Yuwaya Ngarra-li Briefing Paper:

# Sustaining the Walgett Aboriginal Medical Service Community Garden

2022

By Niall Earle

DHARRIWAA ELDERS GROUP
COMMUNITY-LED DEVELOPMENT
UNSW SYDNEY

# Executive summary

Improving food and water security in Walgett has been a long-term priority for the Yuwaya Ngarra-li (YN) partnership between the Dharriwaa Elders Group and UNSW. Since 2019, UNSW staff and students including from the Impact Engineering program have been involved in the rejuvenation of the Walgett Aboriginal Medical Service (WAMS) community garden, which had been badly affected by drought and water restrictions.

Building and sustaining a thriving community garden requires substantial planning, decision-making, management, and day-to-day activities. With all of this the WAMS community garden is on its way to becoming a space for cultivating connections, building skills, and producing fresh and healthy food.

The focus placed by the YN partnership on the WAMS community garden has produced tangible results. From early iterations of wicking beds to the current 50-bed layout, it has drawn on the skills and expertise of stakeholders in Walgett and at UNSW. A community led approach has been crucial to shaping the progress of the garden, and careful planning and delivery has allowed installation at the scale now seen.

Constant work is required in the WAMS community garden to deal with the cycles of harvesting and planting, and the nutrients and water it takes to sustain these.

This briefing paper includes **best practice methods for data collection**, tailored to the needs of building understandings and expectations when it comes to maintaining the garden. This is ultimately aimed at building a more resilient garden that can withstand the next drought. It also includes **recommendations for new development in the garden which will similarly build towards greater resilience**. This includes composting practices, crop rotations, water collection, and citrus trees.

*This Briefing Paper was commissioned by Yuwaya Ngarra-li and drafted by Niall Earle, with input from Wendy Spencer, Annie Deane, Greg Leslie, Pauline Futeran and Ruth McCausland.*

# Contents

**Executive summary** ..... 2
**Statement of purpose** ..... 4
**Situating the garden – context** ..... 5
Trialling the use of wicking beds in the WAMS community garden ..... 6
Embedding and refining the use of wicking beds ..... 7
Ongoing monitoring and evaluation ..... 9
Timeline ..... 10
**To-date data on water use** ..... 11
**Other data from site** ..... 11
Weather data and evapotranspiration ..... 11
Drought and the need for irrigation solutions ..... 12
Sun and shade ..... 13
**Garden output data and regular data gathering** ..... 14
Garden metrics ..... 14
Water consumption ..... 15
Bed water level ..... 15
Soil (pH, salinity, moisture) ..... 15
Planting data ..... 16
Crop yield ..... 16
Compost (temperature, volume) ..... 16
Data sheets and how to use them ..... 17
Drought-proofing and production targets ..... 18
**Recommendations** ..... 19
Developing a compost system ..... 19
*The importance of compost* ..... 19
*Using compost* ..... 19
*Making a healthy compost* ..... 19
*Landfill waste diversion* ..... 21
Crop rotations ..... 21
*Crop rotation in WAMS community garden* ..... 22
Rainwater tanks and equipment shed ..... 24
*Rainwater tanks* ..... 24
*Equipment shed* ..... 25
Citrus trees ..... 25
*Climate* ..... 25
*Planting* ..... 25
*Tree care, pruning and nutrition* ..... 26
*Varieties suited to Walgett* ..... 26
*Harvesting* ..... 26
Garden upscaling ..... 27
*Garden stakes / trellis* ..... 27

Bees ........ 27
Further avenues ........ 27
**Reflections on lessons learned ........ 28**
Learnings........ 28
*Design choices ........ 28*
*Data collection........ 28*
*Collaborating teams ........ 28*
Garden user reflections........ 29
**References ........ 30**

# Statement of purpose

This briefing paper is intended to document what it takes to build and sustain a thriving community garden. By documenting a history of the rebuilt WAMS community garden and the involvement of various stakeholders, it outlines the elements that culminated in 50 productive wicking beds. It then looks to the future to ask what it takes to sustain and build resilience in the garden so that it can *continue* to thrive. The ultimate aim is to create a welcoming intergenerational learning space that is able to consistently deliver fresh fruit and vegetables to the Walgett community.

Set in the context of building food security, the WAMS community garden is one way resilience can be built through food knowledge and practice. Importantly, a well-functioning community garden becomes much more than a place just to grow food. The literature review included in this briefing paper helps outline the range of health and well-being benefits community gardens offer, as spaces for more than just growing fresh food.

This briefing paper is intended for use by YN, the DEG and WAMS to use, add to, and refine as a framework best suited to the garden's longevity. Additionally, the learnings can be used by other communities, organisations, or funders engaged and interested in the process and effectiveness of the WAMS community garden. The hope is that any of the lessons learnt can be applied elsewhere.

# Situating the garden: context

In response to community concerns about food and water security in Walgett, the Yuwaya Ngarra-li Food Forum was convened in April of 2019. Availability and cost of fresh food were raised as urgent problems, along with opportunities for a holistic approach to improving food security and nutrition. The forum demonstrated absolute clarity of understanding from the community about the connection between fresh food and community health. The need for rejuvenation of the Walgett Aboriginal Medical Service (WAMS) community garden, which had been badly affected by drought and water restrictions, were raised by many participants.

In the context of a long-lasting drought, increasingly hot summers and poor management of the Murray Darling Basin rivers, Walgett was left without river water to sustain "critical human needs" and restrictions were introduced on the use of water for gardens in Walgett. This affected the once productive WAMS community garden. While some community assets had been given special provision so they could be watered during Level Five restrictions, the garden had not, and although Dharriwaa Elders Group and WAMS had lobbied Council and the gardener had tried to keep it going with buckets, the garden died from lack of watering. This was a problem on multiple fronts. First, it meant those WAMS clients with chronic illness were no longer receiving regular boxes of fresh locally grown fruit and vegetables. Second, it weakened food sovereignty, increasing dependency on the local IGA which meant limited availability and affordability of fresh produce. Amongst other negative and compounding impacts (eg the loss of river foods and drinking water), an out-of-action community garden disabled a peaceful, hands-on environment for intergenerational connection and learning.

In response to these community concerns and at the invitation of the DEG, Professor Greg Leslie of the UNSW Global Water Institute explored the possibility of student Impact Engineers becoming involved working with Yuwaya Ngarra-li and WAMS to find a way for the garden to not only be revitalised, but to survive the next drought. Guided by the principle of listening carefully and following community advice, there was potential for the multi-disciplinary skills of Impact Engineers to support the revitalisation of the WAMS community garden.

