



Society-Wide Scenarios for Effective Integration of Paris-Aligned Climate Mitigation and Adaptation in National and Regional Policy

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Introduction

Climate science (IPCC 2018) and economics (Emmerling et al. 2019; Burke, Hsiang, and Miguel 2015) together indicate that achieving far earlier and deeper mitigation than pledged to date is likely now critical to effective climate action – particularly to ensure limits to adaptation are not breached. However, clear and coherent comparisons of national and regional climate action have been lacking. Therefore, summarising McMullin et al. (2019), a benchmarking method is presented to establish a prudent, fair share of the remaining global carbon dioxide (CO₂) budget (exclusive of other GHGs) for any Party to the Paris Agreement. Using Ireland as a case study, current policy ambition is analysed relative to this benchmarked national CO₂ quota, demonstrating early emergence of CO₂ debt, and showing tacit mitigation policy reliance on future, large scale carbon dioxide removal (CDR). Toward future research into society-wide scenarios for effective climate action, this paper also presents initial findings on the crucial roles of non-CO₂ mitigation and safeguarding land carbon stocks.

Methods

The strongly linear relationship between nett cumulative anthropogenic CO₂ emissions and resultant global warming permits scientific estimation of the remaining global carbon budget (GCB) to meet the Paris Agreement target of at least limiting to “well below 2 °C” (Rogelj et al. 2019). Estimating a national fair share of the GCB – a cumulative national CO₂ quota (NCQ) – differs from the more prevalent use of point-in-time emission rate targets, which do not, in themselves, allow assessment of good faith, ‘fair share’ contributions to meeting the temperature goals of the Paris Agreement, even on an aspirational basis. Therefore, McMullin et al. (2019) assesses the *prudent*, remaining GCB in per



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capita terms, based on the GCB range estimated by IPCC SR15 (Rogelj et al. 2018). Ireland's *minimally equitable* NCQ is assessed as a national case study: first, by top-down division of the global carbon budget, based on Raupach et al. (2014), allocated by: *population* (equal per capita) division; or *inertia*, grandfathered according to current (inequitable) allocation. This is then compared to cumulative CO₂ emissions on the basis of: current national policy aspirations, based on stated objectives; and current national policy projections, as reported by Ireland to the UNFCCC.

Results (see annex for abbreviations)

The low-end GCB value of 610 GtCO₂ as of 2015, divided by the global population of 7.38 billion, gives a remaining global equal per capita quota of 83 tCO₂, which can only be described as *minimally equitable* as it neglects consumption accounting, prior historical responsibility and current mitigation capacity. On this basis, the carbon quota of any nation is simply given by multiplying this value by the nation's population in 2015. For Ireland, this **Low-GCB-Pop** NCQ was 391 MtCO₂ from 2015. The corresponding exponential, constant, required reduction rate **R** was -11% from 2015, meaning that any failure to meet that reduction rate increases the required rate for subsequent years. For Irish policy aspirations: **NMO-95**, for a 95% reduction by 2050 relative to 1990, total future cumulative CO₂ commitment is 517 MtCO₂, with $R = -8.3\%$; for **NMO-80**, the corresponding values are 917 MtCO₂ with $R = -4.7\%$. For Irish projections: **WEM** (with existing measures) gives cumulative CO₂, only up to the end of 2035, of 964 MtCO₂ with $R = +0.7\%$; the corresponding **WAM** (with additional measures) values are 937 MtCO₂ and $+0.4\%$. Figure 1 compares these results for Ireland on the basis of depletion from the 391 MtCO₂ remaining 2015 NCQ value.

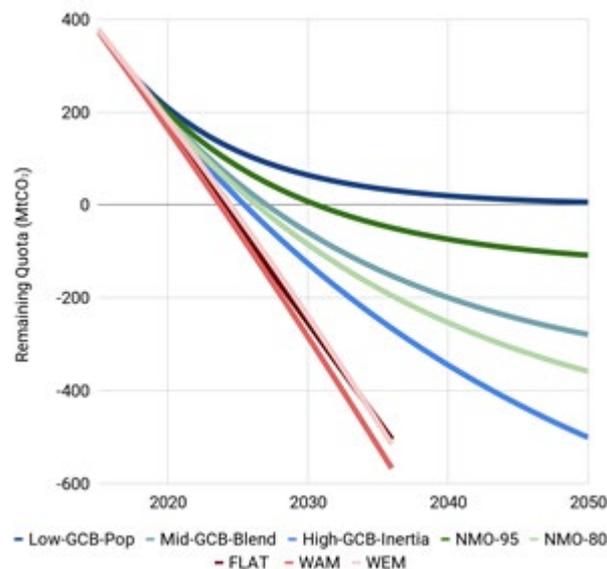


Figure 1. Depletion of Ireland’s prudent, minimally equitable, remaining national CO₂ quota of 391 MtCO₂ from 2015, showing exponential pathways corresponding to the scenarios described in the text. By definition/construction, Low-GCB-Pop is the only scenario which does not go negative (does not enter CO₂ debt relative to that chosen quota).

