D Botanic Gardens as Models of Environmental Sustainability

Part D: Botanic Gardens as Models of Environmental Sustainability

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MANAGING ENVIRONMENTAL SUSTAINABILITY IN TIMES OF RAPID GLOBAL CHANGE

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Managing Environmental Sustainability in Times of Rapid Global Change

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8.0 DEFINITION

Environmental sustainability: Used often synonymously with *sustainable development* which is defined as meeting *'the needs of the present without compromising the ability of future generations to meet their own needs.'* World Commission on Environment and Development (1987).

8.1 INTRODUCTION

Climate change, loss of habitats and biodiversity are a symptom of humanity's unsustainable use of natural resources, particularly in the developed parts of the world. Conventional ways of building and operating will not solve this problem. We need a major paradigm shift in the way we live and operate to reduce the risk of serious climate change and environmental degradation.

Botanic gardens have a strong role to play in promoting environmental sustainability through their own management practices and by engaging and inspiring their visitors, staff and funders to understand the critical role that plants play in supporting life on our planet. This is especially important in times of rapid global change.

KEY MESSAGE

Environmental sustainability has economic, moral, legal and many more benefits for botanic gardens.

8.2 HOW CAN BOTANIC GARDENS DELIVER ENVIRONMENTAL SUSTAINABILITY?

There are many considerations when looking at delivering environmental sustainability in all its forms. An Environmental Management System (EMS) is a framework that can help a botanic garden to achieve its environmental goals through consistent control of its operations. The assumption is that this increased control will improve the environmental performance of the organisation. The EMS itself does not dictate a level of environmental performance that must be achieved – each organisation's EMS is tailored to its business and goals. However, the EMS pulls together documents such as Environmental Policy, Legal Register, Impacts and Aspects Register and Objectives into a logical system.

8.3 ENVIRONMENTAL STANDARDS AND SCHEMES

KEY MESSAGE

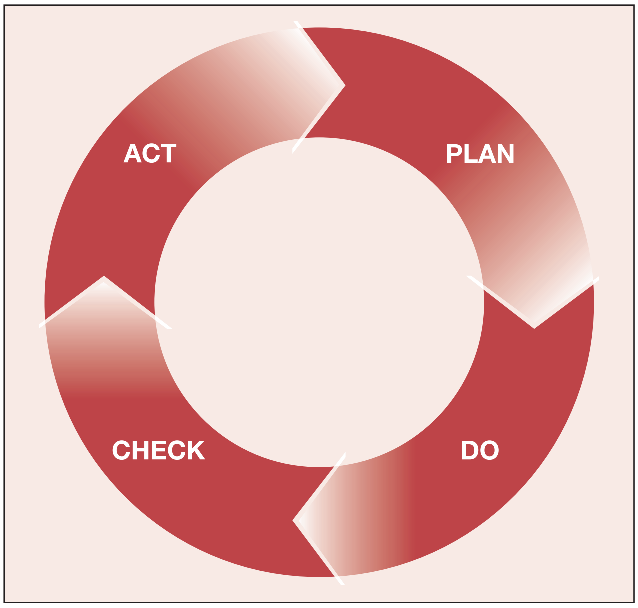
There is a wide range of environmental standards and schemes that botanic gardens can choose from.

ISO 14001 Environmental Management Standard – ISO 14001 is perhaps the best known environmental standard. This internationally recognised system requires, as a minimum, legal compliance with relevant environmental legislation and year-on-year continual improvement. This is demonstrated by means of an annual, external audit of the EMS and its implementation.

Although there is an annual cost associated with ISO 14001 compliance, adherence to the thorough systems allows for comprehensive delivery of environmental sustainability and usually delivers significantly more savings than costs. The annual external audit, combined with the discipline required to maintain the standard, helps to maintain focus and momentum within an organisation.

By application of the management cycle (Figure 8.1), the EMS can be reviewed and any issues can be documented and reported upon.

Figure 8.1 Management cycle



For example, since 2008, Paignton Zoo's Botanic Garden in the United Kingdom has implemented and managed an EMS that has reduced waste and pollution, reduced utility consumption, and positively reported on its conservation work in terms of its impact on the wider environment (Peter Morgan, pers. comm.).

Organisational carbon footprint – Emissions from all the activities across a botanic garden, including energy consumption, industrial processes and travel, can be used to help create a baseline against which total greenhouse gas emissions caused directly and indirectly by a person, organisation, event or product can be monitored and managed (see for instance Carbon Trust Guide).

A carbon footprint is measured in tonnes of carbon dioxide equivalent (tCO2e). The carbon dioxide equivalent (CO2e) allows the different greenhouse gases to be compared on a like-for-like basis relative to one unit of carbon dioxide. A carbon footprint considers all six of the Kyoto Protocol greenhouse gases: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6). CO2e is calculated by multiplying the emissions of each of the six greenhouse gases by its 100 year Global Warming Potential (GWP). A botanic garden may need the assistance of a consultant in order to calculate its carbon footprint.