The Impact Engineering team were welcomed into to the Yuwaya Ngarra-li Partnership with the DEG. The students undertook a comprehensive induction, both on campus with Aboriginal scholars, and on-Country with Elders at the DEG. The aim of these processes was to help the students understand how leadership worked in the collaboration, and to make sure they understood the depth and value of the knowledge already held in Walgett and Yuwaya Ngarra-li's way of working.

# Trialling the use of wicking beds in the WAMS community garden

With the effects of drought in mind and working closely with long-term gardener Sophia Byers and other WAMS staff, the Impact team quickly identified wicking beds as a suitable, well-tested technology. Wicking beds store water in below-soil reservoirs, and through capillary action suck water up and into the soil when needed. The result is that in long periods of no rain and hot summers, water in the topsoil is not as easily evaporated and lost – giving the plants the sustenance they need to survive. Having chosen to explore the viability of wicking beds, the project became a collaborative process as trialling started.

Initially the project sought to re-use the old garden beds. In February 2019 the first iteration of garden beds were installed. Using the pre-existing beds, new soil was put in, and the beds were raised over a layer of scoria. This attempt turned out to be unsuccessful. The leading theory around this failure was that the soil used was the concern, and beds were replicated at UNSW, albeit in Sydney climate conditions, to test this theory. Secondary concerns were how level the ground was, which could lead to run-off and wasted water, and whether the beds were too large. Re-trialling at UNSW was about regaining the confidence wicking beds worked. A partnership was established between UNSW Engineering students and students from the School of the Built Environment and replica wicking beds were made from recycled Intermediate Bulk Containers (known as IBC tanks), again using a layer of scoria to separate the water reservoir from the soil.

Following the early impact doctrine of “minimise innovation”, on reflection the wicking beds were never the ideal solution for the community garden in Walgett. It had been indicated through DEG and WAMS that there were ambitions to scale-up the garden, and so a modular, reliable wicking bed was what was needed. In August 2019, Professor Greg Leslie came across Biofilta wicking beds while attending a conference; as modular one by one metre cube (called Food Cubes) that could be connected in series, they were well-suited to the community garden plans in Walgett. Not long after BioFilta’s wicking beds were identified as an appropriate solution, a cost-benefit analysis was done to compare them to the self-built option. Comparing favourably by most metrics, a few Biofilta wicking beds were ordered in for testing at UNSW.

After a period of testing on campus, it was time to test them in Walgett. In September 2019, the Impact Engineering Team drove up to Walgett again, this time loaded with two pilot Food Cube wicking beds. The garden was levelled (to ensure run-off would not be an issue), and the pilot beds were installed with good quality soil. Hard-copy sheets were also delivered for data logging, to measure things like water level in bed, temperature on watering days. There was relief in November 2019 when these test beds produced results, signalling the end of the trial phase.

## Embedding and refining the use of wicking beds

Once there was good evidence that demonstrated what would work longer-term, WAMS were able to commit staff and resources to developing and sustaining the garden and begin identifying clients who could benefit from receiving produce. In 2020, plans in the community garden became centred around scaling up in line with the additional personnel and identified need in the community. This meant seeking additional funding through the Yuwaya Ngarra-li partnership, the Global Water Institute and the NSW Government[1]. Once secured, the next steps were ordering 50 wicking beds from BioFilta, arranging delivery to Walgett, and working with DEG and WAMS to set them up.

In 2020, after a series of cross faculty meetings Impact Engineers were involved in – the WAMS community garden project became approved to be taught as part of Lucy Marshall's ENGG1000 course. This cemented the value of Impact Engineers as a student-led initiative that could inspire new engineering students to engage with the discipline of humanitarian engineering – using their hard skills in socially beneficial ways. More than this, it represents an encouraging embrace of community-led approaches that engage and work with Indigenous communities to advance their development goals. Successful follow-ups in 2021 and 2022 offer a continuum of refinement and an easy-to-apply channel for students developing an interest in the project.

The big surprise of the year was the outbreak of COVID-19 and adjusting to a new way of operating. This was a dynamic time, where UNSW collaborators had to react quickly so that they could continue to support the embedding of the wicking beds in the community garden remotely. During this stage weekly/fortnightly meetings were held via videoconference and ongoing correspondence between UNSW and Walgett stakeholders helped the project remain collaborative, and allowed a constant feedback loop between what was needed in the garden, and what could be done remotely during the COVID-19 restrictions.

In July 2020, the Impact and UNSW team were able to get together in the UNSW Makerspace for a bed build day. This was an opportunity to get hands on, and document exactly how the wicking beds needed to be constructed once delivered.

The other priority identified during this time was the need for shade structures to encase the wicking beds and protect them from Walgett's climate. Searing summer heat averages maximum temperatures above 30 degrees from November to March, and both demands garden designs that protect against it, while setting boundaries on the materials that can be used in construction.

In light of this, the DEG and WAMS gave feedback on existing shade structures and the impact of wind and heat in the garden. Responding to this, Impact Engineers, with the help of the Maker Space team, developed smaller structures that stood directly above the garden beds, creating cool channels with enough space to move a wheelbarrow through and at a height unaffected by strong wind. This was a

[1] Financial support was provided by DEG, WAMS, private donors to UNSW GWI, Yuwaya Ngarra-li and the NSW Planning Industry and Environment's 2020 "Increasing Resilience to Climate Change Community Grant" project.

process of collaboration between Impact Engineers, DEG/WAMS, and the UNSW faculty, and culminated in a shade construction day in August on the UNSW physics lawn. Here, the UNSW-based team were able to practice the physical construction of the structures. Filming the construction process enabled the development of a demonstration video, representing how meaningful progress could be made during COVID restrictions while also existing as a resource for long-term use. The installation process around both the beds and the tunnels was broken down into a moment by moment practise, so that the process could be supported and communicated remotely.

While this preparation work was happening in Sydney, the garden site was being prepared in Walgett. From June to September the garden was surveyed, levelled, and graded. This was essential for getting the appropriate visual interpretations of the garden and ensuring that the site itself was level enough that there would be no run-off in the beds. In other words, level ground was important for ensuring the wicking worked evenly across beds.

In September 2020, a small UNSW team drove to Walgett to help with the first bed installation. With the appropriate COVID-19 protocols followed the team was able to spend two days in the garden. The team worked closely with Annie Deane, a WAMS staff member who was a keen gardener on top of her role as exercise physiologist. The ins and outs of the wicking bed set-up were worked out in collaboration with Annie, along with their accompanying shade structures, and guidance provided around their ongoing use.

