Water Use Efficiency Manual for Urban Food Gardens

By Dr Georgia Csortan
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A "how to guide" to help people apply the water use efficiency equations developed by the *Edible Gardens project*.

Edible Gardens

The Edible Gardens Project was a citizen science project developed to investigate the productivity, resource efficiency and social value of urban food gardens in South Australia. The project successfully gathered a comprehensive dataset (now publicly available) on the inputs (time, costs and water use) and outputs (yield, retail value and nutritional content) on a diverse range of urban food gardens.

Water use was found to be the most overlooked and understudied aspect of urban food production. Part of this research developed 4 new ways to calculate the water use efficiency of food gardens, 3 of which are explained below.

What is water use efficiency?

The aim with water use efficiency ("WUE" for short), is to reduce your water use as much as possible, while keeping your yields the same or better. Instead of only considering "productivity" this is a more sustainable way to also consider the land and water requirements of our urban food production.

Water use efficiency is a measure of how efficiently a production system (like a garden area), turns water (rainfall and irrigation) into a harvestable yield.

Our 3 water use efficiency equations

These equations are based on measurements of a set area (m^2) over a set period of time.

1. Gross water use efficiency
(total yield to total water use)

(can look like)
2.5 kg / 1 kL

Gross WUE is the simplest measure to tell you how much food you produced per 1 kL of water.

2. Nutritional water use efficiency
(total nutritional content of the yield to total water use)

(can look like)
4,247 kJ / 1 kL

Nutritional WUE is useful to find out whether you are growing enough nutritionally dense foods to help feed yourself and your family.

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3. **Financial water use efficiency**
(total financial value of the yield to total water use)

(can look like)
$38.16 / 1 kL

Financial WUE helps you calculate how much money you are potentially saving compared to your water use (and water costs!).

What measurements do you need?

For all the WUE equations you will need to think about:

Area under production (m²) - you need to know the size of the garden area (or each of the areas) you are interested in studying.

Total crop yield (kg) – for the same area/s. Even if you have recorded all your individual crops, for Gross WUE you want to add them all together for a set time period.

Total water (kL) – Total water is made up of all the irrigation (kL) over your set period, combined with all the rainfall (kL) over the same time.

For the Nutritional WUE equation you will also need to calculate the **nutritional content** (this can be basic energy in kilojoules, or even grams of protein) of the yield for your set garden area. You can do this using the Australian Food Composition Database to look up each of your crops or animal products like chicken eggs.

And for the Financial WUE you will need to estimate the **retail value** of the different food crops. You can do this by looking up the prices online from a major supermarket, or by noting prices at your local store. Pricewise it is best to use to most realistic comparison – what you would pay if you had not grown the food yourself.

How to measure your irrigation

You can measure your garden's water use in a few different ways. It can depend on how many garden areas you want to measure (if you want to compare different areas) and how those areas are watered (your water sources and irrigation methods).

You can use a water meter, for example:

Digital water meters

PROS: small, cheap, click on to taps and hose ends easily, easy to read and move.

CONS: battery-powered, only 90% accurate, measure up to 999L and then need resetting, does not work for low-flow or low-pressure systems (e.g. rainwater tanks).

"Positive displacement" water meter

PROS: very accurate, continuous measurement, no power needed, works for low-flow and low-pressure systems (e.g. rainwater tanks), last a long time.

CONS: more expensive, not as easy to read or move, can be bulky.

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For small areas, you can keep track of how many standard watering cans you use. Other ways to measure your water use is by "calibrating" or testing your water sources or irrigation system/s:

Use the "Timed bucket test"

Useful to find out the flow rate of a water source (like a tap or a hose).

1. Get a timer and bucket (or watering can) with litre measurements on it.
2. Time how many **seconds** it takes to fill the bucket.
3. 10 minutes equals 600 seconds. So divide 600 by however many seconds it took to fill your bucket. For example, 600÷26=23.1.
4. Then multiply that answer by the size of your bucket (usually 9 L). For example, 23.1x9=207.9. 207.9 is how many litres flows from my water source in 10 minutes.
5. Now you can simply keep track of how long you water for and use your flow rate to calculate your water use.

*This test can be used for rainwater tanks without a pump but will need redoing when the water level in the tank drops or rises by more than 1/3.

Use the "Timed whole system test"

If you have an irrigation system which waters separate areas in your garden, you can use this test to calibrate each area.

1. Turn off everything that uses water in your house and garden.
2. Locate your house-block water meter.
3. Write down all eight numbers shown on the water meter (the white numbers on the left are kilolitres (kL), and the first three red numbers on the right are litres (L), while the last number is 0.1 litres). For example: 5229,734.9
4. Pick one of your garden areas and turn on that part of the irrigation line. Leave running for 15 minutes.
5. Turn the irrigation off. Go write down all 8 numbers now shown on your water meter.
6. Subtract your original meter reading from your current meter reading. This will tell you how many litres per 15 minutes that irrigation line dispenses.
7. Repeat for each irrigation line you wish to measure.

