



Good Practice Story Title:

A city *connecting the invisible* – finding low-cost ways to build environmental sensors with community and visitors

Destination: Townsville

Country: Australia

Submitting Organization: Townsville City Council

Category:

- Destination Management
- Nature & Scenery
- Environment & Climate
- Culture & Tradition
- Thriving Communities
- Business & Marketing

Destination description:

Townsville, located in Queensland, Australia, is the largest tropical city in the country. It boasts a diverse range of natural attractions, including ancient Gondwanan rainforests, interconnected wetlands, and 180 kilometres of tropical coastline linking to the Great Barrier Reef Marine Park and its islands. The city, recognized as an ECO Destination (Nature Tourism Level) by Ecotourism Australia, is a hub for both residents and visitors drawn to its unique landscapes and outdoor lifestyle. However, the region's dry tropical climate, mixed ecosystems, and varying weather systems present challenges, especially with the increasing frequency of climate-related events. Townsville never wastes a disaster, and they are developing projects that build resilience for future generations and bringing the community along on the journey. For more than a decade, Townsville City Council, research groups and local businesses have been developing and deploying locally-made smart environmental monitoring technology which capture and map micro-climate data. They have discovered lower cost ways to not only gain deeper insights into how changing weather conditions may impact the community, but how to educate and empower community members and visitors alike to build these sensors. Together, they are *Connecting the Invisible*.



Summary of Good Practice Story:

Townsville's resilience in the face of climate adversity is showcased through its innovative use of locally-made smart environmental monitoring technology. In response to extreme weather events, Townsville City Council has partnered with researchers to develop budget-friendly environmental technology. This initiative enhances understanding of local environmental conditions and empowers participants through education and engagement. Key results include comprehensive environmental data collection, development of sensor building activities into tours, engaging people in STEM education (Science, Technology, Engineering, Maths), and increasing resilience to future climate challenges. The initiative emphasizes practical, hands-on learning and covers topics such as tropicalization, machine learning, and environmental visualization.

A notable success story within this initiative is the hundreds of school students who have participated in workshops learning about sensors and programming, and how to overcome challenges and celebrate successes. Additionally, a major opportunity explored is the applicability to school curriculums and new tourism experience development in edutourism and citizen science. The project has had profound impact and opened the creative thinking of many participants in workshops, activities and tours carried out by Council and stakeholder. The program has followed participants home to locations around the world. The sensor program and increasing needs to see *the invisible* to tackle climate adversity has contributed to Townsville recently achieving internationally-recognised ECO Destination status for its sustainability efforts and building a city of the future.

Issues faced:

In 2019, Townsville experienced a one-in-1000-year Monsoon Trough flooding event, receiving over 2000mm of rainfall in just two weeks. The region also faces frequent tropical cyclones, heatwaves, droughts, rising sea levels, shifting rainfall patterns, and urban development impacts. These factors contribute to high costs for environmental restoration and infrastructure repairs as well as deep economic impacts and barriers to industries such as tourism. To address these challenges, the local government identified the need for sustainable, proactive monitoring solutions. Townsville's high heat, humidity, and UV radiation, known as the "Triple H threat," complicates outdoor monitoring efforts. Environmental sensor equipment can be expensive to procure, install and maintain. To map and collect data across land, water and air, across buildings, homes and natural landscapes, is no easy feat on a large scale. With the goal of making sensors low-cost, and accessible for anyone to build and weather-proof, a decade long journey of trial and error was at hand. For over 12 years, Townsville has been a been dedicated and persistent to take authentic action to overcome environmental monitoring obstacles and focus on "tropicalising" their low-cost technology through what's called the *Townsville City Council Rowes Bay Sensory Network program*.

Over time the program has inspired intuitive ways of "feeling infrastructure and landscapes" such as "seeing what a building feels or a tree may feel" in its messaging. Environmental sensors are providing readings and visuals on how the natural and built world in Townsville is affected by environmental factors, climate and weather. "Connecting the invisible" had become a central theme, spotlighting the otherwise overlooked "invisible" world around us. Be it the interactions and patterns of micro-scale life of bacteria, fungi, and protista in soils and waterways, to macro-scale dynamics of plants, animals, man-made structures, all across the sea, sky and land. The invisible is the interaction and the reaction of the micro and macro coming together, performing tasks before us that are often unseen and unheard. This can include how nutrients cycle through water, carbon cycles through



soil, and energy needs flow across the city and ecosystems. Data is giving rise to a deeper understanding for residents and visitors that our built world behaves similarly to our natural world, in dynamic living systems, and that solutions to human issues require reconnection with the “invisible”, the natural world and the laws that dictate it.