Back at UNSW in the following weeks, the feedback from the garden was positive. The veggies Annie had planted were growing. It was a heart-warming moment to realise the wicking beds, on a 50-large scale, were working. With the beds established it became about what else could be done to sustain a healthy, flourishing garden. A new garden shed was identified as a space that could serve as storage and a nursery in the garden.

In December 2020, a team from UNSW travelled to Walgett to build a timber propagation shed at the garden. It was partly fabricated on-site at UNSW before installation at Walgett and designed to avoid trapping summer heat. In the same trip repairs were made on the polytunnel shade structure which had melted and collapsed in the summer heat. This was a powerful reminder of the need to thoroughly check construction materials, and their ability to survive in trying climates. The vinidex tubes, which were initially chosen because they were slightly bendier (and so softer) and able to stretch in an arc, were replaced by PVC piping – a more rigid material that the Impact Engineers team were able to bend into the appropriate arc.

During that visit, an official launch was held of the WAMS community garden and accompanying Walgett Garden Network, encouraging collaboration between food gardeners across Walgett. It was a wonderful event with representatives from UNSW, Walgett Shire Council, WAMS, and DEG, and significant media coverage on the benefits of community-led collaboration of this kind.

## Ongoing monitoring and evaluation

In 2021, with 50 beds already installed, WAMS, DEG, and UNSW wanted to ensure their longevity and full functioning in the community garden. Initially Impact Engineers were working on a plan for setting up a hydroponic system in the new shed. A hydroponic system offered a way of running an in-garden nursery, growing new vegetable seedlings in water efficient ways before transferring them to the garden beds – with the benefit of reducing the cost of new seeds. With further research it was learnt a hydroponic process was both energy intensive and high maintenance, and therefore not suitable for Walgett. This was a valuable refocusing of the priority for garden projects/designs to be as close to self-sustaining as possible. From this point plans shifted to what could be done to better produce data in the garden to enable long-term monitoring and evaluation of the effectiveness of the wicking beds.

One useful outcome of the hydroponic endeavour was the design of an ENGG1000 project for students to produce their own hydroponic system suited to Walgett's climate. Working within the principles of community engagement and sustainable design, this proved to be a useful, technically challenging project for students to engage with, who were able to produce impressive final reports. More than anything, the consistent engagement with Lucy Marshall and her ENGG1000 class is useful in providing alternative engineering opportunities and maintaining a stream of engaged, socially and culturally conscious engineering students.

In May 2021 the Impact Engineering team drove to Walgett with equipment to enable better data monitoring. Soil moisture probes, pH probes, vegetable harvest log sheets, and a water flow meter were delivered. This would measure bed moisture, soil pH, vegetable output, and water consumption respectively. The team was also able to do some bed maintenance – checking water levels and fixing any leaks.

The Impact team also had valuable time talking to and learning from DEG staff about life in Walgett and priorities moving forward. A trip to the high school in Walgett gave Impact Engineering students an opportunity to connect face-to-face with students, talking about university life and hearing about their interests.

During the May trip, WAMS staff raised that bees in the garden would be a welcome addition, both as providing employment opportunities for clients who had been working in disability employment at a local café which had been forced to close, and as an opportunity to fundraise with sales of honey and beeswax candles. This is currently being explored.

## Timeline

**2019**:

- **April**: Yuwaya Ngarra-Li food forum where it is indicated the community garden needs revitalising and drought-proofing.
- **June**: First iteration of garden beds installed in the WAMS community garden. Beds raised over a layer of scoria and a sheet of tarpaulin.
- **July**: Beds recreated at UNSW with the help of built environment. This time made out of recycled IBC tanks filled with scoria.
- **August**: Greg Leslie comes across Biofilta wicking beds while attending a conference
- **August**: A few Biofilta wicking beds ordered in for testing at UNSW.
- **September**: Pilot beds driven up to Walgett for testing. Garden levelled and pilot beds installed with new soil
- **November**: Results from the garden indicate the beds are working.

**2020:**

- **March**: Outbreak of COVID19.
- **June-August**: Garden is prepared for scaling-up. Site surveyed, levelled, and graded.
- **June**: Practice bed construction day at UNSW.
- **September**: Initial bed instillation in Walgett with accompanying poly-tunnel shading structures.
- **September**: Remaining beds installed.
- **December**: Garden opening ceremony. Garden shed built. Poly-tunnel shading structures repaired.

**2021**:

- **May**: Data collection equipment and sheets delivered to Walgett. Garden beds assessed and leakage fixed. Indication from WAMS that bees could be an addition to the garden.
- **June**: Second outbreak of COVID19. Plans put on hold.

# To-date data on water use

Water consumption data was first initiated with the wicking beds delivered in September 2019. This was through the log sheets delivered to measure water usage and soil moisture. Unfortunately, any results collected have not been stored.

Collection of water consumption data in WAMS community garden was re-initiated in May 2021 with the delivery of smart flow meters. When attached to a tap and hose, smart flow meters measure the litres of water used in a single garden session. Over time, collection of this data allows more certainty around garden water requirements. It is contingent on active recording by garden personal after a gardening session. It is also important that the garden personal/user finds the data log sheet easy to use. So far, no recorded data on water usage has been received by UNSW Impact Engineers from WAMS community garden.

In this briefing paper, new data log sheets have been created in section 8. They are intended to create an ease of use better suited to WAMS community garden. Before being printed, feedback from the WAMS community garden personnel is desirable so that the clearest, easiest to record data log sheet is settled on. It is important that after a log sheet has been filled in, a photo of it is taken and sent back to UNSW so the recordings can be manually plugged into data files and stored.

# Other data from site

Other data from site includes survey drawings made before the initial installation of garden beds, and a Walgett geodatabase which contains documents on the project, cadastral information, and constraints and area analysis. The levelling done to the garden after the survey has ensured there is flat ground and no run-off occurring.

It is clear that for the long-term sustainability of the garden, more data is needed. Specifically, more data on garden output metrics, soil health, compost generation, pest and disease control, and planting schedule would be beneficial to a more resilient garden. Towards achieving this, new garden metrics have been added with accompanying data sheets and necessary equipment in section 8.

## Weather data and evapotranspiration

Weather data taken from the Bureau of Meteorology (Table 7.1 and 7.2) outlines temperature and rainfall expectations on a month-by-month basis in Walgett (BoM 2021).

