



Australia's National
Science Agency

Darwin Living Lab Inaugural Science Symposium



Urban Design and Heat Mitigation in
the Tropics

12-13 December 2019. Charles Darwin University,
Waterfront Campus, Darwin



About

This report was delivered as part of the work of the Darwin Living Lab. The Darwin Living Lab was established to foster improvements in the liveability, sustainability and resilience of the city. The Darwin Living Lab is an initiative under the Darwin City Deal and is a 10-year collaboration between CSIRO and the partners of the Darwin City Deal: Australian Government, Northern Territory Government and the City of Darwin. The City Deal was signed by the Prime Minister of Australia, Chief Minister of the Northern Territory and Lord Mayor of the City of Darwin in November 2018.

More information and contacts available at: <https://research.csiro.au/darwinlivinglab/>

Acknowledgement

We acknowledge the Traditional Owners of the greater Darwin region, the Larrakia people, and recognise their culture, history and connection to this land and water. We pay our respects to their Elders past, present and emerging.

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Executive Summary

This report summarises the outcomes from the inaugural *Darwin Living Lab Science Symposium*, which was organised by CSIRO as part of the Darwin Living Lab (DLL). The Symposium was held in Darwin on the 12th and 13th of December 2019 and brought together leading experts in heat mitigation and urban design from across Australia with local knowledge experts to explore innovative opportunities to transition Darwin to a cool and liveable tropical city.

The overarching objectives for the inaugural Darwin Living Lab Science Symposium were to:

- improve understanding of opportunities to adapt experiences in urban design and heat mitigation from other cities with similar climates to Darwin
- identify the unique aspects of improved tropical design and heat mitigation in Darwin
- collaboratively explore opportunities that can be developed to achieve the vision of Darwin as a “thriving, cool capital of the north” and as an export hub for tropical knowledge on urban design.

The Symposium was structured over two days. The first day – *Science meets Practice* – linked national and global best practice in tropical urbanism with local practitioners such as planners, architects, government and council to explore integrated issues relevant to Darwin’s context and the vision for a “thriving, cool capital of the north”. The second day of the Symposium – *Darwin Living Lab Deep Dive* – allowed local stakeholders to engage in detail with the four initial DLL priority projects. The last session of the day had a future focus that enabled Symposium participants to explore their vision for Darwin and then consider how DLL activities might help achieve that vision.

The Symposium was well attended with more than 75 participants on Day 1 and more than 50 participants on Day 2. Feedback from participants indicated most thought the Symposium achieved its aim to bring local, national, and global expertise together to support knowledge development and transfer.

The presentations and discussions highlighted the potential for improving liveability outcomes in Darwin through tropical design and heat mitigation strategies. The discussions emphasised the importance of co-designed solutions emerging from the local context that reflects the values and knowledge of the Darwin community. The sessions also highlighted the considerable amount of research and adaptation measures already being conducted in Darwin to improve liveability and sustainability, which the Darwin Living Lab can build upon. The participants identified concepts and ideas that could help accelerate the transition of Darwin to a cool and liveable tropical city. The outputs highlighted the importance of innovative built environment responses to improve liveability in the wet/dry tropics, while also ensuring connection with local character and culture.

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Symposium acknowledgements

CSIRO acknowledges that the Symposium was held on the traditional lands of the Larrakia people and pay our respect to elders both past and present. We also acknowledge the contribution of the Larrakia people to the workshop, which included providing a welcome to country and insights from Larrakia Rangers on the seasonal calendar based on local knowledge.

CSIRO is grateful for the time given by all Symposium participants who made the event a success with their active and enthusiastic contributions throughout the program, which included giving presentations, and contributing local knowledge during the sessions.

Abbreviations

CSIRO – Commonwealth Scientific and Industrial Research Organisation

DLL – Darwin Living Lab

ToC – Theory of Change

1 Introduction

1.1 Background

This report summarises the outcomes from the inaugural *Darwin Living Lab Science Symposium*. The Symposium was held in Darwin on the 12th and 13th of December 2019 and brought together leading experts in heat mitigation and urban design from across Australia with local practitioners and decision makers to explore innovative opportunities to transition Darwin to a cool and liveable tropical city.

The Science Symposium was delivered by the Darwin Living Lab. The CSIRO-led Darwin Living Lab was announced as part of the Darwin City Deal and involves a 10-year collaboration with all three tiers of government in Darwin that will test and monitor new ways to improve Darwin's liveability, sustainability and resilience in the wet/dry tropics.

A key objective of the Darwin Living Lab is to support innovative, climate appropriate responses to heat mitigation and tropical urban design that informs future development in Darwin and builds local tropical city knowledge and expertise that can be exported to cities that face similar heat mitigation challenges, such as tropical cities of the Asia-Pacific region. The Inaugural Darwin Living Lab Annual Science Symposium engaged with experts, local community and practitioners to transfer knowledge developed from Living Lab activities and collaboratively identified priorities for further experimentation in heat mitigation and urban design.



Figure 1: Darwin Living Lab Symposium Day 1

1.2 Symposium Overview

The overarching objectives for the inaugural Darwin Living Lab (DLL) Science Symposium were to:

- improve understanding of the opportunities to adapt experiences in urban design and heat mitigation from other cities with similar climates to Darwin
- identify the unique aspects of improved tropical design and heat mitigation in Darwin
- collaboratively explore opportunities that could be developed to achieve the vision of Darwin as a “thriving, cool capital of the north” and as an export hub for tropical knowledge on urban design.

To meet these objectives the program for the Symposium was structured over two days (See Appendix A). The first day – *Science meets Practice* – linked national and global best practice in tropical urbanism with local practitioners such as planners, architects, government and council, which allowed participants to explore integrated issues relevant to Darwin’s context and the vision for a “thriving, cool capital of the north”. It featured technical presentations and facilitated discussions that encouraged cross-disciplinary learning on how examples of tropical urbanism from other cities might be adapted to Darwin’s context.

The second day of the Symposium – *Darwin Living Lab Deep Dive* – allowed local stakeholders to engage in detail with the four initial DLL priority projects. This included providing insights on how projects could be shaped to better use local knowledge and expertise, while identifying innovative approaches to transition Darwin to a cool tropical city. The last session of the day had a future focus that enabled Symposium participants to explore their vision for Darwin and then consider how DLL activities might help achieve that vision.