In 2009, the Royal Botanic Garden Edinburgh began the process of writing and then implementing a carbon management plan. It was partly motivated by the need to be able to quantify its carbon footprint and to allow for monitoring future emission reduction initiatives, but also provided the means to establish a robust and clear carbon management plan in line with the ISO 14001 EMS standard (Case study 8.1).

Living Building Challenge (LBC) – This is an international building certification programme, advocacy tool and philosophy that defines the most advanced measure of sustainability in the built environment possible today and acts to rapidly diminish the gap between current limits and the end-game positive solutions we seek. It is the built environment's most rigorous performance standard. It calls for the creation of building projects at all scales that operate as cleanly, beautifully and efficiently as nature's architecture. To be certified under the Challenge, projects must meet a series of ambitious performance requirements including net-zero energy and water over a minimum of 12 months of continuous occupancy. The Challenge is comprised of seven performance categories called Petals: Place, Water, Energy, Health and Happiness, Materials, Equity and Beauty. Phipps Conservatory's Center for Sustainable Landscapes (Case study 8.5) demonstrates the collaboration of an entire planning team from the start of development through completion by using design charrettes that provided a holistic perspective.

Leadership in Energy and Environmental Design (LEED) – LEED is an international rating system for the design, construction, operation, and maintenance of green buildings. Two botanic gardens using LEED are the Phipps Conservatory and Botanical Gardens tropical forest conservatory and the Brooklyn Botanic Garden Visitor Center, while the Oman Botanic Garden in Muscat aims for LEED certification and has embedded sustainability in all aspects of design and operations.

Ontario EcoCentres Network – The aim of the Ontario Ecocentres Network is to assist learning centres (including botanic gardens) in the process of leading by example and reducing their environmental impact. The Network also provides staff and students with a framework to address sustainability, including energy and water conservation, the enhancement of biodiversity and the pursuit of carbon neutrality. Like LEED, the Ontario EcoCentres Network has different levels of achievement.

Public Gardens Sustainability Index – Maintained by the American Public Gardens Association, the purpose of the Public Gardens Sustainability Index is '*to define and promote leading environmental stewardship practices, and drive innovation and continual improvement in the sustainability performance of the public gardens sector.*'

Sustainable SITES Initiative (US Botanic Garden, Lady Bird Johnson Wildflower Center, American Society of Landscape Architects, ASLA) – This is a set of voluntary guidelines and a rating system for sustainable landscapes, with or without buildings. Examples of botanic gardens using the SITES system are Bartholdi Park and the Phipps Conservatory, the latter with the highest 4 star rating under this scheme.

YOUtopia – The American Public Gardens Association (APGA) also has the YOUtopia programme that aims to increase leadership among cultural institutions and inspire millions of Americans to engage in climate change solutions. Through this program, public gardens lead by example, taking climate change impact reduction measures that affect a wide array of garden operations. Public gardens have unique credibility as trusted sources of non-partisan, highly effective science and conservation information. From designing and building sustainable landscapes and buildings to reducing non-renewable energy consumption, YOUtopia gardens are committed to educate and engage garden visitors, volunteers, staff, and communities to address climate impacts and develop sustainable solutions. The impacts of these actions are monitored, reported, and shared with the public. YOUtopia reporting is designed to utilize the Sustainability Index for North American Public Gardens standards while remaining flexible to individual garden goals and accomplishments.

WELL Building Standard – This international standard is based on creating buildings and building practices that are not only better for the planet, but also for people. It is the first standard of its kind that focuses solely on the health and wellness of building occupants. It identifies 100 performance metrics, design strategies, and policies related to air, water, nourishment, light, fitness, comfort and mind, that can be implemented by the owners, designers, engineers, contractors, users and operators of a building. The standard is based on a thorough review of the existing research on the effects of spaces on individuals and has been advanced through a thorough scientific and technical review. In order to achieve the certification requirements, the space must undergo a process that includes an on-site assessment and performance testing by a third party.

CASE STUDY 8.1

Carbon Management Plan at the Royal Botanic Garden Edinburgh

Mark Richardson, Adelaide, South Australia

The Royal Botanic Garden Edinburgh (RBGE) was founded in the 17th century as a physic garden and now extends over four botanic gardens in Scotland. It is a world-renowned centre for plant science and education.

In order to achieve an environmentally sustainable workplace, the RBGE made a commitment to achieve the international environmental standard ISO 14001. As a part of this, the RBGE joined the Scottish National Heritage Carbon Management-Lite Programme and, in 2009, began the process of writing and implementing a Carbon Management Plan. Since then, the plan has been developed to reduce carbon emissions throughout the organisation's buildings, activities and sites including the three regional gardens at Dawyck, Logan and Benmore.

The purpose of the RBGE Carbon Management Plan has been to lay out the scope, issues, methods, people, paperwork and techniques necessary for RBGE to reduce its energy usage and therefore its carbon emissions. It has done this by calculating the organisation's baseline of annual carbon emissions and then setting targets to reduce these.