Evapotranspiration (ETo) is a measurement of the amount of water needed for crops in a particular climate based on weather conditions. While different crops require different water inputs ETo is a useful guideline for water requirements. Following (Holmes 2021) recent literature review, the United Nations Food and Agriculture Organisation's (UNFAO) ETo Calculator which utilises the Penman-Monteith method (Raes 2009), can be used to calculate the reference ETo. Using the climate data for Walgett taken from BoM and the evapotranspiration rate of a reference surface these calculations have been included as a reference in the rainfall table. The greater the difference between ETo and measured rainfall, the greater the need for well-planned irrigation solutions

**Table 7.1: Rainfall and evapotranspiration – years 1993-2021, taken at Walgett Airport AWS.**

| Rainfall | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Ann. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mean rainfall (mm)** | 53.4 | 49.6 | 41.8 | 21.3 | 28.8 | 34.2 | 27.3 | 19.4 | 26.0 | 38.0 | 47.6 | 48.5 | 419.4 |
| **Mean number of days of rain > 1mm** | 4.6 | 4.2 | 4.0 | 2.5 | 3.2 | 3.7 | 3.3 | 2.3 | 3.1 | 4.0 | 4.5 | 4.9 | 44.3 |
| **ETo (mm/day)** | 6.9 | 6.1 | 5.2 | 4 | 2.9 | 2.2 | 2.3 | 3.1 | 4.3 | 5.5 | 6.4 | 6.9 | 4.65 |

**Table 7.2: Temperature**

| Temp | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Ann. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mean max temp (C°)** | 36.0 | 34.5 | 31.8 | 27.6 | 22.7 | 19.0 | 18.6 | 21.0 | 25.3 | 29.1 | 32.3 | 34.7 | 27.7 |
| **Mean min temp (C°)** | 20.9 | 20.1 | 16.9 | 11.7 | 7.2 | 5.1 | 3.6 | 4.2 | 7.9 | 12.0 | 16.1 | 18.6 | 12.0 |

## Drought and the need for irrigation solutions

Walgett is classified as a semiarid climate, which means it meets a certain bracket of rainfall each year (Bailey 1979). Due to low levels of rainfall, semiarid regions experience problems with droughts (Murungweni et al. 2016). In the context of a community garden, this lack of rainfall means irrigation solutions are necessary.

The department of primary industries has developed useful metrics for mapping and understanding drought. This includes classifications of drought as intense drought, drought, drought affected (intensifying), drought affected (weakening), recovering, and non-drought (DPI 2021a). Based on these stages different water restrictions will be in place which impact how much water will be used in the garden.

Irrigation solutions are necessary to deal with Walgett's high temperatures and low rainfall. Biofilta's FoodCube utilises the principles of wicking to draw water from reservoirs up through plant roots and soil and into the garden bed (Noyce 2019). This results in a decrease of water loss, as water is used up by the plants before it is evaporated from the topsoil (Noyce 2019).

While this irrigation solution is an important way of protecting against drought and limited water availability, data collection that monitors water requirements within the WAMS community garden will help build expectations around their efficiency. This will help establish a more intimate knowledge of what it takes to mitigate water restrictions in times of drought.

## Sun and shade

Other data such as the number of clear and cloudy days is available from the Bureau of Meteorology (BoM). The high number of clear days, taken with a high average temperature, outlines the importance of appropriate shade structures in the garden that provide sun-safety all year round. The below table is taken from the BoM, measured at the Walgett Council Depot between 1981-1993 (BoM 2021).

| Clear/ Cloudy | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mean no of clear days** | 12.5 | 12.8 | 14.8 | 11.8 | 11.7 | 12.7 | 12.1 | 14.9 | 16.0 | 13.7 | 12.3 | 12.2 | 157.5 |
| **Mean no of cloudy days** | 5.5 | 4.8 | 5.3 | 7.1 | 8.3 | 7.3 | 7.6 | 5.5 | 4.8 | 5.9 | 6.4 | 5.3 | 73.8 |

# Garden output data and regular data gathering

## Garden metrics

This section is intended for the development of future best practice around data collection in the garden. Each garden metric has an accompanying data log sheet to be filled in by using the appropriate equipment to take measurements/readings. The equipment can be stored with the log sheets in the garden shed. The data log-sheets are based on amount of sessions in the garden, and once they are complete, taking a photo of them is sufficient to be sent back to UNSW (more information on data-logging is found below). Each subheading below is hyperlinked to its data log sheet.

| Data metric | Equipment used | Reason for measurement |
|---|---|---|
| Water consumption | Smart flow meter | Water use efficiency |
| Bed water level | Manually checking level gauge on wicking bed | Water use efficiency |
| Soil pH | pH probe/ pH testing kit | Plant uptake of nutrients |
| Soil salinity | Electrical conductivity probe / electromagnetic induction (EM) device | Soil health |
| Soil moisture | Soil moisture meter | Water use efficiency |
| Planting data | N/A | Production estimates |
| Crop yield | Kitchen scale | Production estimates |
| Compost temp | A compost specific temp gauge | Compost health |
| Compost volume | A bucket/ and or scale | Emissions reduction and soil replenishment benefit |
| Pest, disease, and plant problems | N/A | Plant health |

**Table 8.1: Garden metrics and equipment**

## Water consumption

This collects data on water usage in the garden on a per bed group basis that can be extended to a per garden basis. Additionally, it references the temperature on the day measurement is taken.

**Frequency of measurement**: Every watering session.

## Bed water level

This collects data on the wicking bed water level, so water storage capabilities and individual bed group can be monitored. This will build greater certainty about water retention within bed groups. It is done by tilting the gauge on either side of the bed group and seeing when water is released.

**Frequency of measurement**: Once fortnightly.

## Soil (pH, salinity, moisture)

**Soil pH:** This collects data on the pH which is important for plants' ability to access nutrient levels in the soil. A pH too high or too low means plant productivity drops. Soil pH must be tested to ensure it is between 6 and 7.

If the pH is below 6 it is too acidic, and the solution is to add agricultural lime (dolomite). If the pH is above 7 it is too alkaline, and the solution is to add compost and manures.

Soil pH is most easily measured with a pH probe which can be put in the soil.

**Frequency of measurement**: Once fortnightly.

**Soil salinity:** Salinity measurements determine whether there has been an increase in salinity over time and can be done at different soil levels. Measurement of soil salinity is important as salinity reduces crop yields for most plants. Salinity is measured using an EM probe which measures the electrical conductivity in the soil.

**Frequency of measurement**: Once fortnightly.

**Moisture:** Measuring the soil moisture level is way of saving water by knowing the soil moisture status – and therefore when it is right to provide water. Soil moisture levels affect salinity, oxygen content, and soil temperature. Soil moisture can be simply measured with a moisture probe.