2 Science meets Practice (Day 1)

2.1 Introducing the Darwin Living Lab

Session Synopsis

The first session started with a presentation by CSIRO's Darwin Living Lab Coordinator Nerida Horner to introduce the DLL. The presentation provided background on the DLL and the objectives that are intended to be achieved over the 10-year life of the Lab. The presentation provided more details to participants on the partners involved in the DLL, how activities will be managed, the initial projects and how people can get involved.

CSIRO Director of the Urban Living Lab projects Dr Tim Muster followed with a presentation that went deeper into the science of urban living labs and why they are an appropriate way to enable collaboration to address the complex challenges in our cities.

Duncan Challen from Celestino presented on the urban living lab at the Sydney Science Park. This illustrated how an urban living lab is being used to trial new innovations that can support the vision for creating a new urban centre that attracts knowledge-based jobs and a science education hub, while providing liveability and lifestyle for residents.

In the final presentation, Tracey Duldig from the Northern Territory Government and Cindy Robson from City of Darwin jointly presented on the development of the *Darwin Heat Mitigation Strategy*. The heat mitigation strategy is being developed collaboratively as part of the Darwin City Deal with input from CSIRO scientists through the DLL. Tracey and Cindy highlighted the context for the *Darwin Heat Mitigation Strategy*, progress to date and next steps.

Reflections

This session highlighted the theory of urban living labs and how this would be applied in Darwin. The initial presentations detailed the conceptual framework and co-design principles that underpin urban living labs, and specifically how this will be applied in Darwin. The Sydney Science Park and *Darwin Heat Mitigation Strategy* presentations provided examples of stakeholders working collaboratively explore innovative approaches to improve liveability outcomes in cities.

2.2 Theme 1 – Darwin Urban Heat and Heat Island Effects

Session Synopsis

This session explored Darwin's climatology and the role that changing climate would have on urban heat and liveability in Darwin city and its surrounds. This session heard from a range of researchers and practitioners that examined climate impacts and solutions at different scales, representing a range of stakeholders interested in creating a cooler and more resilient Darwin.

The session started with a keynote talk from world leading scientist in urban climatology and heat island effects, Professor Mat Santamouris, from the University of New South Wales. He presented data gathered in Darwin City from 2017 and how it extended to a new heat mitigation pilot project on Cavenagh Street in collaboration with the Northern Territory Government.

At the larger landscape scale, CSIRO researcher Jacqui Meyers presented heat maps of Darwin and the surrounds. The heat maps were combined with social data collected from the Australian Bureau of Statistics (ABS) to identify vulnerable areas that could be considered priority areas for heat mitigation interventions.

Rob Grinsell from the City of Darwin focussed on adaptation and introduced participants to footage of previous extreme climate events while speaking about the adaptation needed to maintain assets and infrastructure for future climates. Rob highlighted how the City of Darwin responded to the tree loss from Tropical Cyclone Marcus, which has included a project to classify the resilience of different tree species to tropical cyclones.

CSIRO resource economist Dr Sorada Tapsuwan spoke about valuing green space and trees, taking previous work from Canberra, and considering how similar methodologies could be conducted to value the trees of Darwin as an asset.

This session was concluded with an example of street trees as an adaptive cooling strategy from Tony Cox at Clouston Associates. Tony used Garramilla Boulevard as an example of how the strategic development of street trees on this road could produce a green boulevard into the Darwin Central Business District (CBD).

Reflections

This session revealed the large extent of research and adaptation measures already being conducted in Darwin, and how it could be used in the future to increase the liveability and sustainability of Darwin. Darwin climates are expected to continue to experience high heat and monsoonal rain, but a strategic focus on how and where to green the city to bring about the maximum cooling is a major concern.

Continual work across research communities and stakeholders will be necessary to determine where future pilot projects should occur as part of the Darwin Living Lab. A challenge posed to the panel was that in many cases the technical approaches to mitigating heat are well understood but the task for the Darwin Living Lab is to bring these approaches, such as the use of green infrastructure, into mainstream practice. Panellists' responses highlighted the following:

- The importance of a strong regulatory framework in creating the environment for more widespread adoption of heat mitigation strategies.
- The value of demonstration projects in developing understanding and engagement in novel approaches across all stakeholders, including the local community.
- The need to identify how market forces can be used to encourage more urban greening and the use of passive cooling approaches for improving thermal comfort in buildings.

There was also a discussion around how adapting to heat stress in Darwin needs to go beyond the design approaches to buildings and public open space by also considering behavioural responses.

The example was given that standards for business attire should reflect the local climate, rather than what would be the norm in other Australian capital cities. It was also raised that the norm for thermal comfort temperature for buildings in Darwin should be at the upper end of the acceptable range – around 28° C.

Continual work across research communities and stakeholders will be necessary to determine where the next projects will occur for the Darwin Living Lab that will demonstrate different approaches to mitigating urban heat island effects in Darwin.

2.3 Theme 2 – Building Resilience to Climate and Future Change

Session Synopsis

The keynote address for this session was from Guy Barnett, who coordinates CSIRO's Future Cities initiative. Guy put forward the case for a new research approach in cities to address some of the complex challenges that are likely to be faced in the future. Guy's presentation highlighted how cities can be viewed as complex adaptive systems, and some of the global research initiatives being undertaken to develop resilience to future challenges in cities around the world. Guy concluded by highlighting five key lessons for Darwin from these global experiences that can inform Darwin Living Lab activities, which were:

1. *Context is critical* – solutions need to be tailored to the specific context
2. *Focus on integration* – need to work across spatial/administrative scales and sectors
3. *Strong engagement* – ensure involvement and insights from the broad range of interest groups that make up cities
4. *Measure change* – there is an explosion of available urban data but need to focus on essential indicators that can help to measure change processes across cities
5. *Scaling for impact* – use demonstrations to explore innovations that can have broader impact on sustainability and share lessons learnt.

Jude Scott from the Darwin office of the Bureau of Meteorology gave a presentation on Darwin's climate. Jude highlighted the seasonal influences on thermal comfort in Darwin, which noted the importance of dew point. Jude presented on projected climate change impacts, which emphasised the future challenge in managing thermal comfort and heat stress risks in Darwin when periods of extreme heat are likely to become more frequent.