The project has not only been found to have financial advantages but other benefits that include:

- contributing towards achieving the ISO 14001 standard;
- quantifying RBGE's carbon footprint;
- monitoring future emission reduction initiatives;
- facilitating change in work culture to increase environmental consideration and reduce wastage;
- increasing opportunities to communicate with the public and other stakeholders;
- increasing evidence of environmental stewardship that RBGE could communicate to funders and principle financial awarding agencies.

The original target was for the RBGE to reduce CO2 emissions from its activities by 13% from the 2008 baseline by March 2015. It was estimated that this could be increased to 43% if key structures and heating systems were replaced. Carbon emissions for 2013/14 were 187 tonnes less than the previous year, which is a reduction of 5% of the emissions for 2012/13. This reduction was largely attributed to the replacement of heating equipment in the main building with a new and highly efficient combination of water heater and central heating boiler.

To further reduce emissions, the RBGE has installed air source heat pumps and solar photovoltaic panels to heat the new conservatory at Logan Botanic Garden. This was the first public greenhouse in the United Kingdom to be powered by green energy.

A current issue for the RBGE in relation to the Carbon Management Plan has been the energy inefficiency associated with RBGE's large and outdated glasshouses. However, the planned replacement of these structures and the incorporation of sustainable features into the modern buildings will result in significantly reduced energy use in the long-term. When complete, this major capital project should greatly reduce RBGE's carbon emissions.

The John Hope Gateway, the Royal Botanic Garden Edinburgh's new biodiversity and information centre, is a shining example of green construction: sustainability aspects have been included very early on during the design stage. (Image: Annette Patzelt)

8.4 KEY AREAS OF ENVIRONMENTAL MANAGEMENT

KEY MESSAGE

Improvements in energy, water and waste management can save significant amounts of money, while upgrades in the sustainability of buildings can have significant health benefits for visitors and staff.

8.4.1 Pollution Control

An important element of protecting the environment is pollution control. This pollution includes that of the air, land and water.

Pollution of air includes discharge from boilers, incinerators, exhausts and ventilation systems; leaks from refrigeration systems; and microbial aerosols such as Legionella and fungal spores from composting. Pollution of water can arise from discharge from sewers, drains, compost areas and septic tanks; it also includes fertilizer and pesticide run-off. Pollution of ground soil can stem from leakage from pipes, compost areas and fuel tanks.

Any environmentally hazardous materials should be stored and used appropriately, with relevant safety and environmental information readily available. Dangerous substances include fuels, asbestos, pesticides and herbicides. Safer alternatives should be used where possible, including biological control and insect traps. Appropriate spillage kits and procedures, can mitigate against accidents involving hazardous substances.

Control of pollution relates to thorough maintenance of mechanical and engineering infrastructure, regular inspections and replacement of failing assets.

8.4.2 Building Design

Designing sustainable solutions for new buildings or alterations to existing facilities can dramatically improve a building's environmental performance. For instance, the visitor reception centre of the Australian Arid Lands Botanic Garden in South Australia implemented the following sustainability features:

- The building is oriented to maximize passive heating and cooling;
- Most walls are of rammed earth construction with excellent thermal properties, using soil from site;
- There is a large rain water tank beneath the building;
- All rainwater from the roof is collected and stored in the underground tank for use in the kitchen, cafe and toilets;
- Only plantation timber was used in the construction of the building
- A passive evaporative air conditioning (AC) system is used – the AC plant is away from the building, screened by plants and the cooled air is drawn into the building through large underground pipes, aiding the cooling process;

Biochar makers – a stainable way of recycling, turning organic waste into charcoal. (Image: Kadoorie Farm & Botanic Garden)

- There is a large bank of solar panels on the roof with further expansion planned – providing power for both the building and garden;
- Verandas and awnings provide shaded areas.

8.4.3 Waste Management

Waste management can be encapsulated by three R's: Refrain - buy only what you need; Re-use - wherever possible; and Recycle.

All sources of waste should be monitored and these items recycled wherever possible. It is important to engage with suppliers to reduce and/or recycle packaging. Some waste can become income-generating. Bailing cardboard, paper, plastic and aluminum cans may allow resale for profit.

Wherever possible, sending waste to landfill should be avoided. Organic waste stemming from plant, food and manure can be composted or be anaerobically digested to produce energy. Such green waste processing is illustrated by Shanghai Botanical Garden in Case study 8.2. While composting can emit green house gases, it has been found that a significant reduction of gases such as methane can be achieved by improved compost management for instance by regular watering and turning.

8.4.4 Energy Management

All energy including electricity, oil and gas should be monitored using accurate metering. In some cases metering of individual items of equipment may be possible. Monitoring should be at least every month because this will allow for seasonal and annual comparisons. Annual energy use should be calculated and expressed in terms of cost, kWh and CO_2 equivalents.