Solution:

With the range of challenges to collect environmental data in Townsville, came a range of solutions that are making meaningful change. The local Council has been working with tech entrepreneurs and environmental scientists, including a Townsville-based startup called Lixia, and research professors from James Cook University (JCU) e-research centre to build, revolutionise and industrialise low-cost environmental sensors. The project team had recognised the high costs of environmental technology limits its accessibility and scalability, making it difficult to implement the widespread local data needed to inform solutions.

The *Townsville City Council Rowes Bay Sensory Network* recognised an opportunity for students, businesses, locals and tourists to be engaged in STEM (Science, Technology, Engineering, Maths) and, through this program, recognised what building our own low-cost sensors meant. The increased success and improvement of the Program was due to the recruitment of high school extracurricular students in Council’s *Sensor Laboratory* to help develop programs in sensor building and programming, and identify avenues for application across town. This led to meaningful cost savings for a multitude of monitoring projects using low-cost hand-built sensors. Through the collaboration between project partners, dedicated students and mentors, the sensor building exercises turned into an education pathway to increase scalability and introduce more participants to valuable skill building exercises such as machine learning, programming, prototyping, soldering, data analytics, software development, and more. One such exercise was the development of Micro Weather Stations. As the name suggests, these are small, deployable weather stations that are self-contained (with a battery and solar panel) and designed to be placed anywhere. They can measure:

- Air Temperature
- Case Temperature
- Relative Humidity
- Barometric Pressure
- Solar Irradiance
- Acceleration (3-axis)
- Magnetic Field (3-axis)





Mapping microclimates developed into a partnership with Townsville City Council and JCU e-research centre, which transformed into the *Weather Station Education Program*. From the development of this program, resources were built and made accessible to educators. The program is specifically designed to connect and relate the Year 5 and 6 Australian Curriculum to sustainability and environmental management and aims to assist local teachers to deliver a sustainability unit that is written specifically for the Townsville region. The Program delivers vital components that will enable students to explore and evaluate how weather stations and environmental monitoring technology can help to prepare a city of the future. This includes lesson plans with an introduction from all the project developers, including a video series that walks classes through new topics.

Over the course of the sensor programs that aimed to connect the invisible, a new standard had been developed. For under an average of \$100, a sensor could be built that made previously unseen characteristics of the landscape, such as temperature variation, visible. It provided the ability for community and visitors to “feel” the environment and how it was behaving. It provided the ability for us to see what a landscape was feeling. This could also tell us about the limitations of our environment, such as the likelihood of water quality overturning and forming algae blooms, the likelihood of urban heat becoming a public health issue, or the likelihood that vegetation of native fauna and flora may struggle to find healthy, earthy soils to interact with. The applications are endless.

Inspired by the program, students and patrons were undertaking crash courses in sensor building as part of school visits on Eco Catchment Tours, library education programs, technology “sprints” at university and even at local events such as Eco Fiesta, that recently had 8,000 visitors in 2024. The sensor workshops have given the ability for tourists and visitors to the region to learn and replicate “feeling and seeing their homes across the world” too. The sensor activities are integrated strongly into Eco Catchment Tours and have been hugely popular with the international program *Education First*, which has seen hundreds of students from the USA participate in the workshops, with the opportunity to bring the sensor program home. The program also extends to international conferences Townsville has held, with examples of international delegates collaborating and enhancing the sensor project, deploying sensors around the city, and even “wearing” sensors on their tours that they themselves have built. Tourists and delegates from The Bronx, Palma De Mallorca, Dominican Republic, multiple states across the USA and from across Australia have built sensors and returned home with replicable material of the program.

Methods, Steps, and Tools applied:

The project began with workshops and training sessions for students, teachers, and community members, focusing on sensor technology, electronics, coding, and data analysis. Participants built sensors using affordable materials, learning about components such as microcontrollers, environmental sensors, and power sources. At larger sensor sprints with groups of more than a hundred, key subject matter experts included Townsville City Council, local tech entrepreneurs, James Cook University, and Lixia.





