities.

General requirements of the system that will run are as follows: able to calculate the value of the water footprint food consumption in the Krueng Aceh watershed for Banda Aceh and Aceh Besar

and the water footprint of total food consumption in the Krueng Aceh Watershed, able to display existing data based on previous research or those that are intended to be made, able to enter new data that will be input by the user or user, and designed software was capable in storing new data that has been inputted by the user or *user.*

WFcal stands for Water Footprint Calculator is software created using *Visual Basic*.Net. designed to be able to calculate water footprint of food consumption in the Krueng Aceh watershed. WFcal requires some input data from the user to process the output or results that will be issued such as the number of people in the watershed, the amount of food consumption both vegetable and animal which is the consumption pattern of the community in the watershed.The difference between WFcal and another water footprintcalculation software is WFcal calculates all the total food consumption water needs of the community around the watershed using a water footprint, while other software only calculates water requirements per individual or individual. Tools of this type of individual calculation can be found on sites on the internet with free access.

The designs made on WFcal have 14 Forms in which they are also composed of several components such as Label boxes, Buttons, Text boxes, Panels, Group boxes, Tool Tips, and other components as presented in Figure 1 to 9. The data sourcefor each grid view table in each of these forms is displayed by connecting the previously created database using *Ms. Access* 2010 to *Visual Basic*.Net. Furthermore, these forms are connected one by one to other forms so that they can become a single unit that will be connected with coding later. The user interfaceon WFcal can be seen in the following image.




Figure 1. The interface ofWFcal

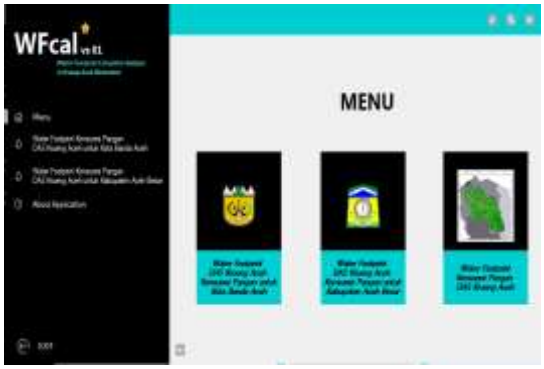


Figure 2. interfaceMenuWFcal

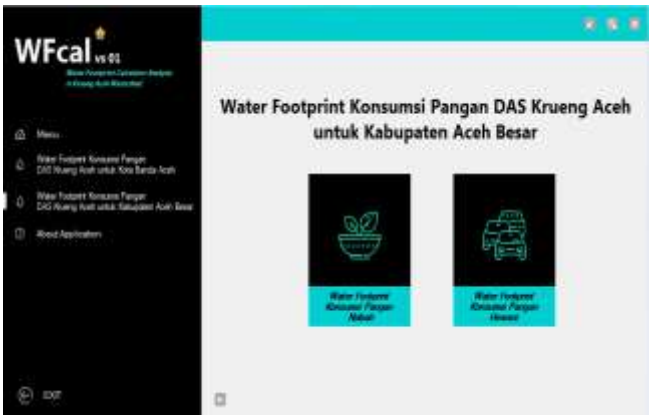


Figure 3. WFcalsub-menu interface for Banda Aceh

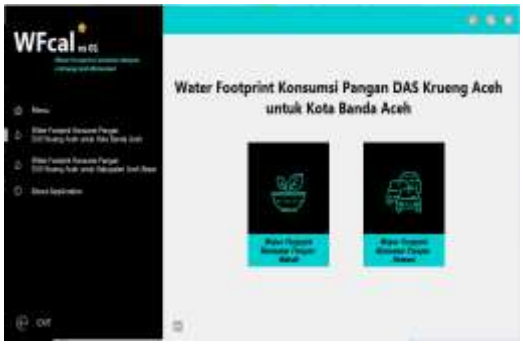


Figure 4. WFcalsub-menu interface for Aceh Besar

Figure 5. Interfacefor calculating WF food consumption (vegetable) in the KA watershed for Banda Acehz