More advanced real time monitoring using data loggers or a Building Management System (BMS) can allow for detailed control of energy including alarm notification if issues occur. Careful management of buildings, including glasshouses, can save large amounts of energy. Simple measures such as ensuring glasshouse windows and doors are shut when heating is applied, can be highly effective.

Key savings will be made through good building design (Section 8.4.2) especially relating to insulation and double glazing, measures that can create significant energy savings.

CASE STUDY 8.2

Green waste processing at Shanghai Botanical Garden

Feng Shucheng, Shanghai, China

The Shanghai Botanical Garden was established in 1974 and is one of the largest municipal botanic gardens in China. An important activity that the Shanghai Botanical Garden undertakes for both itself and surrounding districts is the processing of green waste and production of compost.

The green waste processing plant which is located in the northwest corner of the Garden, has four crushing machines and covers an area of 60,000 m^2. As such, it is the largest processing plant in Shanghai. The plant processes 40,000 tonnes of green waste annually, with the waste coming from the botanic gardens as well as from the Xuhui, Changning, Minhang and Huangpu districts every day.

Since 2006, the Shanghai Botanical Gardens has invested approximately RMB 20 million (USD 3 million) in green waste processing. There are 15 staff working on this project, and they can crush the waste and gather it for composting on the same day it was delivered. After crushing, they add nitrogen fertilizer and microbes to compost the material in 30-40 days. The compost is used on-site at the botanic garden with the remainder being packaged and sold. The kind of compost produced plays an important role in soil improvement, can save energy and reduce emissions. The project continues to develop with government support.

Compost management at Shanghai Botanical Garden. (Image: Feng Shucheng)

If possible, renewable energy sources should be used rather than those derived from fossil fuels. Massive advances have been made in the generation of renewable energy in the last 30 years. Electricity can be generated by photovoltaic panels, wind turbines and water turbines (hydro-electric power). Hot water can be produced by solar panels and biomass boilers can be used to produce heat by direct burning or by production of gas from anaerobic digestion. Combined heat and power (CHP) generation can make more efficient use of energy. A gas fired CHP plant produces electricity via a generator with waste heat recovered and used for heating. The gas can also be from renewable sources such as anaerobic digestion of waste. Heat pump technology has been used for decades and has huge potential. Heat pumps are efficient, electrically driven, they extract heat from air, soil or water. Typically 3 to 5 kWh of heat is generated from each kWh of electricity used.

LED lights have revolutionized the lighting industry and retrospective conversions of existing fluorescent lights to LED ones can make energy savings in excess of 50%. There are significantly greater savings when halogen or incandescent fittings are replaced. The reliability and life of LED lights reduce maintenance costs as well.

Finally, education and behavioral change can prevent energy wastage. Turning off all lights and appliances when not in use saves energy.

An example of a botanic garden energy policy is given in Case study 8.3, while sustainable energy usage is illustrated in Case studies 8.4 and 8.5.

CASE STUDY 8.3

Eden Project Energy Policy 2013

Mark Richardson, Adelaide, South Australia

In an energy policy released in 2013, the Eden Project is working towards sourcing 100% of their energy needs from renewable sources by 2020 and will continue to work in a collaborative way, seeking best practice from a wide variety of stakeholders. The objective of the policy is '*to reduce the environmental impacts of our energy use by driving down consumption and investigating alternative energy sources, communicating the success of low carbon initiatives, and stimulating direct change by increasing the awareness and skills of our visitors, staff and community.*' They seek to reduce their emissions by pursuing on-site geothermal investigations and large-scale solar arrays, purchasing locally-sourced wood-chip and managing energy using the best technologies. For more information see http://www.edenproject.com/eden-story/behind-the-scenes/cutting-energy-and-carbon-at-eden

The Eden Project, continuously working to enhance environmental sustainability. (Image: The Eden Project)

CASE STUDY 8.4

Sustainable energy use at Cairns Botanic Gardens

Mark Richardson, Adelaide, South Australia

The Cairns Botanic Gardens visitor centre, servicing the Cairns Botanic Gardens and Tanks Arts Centre, has been built with sustainability in mind:

The building generates renewable energy with 104 solar panels on the roof of the structure. This 20 kW system generates the equivalent energy usage of five to six average homes a day. Excess energy is fed back into the electricity grid, providing clean energy.

The visitor centre building also has a rainwater catchment system, and the water collected is used in the building for flushing toilets and other non-potable uses. Recycled water from Council's sewerage treatment plant is used for irrigation of the Gardens.

The building design reduces the need for air-conditioning through use of louvers and fans to control air flow in each room.

Solar panels generating renewable energy. (Image: Cairns Botanic Gardens)

CASE STUDY 8.5

Using multiple certifications for the building, landscape and human health: Phipps Conservatory and Botanical Gardens

Richard V. Piacentini, Pittsburgh, Pennsylvania

Phipps Conservatory and Botanical Gardens is located in Pittsburgh, USA and was founded in 1893 by Henry Phipps as a gift to the City of Pittsburgh.

