Name and Title: Dr Stephen M Turton

I have been asked to produce an expert report that addresses the impact of greenhouse gas emissions in relation to the EPBC referral for the HVO Continuation Project (Project), which comprises the continuation of the HVO North (up to 2050) and HVO South (up to 2045) coal mine operations that together form the HVO Continuation Project.

1. **Describe the concept of a global carbon budget and harms expected with different carbon budgets.**

The global carbon budget (cycle) for the decade 2012–2021 (average in Giga tonnes of carbon per year) is shown in Figure 1. As the concentration of carbon dioxide (CO_2) in the atmosphere increases, so does the average global temperature. The components of the CO_2 budget that are reported annually include separate and independent estimates for the carbon dioxide (CO_2) emissions from (1) fossil fuel combustion and oxidation from all energy and industrial processes, including cement production and carbonation, and (2) the emissions resulting from deliberate anthropogenic activities on land, including those leading to land-use change and their partitioning among (3) the growth rate of atmospheric CO_2 concentration (see Figure 2 below) and the uptake (sequestration) of CO_2 (the "CO_2 sinks") in (4) the ocean and (5) on land.

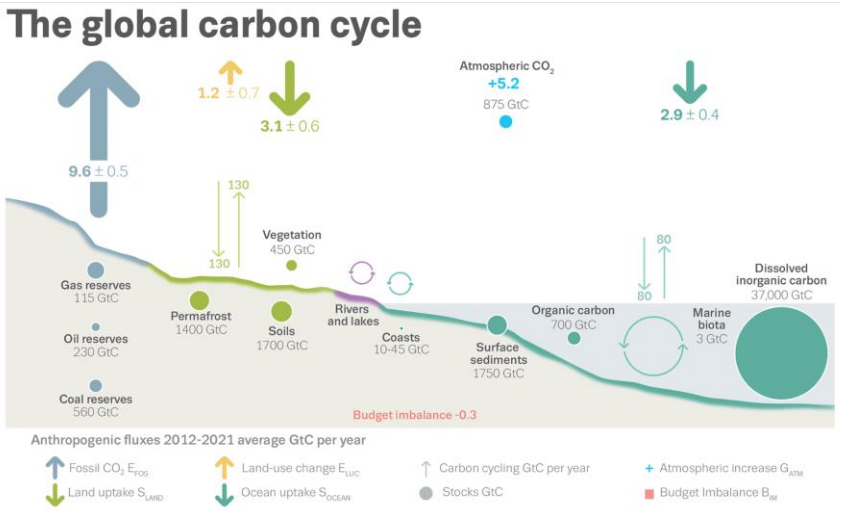

Figure 1: Schematic representation of the overall perturbation of the global carbon budget (cycle) caused by anthropogenic activities averaged globally for the decade 2012-2021 (Canadell et al. 2021).

The latest published inventory for the global carbon budget is for 2021 and includes estimates for 2022[1]. Global fossil CO_2 emissions (including cement carbonation) further increased in 2022, being now slightly above their pre-COVID-19 pandemic 2019 level (see also Figure 3). The 2021 emission increase was 0.46 Gt C/year (1.7 Gt CO_2/year), bringing 2021 emissions to 9.9 ± 0.5 Gt C/year (36.3 ± 1.8 Gt CO_2/year), same as the 2019 emissions level. Preliminary estimates based on data available suggest fossil CO_2 emissions continued to increase by 1.0 % in 2022 relative to 2021 (0.1 % to 1.9 %), bringing emissions of 10.0 Gt C/year (36.6 Gt CO_2/year), slightly above the 2019 level. Emissions from coal, oil, and gas in 2022 are expected to be above their 2021 levels (by 1.0 %, 2.2 % and −0.2 % respectively).

The concentration of CO_2 in the atmosphere averaged 417.06 ppm in 2022 (Figure 2), 51 % above pre-industrial (1750) levels[2]. The atmospheric CO_2 growth was 5.2 ± 0.02 Gt C/year from 2012–2021 (48 % of total CO_2 emissions) with a preliminary 2022 growth rate estimate of around 5.3 Gt C/year (2.5 ppmv).