**Frequency of measurement**: Once fortnightly.

## Planting data

This records the planting cycles; when things are planted, and in which beds they are grown. This is useful for keeping track of what is grown where for crop rotation and companion planting purposes and can be used with crop yield data to determine how successful certain plants are.

**Frequency of measurement**: When crops are planted / after they have harvested

## Crop yield

This is an important output metric, measuring the overall crop production of the garden. Over time this allows better understanding of garden productivity which can offer better preparation for fruit and veg box delivery as well as providing an indication of problems to be addressed should productivity start to decline.

**Frequency of measurement**: When crops are harvested.

## Compost (temperature, volume)

**Temperature**: This is important as an overall check of the compost health.

**Volume**: Measuring the amount of compost by volume or weight allows calculation of the waste diverted from landfill, and subsequently an estimate of the greenhouse gases saved.

More on compost development can be round in section 9.1.

**Frequency of measurement**: Temperature (once fortnightly), Volume (whenever new compost is added).

# Data sheets and how to use them

**Table 8.2 – Data sheets and sessions**

| Data sheet | Sessions (can be changed depending on user preference) |
|---|---|
| Water consumption | 8 |
| Bed water level | 8 |
| Soil data (pH, moisture, salinity) | 5 |
| Planting data | 5 |
| Crop yield data | 5 |
| Pest, disease, and plant problems | Logbook for reporting |
| Incident report | Logbook for reporting |
| Supplier details | Logbook for reporting |

There are 5 data sheets that can be used for regular data gathering and reporting. Each is based on a number of sessions in the garden and is designed to be filled out on the day of collection using the necessary equipment. A temperature reference is included at the bottom of each data sheet which will help build a correlation between garden metrics and the weather. The data sheets are split up because they require different pieces of equipment and can be collected at separate times.

The sheets are on a bed-group basis, so that data can be easily matched. Where there is no data to be collected on a particular bed group it can be left blank. Once all the sessions are complete, a photo of the data sheet can be sent back to UNSW for logging. The data sheets can be found in the appendix.

## Drought-proofing and production targets

Building a data bank will help develop expectations around water consumption and bed productivity. Understanding water consumption requirements will help drought-proof the garden by better alignment with water regulations in times of drought. Additionally, understanding individual plant water requirements will help build resilience in times of drought. Not all plants have the same watering requirement, some plants have low water needs (eg rosemary, oregano, thyme) and some have high water needs (eg fruit trees). Beds might be low-watering zones over winter if there is more rain, and high-watering zones over summer when there is little rain. Knowing water requirements can allow plants with similar requirements to be planted together and will hopefully mean the wicking beds can survive with the bare minimum water input during times of drought.

Data on regular crop yields will help build towards sustaining high crop yields and will help improve expectations for the fruit and vegetable boxes to be delivered to the community. Additionally, in times of drought it will help indicate how well the garden is operating (through crop output) under water stress.

# Recommendations

This section outlines steps needed to improve productivity and viability of the garden. Understanding what builds and sustains the garden is important to ensuring its longevity – and will help protect against drought. As crops are dependent on water and nutrients it is important to develop practices attuned to recognising their needs and replenishing them. The Biofilta wicking bed is an irrigation solution suited to surviving droughts. Keeping soil healthy is less impacted by droughts, however, it is an important factor in maintaining garden productivity. With the basic needs covered, more creative endeavours can follow that expand the garden in exciting and unconventional ways.

## Developing a compost system

### The importance of compost

A functioning compost system is part of a healthy garden. It produces important nutrients that can be put back into the soil and prevents harmful greenhouse gases from entering the atmosphere by breaking down organic waste (Haug 2018). Importantly, it is a way of ensuring soil remains healthy without needing to buy new soil. After a productive summer or harvest, the nutrients taken out with the fresh fruit and vegetables can be replenished with compost produced at the garden.

### Using compost

As a rule of thumb, compost should be added at end of each growing season, or about every 6-months. Nutrients should be replenished before things are replanted otherwise there will be a drop in plant productivity (Diaz et al. 2011).

When harvesting the crops, any plant matter that will not be eaten should be put into the compost. When turning the wicking bed soil, residual root mass should be pulled out for the compost. Once crops have been harvested it is appropriate to add compost. If no compost is available, then manure, blood and bone, store bought compost, or premium soil mix can be used instead. It should be spread across the wicking bed and mixed into the soil.

### Making a healthy compost

Caring for compost is essential to its overall health. It is helpful thinking of a compost as a habitat for microbes. Choosing a good location is important – somewhere wheelbarrow accessible as well as somewhere shady. This way loads of compost can be easily transported to garden beds and the water does not easily evaporate.

A healthy compost can take about three weeks to make once started. It depends on a balance between brown and green waste, to produce conditions that effectively break down organic matter. The rule of thumb is keeping a volume ratio between brown and green waste of about 40:60. Brown waste is carbon heavy, and green waste is nitrogen heavy. Partnerships with local businesses can enable the use of their organic waste in the WAMS community garden. Table 9.1 lists common examples of brown and green waste.

**Table 9.1**

| Browns – Carbon heavy (40) | Greens – Nitrogen heavy (60) |
|---|---|
| Pine bark mulch | Lawn clippings |
| Eucalyptus mulch | Plant cuttings |
| Coffee chaff | Coffee grinds |
| Cardboard | Kitchen waste |
| Wood chips | Manure |
| Saw dust | |
| Shredded paper | |
| Old leaves and twigs | |

## Smell and wetness

Getting the right ratio between brown and green can be difficult and a good way to have an idea is through smell, look, and touch.

- Smells bad = add more carbon
- If it's cold and not much decomposition is happening = add more nitrogen
- If it's too wet = anaerobic (compost lacks oxygen and energy will be released as methane)
- If it's too dry = microbes die of thirst

A useful indicator of the right moisture level can be holding a clump, if water is close to dripping from it, then it is about right.

## Oxygen and size

Allowing oxygen to flow through the compost is very important, since its shape and size can determine how well it flows through the pile

- Too small a size (sawdust) = compost pile suffocates
- Too large a size (logs) = small surface area and hard to break down

Additionally,

- Pile size of the compost too big = it will weigh down on itself and suffocate
- Pile size of the compost too small = heat will be lost too quickly

### Overall care

- Enough water – water when the compost is looking or feeling too dry
- Enough oxygen – turn once a month at least to inject oxygen
- Temperature – a large compost space (1m x 1m) helps creating the right amount of heat within the pile.
- Particle size to ensure airflow: this is about ensuring compost matter is not too big or too small

A compost thermometer is great for measuring the temperature of the compost, which is an indicator of compost health. Taking measurements once every two weeks and logging in will help produce useful compost data.