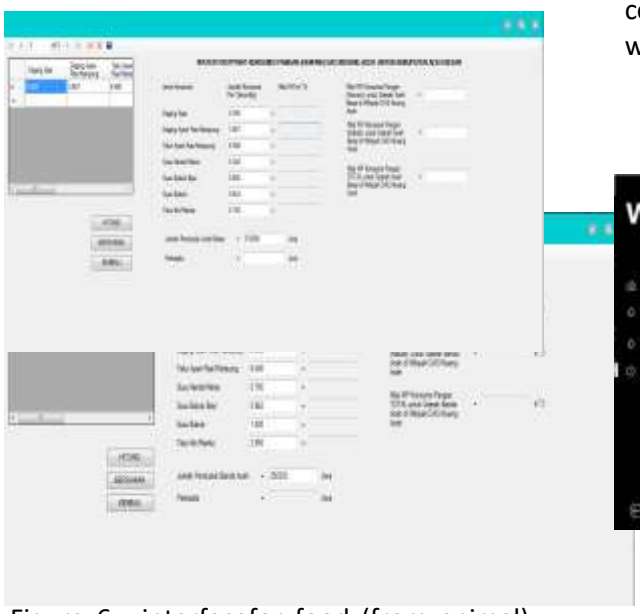

Figure 6. interfacefor food (from animal) consumption in the railway watershed for Banda Aceh

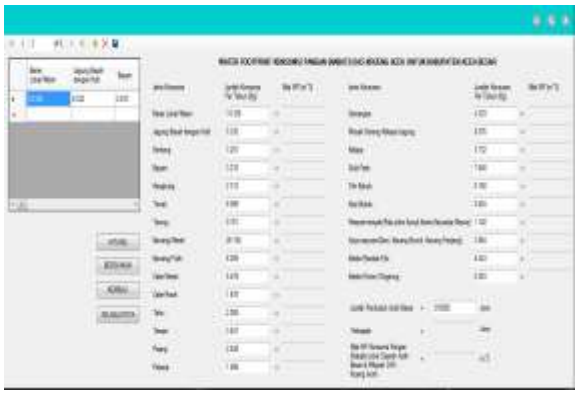

Figure 7. Interface for calculating WF for food consumption (vegetable) for DAS KA for Aceh Besar

FIgure 8. Interface for calculating WF food consumption (from animal) in the KA watershed for



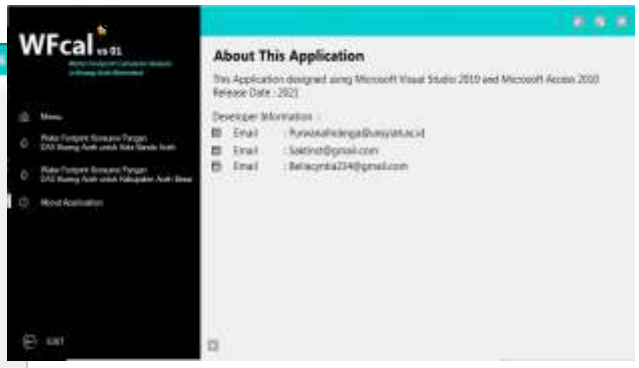


Figure 9. IinterfaceinformationWFcal

The data that was used for WFcal test was taken from previous research data, according to a published dissertation by author. The comparison of the output values of previous studies with the WFcal software can be seen in Table 1 below.

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able 1. Comparison of the output in WF simulation results using WFcal with the results of previous studies.

| Parameter Output | Results of Simulation | Previous Research |
|---|---|---|
| population of DAS KA (people) | 401 | 401 |
| WF urban food consumption ($m^3$) | 971 958.42 | 971 958.42 |
| WF of village food consumption ($m^3$) | 691 172,626 | 691 172,626 |
| WF of food consumption of watershed KA ($m^3$) | 1 663 130,78 | 1 663 130,78 |

From Table 1 it can be seen that the results of the WF calculation in the village area which is a district of Aceh Besar and the city area which is Banda Aceh. The results of the calculations on the WFcal are same as the results of previous studies.From the calculation results, it can be concluded that the tested WFcal is able to calculate WF for food consumption in the KA watershed according to the command and produces the desired output.

## 4. CONCLUSION

Based on the results of research that has been carried out, it can be concluded that the software for simulation and analyzing waterfootprint of food consumption in the Krueng Aceh watershed using *Visual Basic*.Net produces a windows-based program called WFcal. It can be used and able to calculate the waterfootprint of food consumption in Krueng Aceh watershed.The data from WFcal shows that the values generated manually by entering the water footprint equationin the previous study are same as the results issued in WFcal.

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