Australia's National
Science Agency

Darwin Living Lab Symposium 2022

Knowledge into Practice

3 August 2022

George Brown Botanic Gardens Event Centre, Darwin

Australian Government

NORTHERN TERRITORY GOVERNMENT

CITY OF 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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Cover Photo: Charlie Bliss, 2022

Executive Summary

This report summarises the outcomes from the 2022 Science Symposium for the Darwin Living Lab. The Symposium sought to disseminate knowledge accrued in the first three years of the Lab (2019-22) to ensure that local capacity is activated to explore innovative climate-appropriate responses to heat mitigation and tropical urban design that informs future development and urban renewal in Darwin.

The 2022 Symposium engaged with a diversity of local perspectives with an interest in creating a more liveable, cooler and sustainable Darwin. Participants included professionals and practitioners, peak industry representatives, community interest groups, and researchers. The themes for the Symposium were:

- **Navigating change in Darwin**: What changes to Darwin's urban fabric are occurring or being planned, what are the challenges and tensions at play, and what mechanisms are there for Darwin to change toward a cool and thriving capital city?
- **Learning from community and Indigenous ways of improving heat-related liveability:** What approaches are being used to manage personal heat stress? What approaches are being used to cool landscapes, and how can green infrastructure provide increased heat mitigation and biodiversity outcomes for the residents of Darwin?
- **Advancing energy efficiency and indoor thermal comfort in Darwin.** How can Darwin's built environment and occupant behaviour be adapted to improve indoor thermal comfort while reducing emissions associated with cooling indoor spaces?

The Symposium was well attended, with more than 85 participants attending on the day. The event registrations reached the capacity of the venue in the week prior, with feedback from participants noting that some colleagues who missed the registration cut-off would have liked to attend. Feedback from participants highlighted that the Symposium provided an excellent opportunity to network and connect with others and identify opportunities for collaboration. Participants suggested that future Symposiums could have more time for interactive sessions to allow for more detailed discussions. This approach could help progress change and develop specific collaboration opportunities to address Darwin's heat mitigation and liveability challenges.

The keynote presentations, panel discussions, and other outputs from the Symposium are available here. The presentations and discussions highlighted progress to date in delivering the vision for Darwin as a cooler and more liveable city. Making further advances towards such a vision will require sustained government leadership, collaboration across traditional Indigenous and western knowledge systems, and more industry and community engagement in co-developing innovative approaches.

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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 elder, Lorraine Williams on incorporating biodiversity knowledge and values from traditional owners in greening Darwin.

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. CSIRO would like to acknowledge the support and contributions to the Symposium from Darwin Living Lab partners: Australian Government, Northern Territory Government and the City of Darwin.

Abbreviations

CSIRO – Commonwealth Scientific and Industrial Research Organisation

DLL – Darwin Living Lab

1 Introduction

The Darwin Living Lab (the 'Lab') seeks to improve Darwin's liveability, sustainability and resilience through heat mitigation and improved urban design for the wet/dry tropics. The Lab brings together scientific expertise with local knowledge to evaluate innovations for a cooler and more sustainable Darwin. A focus of the Lab is to help engage local practitioners in sharing knowledge, while developing awareness of cooling initiatives and supporting research underway through the Darwin City Deal[1] and the Feeling Cooler in Darwin Heat Mitigation and Adaptation Strategy[2].

This report summarises outcomes from the 2022 Science Symposium for the Darwin Living Lab. The Symposium sought to disseminate knowledge accrued in the first three years of the Lab (2019-22) to ensure that local capacity is activated to explore innovative climate-appropriate responses to heat mitigation and tropical urban design that informs future development and urban renewal in Darwin.

1.1 Symposium overview

The 2022 Symposium engaged with a diversity of local perspectives interested in creating a more liveable, cooler and sustainable Darwin. Participants included professionals and practitioners, peak industry representatives, community interest groups, and researchers. Themes for the Symposium were:

- **Navigating change in Darwin**: What changes to Darwin's urban fabric are occurring or being planned, what are the challenges and tensions at play, and what mechanisms are there for Darwin to change toward a cool and thriving capital city?
- **Learning from community and Indigenous ways of improving heat-related liveability:** What approaches are being used to manage personal heat stress? What approaches are being used to cool landscapes, and how can green infrastructure provide increased heat mitigation and biodiversity outcomes for the residents of Darwin?
- **Advancing energy efficiency and indoor thermal comfort in Darwin.** How can Darwin's built environment and occupant behaviour be adapted to improve indoor thermal comfort while reducing emissions associated with cooling indoor spaces?

[1] https://www.infrastructure.gov.au/territories-regions-cities/cities/city-deals/darwin-city-deal

[2] https://research.csiro.au/darwinlivinglab/darwin-heat-mitigation-and-adaptation-strategy/

Figure 1: Smoking ceremony as part of the Welcome to Country

2 Session 1 – Welcome and introduction to Darwin Living Lab

2.1 Session Overview

The opening session for the Symposium welcomed participants and set the context for the Darwin Living Lab (the 'Lab') and the Symposium. Participants were welcomed to the traditional lands of the Larrakia people by Lynette Fejo, a Larrakia elder, who led a smoking ceremony that highlighted the ongoing connection of the Larrakia people to the lands and waters of the Darwin region. The following summarises the presentations from the opening session.

2.2 Presentations

Lorraine Williams a Larrakia elder provided a Welcome to Country that highlighted her family's connection to country and the impact of colonisation on sites of significance in the Darwin region. Lorraine illustrated how Larrakia traditional knowledge can help monitor and evaluate changes in Darwin. This includes understanding the impacts of climate change through changing seasonality of the flowering and fruiting of important plants.

The Lord Mayor of Darwin, the **Honourable Kon Vatskalis,** provided opening remarks on the importance of greening and cooling initiatives for the City of Darwin for activating Darwin. The Lord Mayor's opening remarks noted the close collaboration between City of Darwin and the Lab in delivering Greening and Climate Emergency strategies for the City of Darwin.