## Landfill waste diversion

A functioning compost also diverts waste from landfill. The kitchen scraps, dead leaves, garden clippings, and organic material that goes into a compost reduces the green waste that releases greenhouse gases in landfill (Haug 2018). Tallying up the amount of compostable waste diverted from landfill, although extra work, helps better overall management of composting and can produce quantitative data on environmental impacts from year to year. Using quantitative measures, estimates can be made on the total $CO_2$ emissions reductions (Haug 2018).

The data sheet designed for compost in section 8 uses a by volume approach, where a bucket of known size is used to measure the organic waste before addition to compost.

# Crop rotations

Rotating crops is part of sustaining a healthy garden. It is a practice designed to minimise diseases and pests, reduce chemical use, and maintain and enhance nutrients – all of which help overall crop yield (MANUAL 2009).

**Reasons to rotate crops**

| | |
|---|---|
| **Disease prevention** | The main reason to rotate crops is to prevent the spread of plant disease. Disease organisms can build up over time, resulting in eventual crop failure. Rotating crops keeps these organisms in check. |
| **Insect Control** | Crop rotation also helps reduce insect infestations. |
| **Nutrient Balance** | Different families of plants require different nutrients. By rotating crops, soil is kept from being depleted and maintain a stable soil pH. |
| **Nutrient Enhancement** | Some plants enhance the soil, so rotating them through the garden can produce free organic soil conditioning. Adding compost further enhances soil conditions. |

Crop rotation involves dividing the garden beds up into sections and planting a different plant family in them every year. A system that has four rotating plant groups is sufficient for the process to work (Sumner 2018). Generally, crop rotation plans can be made for a three-to-six-year time period. Table 9.2.1 and Table 9.2.2 offer an example of crop family groups and a four-year yearly rotation plan (ABC 2021)

**Table 9.2.1**

| Legumes & Pod Crops | Brassicas & Leaf Vegetables | Alliums | Other (Root and Fruiting Crops) |
|---|---|---|---|
| Okra | Kales, Cauliflowers | Onions (All types) | Capsicums, Tomatoes, |
| Runner Beans | Cabbages, Brussels Sprouts | Shallots | Celery, Beetroot, Salsify |
| Lima Beans | Mustard Greens, Pak Choi | Chives | Parsnips, Carrots, Potatoes |
| Peas | Swedes & other Turnips | Leeks | Sweet Potatoes, Corn |
| Broad Beans | Radishes, Silverbeet, Spinach | Garlic | |

**Table 9.2.2**

| | Bed 1 | Bed 2 | Bed 3 | Bed 4 |
|---|---|---|---|---|
| Year 1 | Brassicas | Other | Alliums | Legumes |
| Year 2 | Legumes | Brassicas | Other | Alliums |
| Year 3 | Alliums | Legumes | Brassicas | Other |
| Year 4 | Other | Alliums | Legumes | Brassicas |

## Crop rotation in WAMS community garden

Since the WAMS community garden is operating with 50 beds, crop rotation requires a little more planning. Good signage that clearly indicates the plant family and plant species will help with the rotations. Since there are four bed groupings in Row A, four in Row B, and four between Row C and D, the rotating plant groups can work within them. Using the system above, an example based on Walgett's bed groups could look like this.

| | A1-A4 | A5-A8 | A9-A12 | A13-A16 |
|---|---|---|---|---|
| Year 1 | Brassicas | Other | Alliums | Legumes |
| Year 2 | Legumes | Brassicas | Other | Alliums |
| Year 3 | Alliums | Legumes | Brassicas | Other |
| Year 4 | Other | Alliums | Legumes | Brassicas |

| | B1-B4 | B5-B8 | B9-B12 | B13-B16 |
|---|---|---|---|---|
| Year 1 | Brassicas | Other | Alliums | Legumes |
| Year 2 | Legumes | Brassicas | Other | Alliums |
| Year 3 | Alliums | Legumes | Brassicas | Other |
| Year 4 | Other | Alliums | Legumes | Brassicas |

| | C1-C4 | C5-C8 | D1-D5 | D6-D10 |
|---|---|---|---|---|
| Year 1 | Brassicas | Other | Alliums | Legumes |
| Year 2 | Legumes | Brassicas | Other | Alliums |
| Year 3 | Alliums | Legumes | Brassicas | Other |
| Year 4 | Other | Alliums | Legumes | Brassicas |

# Rainwater tanks and equipment shed

## Rainwater tanks

Making use of available roofing for rainwater collection is a useful way of collecting and storing extra water. It is also a useful way of ensuring a high-level quality of water. To do this, appropriate guttering and rainwater tanks are necessary. This way, any rain that falls on the roof is collected in gutters and funnelled into the rainwater tanks.

Roughly speaking, 1 millimetre of rain over 1 square meter of roof equals 1 litre of water (Co 2017). Therefore we can use the equation:

*Annual rainfall (in mms) x Roof surface area (in square metres) = Roof catchment capacity (litres)*

Not only can rainwater use in gardens reduce demand on mains systems – it has a range of other benefits.

**Nitrogen**: rainwater contains some nitrogen, useful to plant growth.

**No chlorine**: The chlorine that is useful and present in drinking water is not so useful for gardening water. This is because it can kill microorganisms useful for plants.

**No salt**: Water from the Great Artesian Basin contains salt, while rainwater does not. Salt-stressed plants often lose their colour and appear wilted. Salt affects vegetation depending on the species.

**Table 9.3: Salt sensitivity**

| Salt sensitivity | Plants |
|---|---|
| Highly salt sensitive plants | **Fruit**: persimmon, passionfruit, strawberry, raspberry, avocado, loquat, almond, stone fruit, citrus fruit, apples, pears.<br>**Vegetables**: green beans, parsnips, celery, radish, squash, peas, onion, carrot. |
| Slightly less sensitive plants | **Fruit**: mulberry, grape.<br>**Vegetables**: cucumber, capsicum, lettuce, sweet corn, rockmelon, potatoes, cauliflower, cabbage, watermelon, broccoli, pumpkin, tomato. |
| Moderately salt tolerant plants | **Fruit**: olive, fig, pomegranate.<br>**Vegetables**: spinach, asparagus, kale, beetroot. |

Rainwater tanks also offer the potential to colour up the garden through artistic work.  Painting the tanks showcases local art and makes the garden a more creative and visually welcoming space.