Larrakia rangers, including Jess Puntoriero, provided an overview of how the local knowledge of the Larrakia people, the traditional owners of the Darwin region, has been used to develop a seasonal calendar. This seasonal calendar reflects their deep cultural connection with the land and sea.

The final presentation from this session was from Yeong Zee Kin from Singapore. His presentation highlighted the ethical opportunities and challenges of using artificial intelligence to improve decision-making based on the Singapore experience with consideration of the potential implications for Darwin.

Reflections

This session revealed how lessons learnt in other contexts can help inform Darwin Living Lab activities, but that the solutions will need to emerge from the local context, values and knowledge of the Darwin community. In particular, the presentation from the Larrakia rangers highlighted the value of combining tacit local knowledge with scientific expertise to understand complex phenomena such as climate seasonality in Darwin. Points made during the panel discussion:

- The value of learning from history around how to cool the city and adapt behaviour to cope with heat stress. This included exploring the potential applicability of approaches prevalent in tropical architectural prior to the availability of mechanical cooling.
- Examples were given of how traditional knowledge from Indigenous communities is being applied to adapt to a changing climate both in Australia and overseas.
- It was also raised that biomimicry can be used in tropical architecture, where the adaption responses of species to local climate conditions is used to inspire architectural responses in the built environment.

2.4 Theme 3 – Tropical Urban Design for the Future

Session Synopsis

TPG Architects' Roger Mainwood delivered the keynote address in this session, highlighting their experience in developing best practice approaches to tropical urbanism in Cairns that caters for heat mitigation and sustainable water use. The presentation highlighted how guidelines for tropical urbanism in Cairns have been developed by practising architects and local government planners effectively collaborating with academics and students from James Cook University's Tropical Urbanism and Design Lab. This enabled the development of effective design responses for Cairns' climate and character that can be embedded in practice, such as the Cairns City Centre Masterplan.

Stephen Cook from the CSIRO DLL project team presented on the Your Tropical City online resource and knowledge hub. Stephen explained how the website is being designed and developed to provide a knowledge hub on tropical design in Darwin, in collaboration with local partners and experts. The website will feature approaches to improve liveability and thermal comfort in Darwin's tropical climate that is suitable for different audiences (Darwin community, planners and decision makers and researchers). The presentation noted that the online resource will evolve over the life of the DLL, as data and other research outputs are developed.

Jethro Laidlaw from Power and Water Corporation provided an overview of the Darwin Weather Web and opportunities for more efficient garden and landscape irrigation. Darwin has the highest per capita water use when compared to other capital cities, which is mainly due to watering gardens and landscape, particularly during the dry season. The *Darwin Weather Web* is a network of weather stations installed in schools around the Darwin region.

In the final presentation of the session, Jo Cruikshank from the Northern Territory Government's Department of Infrastructure, Planning and Logistics provided an overview for increased adoption of active transport in Darwin. Jo highlighted the benefits of increased walking and cycling as a

means of getting around and the natural advantages that Darwin has in active transport, which includes short travel distances, little traffic congestion and warm weather.



Figure 2: Panel discussion of presenters from Theme 3

Reflections

This session highlighted how policy and practice can be used to embed a local understanding of tropical urban design. The keynote address from Roger emphasised the importance of collaboration across government agencies and researchers to explore approaches to improved tropical design that reflects the local climate and character. The keynote was supported by other presentations that provided examples where collaborative partnerships in design and planning are reflected through implementation such as web-based information on sustainable initiatives including monitoring water use and active transport.

The panel discussion following the presentations highlighted the following:

- The recent rise of e-mobility, such as electric bikes and scooters, has the potential to increase the uptake of active transport. E-mobility might increase active transport uptake across a wider range of people in the community, while also increasing the potential distance that can be covered easily. However, it was raised that e-mobility raises the potential for conflict with walkers and pedal cyclists on shared pathways, which will need to be considered as this transport technology becomes more common.
- In Darwin water conservation is focussed on encouraging behavioural change to reduce water use rather than water restrictions. Although restrictions can be triggered if water storages fall to critical levels. The Weather Web as part of the Living Water Smart program

helps to provide the information to householders that can inform decisions on efficient water use.

3 Project Deep Dives and Future Focus (Day 2)

3.1 Overview

The second day of the Symposium began with a series of participatory deep dives on the initial series of projects for the DLL. The deep dives were designed to elicit local knowledge and values from participants to ensure that the projects are aligned with local needs and appropriate to the Darwin context.

The session then focussed on the future, with a series of exercises to explore participants' vision for a future Darwin and how the vision could be achieved.

3.2 Project Deep Dives

Darwin Heat Mitigation Strategy

The first deep dive workshop of the day, attended by about 45 participants, involved a conversation mapping exercise to develop the strategies and actions for heat mitigation in Darwin. The participants split into five groups – one for each heat mitigating strategy – and rotated around all five tables throughout the workshop period. The strategies that provided the starting point for conversations at each table were:

- Cool roads and paths
- Vegetation
- Education and awareness
- Cool buildings
- Water features

The conversation mapping process allowed participants to build upon each other's ideas and to identify and refine potential projects for the future as they moved around the tables. Some participants preferred to work silently while others collaboratively developed ideas.

Once all participants had visited all five tables, they were able to roam across the various conversation maps to read through the different ideas. They were then asked to vote (using check marks as a sign of support) for the ideas that they felt were most important for Darwin to trial. These project ideas will be considered in the development of the *Darwin Heat Mitigation Strategy*.

An example conversation map and its main points are summarised in Figure 1. (Please see the report "Developing a *Darwin Heat Mitigation Strategy*" for further information on the other strategies.)



Figure 3: Example of workshop conversation map - urban green infrastructure/vegetation

Summary of the Urban Green Vegetation and Infrastructure Breakout Table

The discussion around urban green space and vegetation centred on where green space is needed and what type of green space people wanted.

A strong theme was for green space to be developed within Darwin that takes advantage and showcases the native vegetation and biodiversity. This expanded into ideas of how to encourage the use of bush tucker in green spaces, especially in urban farming systems. The ideas that were generated included:

- considering Darwin’s unique ecosystem and biodiversity when designing complex green space
- increasing the education and knowledge sharing around how to protect and expand native vegetation across the city
- providing educational opportunities for people to engage with native plants – this can include in nature spaces, but also native foods and bush tucker
- consider farming the city and linking the greening with food initiatives – urban orchards and gardens.