1. Development of Sensors:

- 3 low cost, multi-purpose floating water quality sensors capable of reading temperature, dissolved oxygen, GPS, and turbidity parameters in a lakes and waterways. Built for under \$500 each, they deliver real-time data accessible anywhere updated in 15min intervals. This led to an increased predictability of seasonal, tropical algae blooms that may lead to fish kills. Staff have an increased opportunity to manage water quality turnover, preventing and protecting impacts.
- Over 100 multipurpose microclimate air quality and temperature sensors as part of Micro Weather Station network have been built by visitors on tours and residents. An array of sensor building workshops and class programs have enabled large amounts of participants to engage in the benefits of building and fitting sensors across the landscape. This includes the ability to map and visualise climate change impacts in Townsville.
- 10+ multipurpose soil quality sensors that measure pH, moisture content, salinity levels, and temperature of soil profiles were developed in the *Sensor Lab*. This provides real-time valuable information on soil health, and utilises AI learning, to enhance understanding on a range of soil projects. It can include the identification of corrosive soil sites and hypersaline areas.
- 60 single purpose water height sensors and 40 rainfall buckets were deployed in response to the 2019 flood event that map and monitor urban and natural areas across the floodplain. The sensors feed back the water level readings relevant to the placement of the sensor in real-time. This helps better plan and prepare for storm tides and rainfall events.

2. Sourcing components and data visualisation:

- To source materials such as sensor components (think breadboards, wires, and more) local options were always first and then online sources to find specific components required. Purchasing for the components followed ethical and sustainable procurement pathways where possible, including supply chain analysis and end of life for the components and products purchased.
- These sensors upload data via LoRaWan Network transmitting data from anywhere to Council's Enterprise Energy Management Systems (EEMS) or apps. The LoRaWan network allowed security and localised solutions in data and internet-of-things management.
- User-friendly visualization tools were developed to help the community understand environmental trends and patterns, aiding in decision-making for urban planning and environmental management. This included the development of EEMS as well as suppositories for programs including Github, ThingSpeak and more.





3. Community Engagement, Education and Sustainable Tourism programs:

- 2 x major sensor sprint events that hold hundreds of STEM-based students completing a challenge and operate over multiple days with a cohort of subject matter experts. Fun fact, one sensor sprint was hosted in a airplane hangar at Townsville Airport.
- 4 x annual community events and tours demonstrated the sensors in action, highlighting the importance of environmental monitoring.
- 29 x Educational resources were created to align with the Australian Curriculum, specifically designed for local teachers to deliver sustainability units.
- 7 x educational videos developed to assist with Weather Station Education Program
- Tourism programs that are part of Townsville’s ECO Destination are developing new experiences and opportunities for visitors to the region to participate in ecotourism, edutourism, regenerative tourism and voluntourism. Just like the Eco Catchment Tours, the sensor program as well as the program’s lessons and stories, are able to be replicated elsewhere across the tourism industry in Townsville and across the world. A sensor workshop is a great educational tool!
- To convey messaging about this project, Townsville City Council uses thematic communications methods to create imaginative and relevant messaging that sparks curiosity in readers. For example, what is a building feeling? was popular messaging that sparked curiosity for people to delve into the capability of sensors in built settings, this has led to energy savings from heating and cooling. Other messaging includes “Connecting the invisible” which has shed light on the visual capabilities of modern software to provide visual data of the hidden world to help people see interactions and reactions. The applications are endless.





Achievements and Results:

In 2024, over 100 active sensors are reading the Townsville region in and on buildings, boardwalks, pathways and infrastructure to map and enhance our understanding of the environment. With realising the potential of low-cost sensor building, the goal of the Council was to bring the public along the journey to learn about the science and provide hands-on experiences in citizen science. The project significantly benefited both the participants and the environment. Hundreds of students and community members gained practical STEM skills, bridging the gap between theoretical learning and real-world application. The network of budget-friendly sensors provided comprehensive, real-time data on various environmental factors, aiding in understanding local conditions and addressing issues promptly. The initiative empowered the community to engage in environmental monitoring and sustainability practices, fostering a sense of ownership and responsibility. Machine learning and data visualization demonstrated the potential of advanced technologies in community-driven projects, facilitating better decision-making. JCU e-research centre has conducted ongoing research into the long-term benefits of these programs. Educators from local schools have found the programs inspiring and a great way to engage students. The program's extracurricular volunteer students have developed valuable skills from prototyping, programming and more, and have moved into engineering roles creating state-of-the-art innovations. The program has been tested in tourism experiences and provided insightful, exciting citizen science experiences to visitors to the Region, with many taking the program across the world with them. The continued involvement exemplifies the project's impact, showcasing the educational and motivational benefits for participants.