The Phipps Center for Sustainable Landscapes (CSL) was designed to be one of the most environmentally sustainable buildings in the world. It is the only building to have ever met the Living Building Challenge, LEED Platinum, 4 Stars Sustainable SITES and Platinum WELL Building certification. To achieve this, the CSL uses a range of technologies and strategies including:

Energy

- The building emphasizes passive energy-saving strategies and uses 70% less energy than a typical office building. It is long and narrow and faces south to maximize natural daylighting and ventilation.
- Strategic window placement and light shelves that direct the sun's rays and reflective ceiling material all allow daylight to naturally illuminate the interior 80 percent of the time. This reduces the need for energy-intensive artificial lighting. A green roof, high performance insulation and triple-pane, low energy windows help keep heat inside during the winter and outside during the summer.
- Onsite 125 KW photovoltaic solar panels produce more energy than the building uses on an annual basis.
- A vertical axis wind turbine, the first to be commissioned in the City of Pittsburgh, produces energy with winds as low as 6.8 kph.
- A series of six geothermal wells buried 500 feet below ground are used to capture heating and cooling temperatures.

Storm Water

- The building captures and treats all storm water (12.3 million litres) that lands on the site using the following strategies:
- A former Public Works and brownfield site. Over 2 acres of asphalt was removed and replaced with a landscape entirely made up of 100 species of plants native to within 320 kilometres of Pittsburgh.
- A green roof on the CSL captures rainwater. It also is accessible to the public and is part of the visitor experience.
- Five raingardens, strategically located, capture surface runoff from the landscape and roads.
- Permeable asphalt allows storm water to directly infiltrate into the ground.
- Excess water from the green roof and gardens is stored in a lagoon, which is also an important visitor amenity.
- If the lagoon overflows, excess water is captured in a 302,000 litre underground rain tank. That water can either be used for irrigation or infiltrated into the ground.

Phipps Center for Sustainable Landscapes. (Image: Denmarsh Photography Inc)

Sanitary Water

- All 300,000 litres of sanitary water from the CSL is treated on site.
- The initial water, and make up water, for the toilets is captured from a conservatory roof and stored in a 6,400 litre cistern.
- Water from the toilets and sinks is treated on site for reuse in flushing the toilets using a constructed wetland, sand filters and UV sterilization.
- Two 45,400 litre fuel tanks were repurposed to capture sanitary water overflow until it can be treated on-site.

Materials

- All buildings materials are Red List toxin free.
- All heavy building materials are sourced from within 800 kilometres to reduce the energy costs associated with transportation.

Human Health

- The building is WELL Building Platinum certified. This programme requires strategies to address how the built environment effects human health in seven critical areas: Air, Water, Nourishment, Light, Fitness, Comfort and Mind.

Education

- The green roof, landscape and atrium of the building is accessible to all 450,000 of Phipps' annual visitors.
- Educational signage and docent led tours help interpret how the building works for the public.
- The primary classroom for children's programmes is located in the CSL.
- A Biophilic Art programme helps interpret why connections to nature are important for human and environmental health.

In producing all of its own renewable energy, the CSL has achieved the Living Building Challenge, Net Zero Energy, LEED Platinum, 4 Stars Sustainable SITES and Platinum WELL Building certification.

CSL serves as a key part of the botanic gardens visitor experience as well as being a facility that houses administrative offices as well as groundbreaking sustainability research and science education programmes.

8.4.5 Water Management

Water is frequently the forgotten utility. Drinking water is a finite, valuable resource with significant financial cost. It is advisable to monitor drinking water use via accurate metering and sub-metering. Waste water (sewage) charges are sometimes based on a proportion of the drinking water usage. Reduction in drinking water use therefore reduces charges for both water and waste water.

Reducing the use of drinkable water for irrigation has probably been one of the Royal Botanic Gardens Victoria's most significant environmental challenges. Through a range of approaches such as staff training, research programmes, irrigation efficiency measures and managing irrigation demand, over 50% reduction in annual drinkable water use for irrigation has been achieved since the early 1990s.

A number of other approaches to careful water management are presented below:

Use of drought tolerant plants – By using the drought-tolerant flora of arid central Australia in its collections, the Alice Springs Desert Park is a very efficient water user. They use on average 2 mega-litres/ha/year. This is well below industry standard usage and better than other local park areas.

Use of young plants – Starting with young plants and growing them 'hard' in their early period of establishment has been shown to pay dividends when they eventually establish and grow on. Trees that are planted as young whips often establish faster (acclimation) and then grow on to out-perform larger root balled plants. Large plants often struggle to establish (called 'planting shock'), exhibit smaller leaves, have fewer roots extending into wider soil horizons and require substantially more nutrient and water use in the first three years of establishment.