Themes of greening the road corridors were a major conversation point in the maps. Participants were very supportive of trees within transport corridors, suggesting two specific areas:

- greening the road corridor from the airport to Darwin CBD
- creating vegetated road medians especially in residential streets.

There was a discussion about greening in buildings and ideas such as balcony gardens and growing trees indoors were encouraged. Although people like the idea of green roofs and green facades, they also recognise they may be expensive and difficult to maintain.

Your Tropical City – Urban Design Knowledge Hub

A project deep dive session was held for the *Your Tropical City* website. *Your Tropical City* will be an online resource that is being developed to highlight opportunities for tropical design that is responsive to Darwin’s character and climate. The website will provide information on tropical design in Darwin through fact sheets on key topics, case studies on best practice and links to other useful material.

Collaboration between partners will greatly enhance the success of *Your Tropical City*. To achieve this the focus of the deep dive was to draw on the collective knowledge and expertise in the room to identify the type of content that should be prepared for the website to ensure broad ownership, acceptance and utility of the resource to inform tropical design in Darwin. The session posed three questions to participants:

1. Existing information – What information is currently available that could be communicated through the *Your Tropical City* website for Darwin?
2. Gaps – What are the gaps in information and knowledge on tropical design in Darwin that could be addressed through the *Your Tropical City* website?
3. Vision – What is your vision for the *Your Tropical City* website?

Each of these questions was recorded on a whiteboard where participants were invited by the facilitator to share their thoughts by writing on sticky notes placed on the whiteboard. Other participants could endorse the comment by adding a tick or expand on the comment by adding an adjacent sticky note. The 45 participants initially self-selected to one of the questions and were asked to change questions every 15 minutes. Figure 4 provides an example of the output from the deep dive, which collates the participants’ vision for *Your Tropical City* in a mind-map format.

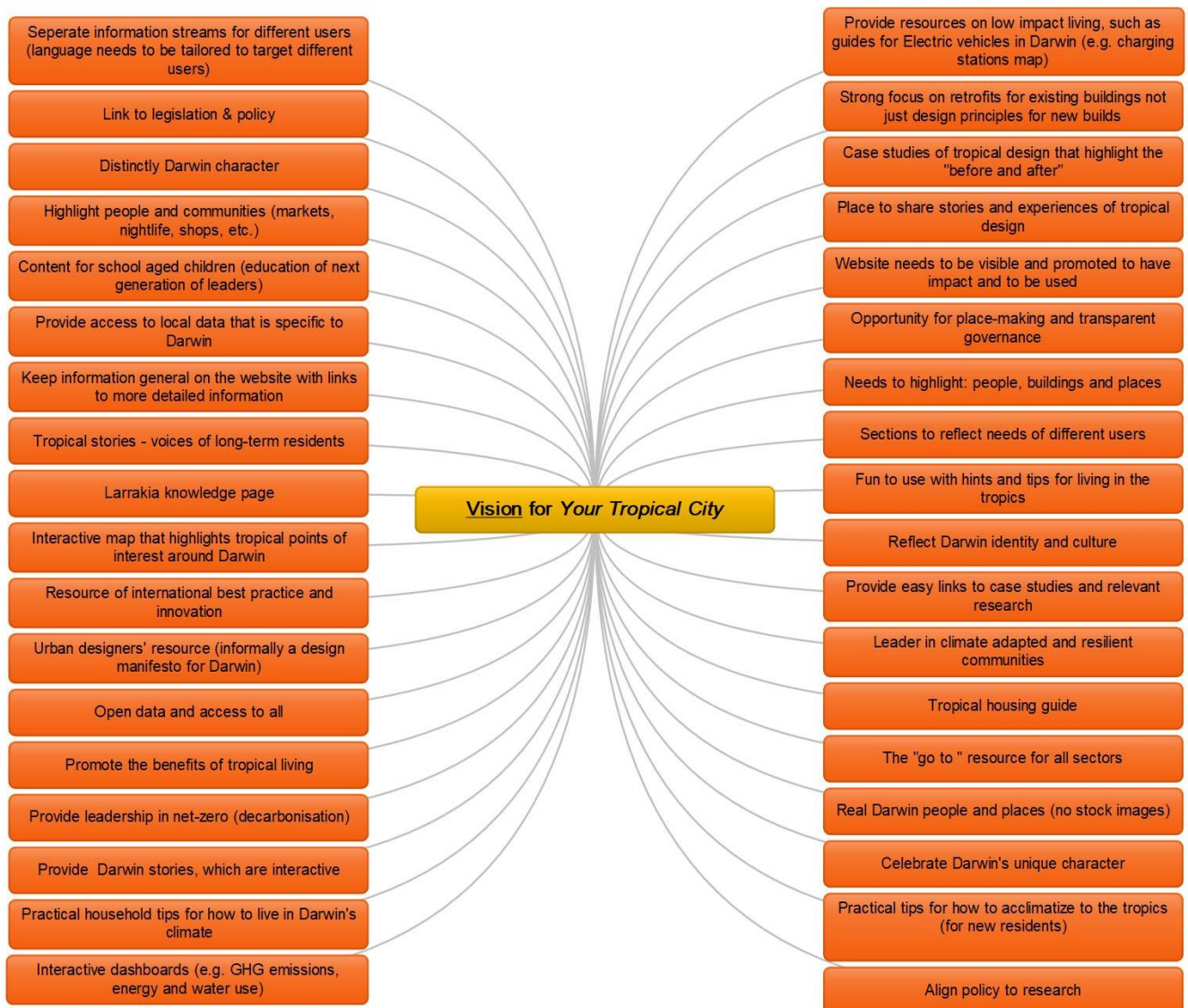


Figure 4: Mind map - Vision for Your Tropical City

Your Tropical City Deep Dive – Reflections

The deep dive identified many of the existing knowledge bases and Darwin expertise for *Your Tropical City* website can build on. Specific opportunities identified included:

- *Cool Mob's* sustainable tropical design guide
- visualising existing data sets on water and energy demand
- review tropical design guidelines and heat mitigation strategies from cities with similar climates
- use expertise from community groups, would need to consider how to moderate content for accuracy.

Participants identified current gaps in the Darwin knowledge base about tropical design and heat mitigation that *Your Tropical City* could help address, which included:

- local case studies of best practice

- hub for community collaboration and knowledge exchange
- provide evidence base to support policy development
- provide resources that are inclusive of all in the Darwin community.