Tiffany Karlsson, Assistant Secretary in the Cities Division from the Department of Infrastructure, Transport, Regional Development, Communications and the Arts provided an overview of the Darwin City Deal. Tiffany's remarks highlighted progress to date on the significant City Deal projects that are helping to deliver the vision of a cooler and greener Darwin, and the role of the Lab in providing the underpinning science to monitor and evaluate outcomes.

Bridgette Bellenger, General Manager for the Department of the Chief Minister and Cabinet provided an overview of Darwin City revitalisation projects, which are helping to activate and cool the city. Bridgette's presentation highlighted the importance of these projects for supporting NT Government economic development, and the role of research to inform and evaluate projects. Bridgette acknowledged the foundation work provided by Prof. Mat Santamouris and the UNSW team on mapping out heat challenge and opportunities for Darwin.

Dr Chris Chilcott, Deputy Director in CSIRO Land and Water and the Research Leader for Northern Australian Development introduced the CSIRO-led Darwin Living Lab. Chris highlighted progress to date from the Lab. Chris concluded by noting the Symposium themes were aligned to the research agenda of the Lab and participants' input will help to inform research in coming years.

Dr Josh Byrne, Josh Byrne & Associates, provided the opening keynote address for the Symposium - **Josh's House Living Laboratory – Monitoring, Evaluating and Communicating the Journey**. Josh's presentation took participants through how he applied a living lab approach in the development of his home to showcase how sustainable living could be incorporated in volume building. A recording of Josh's presentation is available here.

Table 1: Session 1 presentations

Dr Josh Byrne on the role of Living Labs in urban innovation

Background

Dr Josh Byrne is an environmental scientist and urban design professional with a national profile as a consultant, researcher and communicator in urban sustainability. His approach is leadership through demonstration by engaging in projects that provide opportunities to test innovation, build capacity and share learnings with stakeholders and the wider community.

Josh has a long association with applied research in water sensitive design, energy efficient housing and sustainable urban development, and he looks for opportunities to test innovation, build capacity and share learnings with the wider community.

Josh is well known as the WA presenter on ABC TV's Gardening Australia program where over the past 20 years he has demonstrated how gardening can improve urban liveability to a national audience. He is a regular contributor to print and radio media, and author of three popular books on sustainable gardening and low carbon living.

Key points from presentation

- The methodology used to set up Josh's House Living Lab, including partnerships required and communication platforms to allow learning to be shared
- High performance climate responsive housing that is cost effective is available using the volume building industry
- Climate-responsive design for indoor and outdoor liveability and sustainability
- All-electric home configuration and operation.

2.3 Reflections on session

The opening presentations highlighted that the journey to deliver Darwin's vision as a cooler, more vibrant, liveable, sustainable and resilient city remains highly relevant to the Darwin Living Lab partners. To make further advances towards the vision will require sustained leadership of government, collaboration across traditional Indigenous and western knowledge systems, and regular inputs and feedback from industry and community.

Advances have been made in the areas of cooling and greening public spaces under the Darwin City Deal, and commitments within the co-developed Heat Mitigation and Adaptation Strategy will support further actions and outcomes for Darwin.

The Heat Mitigation and Adaptation Strategy emphasises the need for ‘Innovation’ and to do things differently. The Keynote presentation by Dr Josh Byrne demonstrated how innovations could be implemented in a place-based approach to allow learning and sharing of the effectiveness of new approaches and the possibility of accelerating wider uptake of successful innovations.

3 Session 2 - Navigating change in Darwin

3.1 Session overview

The Navigating change in Darwin session was chaired by Dr Sorada Tapsuwan, a Senior Research Scientist in CSIRO who specialises in environmental and natural resource economics and is an expert in the non-market valuation of environmental assets. Sorada is leading the Lab project - a Digital Twin of Darwin to monitor and navigate change.

This session explored what changes to Darwin's urban fabric are occurring or being planned, what are the challenges and tensions at play, and what mechanisms are there for Darwin to change toward a cool and thriving capital city?

3.2 Presentations

Douglas Lesh who is the Executive Director of Planning in the Department of Infrastructure, Planning and Logistics provided a keynote presentation - **Land use planning and development in a changing climate**. This presentation highlighted the role of planning instruments in responding to climate change and developing resilience in Darwin's built form. A recording of Douglas's presentation is available here.

Alice Percy, the General Manager Innovation for the City of Darwin, provided the second keynote presentation in this session – **The Future of Darwin**. Alice's presentation highlighted the City of Darwin strategies and programs that support the future vision of a cooler and more liveable Darwin and the value of collaboration in delivering these strategies. A recording of Alice's presentation is available here.

	**Dr Raymundo Marcos-Martinez,** a Research Scientist from CSIRO, provided a presentation - **Developing the Digital Twin of Darwin to monitor and navigate change**. Ray's presentation highlighted the current and future functionalities of the Lab's Digital Twin. The current focus is the analysis of ecosystem services provided by trees across Darwin and informing investment in future greening.
	**Catriona Tatam**, the Chief Executive Officer of the Urban Development Institute of Australia (UDIA - NT) provided a **Perspective from the development sector in planning for a future Darwin**. Catriona's presentation highlighted the challenges and opportunities for the development sector in incorporating approaches that improve sustainability and are adapted to a future climate. Including the potential for developer incentives to drive change.
	**Louise McCormick,** the Northern Territory Infrastructure Commissioner provided introductory comments to the Panel session on how investment guided by the NT Infrastructure Strategy is supporting sustainable economic development in the NT and helping to attract and retain population. Louise highlighted the need to consider future technology changes in investing in long-lived infrastructure.

Table 2: Session 2 presentations and panel members

3.3 Workshopping session on navigating change in Darwin

The Darwin Living Lab worked with partners in 2019-20 to develop a description of how Darwin could change over time to achieve its vision of a cooler and thriving city. Further information can be found within the DLL Tracking Darwin framework. Now three years into the DLL, this workshop session sought to revisit and test some of the earlier assumptions and gather new data on how change might be progressed, and what indicators might be used to demonstrate success.