CO_2 is the most common well-mixed primary greenhouse gas (GHG) with a long residence time (300-1000 years) in the atmosphere, once released from geological reservoirs through the combustion of fossil fuels[3]. This means accumulated emissions from anthropogenic sources since the beginning of the Industrial Revolution continue to persist in the atmosphere and are providing significant positive radiative forcing (warming) of the climate system (atmosphere, land and particularly the ocean). If we are to avoid "dangerous" climate change later this century, there needs to be a massive global effort to reduce CO_2

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[1] https://essd.copernicus.org/articles/14/4811/2022/

[2] https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide#:~:text=Each%20year%2C%20human%20activities%20release,2022%3A%20417.06%20parts%20per%20million.

[3] https://climate.nasa.gov/news/2915/the-atmosphere-getting-a-handle-on-carbon-dioxide/#:~:text=Carbon%20dioxide%20is%20a%20different,timescale%20of%20many%20human%20lives.

emissions from fossil fuel sources and strategies to enhance carbon sinks in land and ocean reservoirs. Given that CO_2 and other well-mixed primary GHGs from anthropogenic sources (methane and nitrous oxide) continue to rise rapidly in the atmosphere (Figure 2), the most efficient way to lower CO_2 concentrations is to rapidly reduce global carbon emissions, particularly from fossil fuel sources. Carbon sequestration strategies (e.g. soil and biomass carbon sinks) - while important - will be insufficient to offset all current and accumulated (historical) fossil carbon emissions, due to the very “long tail” in the lifetime of atmospheric fossil CO_2[4].

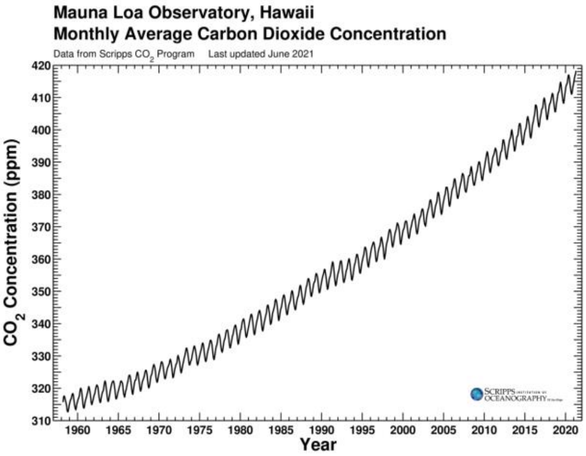

Figure 2: Monthly average atmospheric carbon dioxide concentration versus time at Mauna Loa Observatory, Hawaii, USA (20 °N, 156 °W) where CO_2 concentration is in parts per million in the mole fraction (ppmv.). The curve is a spline through the data. Credit: Data from Scripps CO2 Program, Scripps Institution of Oceanography/Open Access/Public Domain.

By comparing the CO_2 budget (Figure 1) with current annual CO_2 concentrations (Figure 2), we can calculate how long the carbon budget will last if no changes are made. This assessment indicates the degree of urgency of global action (see the next section and Figure 3). The latest IPCC climate change Assessment Report[5] refers to a set of five carbon emissions scenarios or pathways (Table 1). These Shared Socio-Economic Pathways (SSPs) explore the climate response to a broader range of GHGs, land use and air pollutant futures. This set of emissions drives climate model projections of changes in Earth’s climate system in the near term (2021–2040), mid-term (2041–2060) and long-term (2081–2100). The SSPs comprise the latest IPCC scenario framework, to facilitate the integrated analysis of future climate impacts, vulnerabilities, adaptation and mitigation.

Each of the five SSPs has a narrative (Table 1) describing alternative socio-economic developments, including sustainable development, regional rivalry, inequality, fossil-fuelled development and middle-of-the-road development. Notably, the SSPs’ long-term population and economic projections (Table 1) represent a wide uncertainty range consistent with the scenario literature. For example, future annual emissions of CO_2 will be about 75 Gt/year by 2050 under the fossil-fuelled development scenario (RCP5–8.5), rising to near 130 Gt/year by 2100. Under the regional rivalry scenario (SSP2–4.5), CO_2 emissions will be about 45 Gt/year by 2050 (like 2015 rates), declining to near 10 Gt/year by 2100. In the case of the middle-of-the-road scenario (SSP1–2.6), CO_2 emissions will decrease from 40 Gt/year (2015 rate) to about 22 Gt/year by 2050 and decline further to near -10 Gt/year by 2100. Under this GHG emissions scenario, decarbonisation of the atmosphere (or net-zero emissions) will commence in the 2080s. In the case of the very ambitious SSP1–1.9 scenario, net-zero CO_2 emissions will begin in the 2050s, with net CO_2 emission rates reaching about -15 Gt/year by 2100. Under scenarios with increasing CO_2 emissions, the ocean and land carbon sinks (Figure 1) are projected to be less effective at reducing the accumulation of CO_2 in the atmosphere. SSP1–1.9 and SSP1–2.6 more or less equate to the lower and upper limits of the Paris Agreement targets of 1.5° C and 2.0° C above pre-industrial (1850–1900) temperatures by 2100, respectively. The other three higher emissions SSPs (Table 1) are *highly likely* to force the planetary climate system to a threshold level of warming beyond which irreversible