## Equipment shed

Equipment sheds are a useful place to store all the garden gear. This makes keeping things organised a little easier. For example, a section of the shed might be dedicated to the data log sheets and data measuring equipment, while another section might be dedicated to garden digging and harvesting tools. Having things organised also provides quicker access to needed garden tools while freeing up space in other parts of the garden.

# Citrus trees

Apart from the benefit of fresh fruit being readily available, citrus trees offer the WAMS community garden an attractive shiny green foliage that smells pleasant and provides shade. They create a place of refuge in the garden, away from the hot sun, and their fresh fruit is nutritious and refreshing. This section outlines some of the practical steps in setting up citrus trees in the community garden.

## Climate

Citrus trees are considered subtropical but will grow in most regions of NSW (DPI 2021b). The biggest threat to them is the cold, where severe frosts damage the tree and fruit. In Walgett's hot conditions, they will survive with good irrigation, although fruit might occasionally be sunburnt (DPI 2021b).

## Planting

Citrus trees are best suited to well-drained, deep (50 cm), sandy loam soils (DPI 2021b). They prefer a soil pH in the range of 6-7, not too acidic or alkaline. They are well suited to Walgett in that the maximum amount of sunlight is desirable for the growth, setting and maturity of the fruit

Citrus nursery trees are usually sold in containers, but sometimes they can be bought as bare rooted trees. The planting site can be prepared by digging over several months prior and mixing in organic matter and removing any weeds (DPI 2021b). Since Walgett's summers are hot and dry and their winters are mild, they are not at risk of frost, and so can be planted all year round. Once planted create a small basin at the base of the tree and pour about 10L of water slowly into it to consolidate the tree and provide a reservoir of moisture. Until new shoots appear, it should be rewatered several times a week.

With these planting considerations it is NOT RECOMMENDED to plant citrus tree in wicking beds, as they require good drainage, and they are already suited to the climate and soil in Walgett. Before planting, if more help is required, comprehensive guides can be found online including walk through YouTube videos

## Tree care, pruning and nutrition

The appropriate care will ensure the longevity of the citrus trees. Regular watering is important during hot, dry, windy periods. In the first year of growth, watering the citrus trees between 4-7 days depending on the weather in adequate.

Once the trees are established, watering once a week is enough. The root system of the citrus trees is most often concentrated in the top 30cm of soil. It is important to take care when digging around the tree as an injury to the roots may result in the invasion of wood-rotting fungi. Heaping grass clippings or other materials around the base of the trunk is can also be damaging. Remove weeds carefully that form by the base of the tree.

There is no need to prune the citrus trees until dead wood has to be removed. While the citrus tree shapes itself, in time the shaded inside twigs and limbs should be removed to open the centre and reduce the risk of fungal diseases.

Nitrogen is the most important nutrient for citrus trees. It promotes growth and fruit size. Other nutrients that can be important are phosphorous (if the soil is sandy), and magnesium and calcium. These can all be acquired through the regular addition of organic matter or fertiliser. As a rule of thumb, 4-8kg of manure is recommended in the first year of growth, to be increased annually to 16-32kg in the eighth year of growth (DPI 2021b).

## Varieties suited to Walgett

There are a wide range of citrus tree available in Australia. By having a number of varieties growing, fresh fruit can be available almost all year round. Many species of oranges and lemons are suited to the hot dry conditions of Walgett. Species of grapefruit are particularly suited to Walgett’s climate. More information on the suitable citrus species can be found at the department of industries NSW.

## Harvesting

For all citrus trees apart from lime, the fruit should be left on the tree until it is fully developed. Most citrus can be held on the fruit for some time; however, quality will eventually deteriorate. The fruit should be picked by a twisting-pulling action which breaks the stalk but that does not damage the fruit. Surplus fruit can be stored for several weeks in a refrigerator.

For any problems with diseases or pests, please refer to the Department of Industries troubleshooting page for citrus trees.

# Garden upscaling

Garden upscaling offers a huge increase in fruit and vegetable production in the garden. With it comes more tasks to do with upkeep and organisation. Similar to the first 50 garden beds, the layout of the new beds will have to be planned so as to allow easy access throughout the garden with a wheelbarrow. Ground must be level in order to prevent uneven water distribution in the bed reservoirs.

Additionally, data logging best practice will help sustain and organise the garden. Knowing where things are planted, when they are harvested, how healthy the soil is, and how much water is used, will ultimately help build resilience.

## Garden stakes / trellis

Trellises, or supporting structures, are important for climbing plants. Once planting routines are known, garden beds with climbing plants can be fitted with structures that help them grow vertically. Selecting a supporting structure is about choosing one that is sturdy enough to support whatever type of vine is growing. Aside from this, there is room for creativity using recycled materials to construct them.

**Some options**:

- Bamboo sticks are great for this, they can be tied in tee-pee structures in the beds
- Using recycled metal to create supporting structures
- Biofilta also sell trellises that can be manually attached to the modular FoodCube wicking beds

# Bees

Installation of beehives offer another avenue for the WAMS community garden. They would function to pollinate the garden and surrounding land, as well as produce honey and wax as a product to be distributed to community members or sold to the local town stores. Currently a Sydney beehive retailer, The Urban BeeHive, is listed as a UNSW vendor ready to be engaged for the delivery of beehives and harvesting equipment.

# Further avenues

There are multiple further developments that could take place in the WAMS community garden. They should be based on the needs and desires of the Walgett stakeholders. As a way of noting potential avenues a few more are listed here although not explored in-depth:

- Barbeques in the garden
- Recipes based on fresh garden vegetables
- Garden workshops with community members and local schoolchildren

# Reflections on lessons learned

## Learnings

### Design choices

Making sensible design choices was an important part of the work done in the WAMS community garden. To do this, the boundaries and desired outcomes were important factors. The main physical boundary from the outset was the immediate climate – and that impacted the type of irrigation system required.

The desire for a large-scale garden that could provide multiple fruit and veg boxes to the community also impacted the type of irrigation system. The failure of self-constructed wicking beds quickly moved things towards what was commercially available. Biofilta FoodCubes, although a larger upfront investment, were easier to set-up, and more-widely tested. They also allowed easy scaling up the garden.

### Data collection

Data collection has proven one of the hardest challenges in the recent history of the WAMS community garden. Data collection in the garden depends upon building up a routine of recording and storing. Previous attempts at data recording have fallen short of storing any logged data, and so renewed attempts are necessary. This means building an understanding of what each data metric relates to, how often it should be monitored, with what equipment it should be monitored, and in what easy-to-use format it should be logged. The data sheets constructed in this report seek to address this and should ultimately be changed in ways deemed useful / easy-to-use by the everyday WAMS community gardeners.