Use of storm water and sustainable urban drainage systems within the botanic garden – Wherever possible, direct downspouts toward plants, trees and shrubs and use porous materials for walkways and driveways. It is helpful to develop rain gardens in natural or man-made depressions in the landscape to capture and soak up runoff from rooftops, driveways and walkways. Similarly, green walls and living roofs reduce rapid run-off of rainwater (Case studies 8.5, 8.6 and 8.7).

Irrigation systems – Low pressure or low volume systems such as drip irrigation or soaker hoses should be used, not oscillating sprayers. This allows for less evaporation and more direct watering of the root area. Systems with rain sensors prevent unnecessary watering and checking of the system for overspray keeps water loss at a minimum.

Correct management of lawns – Grasses compete for water in the top 5 cm of the soil and have a large water demand that often outcompetes other plants to their detriment. Removal or reduction of the lawn area should be considered along with selection of grasses that require less moisture. Moisture can be retained by raising mower height to ensure survival during drought or extreme heat and by leaving clippings on the lawn. Allowing the lawn to go dormant during mid-summer is another way to ensure survival of cool season grasses. Finally, lawns should be watered when evaporation is at a minimum.

Mulching and compost – Mulch should be applied around plants to aid moisture retention and to reduce surface evaporation. It is important to select a type of mulch that is best suited to different plants and to mulch in late winter to 'lock in' soil moisture and help prevent weeds growing in spring. Compost should be used as part of the refill when planting, to provide additional water-holding organic matter.

Containers – Container gardening can also be a good method which uses less water provided the species grown and container sizes are appropriate. Saucers under containers prevent water running away and can help reduce the time spent watering. Water-storing crystals in the potting mix reduce the amount of watering needed. Finally, limit the use of hanging baskets.

Maintenance – Irrigation, hoses and outside taps need to be checked regularly for leaks with repairs carried out as needed. Similarly, the programming on irrigation systems needs to be checked regularly.

Irrigate appropriately – Use of excessive amounts of water which simply drains away should be avoided as should insufficient water which just wets the soil's surface and evaporates. Watering should be carried out at dawn or dusk to minimise evaporative losses and reduce the visitor impression that water is being wasted.

Rainwater capture – Rainwater from buildings or hard surfaces may be used as irrigation for plants. If stored, this water should be kept cool and dark to prevent it deteriorating in quality due to growth of micro-organisms including algae (see Case study 8.6).

Extraction – Water may be extracted from boreholes (wells) subject to local regulations. Water extracted from lakes, ponds or rivers is likely to contain suspended solids which may block pumps and nozzles. It may also be nutrient rich leading to quality deterioration and anaerobic conditions as it is likely to contain significant microbiological contamination, some of which may be harmful such as *Legionella* or *Leptospirosis*. Consideration should be given to treating this water prior to use. Treatments could include filtration, UV sterilisation and aeration.

8.4.6 Travel

Travel by staff, visitors and contractors contributes to energy consumption and related pollution. This should be monitored and reduced where possible.

Use of low energy vehicles including electric or hybrid technology can reduce carbon emissions and save money. Encouraging car sharing by staff and reducing unnecessary deliveries are also beneficial. Although monitoring travel-related energy use and carbon production can be challenging, it is necessary to calculate environmental impacts. There are various tools for measuring your carbon emissions on line, for example myclimate.org

For overseas travel, especially flights, consideration could be given to carbon 'off setting' via appropriate schemes. The Eden Project offers a 'Green Travel Discount' to visitors who travel to the garden by foot, bicycle or bus rather than by car.

CASE STUDY 8.6

Sustainable Rainwater Management at the Auckland Botanic Gardens

Jack Hobbs, Auckland, New Zealand

Typically, rainwater is collected by drains and piped away to be released untreated into streams, waterways and the sea. Auckland Botanic Gardens now incorporates sustainable rainwater management wherever possible. The rainwater management includes:

- **Nursery:** Nursery rainwater (and irrigation) run-off is collected in a 30,000 litre underground tank and is pumped back through sprinklers to water the plants. The nutrients that have washed out of the potting mix are reapplied with each watering.
- **Visitor centre:** Rainwater is collected from the visitor centre roof and stored in an underground tank. It is then used to run a water feature at the entrance to the centre and to flush the toilets.
- **Children's garden:** Rainwater collected from the roof of the large shelter in the Potter Children's Garden is stored in a tank that is used for irrigation to demonstrate water re-use in education programmes.
- **Rain gardens:** Rain gardens have been established at the carpark where contaminants such as heavy metals and oil wash off vehicles. As this is at the highest point of the Auckland Botanic Gardens, the rain garden captures and treats this water before it flows into the botanic garden. The water pools for up to 24 hours in the rain garden, allowing sediment and other contaminants to settle into the soil, or be absorbed by plants. The water then slowly seeps through the growing medium and restocks ground water, with excess ground water draining into a stream.