Each table or table sub-group was asked to discuss the following questions and was given 3-5 minutes to develop three agreed responses and submit them via the Slido Poll software. Appendix A.1 provides a complete list of answers that are summarised briefly below.

3.3.1 What are the top 3 actions that could transform Darwin into a cooler and thriving city in the near future (next 5-10 years)?

Symposium participants placed emphasis on the following actions to make a difference:

- Planting more trees throughout the city and considering their planting design and placement. Having appropriate governance of maintaining greenspace and considering a revision of NT legislation to enable tree retention and protection.
- There were themes around transport networks and urban form: shift from a focus on providing roads and car-parking (less asphalt) to improved public transport services and (shaded) active transport networks. Densification of living with more compact development. More shade for public areas. Green networks (also allowing for cooling breezes). Shade between spaces and in front of buildings to connect places.
- Trials to gain understanding, education and incentive approaches: create built form demonstration sites, with further investment into cool roofs and cool surfaces, pavements and reflective paints, innovative construction materials, and retrofitting to improve building energy efficiency. Enable more buildings to capture solar and integrate with the network. Education of developers and home-owners, increased exposure of incentives, guidance on what trees and where to plant them, and retrofits to make a difference (facades, painting).
- New policy: Prioritising urban heat - going beyond incentives and setting mandatory urban heat requirements. New planning guidelines. More greenspace in developments. Increase energy-efficiency requirements and monitor and enforce compliance, Section J adoption. Tree retention (as above)
- Adjust social cultural mindsets and CBD business hours to open at night to match climate conditions, similar to neighbouring south-east Asian countries.

3.3.2 What are the key indicators of success?

Figure 2 presents the word cloud of the responses on key indicators.

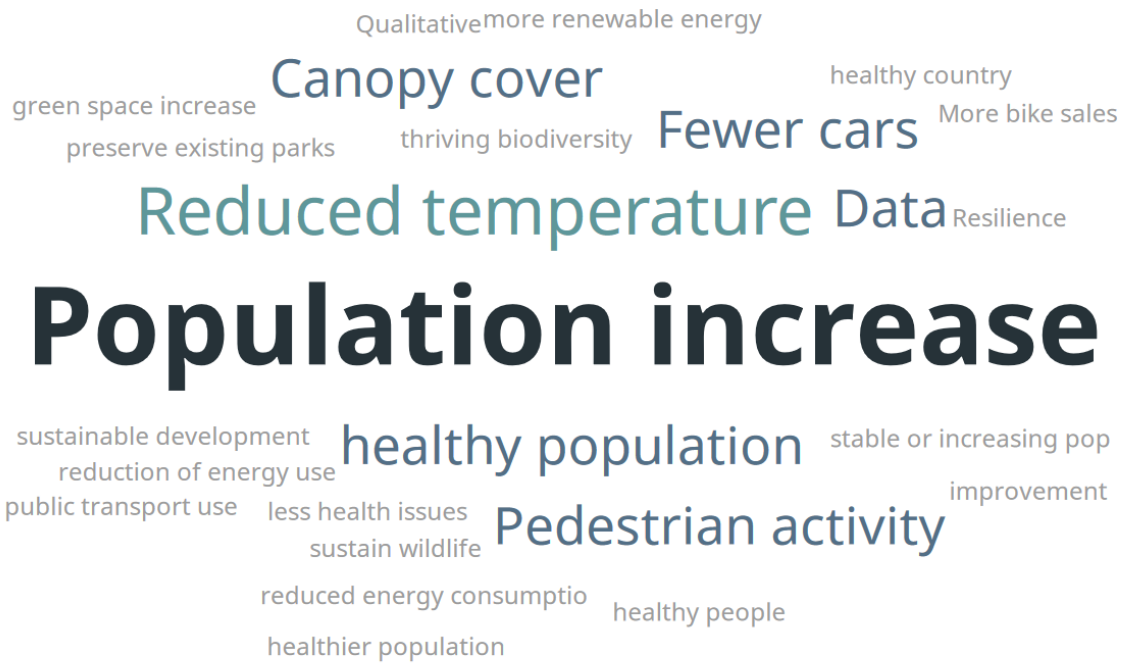


Figure 2: Key indicators of success that Darwin has transformed into a cooler and thriving city

3.3.3 What are the top 3 barriers that we need to consider?

Symposium participants noted the following as potential barriers to be aware of while navigating change in Darwin (in no particular order):

- Leadership and collaboration: competing priorities and political inertia, not enough collaboration (working in silos) and low investment in education. Need for leadership and to champion change to make it easier for behavioural change.
- Social/Community: existing culture of people and lack of social buy-in, continued desire for convenience, lack of communication and information (fear of change and unwillingness to change). Split incentives.
- Funding and funding models: lack of funding, prioritising investment and conflicting demands for limited resources, balance of investment and viability, cost of service and density, decision-making based on upfront costs and not whole of life benefits.
- Complexities and uncertainties: system complexity, red-tape, policy, legislation, budgets and investment, slow policy, planning controls not clear on shared direction, maintenance costs of implementing (e.g. tree maintenance, water security).
- Existing structures: existing buildings and infrastructure creates system lock-in and limits change (e.g. not much room in the city to build gardens, low-density, car dependence).
- Regardless of actions, it will still be humid and regularly exceed thermal comfort limits.

3.4 Reflections on session

Navigating change in Darwin was an intensive session that gave the opportunity for NT Government and City of Darwin to share their priorities for change in Darwin and worked through to all participants being able to contribute views on how change may occur. Government priorities included policies for land-use and planning, infrastructure and operations to meet the challenges of a changing climate, sustainability and economic productivity. The digital twin presentation explored how data and evidence is being brought together to increase learning and knowledge about aspects of the city's baseline and performance. Development industry presented challenges to delivering future-ready infrastructure that meets the market's expectations.