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[4] https://theconversation.com/a-tonne-of-fossil-carbon-isnt-the-same-as-a-tonne-of-new-trees-why-offsets-cant-save-us-200901

[5] https://www.ipcc.ch/report/ar6/wg1/

damage will occur to our environment. There are likely to be cascading, compounding and aggregate impacts on natural, economic and social systems. The window to prevent dangerous climate change is rapidly closing, but is still feasible if fossil fuels can be rapidly phased out from now on.

Table 1: Five illustrative Shared Socio-economic Pathways (SSPs) (emission scenarios) and projected changes in global temperature for three 20-year time periods. Projected changes in global temperatures (°C) are shown for the near-term (2021-2040), mid-term (2041-2060) and long-term (2081-2100), relative to the 1850-1900 baseline. Sources: Riahi et al. (2017), IPCC (2021).

Shared Socio-economic Pathway (SSP) and its effective radiative forcing (ERF) of the climate system in W m^{-2} **Emissions trend in parentheses**	**Changes in global surface temperature (°C) for selected 20-year time periods. Best estimate and very likely range in parentheses**
SSP1–1.9 (ERF=1.9): *Sustainability – Taking the Green Road* (Low challenges to mitigation and adaptation) (Very strongly declining emissions)	Near term: 1.5 (1.2 to 1.7) Mid-term: 1.6 (1.2 to 2.0) Long-term: 1.4 (1.0 to 1.8)
SSP1–2.6 (EFR=2.6): *Middle-of-the-Road* (Medium challenges to mitigation and adaptation) (Strongly declining emissions)	Near term: 1.5 (1.2 to 1.8) Mid-term: 1.7 (1.3 to 2.2) Long-term: 1.8 (1.3 to 2.4)
SSP2–4.5 (ERF=4.5): *Regional Rivalry – A Rocky Road* (High challenges to mitigation and adaptation) (Slowly declining emissions)	Near term: 1.5 (1.2 to 1.8) Mid-term: 2.0 (1.6 to 2.5) Long-term: 2.7 (2.1 to 3.5)
SSP3–7.0 (ERF=7.0): *Inequality – A Road Divided* (Low challenges to mitigation, high challenges to adaptation) (Stabilising emissions)	Near term: 1.5 (1.2 to 1.8) Mid-term: 2.1 (1.7 to 2.6) Long-term: 3.6 (2.8 to 4.6)
SSP5–8.5 (ERF=8.5): *Fossil-fuelled Development – Taking the Highway* (High challenges to mitigation, low challenges to adaptation) (Rising emissions)	Near term: 1.6 (1.3 to 1.9) Mid-term: 2.4 (1.9 to 3.0) Long-term: 4.4 (3.3 to 5.7)

Note: The SSPs drives climate model projections of changes in the climate system. These projections account for solar activity and background radiative forcing from volcanoes.

The average growth in global fossil CO_2 emissions peaked at +3 % per year during the 2000s, propelled by the rapid growth in emissions in China. However, over 2012–2021 the global CO_2 emissions growth rate has slowly declined, reaching a low +0.5 % per year over the period. This trend includes the 2020 COVID-19-driven global decline and the 2021 emissions rebound (see Figure 3). While this fall in global fossil CO_2 emissions growth is welcome, the world is still way off the large CO_2 emissions decline required to be consistent with the temperature goals of the Paris Agreement. The global average temperature today is about 1.1° C above the global average for 1850–1900. Concerningly, on 17 November 2023 this same metric reached 2.07° C above the pre-industrial average[6]. While this global temperature record is not considered permanent at this stage, it is still indicative that Earth's climate system is approaching a dangerous level at a rapid pace.