Living roof with native plants at Auckland Botanic Gardens. (Image: Jack Hobbs)

- **Living roofs:** Living roofs act as a trap for rainwater, decreasing the rainwater volume flowing off it by up to 65% and slowing the water speed down to a trickle. The native living roof, on the Potter Children's Garden toilet block, is a trial and is testing many different native species for New Zealand roofs.
- **Riparian planting:** A large number of New Zealand's native species are planted around the lakes and along streams in the gardens. These plants continue to clean the water as well as slow the rainwater flow, reducing the risk of bank erosion. Trees also provide cooling shade, discouraging algae growth in the water.
- **Swales:** Swales are suitable for many situations where rainwater needs to be slowed and moved to be further treated. They are commonly seen alongside car parks, roads and motorways. Conditions vary from very dry to very wet, so the plants need to be hardy. One of the swales at the Auckland Botanic Gardens is used to move the rainwater from the visitor car park, paths and nursery overflow down to the sediment.
- **Permeable surfaces:** Permeable surfaces allow rainwater to flow right through them and gravel, sand and crushed shells are permeable surfaces often used for garden paths and driveways. In areas where harder more robust surfaces are needed, porous pavers can be used.
- **Rainwater tree pits:** Rainwater tree pits are designed to treat large volumes of rainwater from roads and car parks. Under light rain conditions the plants and the planting medium within the tree pit act as a biological filter to treat and slow rainwater. When heavy downpours create large volumes of rainwater, the water overflows from the planted area into underground filter chambers (beneath the green mesh cover). The filter chambers use chemical processes to remove pollutants from the water including hydrocarbons.
- **Planter boxes:** Planter boxes have also been used to treat rainwater. At the Potter Children's Garden, water flows in to two planter boxes, fed by rain falling on the roof of the Education Centre roof. A perforated pipe disperses water across the surface of the planter boxes, where it slowly seeps down through the soil mix. The boxes are completely lined so water won't seep into the ground and around building foundations. Any water that eventually flows out from a drainage pipe at the base of the planter boxes is directed through further treatments and finally to the gardens wetland area.
- **Infiltration trenching:** The use infiltration trench has also provided rainwater treatment. Water is held within the trench slowly absorbing into the surrounding soil. This re-stocks groundwater, which is beneficial to surrounding trees. Sediment and other contaminants carried in by the water settle to the bottom of the trench. The trench is 10 metres long, by 1 metre deep and is filled with small porous rocks. The infiltration trench is part of a 'treatment train', where a series of rainwater treatments are linked together.
- **Wetland area:** The wetland naturally collects surface run-off and ground seepage from the surrounding lawns and gardens. Wetlands effectively treat the collected rainwater, trapping sediment and other contaminants, and correcting the water's pH and temperature levels. Over long periods of time they also help store carbon.
- **Areas outside the botanic garden:** Pipes also deliver rainwater into the gardens from the surrounding suburb and roads. It is first collected and treated in a sediment reservoir.

CASE STUDY 8.7

Changing to non-potable water for irrigation at Adelaide Botanic Garden

Sam Phillips, Adelaide, South Australia

The Adelaide Botanic Garden in South Australia was officially opened in 1857. It occupies 51 hectares of land and is part of the South Australian government's Department of Environment, Water and Natural Resources.

Of all the Australian capital cities, Adelaide is the driest, receiving an average of 545mm of rain per year. The rainfall is unreliable, light and infrequent throughout the summer. Temperatures are high in Adelaide, and irrigation has always been important for the botanic garden's living collections, which have used the city's potable water since it was available. To address this, the Adelaide Botanic Garden created First Creek Wetland, officially opened in 2013, to replace the use of potable water for irrigation of the botanic garden with stormwater from the wetland.

First Creek Wetland at Adelaide Botanic Garden. (Image: Jake Dean)

The stormwater is collected during winter, stored in the aquifer below and then recovered for botanic garden irrigation use in summer. To achieve this, a small amount of stormwater is diverted from First Creek as it enters the botanic garden, where a pollutant trap removes litter and improves the quality of the water. In the wetland, a sedimentation pond removes the silt from the water. Plants in the main wetland pond remove heavy metals and other contaminants, cleaning the water so that it can be stored in an underground aquifer for later use. Within about eight years from its construction, the wetland is expected to be able to recover enough water to sustainably irrigate the entire Adelaide Botanic Garden. Key design features include, a sedimentation pond to limit the quantity of sediment entering the macrophyte zone which is planted with wetland plants to improve the quality of water prior to injection into the aquifer, a mechanical filtration system to further improve water quality, a storage pond to provide storage of water retrieved from the aquifer for irrigation and an irrigation pump station to deliver water into the existing irrigation network.

The First Creek Wetland also complements the Adelaide Botanic Garden's goal of connecting people with plants, and shows visitors a function of plants which they may never have considered - cleaning water. The project has been developed as an important educational facility to help the community understand the role of wetlands, especially in an urban environment. The wetland features pathways and viewing platforms, as well as educational signs to explain the aquifer system and the importance of wetlands to the 1.6 million annual visitors to Adelaide Botanic Garden, including 50,000 school students.