A common theme that emerged strongly in participants' vision for *Your Tropical City* website was the value of including Aboriginal and Torres Strait Islander peoples' knowledge, particularly Larrakia people. Participants highlighted the importance of the website reflecting Darwin character by ensuring that local knowledge and expertise is prominent.

3.3 Overview

The first day began with a session on urban living labs by introducing the framework and principles that guide how urban living labs are implemented. The purpose was to highlight how urban living labs are well suited to addressing complex challenges in cities, such as heat mitigation and climate adaptation. The sessions for Day 1 were organised in themes where presentations and facilitated panel discussions explored change processes. The discussions during these sessions were designed to create a foundation for collaborative discussions on Day 2, where the implications and future focus areas were considered for the Darwin Living Lab.

Tracking Darwin – Monitoring and evaluating change and impact

In the third deep dive session CSIRO shared the draft *Tracking and Learning from Change* framework with attendees and invited them to contribute to two components:

- the working Theory of Change (ToC) for the DLL
- the proposed indicators to use to track changes in Darwin over time.

A3 copies of the ToC diagram were located on seven tables in the room and people were asked to add additional elements they thought were needed by writing on the diagram directly or on sticky notes to attach to the diagram.

Each table were provided with a list of the indicators for tracking changes in Darwin overall, what we hoped to learn from tracking those indicators and a third column for people to share their knowledge of what data already exists and who collects/owns it.

(Please see the report "*Tracking and Learning for Change in Darwin*" for further information on the draft *Tracking Darwin* framework.)

An example of the ToC feedback provided from one group is shown in the figure below.

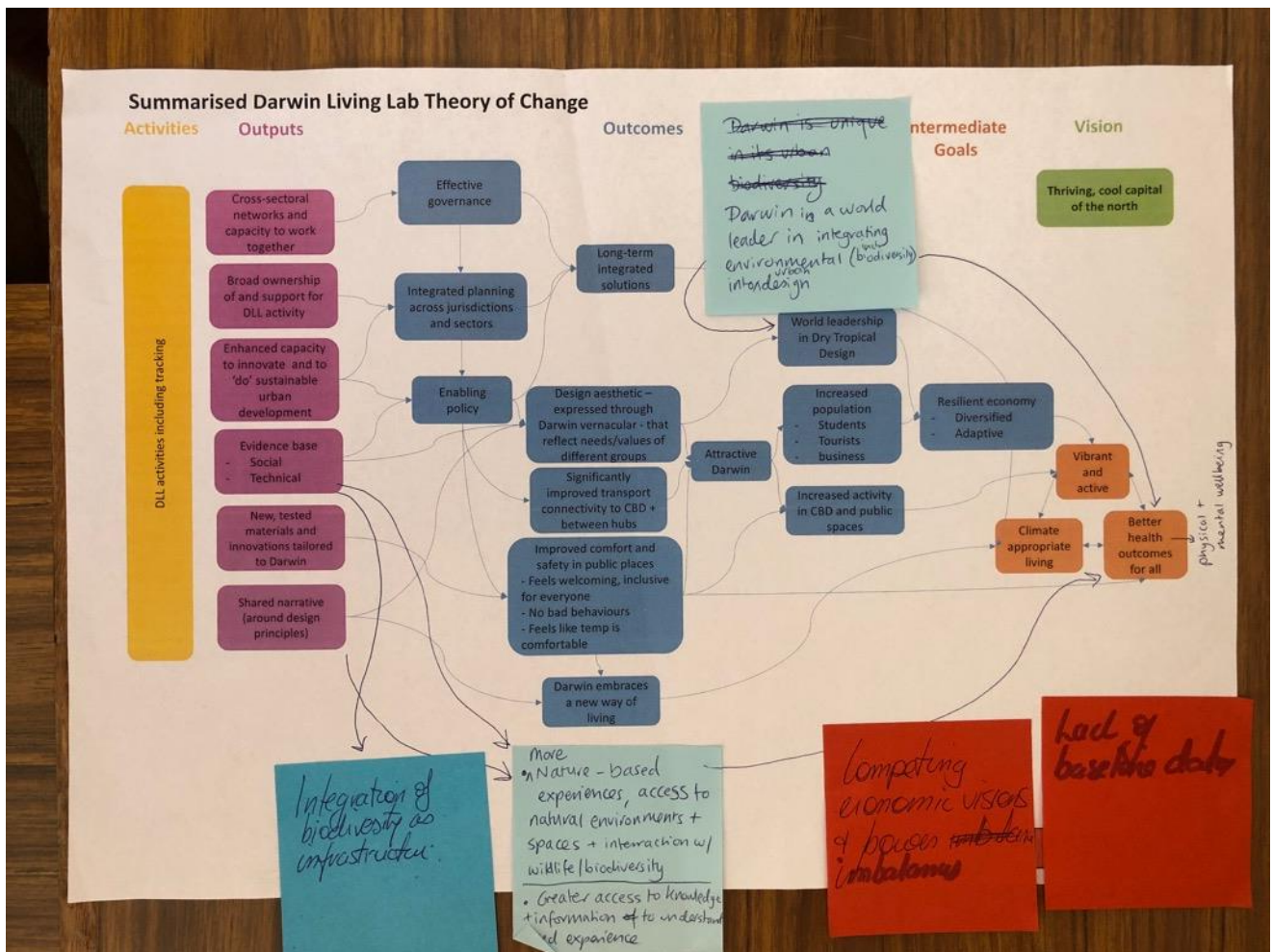


Figure 5: Example of workshop feedback on Theory of Change

Inputs to the ToC will be consolidated and once the Darwin Living Lab has been operating for a period, the ToC will be reviewed and updated to reflect what has been learned. The feedback will help identify future project options for the DLL.

Specific themes included:

- Involving and addressing a diversity of voices and needs, particularly Indigenous perspectives.
- Improving cooperation between all stakeholders.
- Openness to diverse ideas.
- Integrating biodiversity considerations into infrastructure for heat mitigation, such as increased tree canopy, which can provide a connection to nature in the City.
- The need for baseline measurements to determine the current state of indicators.