Louise McCormick, the NT Infrastructure Commissioner, highlighted how the Northern Territory Government's Infrastructure Framework aims to improve liveability and embed sustainability and resilience in infrastructure planning and investment to deliver on the goals of a sustainable and diverse $40 billion economy by 2030. The panel were challenged to explore aspects where policy advances could be made to advance Darwin's liveability, sustainability and resilience. The recording of the panel discussion is available here. The session revealed the overlapping interests between layers of government and the need for increased collaboration to deliver on objectives for a cooler and more liveable Darwin.

The working session on Navigating change in Darwin provided the ability for participants to share their thoughts and understanding on how to progress Darwin towards a cool and thriving city and the barriers that need to be considered. The level of engagement in these exercises provided a substantial amount of data that is now available for city leaders and decision-makers to draw upon in progressing change in Darwin.

4 Session 3 - Learning from community and Indigenous ways of improving heat-related liveability

4.1 Session Overview

Session 3 was chaired by Dr Maxine Piggott, who is a Northern Australia Research Consultant for CSIRO. This session explored the relationship that people in Darwin have with heat, the environment and its biodiversity. The session welcomed input from a Larrakia Elder, Lorraine Williams, on the importance of incorporating traditional owners' cultural knowledge in protecting biodiversity values. Outcomes from a recent Lab project were presented on how vulnerable population groups are managing the health implications of exposure to heat and smoke. The session also explored the considerations for planning to achieve improved environmental and biodiversity outcomes, and with changing climate and seasons.

4.2 Presentations

Lorraine Williams, a Larrakia Elder and **Dr Emma Woodward**, a CSIRO Senior Research Scientist, co-presented on the Lab project - **Larrakia-led Darwin biodiversity values**. Lorraine's presentation outlined approaches that are being used to better understand Larrakia people's biodiversity knowledge and values. Highlighted the pressure on these values and cultural connection to place of significance due to land use and management changes.

Dr Sharon Campbell from the Menzies Institute for Medical Research, University of Tasmania presented findings from the recently concluded project - **Managing heat and smoke in the Top End: Stories from vulnerable groups**. Sharon's presentation provided insights on the risks to vulnerable groups of exposure to extreme heat and the specific gaps

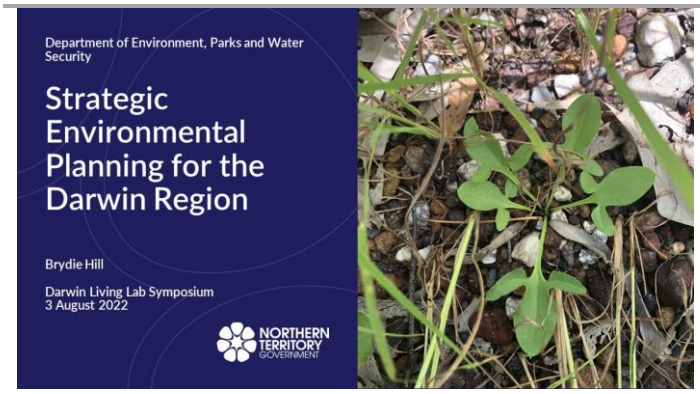
	identified in policy and infrastructure to improve health outcomes.
	**Brydie Hill,** a Senior Director from the Information and Advice Flora and Fauna Division of the Department of Environment, Parks and Water Security presented - **Strategic environmental planning for the Darwin Region**. Brydie's presentation explored the balance between protecting areas of high biodiversity value in greater Darwin and priority areas for development.
	**Dr Mark De Souza** also contributed to the panel session. Mark is an emergency specialist at the Royal Darwin Hospital where he also leads the Sustainable Healthcare Committee for NT Health that is undertaking initiatives to green the campus and adapt to climate change. Mark highlighted the benefits to healthcare staff of biophilic design that provides cool, green spaces.

Table 3: Session 3 presentations

4.3 Workshopping session on local approaches to staying cool

4.3.1 Brainstorming session

The workshopping session explored individual responses to coping with heat and humidity in Darwin. This enabled the opportunity to share ideas and learn from others on managing extreme heat that is specific to Darwin.

Participants were presented with the following list of recommended approaches identified from the literature for staying cool. They were asked to reflect on the list and then add what they do to stay cool that is not on the list.

Literature suggests the following advice for staying cool:

- wearing loose fitting and light weight clothes
- staying in the shade
- drinking lots of water
- avoiding the use of heat emitting appliances such as a stove or an oven

- submerging oneself in water for evaporative cooling
- wearing hats
- avoiding outdoor work
- going to an air-conditioned centre.

Figure 3 summarises the results of this brainstorming. Participants took a somewhat light-hearted approach that reflected how they adapt their daily lives to cope with extreme heat during the build-up. This included adapting what they wear and activities they undertake to mitigate heat stress risks.