### Collaborating teams

Since the WAMS community garden collaborates with UNSW, it is important all collaborating teams invited to work in the space follow the community-led approach. This means listening and following the lead of the DEG and WAMS as the leaders and Walgett community members with the best understanding of what is needed. It means recognising and supporting WAMS' limited capacity and barely-funded garden workforce. It also means a careful acknowledgement of post-colonial Australia and the racial structures that continue to inform Australian government and society.

## Garden user reflections

The most intimate knowledge of the garden is held by those who physically look after it. Planting, watering, harvesting, and testing, are all things that over time attune the garden users to the health of the garden and what seems to be working and what is not. Therefore, it is useful at the end of a harvesting season for the garden users to reflect on their observations. These might help with the way things operate in the future. Appendix B.1 can be printed off and used as a logbook for these reflections.

The desire for a large-scale garden that could provide multiple fruit and veg boxes to the community also impacted the type of irrigation system. The failure of self-constructed wicking beds quickly moved things towards what was commercially available. Biofilta FoodCubes, although a larger upfront investment, were easier to set-up, and more-widely tested. They also allowed easy scaling up the garden.

# References

ABC. 2021. *The Vegie Guide: Crop Rotation* [Online]. https://www.abc.net.au/gardening/factsheets/the-vegie-guide-crop-rotation/9375784. [Accessed 14th December 2021 2021].

Bailey, H. 1979. Semi-Arid Climates: Their Definition and Distribution. *Agriculture in Semi-Arid Environments.* Springer.

Baker, L. E. (2004) 'Tending Cultural Landscapes and Food Citizenship in Toronto's Community Gardens'. *Geographical review,* 94**,** 305-325.

BOM 2021. Climate Statistics for Australian Locations. 09/12/2021 ed. http://www.bom.gov.au/climate/averages/tables/cw_052088.shtml: Bureau of Meteorology.

Chao, S. (2021) 'Gastrocolonialism: The Intersections of Race, Food, and Development in West Papua'. *The International Journal of Human Rights***,** 1-22.

Co, B. 2017. *Calculating Your Roof Surface Area for Rain Harvesting* [Online]. https://rainharvesting.com.au/field-notes/articles/rain-harvesting/calculating-your-roof-surface-area-for-rain-harvesting/: Blue Mountain Co. [Accessed 14th December 2021].

Corrigan, M. P. (2011) 'Growing What You Eat: Developing Community Gardens in Baltimore, Maryland'. *Applied Geography,* 31**,** 1232-1241.

Cumbers, A., Shaw, D., Crossan, J. & Mcmaster, R. (2018) 'The Work of Community Gardens: Reclaiming Place for Community in the City'. *Work, employment and society,* 32**,** 133-149.

Diaz, L. F., De Bertoldi, M. & Bidlingmaier, W. (2011) *Compost Science and Technology*, Elsevier.

Dpi 2021a. Combined Drought Indicator. 12/12/2021 ed. https://edis.dpi.nsw.gov.au/: Department of Primary Industries.

Dpi. 2021b. *Planting Citrus Trees* [Online]. https://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/content/orchard-development/planting: Department of Primary Industries. [Accessed 14th December 2021].

Ferris, J., Norman, C. & Sempik, J. (2001) 'People, Land and Sustainability: Community Gardens and the Social Dimension of Sustainable Development'. *Social Policy & Administration,* 35**,** 559-568.

Firth, C., Maye, D. & Pearson, D. (2011) 'Developing "Community" in Community Gardens'. *Local Environment,* 16**,** 555-568.

Gregis, A., Ghisalberti, C., Sciascia, S., Sottile, F. & Peano, C. (2021) 'Community Garden Initiatives Addressing Health and Well-Being Outcomes: A Systematic Review of Infodemiology Aspects, Outcomes, and Target Populations'. *International Journal of Environmental Research and Public Health,* 18**,** 1943.

Haug, R. T. (2018) *The Practical Handbook of Compost Engineering*, Routledge.

Holland, L. (2004) 'Diversity and Connections in Community Gardens: A Contribution to Local Sustainability'. *Local environment,* 9**,** 285-305.

Holmes, R. (2021). *Identifying Most Efficient Irrigation Systems Based on Determination of Minimum Water Budgets for Locally Source Vegetable Intake in a Healthy Diet.* Chemical Engineering, UNSW.

Hond, R., Ratima, M. & Edwards, W. (2019) 'The Role of Māori Community Gardens in Health Promotion: A Land-Based Community Development Response by Tangata Whenua, People of Their Land'. *Global health promotion,* 26**,** 44-53.

Hume, A., O'dea, K. & Brimblecombe, J. (2013) '"We Need Our Own Food, to Grow Our Own Veggies…" Remote Aboriginal Food Gardens in the Top End of Australia's Northern Territory'. *Australian and New Zealand journal of public health,* 37**,** 434-441.

Kingsley, J. & Townsend, M. (2006) ''Dig In'to Social Capital: Community Gardens as Mechanisms for Growing Urban Social Connectedness'. *Urban Policy and Research,* 24**,** 525-537.

Linn, K. (2007) *Building Commons and Community*, New Village Press.

Manual, A. P. (2009) 'Crop Rotation'.

Massey, D. (2008) *A Global Sense of Place*, Routledge.

Moseley, M. (2003) *Rural Development: Principles and Practice*, Sage.

Murungweni, C., Van Wijk, M., Smaling, E. & Giller, K. (2016) 'Climate-Smart Crop Production in Semi-Arid Areas through Increased Knowledge of Varieties, Environment and Management Factors'. *Nutrient Cycling in Agroecosystems,* 105**,** 183-197.

Nixon, R. (2011) *Slow Violence and the Environmentalism of the Poor*, Harvard University Press.

Noyce, M. 2019. Weathering the 'Perfect Storm': Transforming Cities into Water Catchments and Urban Farms.

Raes, D. (2009) 'The Eto Calculator, Evapotranspiration from a Reference Surface. Reference Manual Version 3.1, January. Food and Agriculture Organization of the United Nations'. *Land and Water Division*.

Schultz, M. C. (2013). *A Survey of Successful Community Gardens in Small Us Towns.* Mississippi State University.

Sumner, D. R. 2018. Crop Rotation and Plant Productivity. *Crc Handbook of Agricultural Productivity.* CRC Press.

Wood, C. J., Pretty, J. & Griffin, M. (2016) 'A Case–Control Study of the Health and Well-Being Benefits of Allotment Gardening'. *Journal of Public Health,* 38**,** e336-e344.