The feedback on indicators mostly validated what had been proposed, with the suggestion of adding a measure of water quality. The session revealed many useful suggestions for data sources that could be used in reporting on the indicators. The feedback highlighted a gap with data sources and measures relating to Darwin's economic resilience, which is currently being explored by CSIRO.

3.4 Future focus

3.4.1 'A Day in the Life'

During a session facilitated by Founder and Director of Village Well Gilbert Rouchecoste, participants were asked to consider what a 'day in the life' would look like when living in a future 'Thriving and Cool Darwin in the Year 2030'. Participants considered what their vision was, what 'rituals' would take place and what would be the 'great things' about Darwin. Figure 6 is an example that provides a snapshot of the type of information collected from participants on their vision for a future Darwin.

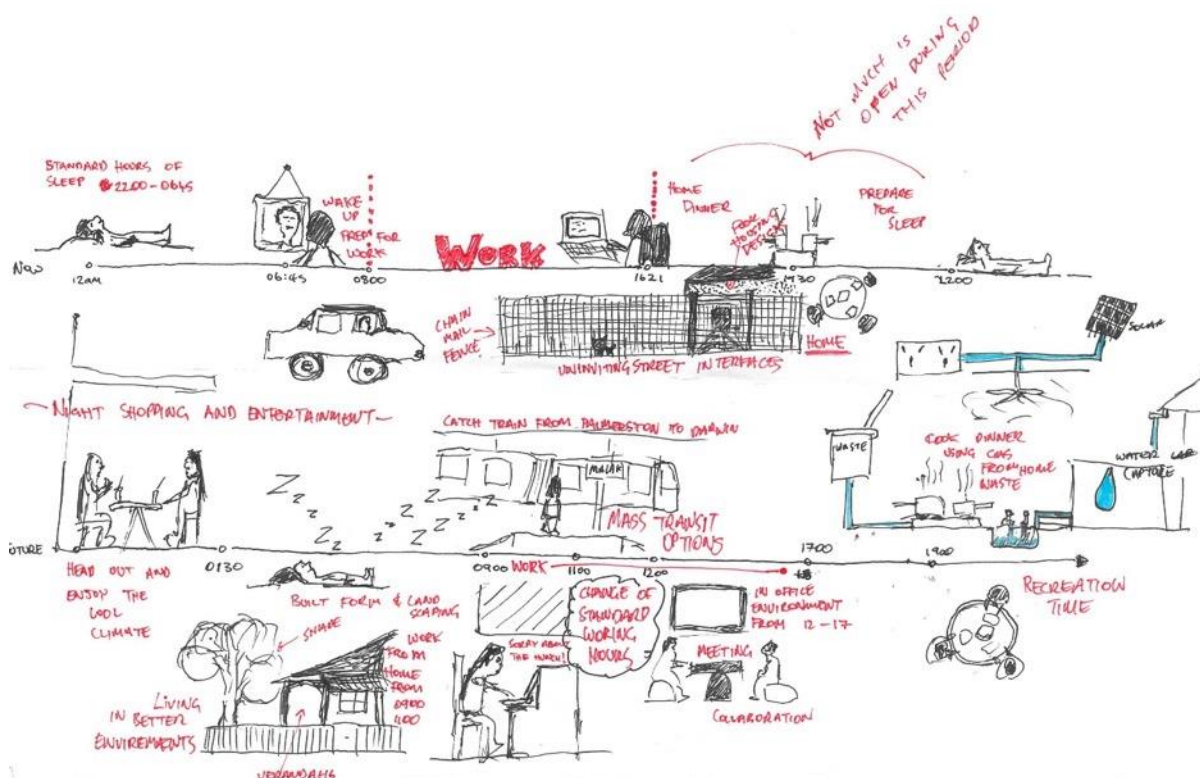


Figure 6. Example image from an attendee's 'day in the life' describing altered work hours, mass transit and renewable energy.

During the session, three key starting points for narratives appeared to dominate participants vision for the future:

- **Culture:** developing a Darwin culture beyond crocodiles and World War II that embraces a highly multicultural and inclusive way of living that celebrates local foods and drinks, marketplaces, Larrakia culture, Vietnamese Iced Coffee and being able to eat local fruit picked from street trees. The streets become safer and friendlier and many 'crimsafe' features are being removed. Business norms allow more climate appropriate dress codes, such as shorts and sarongs, and altered work hours that embrace siestas. It's okay to sweat on the way to work! Darwin lit up with LED lights is dynamic in the cool of the night – it develops a vibrant trading culture, is quirky and fun.
- **Sustainable Darwin:** focuses on reducing emissions and embracing the digital age and new technologies to allow movement across the city. There is decreased waste and an increase

in renewable energy generation, including solar and biogas. The Darwin CBD embraces active transport and there is substantial uptake of electric scooters and cars, renewed free mass transport between major centres such as Palmerston and Darwin, and a new hovercraft link between Darwin and Mandorah on the Cox Peninsula.

- **Cool Green Darwin:** satellite images from above show a forest of green canopy covering the city, providing abundant shade to allow for active movement through the city and increased biodiversity and wildlife. Most people start and finish their days outdoors, socialising with others, enjoying the nature within the city. We live in passively cooled buildings and are happy with a temperature setpoint of 27°C, we walk in shaded streets, trade locally, and have an evening toast to the 'best city in the world'.



Figure 7: Break-out groups at Symposium

3.4.2 Future ideas and connecting vision to action

The final session of the symposium asked participants to stretch their thinking to consider the possible future where Darwin would achieve the vision of a cool and thriving capital of the north. Figure 8 provides an overview of some of the ideas for Darwin that could help move the city towards this vision and highlights the main themes that emerged during the session. Greening and tropical design ideas were prominent, as was to be expected given the focus of the symposium, but ideas for increasing the vibrancy of Darwin through cultural events and public art were also identified. Participants commonly identified ideas for increasing the number of trips by sustainable transport modes, such as walking and cycling. Figure 9 highlights actions to help achieve the vision for Darwin.