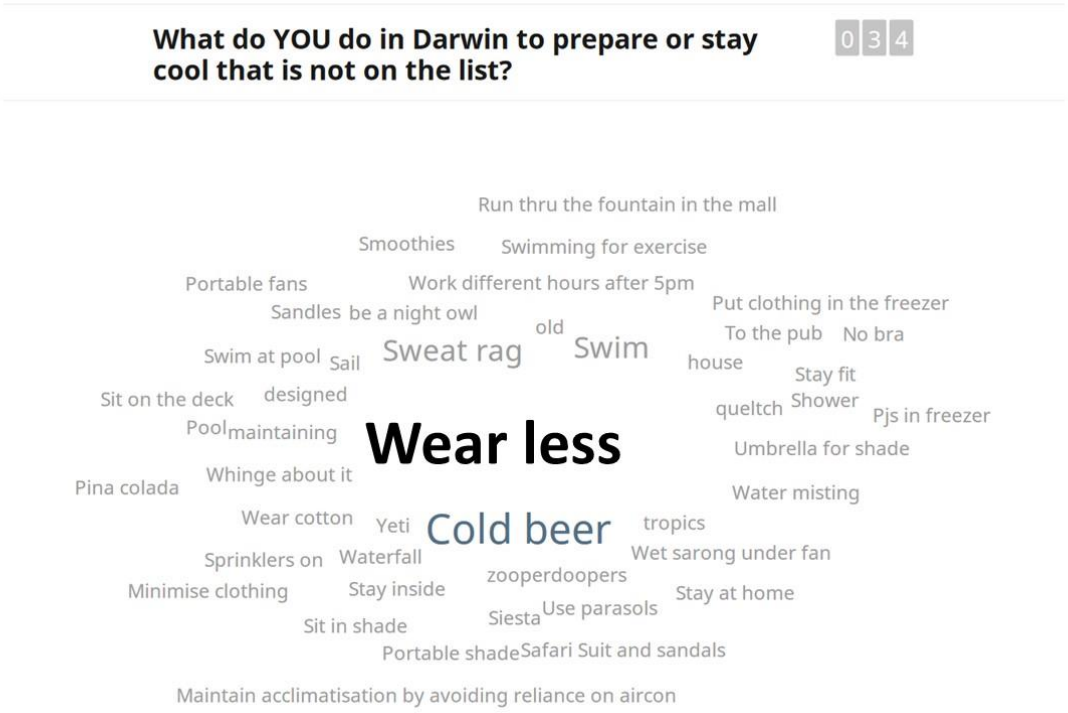


Figure 3: Word cloud on ideas to stay cool

Figure 4: Participants adding their ideas on how they stay cool

4.4 Reflections on session

The session explored the relationship that people in Darwin have with heat, the environment, and its biodiversity. Lorraine's presentation highlighted that the traditional owners of Darwin have a vast knowledge of living in Darwin's climate and managing the country to maintain biodiversity values, which is not yet well integrated with western science in responding to challenges such as climate change in Darwin's natural and cultural values. Brydie's presentation illustrated the need to balance development to support population and economic growth with protecting areas of high biodiversity values across greater Darwin.

Developing a cooler and more climate-adapted Darwin can help to mitigate heat stress risks across the community. However, there is a need to address the specific risks to vulnerable groups that are particularly exposed, such as outdoor workers. Dr Mark De Souza's comments highlighted the potential benefits for healthcare sector workers of integrating greening and climate adaptation into the design of healthcare precincts. The benefits are not only the direct cooling benefits, as access to cool green spaces can improve the wellbeing of both staff and patients.

The interactive session highlighted the individual adaptive approaches that people take in Darwin to manage heat stress risks. Sharing this knowledge can help to build an understanding of the specific heat mitigation approaches that are being applied in Darwin and where there are knowledge gaps on the effectiveness of approaches that requires further research.

5 Session 4 – Improving thermal comfort in Darwin's indoor environment

5.1 Session overview

This session was structured around a new project for the Lab - **Darwin House Comfort Rating**. This project has the intent to develop a user-friendly tool that provides thermal comfort ratings for Darwin's hot and humid climate. Following the presentations there was a panel discussion, which included the opportunity for participants to vote on what their preference was for basis of thermal comfort rating for Darwin homes. The intention is that the 'for information' ratings can inform climate responsive design for the hot humid tropics and improve thermal comfort outcomes when homes are operated in passive mode (i.e., without air-conditioning).

5.2 Presentations

Terry Williamson, Adjunct Professor, School of Architecture & Built Environment at the University of Adelaide, provided a presentation - **Field validation of modelled thermal comfort and Darwinian's thermal comfort thresholds**. Terry's presentation went through monitoring studies that validated the performance of energy rating software for Darwin residential buildings. A recording of Terry's keynote address is available here.

Valerie Nullet, Project Director, Housing Program Office from the Department of Infrastructure, Planning and Logistics provided a presentation - **Energy efficiency options for tropical housing**. Valerie's presentation highlighted how remote community housing is exceeding minimum energy efficiency ratings and delivering housing that reduces energy demand for cooling and improves thermal comfort.

	**Jo Kieboom**, a Senior Ecological Sustainability Engineer in the Strategic Asset Management of the Department of Infrastructure, Planning and Logistics introduced the Darwin Living Lab Darwin Home Comfort Rating Project. Jo's presentation went through the background and objectives for the project and provided context for the participants before seeking their input on what they would like to see as the basis for thermal comfort ratings in Darwin homes.

Table 4: Session 3 presentations

5.3 Panel discussion and voting on thermal comfort metrics

Jo Kieboom, who is co-lead for the project chaired a panel discussion, which included presenters and two additional panellists who are also part of the project team.

- Dr Dong Chen (CSIRO Energy) – Dong is currently leading the development of AccuRate and the Chenath engine, the benchmark software tool for the Nationwide House Energy Rating Scheme.
- Dr Wendy Miller (Queensland University of Technology) – Wendy has led research in energy efficiency, renewable energy and resilience in the built environment, with a particular focus on subtropical and tropical housing.

A recording of the panel discussion is available here. Participants were asked to provide their input on what they would like to see as the basis for different aspects of thermal comfort rating. Figure 6 highlighted participants were divided on the metric to use for home comfort ratings. A slight majority preferred to focus on the percentage of time that rooms are outside of an acceptable thermal comfort range compared to the total hours over the year that rooms exceed a thermal comfort threshold. The discussion highlighted the need for any metric to be translated to a rating that can be easily communicated to home-owners so they can make informed decisions. Most participants indicated a preference for thermal comfort ratings to be based on the expectations/needs of an average person (Figure 7). The discussion highlighted that a challenge with using averages is that expectations and needs can vary significantly and change over time. There was a preference for bedroom comfort rating to be based on the worst performing bedroom (Figure 8). This would provide information on the minimum thermal comfort in bedrooms, rather than an average that could obscure the variability in thermal comfort between bedrooms.