2. What, if any, is the remaining global carbon budget to limit climate change to 1.5° C and 2.0° C above pre-industrial levels?

The IPCC 2021 Report states that 2495 Gt CO_2 (from anthropogenic sources) has been emitted into the climate system since 1850. This long-lived GHG continues to circulate in the atmosphere where it is driving global warming. Despite the slowing growth in global fossil CO_2 emissions, the recent growth rates are far from the reductions needed to meet the ambitious climate goals of the UNFCCC Paris Agreement[7]. The estimated 2020 to 2022 emissions from fossil fuel combustion and land-use changes has been updated from

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[6] https://climate.copernicus.eu/global-temperature-exceeds-2degc-above-pre-industrial-average-17-november#:~:text=The%20ERA5%20data%20indicate%20that,extensive%20use%20of%20fossil%20fuels

[7] https://unfccc.int/process-and-meetings/the-paris-agreement

the IPCC 2021 Report[8]. From January 2023, the remaining carbon (50 % likelihood) for limiting global warming to 1.5° and 2.0° C above pre-industrial levels is estimated to be 105 and 335 Gt C (380 and 1230 Gt CO_2), respectively (see Figure 3). These numbers include an uncertainty based on model spread (as in IPCC 2021), which is reflected through the percent likelihood of exceeding the given temperature threshold. The remaining time to achieve these carbon amounts corresponds, respectively, to about 9 and 30 years, from the beginning of 2023 at the 2022 level of total CO_2 emissions. Reaching net zero CO_2 emissions by 2050 entails cutting total anthropogenic CO_2 emissions by about 0.4 Gt C (1.4 Gt CO_2) each year on average (linear decrease), comparable to the decrease observed in 2020 during the COVID-19 pandemic. This is likely to be very challenging (if not impossible) if governments, like Australia, keep approving extended or new fossil fuel projects, such as this coal project. These necessary steep emissions cuts (Figure 3) highlight the enormous scale of global action required.

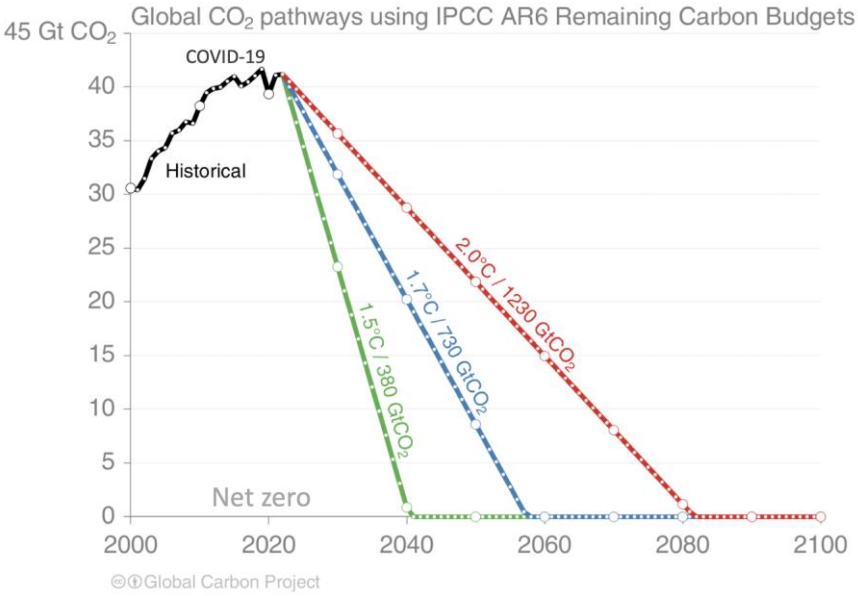

Figure 3: Global carbon dioxide pathways, based on the IPCC (2021) remaining carbon budgets. Global CO2 emissions must reach net zero by 2050 to limit global warming. Reaching net zero CO_2 emissions by 2050 would require a decrease of about 1.4 Gt CO_2 per year from now on, comparable to the COVID-related 2020 decline. Sources: Friedlingstein et al. (2021)[9], Global Carbon Project (2022)[10].