Figure 8: 'Cool and crazy' ideas for Darwin

Taking action on sustainability	Bespoke places, markets and food	Community involvement and acceptance	Whacky Cooling	Celebrating Indigenous and other cultures	Working across silos
<ul style="list-style-type: none"> A multicultural wellness centre Market and educate: know what is used, how used, and only use what is needed Water+energy+food+waste Better recycling options and facilities Better or free carbon-free public transport, and shared rides, incentives and policies Renewable energy from solar and tidal Knowledge sharing for innovation Improve diet and increase plant-based Increase use of solar-powered ferries vs cars Water efficiencies, i.e. water basin over toilet and more 'green' plumbers Education of trades to be more efficient at every stage Include in school curriculum as essential (not elective) Use thin film solar panels Reduce and closed cycle initiatives 	<ul style="list-style-type: none"> Long table dinners for public/neighbourhoods Circular economy - local waste streams 24 hr markets (e.g. 24 Laksa gyro bowl) Pop-up street parties Food van culture Urban farms An eating within 50 km experience (locally grown, e.g. restaurant or market stall or community dinner or festival) Themed clusters: food, plant, activities focussed around cultures Spaced for wet season/all season markets and other activities More verge/community/kitchen gardens Extend the idea of reusable container beyond markets 	<ul style="list-style-type: none"> Build on existing community activities and cultural events Celebrate our differences Engage diversity of community members Who benefits as a guiding principle. Focus on benefit sharing and benefit mapping - keeping it local Integrating the ease of volunteering Quality education to create buy-in and understanding of future issues Build cross-institutional partnerships for youth and other engagement (e.g. Uni, City of Darwin, Landcare etc.) Enabling connections across age and culture - creating new norms such as water consumption Get rid of "us" and "them", we are all in this together Prioritising the resourcing to address social inequity, developing an understanding of root causes and problems Community connectedness (youth engagement and supporting families, reducing isolation for ill and elderly, engage with disability sector) 	<ul style="list-style-type: none"> Compressed air being released as a chiller (heat exchange) QANAT - sloping movement of water and solar PV Outdoor installations of "Big Fans" in public space Retrofit to new energy efficiency ratings Superinsulation developed - ultrathin Peltier electrothermal cladding (solar powered) make from NT silicon Vacuum insulation (walls and windows) Natural properties of water with expansion/contraction and density effects (thermal gradients in thermally-stratified lakes) Thermo-syphoning of warm water (useful energy storage similar to pumped hydro) Insulation properties of ice Ice caves used for pubs and restaurants Dew point mitigation through vertical movement of air (induce cumulonimbus) during build up season Capturing condensate from HVAC to distribute heat (internal precipitation) 	<ul style="list-style-type: none"> Public art Design Showcase of bush food and art More defined cultural precincts More flexible governance (early engagement and involvement at the start - reflect on Indigenous values and the way things are done) Co-production of knowledge Integrate into education system Celebrating and educating Indigenous seasons and foods Create the community spaces for meeting 	<ul style="list-style-type: none"> Bridge silos by valuing community and bringing business, government depts together through a shared goal DLL to help bridge silos through projects, workshops etc. Consistency of employment by public servants (good careers and supportive work environment) Strengthen what already works in collaboration Public servants to serve the people Overarching strategy through Fed Gov and City Deal, that coordinates and drives change, and provides \$\$\$ that are impact-focussed Connecting decisions, actions at different scales/levels More from talk to action Making information/knowledge available and share-able Town teams lead by women Government commitment beyond roads and water

Figure 9: Connecting vision with actions

4 Symposium evaluation and lessons learnt

4.1 Introduction

This section of the report reflects on the Symposium as a whole, what worked, what could be improved and what lessons can be learnt for future symposiums. This evaluation is made up of contributions from 16 symposium participants via an online survey voluntarily completed shortly after the Symposium, as well as additional reflections from the CSIRO team.

The symposium had 75 people participants on the first day and about 50 on the deep dive second day. In addition to project partners there was good representation from local government and the private sector, as well as private individuals and community groups.

4.2 Verdict

Overall most of the respondents considered the Symposium achieved its aim to bring local, national, and global expertise together to support knowledge development and transfer. Individuals felt the event was well run with a diverse range of participants and a good variety of speakers, and particularly appreciated getting to meet new people while learning about positive and exciting new topics and projects.

Most of the respondents indicated that their knowledge and awareness of the challenges and opportunities for Darwin issues grew as a result of participating in the Symposium. People felt the Symposium inspired hope for the future with a greater understanding of what the Darwin Living Lab aims to achieve, what work is already underway and how others can contribute.

Several respondents commented that they appreciated the effort that had been made to tailor the symposium sessions and associated materials to the Darwin context.

Other highlights identified by participants included:

- the short scene setting presentations on Day 1 that covered a wide variety of material, followed by a more interactive deep dive on Day 2, which helped build understanding and ownership of what the Lab is doing
- providing relevant science and economics on climate, urban heat and mitigation strategies to policymakers and stakeholders that will be used to inform decision making processes
- opportunities to learn about different but potentially connected issues, not just from the presenters but from others by sharing thoughts at the workshop tables
- networking opportunities, especially for local people.

Those that felt the Symposium only partially met its objectives suggested that while the event had brought together a great selection of people across industry and government, they recommended a greater diversity of participants is needed in the future. Other suggestions and lessons for future symposiums are outlined by theme below.

4.2.1 Symposium design

There is a strong desire to have the next Symposium articulate a clearer aim, with each future symposium exploring a theme. It was felt that the Program for the 2019 Symposium schedule was too busy for the time available. However, rather than having a smaller symposium, respondents suggested they wanted to expand the scope with a bigger venue, more speakers over more days. By having a more substantial symposium, respondents suggested that they would hope that there would be more opportunity for engagement, including a mix of presentations and workshop

sessions each day, as well as additional opportunities for insights into government strategies and issues.

4.2.2 Invited guests and speakers

While respondents enjoyed the mix of speakers, some suggested that the symposium could be improved by having a better and more tailored mix of speakers. There was a request for more local and national speakers, as well as more international speakers, such as subject matter experts from similar climatic zones. In line with this some people felt there had been too much focus on interstate examples, which were not relevant for Darwin.

By having more speakers over a longer time, respondents felt that there would be more opportunity for discussing collaborations and sharing Darwin appropriate lessons, including what had been tried before that did not work.

4.2.3 Diversity of participants

Over half of respondents suggested that they would like to see a wider mix of participants, which aligns with the intention of the DLL to be more inclusive. People mentioned they would like to see more members of the community and industry participate, especially design professionals, horticulture and other outdoor workers. People also wanted to see greater representation from government, particularly senior local government and Northern Territory Government staff.