Figure 5: Panel discussion on improving thermal comfort in Darwin's homes

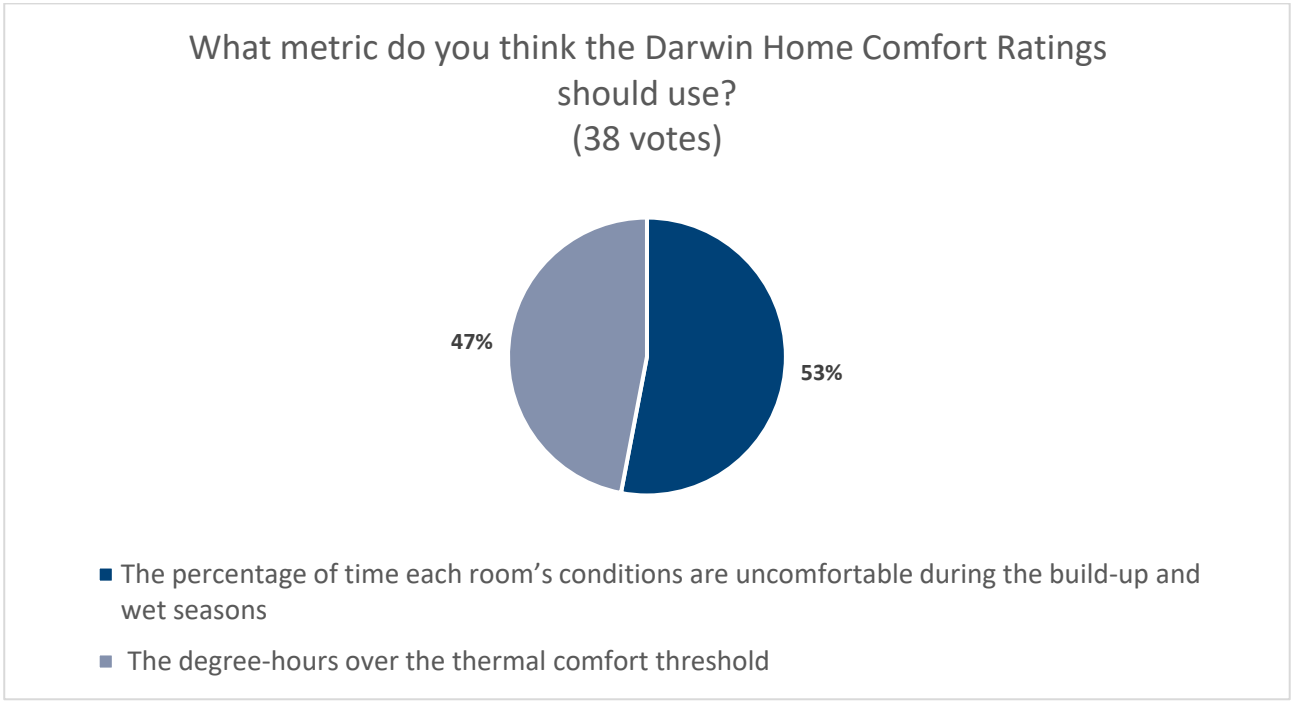


Figure 6: Vote 1 – Metric for Darwin Home Comfort Ratings

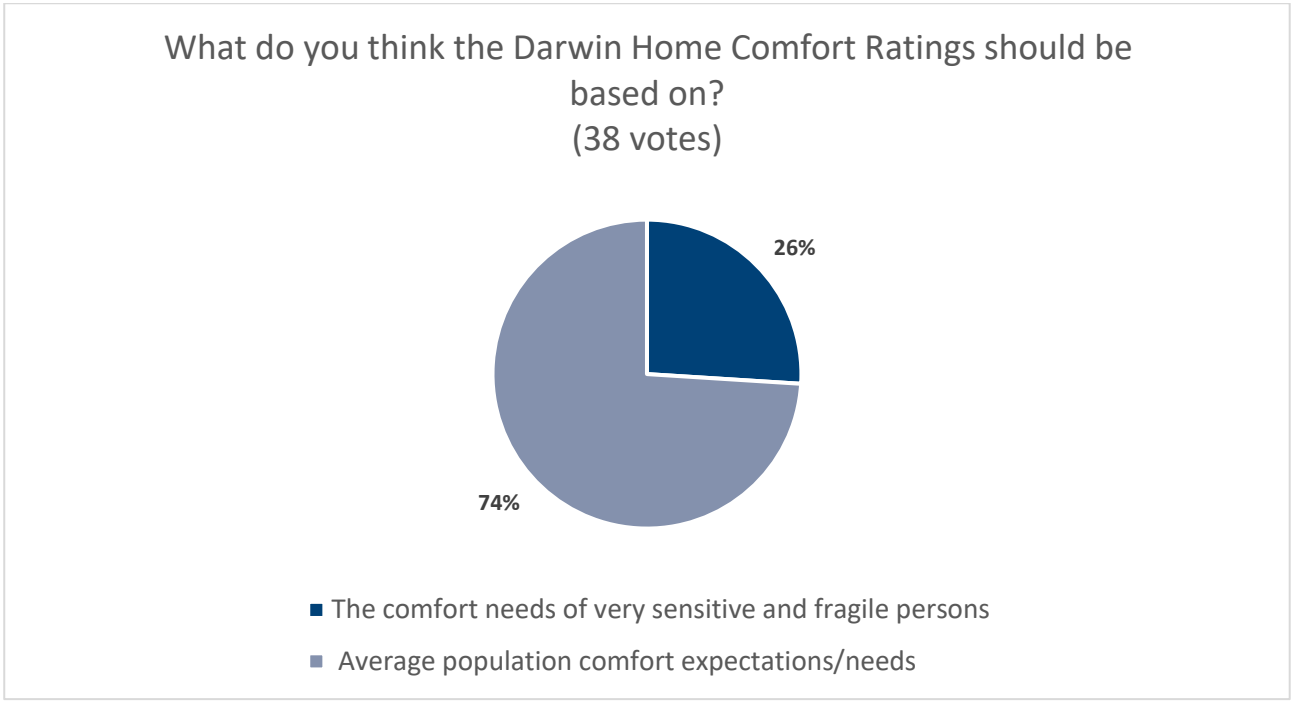


Figure 7: Vote 2 - Basis for Darwin Home Comfort Ratings

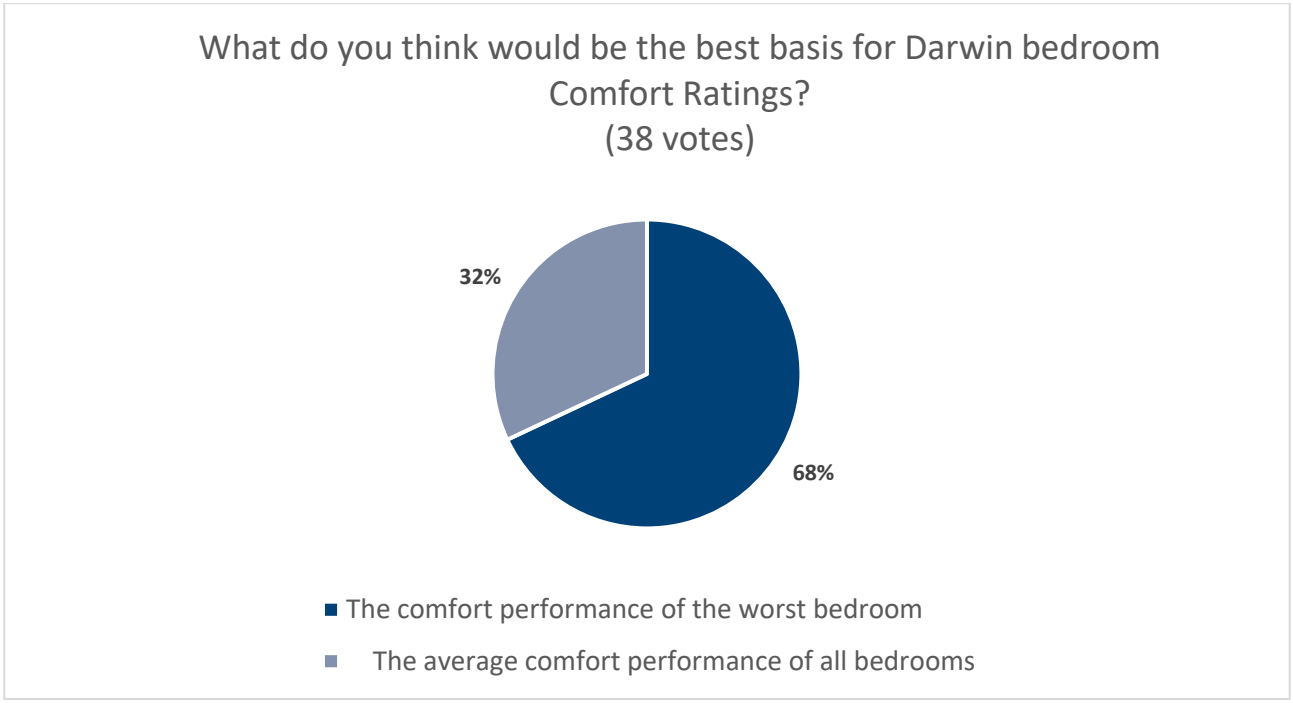


Figure 8: Vote 3 – Preference for Comfort Ratings for Darwin Bedrooms

5.4 Reflections on session

Darwin's tropical climate means there is a unique challenge in considering thermal comfort and overheating risks compared to other capital cities. A thermal comfort rating can provide insights into opportunities to develop climate-responsive housing that can maintain acceptable thermal comfort levels without air-conditioning.

The discussion highlighted that the thermal comfort ratings are being developed for information only, so they are not intended to provide a basis for regulating a minimum thermal comfort rating to be achieved when homes are operating without air conditioning. However, the voluntary application of the rating can provide information to residents so they can make informed decisions when purchasing or renovating houses on the thermal comfort performance in addition to the existing energy efficiency rating.

6 Participant evaluation of workshop

6.1 Overview

At the conclusion of the event participants were invited to evaluate the Symposium. The lessons learnt from this evaluation will be used by the CSIRO team to refine planning for future symposiums and other engagement activities. The following open-ended questions were asked of participants with main themes emerging from responses summarised below.

6.1.1 What was the most useful thing you got out of the event?

Participants commented that the Symposium provided a good opportunity to network and connect with others and identify opportunities for collaboration. Responses also emphasised the value to participants of sharing information that provided a better understanding of the status of heat mitigation and liveability policies and projects underway in Darwin. Furthermore, hearing directly from decision-makers who are in a position to influence change was seen as useful. Participants noted that the Symposium provided good visibility of the Darwin Living Lab and current research activities.