3. **In your opinion, what, if any, contribution would the revised GHG emissions (Scope 1, 2, and 3) from the Project make to future climate change:**

    a. **In absolute terms (in terms of an increase to global average temperatures or otherwise).** The latest IPCC 2023 Synthesis Report warns that fossil fuels are wreaking havoc on the planet and the use of fossil fuels is overwhelming driving global warming[11]. The UN Secretary General António Guterres calls for an "Accelerated Agenda" for a number of global actions on climate change, which in regard to this project includes no new coal projects and the phasing out of coal by 2030 in OECD countries and 2040 in all other countries. Given that this largely thermal coal project has a 2045–2050 timeline, I am of the strong opinion that its legitimacy and integrity in the global climate change arena must be seriously questioned and challenged.

    Table 4.1 of the submission report, dated November 2023 provides revised figures for Scope 1, 2 and 3 GHG emissions from the project (expressed as Mega tonne CO_2 equivalents[12]). The revised total (domestic + global) emissions over the life of the project amount to 1,165.02 Mt CO_2-e (1.16 Gt CO_2-

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[8] https://essd.copernicus.org/articles/14/4811/2022/#section4

[9] Freidlingstein et al. (2021). Global Carbon Budget 2022. *Earth System Science Data*, vol. 14(11), 4811-4900.

[10] https://www.globalcarbonproject.org/carbonbudget/

[11] https://www.ipcc.ch/report/ar6/syr/

[12] A carbon dioxide equivalent or CO_2 equivalent, abbreviated as CO_2-e is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential.

e). Annual average total estimated GHG emissions over the life of the project are 43.15 Mt CO_2-e/year (0.043 Gt CO_2-e/year).

From a global warming perspective, the total estimated 1,165.02 Mt CO_2-e emissions from 2024-2050 are very relevant. In fact, research shows 90% of coal and 60% of oil and gas reserves must stay in the ground if we are to have a 50% chance of limiting global warming to 1.5°C above pre-industrial levels this century[13]. Every bit of warming matters if we want to avoid the worst impacts for climate change, as the latest report from the IPCC (2021) shows. Given that CO_2 is a long-lived GHG, I argue that total carbon emissions from this project will contribute to the growing pool of fossil CO_2 in the atmosphere with an expected lifetime of 300-1000 years. It will therefore directly contribute to global warming. For context, the lifetime carbon emissions from this single project (1.16 Gt CO_2-e) are about 83 % of the annual global emissions cuts of 1.4 Gt CO_2-e/year that must be achieved to reach net zero emissions by 2050 (Figure 3).

b. **In the context of the remaining global carbon budget for 1.5°C and 2°C above pre-industrial times.** This project will remove 0.3 % and 0.09 % of the remaining atmospheric CO_2 budget, respectively, required for limiting global warming to 1.5° and 2.0° C above pre-industrial levels. My main concern is for the "cumulative" carbon emissions from this project and other fossil fuel projects in Australia and around the world. Emissions from this project, recently approved projects (including several large fossil fuel projects in Australia), and other yet to be approved fossil fuel projects will collectively add to the global carbon budget (Figure 1), rather than decreasing it in line with the Paris targets (Figure 3). It is my opinion that approving this project will send a negative signal to the global community about Australia's leadership in climate mitigation, and will be counter-productive to the Paris Agreement goal to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels." As stated by the UN Secretary General this year, "Every country must be part of the solution. Demanding others move first only ensures humanity comes last."

c. **Relative to Australia's current GHG emissions.** Australia's total domestic greenhouse gas emissions (all sources) in 2021–2022 were about 490 Mt CO_2-e[14]. The Scope 1 and 2 (domestic) emissions from this project are only 1.10 Mt CO_2-e. However, together with this proposed project, Australia has 116 new coal, oil and gas projects in the pipeline. If they all proceed as planned, an extra 1.4 Gt of CO_2-e/year (1,466 Mt CO_2-e/year) would be released into the atmosphere by 2030[15]. This also equates to the quantity of annual global CO_2 emissions that must be avoided if we are to reach net zero by 2050 (Figure 3).

Annual emissions from these proposed 116 projects would be the almost three times larger than Australia's CO_2-e emissions in 2021–2022. This is equivalent to commissioning 215 new coal power stations, based on the average emissions of Australia's current existing coal power stations. Concerningly, their methane leaks, fuel use and other relevant Scope 1 and 2 domestic emissions will add 344 Mt CO_2-e into the atmosphere by 2030. This amount far exceeds the 200 Mt CO_2-e the entire Safeguard Mechanism is supposed to avert over that same period[16].