Combing the major sensor sprint events that brought in 400 students each, hundreds of participants in sustainability tours at the Rowes Bay Sensory Network, and routine classroom visits for the Micro Weather Network, as well as hundreds of *Education First* and conference delegates on Eco Catchment Tours participating in sensor workshops, it's easy to estimate that over a thousand people have *connected the invisible*. Having engaged the audience in a deeper way to learn about the environment, the sensor activities and readings give patrons a sense of contribution to a meaningful project in the Region. The Program and sensing the environment, is closely connected to a sense of place. The program has proven adaptable and would be a worthwhile, interactive experience for nature-based tourism operators, teachers, tech entrepreneurs and local businesses looking to engage their customers or community. Not only could it introduce someone to new skills, but it can also benefit monitoring that your organisation and Region aims for. It may just be the way to *connect your invisible*.



Lessons Learned and Advice:

- Community engagement from the outset is crucial for sustainability and impact.
- Utilizing affordable, accessible technology democratizes environmental monitoring and empowers a broad audience.
- Comprehensive education and training are essential for successful implementation and long-term sustainability.
- Ensuring technology resilience to local conditions enhances durability and effectiveness.
- Sustainable tourism opportunities are ripe in programs such as environmental technology and citizen science community projects.
- Continuous feedback and improvements are necessary to adapt to changing needs and advancements.
- The importance of local knowledge and involvement cannot be overstated; engaging the community ensures a strong foundation for success.
- Overcoming initial challenges often leads to substantial achievements, emphasizing the value of persistence and innovation in sustainable practices.
- A project with data is valuable, but knowing what data to collect and how to visualise it to the audience where it counts, will make it meaningful.

Recognitions and Additional References

In 2024, Townsville was awarded ECO Destination (Nature Tourism level) status from Ecotourism Australia. Connecting the Invisible through climate data and environmental technology was an example of one of the many sustainability projects active in Townsville that led to the achievement of global best practice standards in sustainable destination management.



References

<https://www.townsville.qld.gov.au/water-waste-and-environment/creek-to-coral/sustainability-tours/sustainability-education-resources>

https://www.youtube.com/watch?v=4_O6le-G2CI&ab_channel=TownsvilleCityCouncil

<https://www.townsville.qld.gov.au/about-council/news-and-publications/media-releases/2022/november/environmental-sensors-deployed-to-capture-microclimate-data>

<https://www.townsville.qld.gov.au/about-council/news-and-publications/media-releases/2017/february/sensors-provide-environmental-data-to-assist-project-planning>

<https://www.townsville.qld.gov.au/about-council/news-and-publications/media-releases/2022/july/new-sensors-speed-up-blue-green-algae-detection>

Micro Weather-Stations video series:

Intro from Council:

https://www.youtube.com/watch?v=Wdjfjb7vLB8&ab_channel=TownsvilleCityCouncil

Intro from JCU:

https://www.youtube.com/watch?v=LuWaSCKXVsA&ab_channel=TownsvilleCityCouncil

https://www.youtube.com/watch?v=fuw5rHNgu2A&ab_channel=TownsvilleCityCouncil

https://www.youtube.com/watch?v=gQ5i2J0xutw&ab_channel=TownsvilleCityCouncil

How to build a micro-weather station:

https://www.youtube.com/watch?v=ofePVWdSKi8&ab_channel=TownsvilleCityCouncil

<https://councilmagazine.com.au/townsville-puts-sustainable-sensors-to-the-test/>

<https://robotics.jcu.io/tcc-sprint-day/>

<https://www.abc.net.au/news/2016-08-04/science-kids-inform-council-development/7684988>