BEFORE watering

AFTER watering

= 17 litres / per 15 mins

**Did you know? 1 kilolitre (kL) = 1000 litres (L)*

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How to measure your rainfall

There are a couple of different ways to measure rainfall falling on your food garden. The first is to setup your own rain gauge in your garden. This will give you the most accurate information, but it does require you to check it frequently (see the Bureau of Meteorology website (BOM) for more info).

Another way is to lookup local rainfall data from the Bureau of Meteorology. Use their "Climate Data Online" system to locate your nearest weather station and access the rainfall data. You can download the data as a PDF or as an excel spreadsheet to use for your own files.

** Did you know? 1mm of rainfall = 1L of water per square metre*

To apply the rainfall data to an area of your garden, multiply the rainfall (mm) of that month (or that year) by the size of the garden area you are studying. For example, a garden bed of 36m² in Highgate SA, received 52mm of rainfall over January. 36 x 52 = 1,872 L of rainfall.

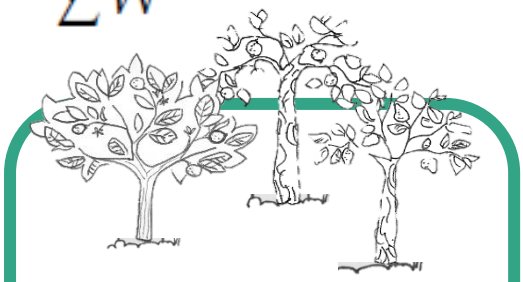
Worked examples of the WUE equations

All the data used in this section is garden data from the Edible Gardens Project. Below Gross WUE has been calculated for a vegetable patch and for a patch of fruit trees.

$$WUE_{gross} = \frac{\sum Y}{\sum W}$$

Area: 4m² Time period: 60 days
Total yield (*Y*): 18.9 kg
Total irrigation: 5.84 kL
Total rainfall: 0.2 kL (49.6 mm)
Total water (*W*): 6.04 kL

$$\frac{(Y)\ 18.9}{(W)\ 6.04} = 3.13\ \text{kg /kL}$$



Area: 10m² Time period: 242 days
Total yield (*Y*): 15.6 kg
Total irrigation: 0.6 kL
Total rainfall: 1.41 kL (140.9mm)
Total water (*W*): 2.04 kL

$$\frac{(Y)\ 15.6}{(W)\ 2.04} = 7.65\ \text{kg /kL}$$

The patch of fruit trees produced a greater yield for less water

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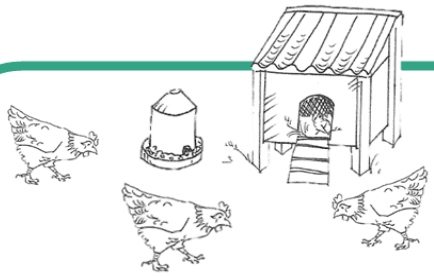
Next, Nutritional WUE has been calculated for a chicken run and the same patch of fruit trees. Note that as rainfall does not directly water chickens, it has not been included in their calculation.

$$WUE_{nut} = \frac{\sum(Y_k N_k)}{W}$$



Area: 18m² Time period: 59 days
Total yield (Y_k): 1.4 kg
Total nutrition (N_k): 7,354 kJ of energy
Total irrigation: 0.2 kL Total rainfall: 0 kL
Total water (W): 0.2 kL

Area: 10m² Time period: 242 days
Total yield (Y): 15.6 kg
Total nutrition (N_k): 17,119 kJ of energy
Total irrigation: 0.6 kL
Total rainfall: 1.41 kL (140.9mm)
Total water (W): 2.04 kL

$$\frac{(Y_k N_k)\ 7{,}354}{(W)\ 0.2} = 36{,}770\ \text{kJ /kL} \qquad \frac{(Y_k N_k)\ 17{,}119}{(W)\ 2.04} = 8{,}400\ \text{kJ /kL}$$

And finally, Financial WUE has been calculated for the vegetable patch and a raised garden bed.

$$WUE_{fin} = \frac{\sum(Y_k F_k)}{W}$$

Area: 4m² Time period: 60 days
Total yield (Y_k): 18.9 kg
Total retail value (F_k): $342.32
Total irrigation: 5.84 kL
Total rainfall: 0.2 kL (49.6 mm)
Total water (W): 6.04 kL

Area: 35m² Time period: 343 days
Total yield (Y_k): 51.0 kg
Total retail value (F_k): $689.66
Total irrigation: 23.6 kL
Total rainfall: 17.09 kL (488.3 mm)
Total water (W): 40.7 kL

$$\frac{(Y_k F_k)\ 342.32}{(W)\ 6.04} = \$56.70\ \text{/kL} \qquad \frac{(Y_k F_k)\ 689.66}{(W)\ 40.7} = \$16.94\ \text{/kL}$$

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