6.1.2 What else would you have liked to get out of the event?

Several participants noted they would have liked more time in the program for the workshop sessions and networking opportunities. It was noted that with a busy program, it was hard to connect with others across the day, with a suggestion that in future Symposium it would be good to encourage more mixing of participants. It was also noted that some of the interactive sessions did not have sufficient time to work through in more detail ideas for progressing current challenges and identifying opportunities for change.

It was noted that the content of the Symposium could be expanded to cover specific aspects comprehensively, such as the implications of greening for water sustainability and heat health impacts of climate change. Participants noted there also could have been more information on how participants could engage with Lab activities and explore collaboration opportunities.

6.1.3 What aspects of the process worked well for you?

Participants who responded felt that the following aspects worked well:

- Presenters- Participants appreciated the quality of presenters that provided relevant insights and a good cross-section of perspectives across key themes.
- Master of ceremonies – Participants noted that Chris Krishna-Pillay (CSIRO) was excellent in keeping the content engaging and effectively coordinated the sessions.
- Panel sessions - noted this was a better format than questions following presentations to explore topics.

- Slido polls – participants remarked these worked well, but there could have been more time to discuss results.
- Overall event organisation – several participants noted that the event was well organised and delivered effectively on the day.
- Venue and catering – Several participants highlighted the venue, set-up and the catering were excellent which contributed to an enjoyable event.