Policy relevance: This method enables analysis of proposed policy. For example, in the case of Ireland a new Climate Action Plan (DCCA 2019) aims to strengthen climate governance; however, insofar as they can be inferred, the mitigation trajectories implied by the plan still suggest a very early exhaustion of the assessed prudent, fair share (Paris-aligned) CO₂ quota by 2024, with consequent emergence of CO₂ debt – reaching net zero emissions in 2050, but an accumulated CO₂ debt of ~580 MtCO₂. Given the CO₂ debt apparent even in high ambition energy CO₂ mitigation pathways, further research is now examining society-wide scenarios. Ireland’s forestry CO₂ removals are projected to fall, and CO₂ emissions due to organic soil emissions and extraction (for horticulture and energy) continue to be high. Immediate cessation of peat extraction and limiting timber harvest – potentially retaining biomass toward future permanent CDR via Bioenergy with Carbon Capture and Storage – could become mitigation priorities.

Ongoing and further research: Further research is needed to develop policy-relevant, society-wide scenarios for effective climate change mitigation and adaptation. In particular, non-CO₂ emissions affect CO₂-only budgets. This is particularly so in Ireland, which has the highest per capita nitrous oxide and methane emissions in the EU (the latter currently rising at 2% per



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year) due to increasing nitrogen fertiliser use to increase dairy and beef production. Extending the above research, a scenario comparison tool, based on the new GWP* warming-equivalent method (Cain et al. 2019), is indicating that capping system fertiliser input would provide a policy driver for steady/permanent reduction in methane emissions (through cattle herd reduction). A substantial reduction in climate forcing due to methane (Fuglestedt et al. 2018), would thereby be enabled that could be essential to achieving credible Paris Agreement -aligned mitigation for Ireland and reduced reliance on speculative future CDR.

Conclusions

For developed countries with heavy fossil fuel reliance, current approaches to decarbonisation are grossly inadequate. Analyses that stress long-term and sectoral measures or percentage renewable energy penetration targets can divert attention from the primary near-term mitigation priority of quickly reducing unabated fossil carbon combustion. Our analysis highlights that vulnerable islands and small developing countries generally have far slower depletion rates of their 2015 CO₂ quotas than developed nations, therefore they have more time and emissions ‘space’ within their per capita quota to enable adaptation and mitigation. By contrast, comparable NCQs and CO₂-debt trajectories for developed nations starkly illustrate the urgency needed for them to achieve radical near-term action and limit the escalating risk of catastrophic policy failure. The core recommendation for both national and global climate action must be the prioritisation of achieving nett zero CO₂ emissions within a *stated* overarching nett CO₂ cumulative quota constraint, supplemented by non-CO₂ mitigation, while limiting commitment to CO₂ debt and rigorously respecting a *nett* CO₂ annual emission rate pathway that is commensurate with satisfying this cumulative constraint. The key message from this analysis is that delayed climate action is escalating risks of catastrophic policy failure in mitigation and adaptation.

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Abbreviations

CDR Carbon dioxide removal from the atmosphere via biological or chemical pathways to land, ocean or geological storage.

GCB Global carbon budget, the remaining cumulative CO₂ (in this analysis based on the reference year of 2015) relating to likelihood of limiting to a stated temperature limit to global mean surface warming.

NMO National Mitigation Objective: by 2050, reducing national GHG emissions by either 80% or 95% relative to 1990.

NCQ National CO₂-only quota. Defined in this research as an equal per capita share of a prudent, minimally equitable fair share of the remaining global carbon budget.

WAM With Additional Measures. Scenario reported to EU including proposed policy measures.

WEM With Existing Measures. Scenario reported to EU including only existing policy measures.

Low-GCB-Pop National CO₂-only quota based on an equal per capita share of the 2015 GCB.

Mid GCB-Blend National CO₂-only quota based on mid-value blending inertia and population.

High-GCB-Inertia National CO₂-only quota by current per capita share of 2015 global emissions.