It was noted that greater representation from Indigenous people was vital for moving forward. However, it was suggested that the Symposium may not be the most effective way to engage with the Larrakia people and CSIRO should ask how they want to provide their input into the DLL.

One way suggested to increase the diversity of participants would be for the Symposium to offer scholarships or discounted tickets for particular groups, such as students or other under-represented groups.

4.2.4 Symposium advertising, communication and materials

Symposium participants felt there were people missing who should have been encouraged to attend the event. Several suggestions were made about how to increase participation in future symposiums, particularly for under-represented groups as discussed earlier.

Overall, it was felt that the Symposium could have been advertised more widely over a longer lead time. Advertising in a myriad of ways, including engaging with the media early given their interest in the 2019 Symposium, would raise awareness of the Symposium and improve accessibility through planning and potential scholarships.

Following on from the Symposium, participants indicated they would like the presentation materials to be shared with them and have ways to stay engaged in the DLL.

4.3 Following on from the symposium and next steps

Respondents commented that the Symposium provided an opportunity for a diverse range of participants to interact and to discover work being completed locally, nationally and internationally. People felt barriers were broken down and that it was a comfortable environment in which to share.

Most respondents said they met people who they would follow up with and suggested they had already organised to re-connect with some new connections.

Respondents felt that having CSIRO run the 10-year program fostered confidence, and that the Symposium helped establish and strengthen connections between CSIRO and local stakeholders, especially local and Territory governments. Although it was noted that the DLL would need to

demonstrate influence on policies and activities in Darwin by the next Symposium to maintain confidence.



Figure 10: Break-out table discussion

Appendix A – Symposium Agenda

Urban Design and Heat Mitigation in the Tropics

Inaugural Science Symposium hosted by the Darwin Living Lab

Venue: Charles Darwin University, Waterfront Campus, Darwin.

Day 1 - Science Day

Time	Title	Presenter
8:15	Registration and arrival tea and coffee	
8:30	Welcome to Country	Larrakia Nation
8:40	Official Opening The Hon. Eva Lawler, Minister for Environment and Natural Resources; Minister for Infrastructure, Planning and Logistics; Minister for Climate Change Hon. Kon Vatskalis, Lord Mayor, City of Darwin	
8:55	Welcome	Chris Chilcott, CSIRO
An Introduction to the Darwin Living Lab		Chair: Nerida Horner, CSIRO
9:00	The Darwin Living Lab. Science and collaboration supporting the Liveability, Sustainability and Resilience of our city.	Nerida Horner, CSIRO
9:10	The science of CSIRO Urban Living Labs, pushing the boundaries	Dr Tim Muster, CSIRO
9:20	Keynote: Sydney Science Park CSIRO Urban Living Lab	Duncan Challen, Celestino
9:40	Developing a Darwin Heat Mitigation Strategy	Tracey Duldig, NT Government Cindy Robson, City of Darwin and Dr Brenda Lin, CSIRO
10:00	MORNING TEA BREAK	30 mins


Theme 1 – Darwin Urban Heat and Heat Island Effects		Chair: Brenda Lin, CSIRO
10:30	Keynote: Global efforts to reduce urban heat and emerging technologies. Summary of Darwin initial work.	Prof. Mat Santamouris, UNSW
10:50	Land surface temperature and heat vulnerability in Darwin	Jacqui Meyers, CSIRO
11:05	Darwin Urban Greening Initiatives	Ron Grinsell, City of Darwin
11:20	Valuing the benefits of urban trees and green space	Dr Sorada Tapsuwan, CSIRO
11:35	Garramilla Boulevard – How water and heat was factored into the green design	Tony Cox, Clouston Associates Landscape Architects
11:50	Interactive Panel Discussion on ways forward	Panel of the above speakers.
12:30pm	LUNCH BREAK	45 mins
Theme 2 – Building Resilience to Climate and Future Change		Chair: Seona Meharg
13:15	Keynote: Global Future Cities and resilience initiatives	Guy Barnett, CSIRO
13:35	The seasons of Darwin, current and future climate projections.	Bureau of Meteorology
13:50	Larrakia perspectives on Darwin’s climate and seasons	Larrakia Nation
14:05	Smart City – informing change through the ethical use of AI – case study of Singapore’s approach to Human-Centric AI	Josh Sattler, City of Darwin and Yeong Zee Kin, IMDA Singapore
14:25	Interactive Panel Discussion on responses to Future Change in Darwin	Panel of the above speakers
15:15	AFTERNOON BREAK	30 mins

Theme 3 – Tropical Urban Design for the Future		Chair: Guy Barnett, CSIRO
15:45	Keynote: Liveable Tropics - Cairns JCU Tropical Urbanism and Design Lab. Urban Heat – Urban water – Urban Design	4.3.1 Roger Mainwood, TPG Architects
16:05	Your Tropical City – resource and knowledge hub	Stephen Cook, CSIRO
16:20	Darwin’s Weather Web – Cool gardens using less water	Jethro Laidlaw, Power and Water Corporation
16:35	Getting around in the dry tropics - Active Transport in Darwin	Jo Cruikshank, NT Department of Infrastructure, Planning and Logistics
16:50	Interactive Panel Discussion on Darwin Dry tropical living	Panel of the above speakers
17:30	Day close	
17:30 – 19:00	Networking with refreshments and substantial canapes	Waterfront Restaurant

Day 2 - Darwin Living Lab Deep Dive: the place and projects

Time	Title	Presenter
8:15	Arrival coffee and tea	
8:30	Keynote: Climate Resilience as a Thought Leader in Regenerative Cities	Gilbert Rouchecoste, Village Well
Darwin Living Lab Project Deep Dives – interactive workshop sessions		Chair: Dr Tim Muster, CSIRO
8:50	Developing a Darwin Heat Mitigation Strategy	Dr Brenda Lin, CSIRO
9:30	Your Tropical City - Urban Design Knowledge Hub	Stephen Cook, CSIRO

10:10	Tracking Darwin - Monitoring and evaluating change and impact	Dr Rachel Williams, CSIRO
10:50	Morning Tea	20 mins
11:10	Interactive Ideation Session – future focus and exploring new approaches for Darwin	Facilitated by Gilbert Rouchecouste, Village Well
12:45	Wrap-up and next steps	Nerida Horner, CSIRO
13:00	Light lunch	
13:30	Close	



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