6.1.4 What aspects of the process worked less well for you and how could they have been improved?

Participants noted the following aspects of the symposium process that could be improved for next time:

- Timing - Need to keep presenters to time, which could provide more time for group discussions that were cut short for some sessions and not feeling rushed through a busy agenda
- Room set-up – it was noted that screens were too small to see presentations from the back of the room and that chairs were a little uncomfortable when sitting for extended periods
- Structure of sessions – technical presentations would be better earlier in day when people might be more receptive, and need to ensure that technical presentations connect to practice
- Opportunities to collaborate – more time to workshop ideas that could be used to develop collaborations and inform development of strategies and actions. Nametags could include topics of interest for each person to encourage more conversations.
- Facilitation – facilitating more detailed discussions of expert panels could have provided opportunities to go a little deeper on poll results and also opportunity to allow for some challenges and debates of viewpoints put forward.

6.1.5 What type of engagement events would you like to see Darwin Living Lab support in the future?

The types of engagement events that participants would like to see the Lab support in the future included:

- More school and STEM engagement
- Developing community awareness through demonstrations and explanatory signs and apps that support citizen science
- More engagement with industry sector, particularly through engagement in peak bodies as this provides the opportunity to develop awareness across
- Workshops that develop future projects and collaborations across government, industry and the wider community. These workshops could be focused on specific issues to allow

for more detailed discussions that can help to resolve sticking points and develop future research ideas and collaborations.

- Lab should engage and represent the research at other public facing events in Darwin that can help develop awareness more broadly of cooling initiatives and how it relates to daily lives of people from across the community.

A.1 Navigating change – Poll results on transforming Darwin to a cooler and thriving city

A.1.1 What are the top 3 actions that could transform Darwin into a cooler and thriving city in the near future (next 5-10 years)?

Action priority	Actions
First	• Planting millions of the right trees • More shaded public areas • Planting more greenery and implementing cooling facilities throughout the city e.g., pavements and paint used in Cavenagh Street. • Monoculture of weeds (Gamba Grass) • Create built form demonstration sites • Cooling roof, cooling surface • Going beyond incentives i.e., set mandatory urban heat island requirements for new buildings and refurbishments • Active transport networks (cycling, pedestrian) and more accessible, more regular public transport • Shift road building funding to public transport. • State legislation for tree protection. Stronger Development approvals process for tree retention. State & Local Government levels. Tree evaluation system, trees viewed as living assets. • Maintain City of Darwin policy of planting and consider design for planting. • Shading network between spaces, in front of buildings that connect uses • Increase energy efficiency requirements and monitor and enforce compliance. • incentives to bring developers on board to take advantage of the planning changes. education to developers the are isolated to the incentives. • Trees • Plant more trees
Second	• Protect existing green spaces and corridors to eliminate tree felling • Less asphalt • Prioritising the factors that influence urban heat islands • Protection of mangroves and remnant monsoonal forests. • Adjust social cultural mindset and CBD business hours to open at night to match climate, similar to Asian countries.

	• Tree and lawn irrigated • Maximise tree cover beyond city boundaries, including along paths • Liveable densification • Encourage balcony and gardening as a planning requirement. • Use of innovative construction materials, less hard space, heat island surfaces • Appropriate planning guidelines or initiatives to incentivise greening and cooling of development. e.g., vertical gardens • Ring network of public transport, hyperloop around the city • Green network/connectivity - trees, grass, wind network. Retaining the trees we have. • continuation of greening the city. requires greater tree coverage following serious deficit • Data Driven decision making • Compact development
Third	• Enable buildings to capture solar energy without overloading transmission network • Incentives to retain native tree cover in urban development/planning • Developing a comprehensive document that is suited to Darwin home living. For e.g. what trees and plants are most suitable for backyards / indoors that will help to mitigate heat / stand up against cyclones. • More adequate shade structures • Increased greening • Retrofitting house to reduce the requirement of mechanical cooling. • Adopt NCC 2022 section J - minimum commercial building energy efficiency requirements • More trees, shade, greening to balance higher density • Incentivising the worst offenders to improve their actions. • More green space incorporated into development, higher percentage of green space allocations in development • Proper governance and oversight of maintaining green spaces/planting. For example, incorporate into Body Corporate. • Building facade improvements (roof painting). Incentives to undertake and complete these works • Car parks- green, trees, shade structures. More underground car parking. Cooler and resilient planning/infrastructure. Improved public transport. • Greater housing density and strengthened transport routes. • Education and Knowledge Gap Awareness, Integration

	• Support on policies, regulations, governance on future developments

A.1.2 What are the top three barriers to achieving this vision for Darwin?

Barrier priority	Barriers
First	• Legislation/education/public discourse/coordination/collaboration to support good planning. • Sustainability • Humidity. Comfort limits • Split incentive • Desire for convenience • Lack of communication and information (fear of change) • Culture of people • Lack of appropriate policies for desired outcome • Prioritise cars over everything • Decision making based on upfront costs not whole of life benefits • Humidity • Cost of service and density • Not enough collaboration and education • prioritising investment • Retaining existing urban forest as well as increasing canopy cover. Tree protection legislation • Funding
Second	• Localised best practice guidance for energy efficiency in different building types. • Balance of investment and viability • Planning controls. Not clear on shared direction • Inertia • Lack of collaboration between parties (working in silos) • Understanding longer term ROI • Competing priorities • political inertia

	• Ease of access to enabling technologies and mechanisms • Mindsets, people set in their ways • Hyper-political context • Red tape, Policy, Legislation, Budgets and Investment • Political environment/game. • Conflicting demands for limited resources i.e. funding • Communication
Third	• Funding and social buy in challenges. • Complex regulations-cut red tape to incentive greening and cooling • Maintenance costs of implementing. e.g. tree maintenance. Water security. • System complexity • Existing infrastructure limiting change (not much room in city to build gardens) • Slow policy • Lack of funding support • economy over environmental, social, health benefits • Public services resourcing to progress new initiatives • Existing building and infrastructure • Leadership and championing change. How to make it easier for behavioural changes. Following the norm • Community drive and interest • cultural shift to drive change. government/people • Public education and awareness of issues • Willingness to make change

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