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[13] https://theconversation.com/climate-change-ditch-90-of-worlds-coal-and-60-of-oil-and-gas-to-limit-warming-to-1-5-c-experts-167494

[14] https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-gas-inventory-quarterly-update-june-2022

[15] https://australiainstitute.org.au/post/116-new-fossil-fuel-projects-4-8b-tonnes-of-pollution-24x-safeguard-cuts/

[16] https://www.dcceew.gov.au/sites/default/files/documents/safeguard-mechanism-reforms-factsheet-2023.pdf

Short CV
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Positions held:

- Retired (2016-) Environmental Consultant (Climate change impacts and adaptation)
- Adjunct Professor of Environmental Geography, CQUniversity (2016-)
- Professor of Environmental Geography, James Cook University (2009-2016)
- Professor & Executive Director: JCU/CSIRO Tropical Landscapes Joint Venture (2005-2009)
- Associate Professor and Director of Research: Rainforest CRC (2002-2005)
- Lecturer/Senior Lecturer: JCU (1984-2002)

Formal Qualifications:

- PhD in environmental science, *James Cook,* 1992
- MSc in physical geography, *Canterbury*, 1983
- BSc in geography, *Canterbury*, 1981

Academic, Research, Teaching and Professional Experience:

My research, teaching and scholarly interests include: environmental geography, tropical climatology, rainforest disturbance ecology, adaptation of tourism, agriculture and forestry sectors to climate change, ecosystems services in tropical forests, natural resource management, and citizen science. I have published over 130 scientific papers in these fields of study, comprising refereed journal articles, book chapters and numerous research and technical reports. I have also supervised over 40 higher degree research students during my academic career. Climate change adaptation and natural resource management in tropical Queensland, eastern Indonesia, Solomon Islands and Bangladesh has been the focus of research projects being undertaken by my postdocs and HDR students over the past 20 years. I am also interested in world heritage and protected area management issues in Australia, Indonesia and Solomon Islands. I publish occasional articles for *The Conversation*, and am regularly interviewed by media on a range of topics, including climate change impacts and adaptation, El Niño-Southern Oscillation events, tropical cyclones, flood events, and catchment management in the Wet Tropics of Queensland.

Esteem Factors:

- Ordinary Member, National Committee for Geographical Sciences, Australian Academy of Science (2020-)
- Vice Chair: National Management Committee, Australian Citizen Science Association (2020-)
- Independent Chair: Wet Tropics Waterways Partnership (2018-2022)
- Councillor, Royal Geographical Society of Queensland Ltd (2018-2022)
- Past Chair, National Committee for Geographical Sciences, Australian Academy of Science (2016-2020)
- Co-chair of the Conservation Committee, Association for Tropical Biology and Conservation (2014-19)
- A Past President: Institute of Australian Geographers (2014-18)
- A Past President: Australian Council of Environmental Deans & Directors (2010-2014)
- Past Chair: Partners' Advisory Group, National Climate Change Adaptation Research Facility (2006-2008)
- Cassowary Award for Science (2009), Wet Tropics Management Authority
- Councillor (Institute of Australian Geographers (2006-2009)
- Expert Reviewer: Working Group II, IPCC's 5th and 6th Assessment Reports

- Member of the Australian Government’s Excellence in Research Australia (ERA) initiative in 2010: Panel 5- Engineering and Environmental Sciences
- Distinguished Fellow of the Institute of Australian Geographers (2016)
- JP Thomson Medal, Royal Geographical Society of Queensland Inc. (2017)
- Director: Terrain (Wet Tropics) NRM Ltd (2016-19)
- Independent Chair, Mt Emerald Wind Farm Community Consultative Committee (2016-2020)
- Associate editor, *Geographical Research* (2017-2022)

Publications:

Total career publications: >80 refereed journal articles/book chapters plus >50 refereed scientific/technical reports in the fields of physical geography, environmental geography, ecological applications and environmental science and management, climate impacts and adaptation (>130 publications).

Selected publications:

Turton, S.M. (2023) *Surviving the Climate Crisis: Australian perspectives and solutions* (CRC Press, Taylor and Francis Group, London UK), 256 p.

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