8.4.7 Procurement

Sustainable procurement can have huge benefits, ensuring that the suppliers of goods and services are also minimising environmental impact by reducing energy, waste and pollution. The 'full life costing' model considers energy and water efficiency, waste costs, building quality as well as the initial purchase price over a defined period. This inclusive system supports environmental sustainability.

For example, the Eden Project has an ethical procurement policy for its catering and the products it sells in its shop – *Ethical buying at Eden*. This includes purchasing locally produced goods, things that are made from plants, products that promote sustainable living, fairly traded goods and recycled products.

8.4.8 Biodiversity

The very nature of a botanic garden's business can have a positive environmental impact including increase in biodiversity and carbon sequestration via living collections, reintroductions and support to restoration projects (Chapter 7, Section 7.1.1).

Selection of plant collections – Showcasing local plants (Case study 8.8) can help encourage the community to use plants that are well adapted to the local environment with concomitant reduction in water and other inputs. In many cases this approach has resulted in whole gardens becoming devoted to the local or regional flora. For example, by using only local plants in Barossa Bushgardens Regional Native Flora Centre in Nuriootpa, South Australia, the garden is not only reducing water use, it is also helping to increase local biodiversity, as the local flora is the preferred habitat for the local fauna. This approach is seen as effectively working with the local environment and not against it (Chris Hall, pers. comm.).

Careful consideration should be applied to which exotic species are grown and, where possible, plants requiring excessive water or energy inputs, should be avoided. Transfer of such material to better suited gardens should be considered. For instance, Asian species considered to be at threat from climate change in the Royal Botanic Gardens Victoria living collection near the centre of Melbourne, South Australia, have been re-located to a higher elevation at the Dandenong Ranges Gardens east of Melbourne which is likely to be much better suited now and into the future.

8.5 EDUCATION AND COMMUNICATION

KEY MESSAGE

Visitors are increasingly expecting botanic gardens to demonstrate leadership in environmental sustainability.

There is increasing evidence that visitors are expecting conservation and education organisations, like botanic gardens, to address sustainability and related issues. Botanic gardens have a huge opportunity to engage and inspire their visitors and staff on environmental sustainability by embedding it throughout their range of activities. Not only can visitors see sustainability in operation but there are rich opportunities to showcase it in outreach projects in communities, local schools, colleges and universities (Chapter 7, Sections 7.2, 7.3, 7.4 and 7.5). There are also opportunities to link up with local businesses or industries with corporate social responsibility programmes.

8.6 CONCLUSION

Successful environmental sustainability must have 'buy in' from all levels of the botanic garden and particularly that of management. In turn, managers need to make sufficient people and financial resources available. Initially, botanic gardens may find it helpful to enlist the services of a competent environmental adviser/consultant to help establish the system and provide sound advice. As financial savings from lower energy or water use are made, managers should consider re-investing them in further environmental sustainability measures.

Good communication within the organization and to its stakeholders and visitors is essential. This needs to not only detail the organisation's commitment to environmental sustainability, but publish its annual progress and celebrate its successes.

Finally, it is important to ensure that the sustainability 'ethos' is supported by all staff, who will be crucial to its achievement. The staff team will be the force that transforms policies and our environmental rhetoric into the practical action that will deliver the model of sustainability that we all wish to achieve for our institutions.
Wyse Jackson (2009)

CASE STUDY 8.8

Growing, conserving and promoting the native flora at the Royal Botanic Garden of Jordan

Tariq Abu Taleb, Amman, Jordan

The Royal Botanic Garden (RBG) is located in Tel Al-Rumman, Jordan, about 25 km north of Amman and beside the King Talal Dam. The botanic garden was founded in 2005 as a non-government, non-profit entity. Its role is to conserve the flora and biodiversity of Jordan by propagating and displaying native plants, rehabilitating habitats, conducting research, demonstrating sustainable practices and sharing information.

Native plants are being propagated in the RBG's nursery to enable the re-creation of authentic Jordanian habitats for research, display and educational purposes. A seed bank is being developed to save the seeds of Jordan's native plants and crop wild relatives. At the RBG herbarium, dried specimens of Jordan's plants are being preserved.

Display gardens will follow specific themes while highlighting the practicality of using native dryland plants, which are best adapted to Jordan's arid climate. Five typical Jordanian habitats are being re-created on the site: deciduous oak-, pine- and juniper forests, riparian freshwater as well as Jordan Valley and Dead Sea habitats.

The RBG works closely with people in the nearby village and region. The Garden consults and cooperates with the community in its work through initiatives like the Community-Based Rangeland Rehabilitation programme and teaches best practice and sustainable living skills to pastoralists, farmers and families. As a result, local employment rates are on the rise, individual and regional capacities are being built, and the native flora is better protected. These positive effects are already measurable and sustainable.

Native plants garden, Royal Botanic Garden, Jordan. (Image: Tariq Abu Taleb)

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