



## Society-wide scenarios for effective integration of Paris-aligned climate mitigation and adaptation in national and regional policy

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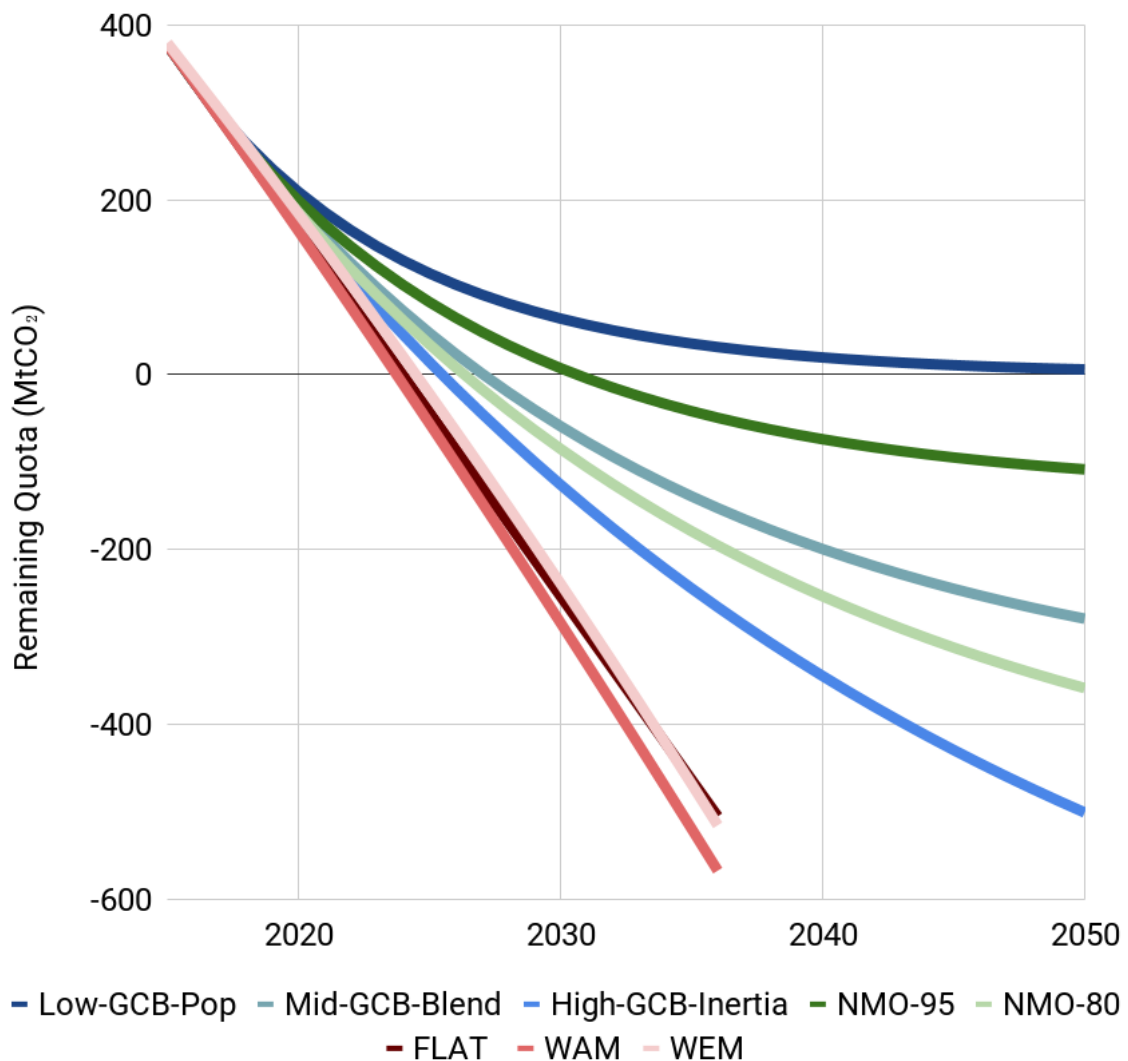
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Climate science (IPCC 2018) and economics (Emmerling et al. 2019; Burke, Hsiang, and Miguel 2015) indicates that achieving far earlier and deeper mitigation than pledged to date is likely now critical to effective climate action – particularly to ensure limits to adaptation are not breached. However, clear and coherent comparisons of national and regional climate action have been lacking. Therefore, here we summarise a benchmarking method (McMullin et al. 2019) to establish a prudent, fair share of the remaining global CO<sub>2</sub> budget for any Party to the Paris Agreement. Using Ireland as a case study, we analyse current policy ambition relative to this benchmarked national CO<sub>2</sub> quota, demonstrate early emergence of CO<sub>2</sub> debt, and show tacit mitigation policy reliance on future large scale carbon dioxide removal (CDR). Toward society-wide scenarios for effective climate action, we further examine the crucial roles of non-CO<sub>2</sub> mitigation and safeguarding land carbon stocks.

The strongly linear relationship between nett cumulative anthropogenic CO<sub>2</sub> emissions and resultant global warming enables a scientific estimate 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 CO<sub>2</sub> 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, in McMullin et al. (2019), we assess the *prudent*, remaining GCB in per capita terms, based on the GCB range estimated by IPCC SR15 (Rogelj et al. 2018). As a national case study, we assess Ireland’s *minimally equitable* NCQ: 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 CO<sub>2</sub> emissions for: current national policy aspirations, based on stated objectives; and current national policy projections, as reported by Ireland to the UNFCCC.

The low-end GCB value of 610 GtCO<sub>2</sub> as of 2015, divided by the global population of 7.38 billion, gives a remaining global equal per capita quota of 83 tCO<sub>2</sub>; we term this *minimally equitable* as it excludes aviation, 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 MtCO<sub>2</sub> 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 CO<sub>2</sub> commitment is 517 MtCO<sub>2</sub>, with *R* = -8.3%; for *NMO-80*, the corresponding values are 917

MtCO<sub>2</sub> with R = -4.7%. For Irish projections: *WEM* (with existing measures) gives cumulative CO<sub>2</sub>, only up to the end of 2035, of 964 MtCO<sub>2</sub> with R = +0.7%; the corresponding *WAM* (with additional measures) values are 937 MtCO<sub>2</sub> and +0.4%. Figure 1 compares these results for Ireland on the basis of depletion from the 391 MtCO<sub>2</sub> remaining 2015 NCQ value.



**Figure 1.** Depletion of Ireland’s prudent, minimally equitable, remaining national CO<sub>2</sub> quota of 391 MtCO<sub>2</sub> 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 CO<sub>2</sub> debt relative to that chosen quota).

Ireland has recently published a new Climate Action Plan (DCCAIE 2019) proposing a significant strengthening in climate governance; however, we find that the mitigation trajectories implied by the plan, insofar as they can be inferred, still suggest, a very early exhaustion of the assessed prudent, fair share (Paris-aligned) CO<sub>2</sub> quota by 2024, and consequent emergence of CO<sub>2</sub> debt, reaching net zero



emissions in 2050 but with a CO<sub>2</sub> debt of ~580 MtCO<sub>2</sub>. Given the CO<sub>2</sub> debt apparent even in high ambition energy CO<sub>2</sub> mitigation pathways, we are examining society-wide scenarios. Ireland's forestry CO<sub>2</sub> removals are projected to fall, and CO<sub>2</sub> emissions due to organic soil emissions and extraction (for horticulture and energy) continue to be high. Limiting timber harvest – potentially saving biomass toward CDR via Bioenergy with Carbon Capture and Storage – and immediate cessation of peat extraction could become mitigation priorities. Ireland also has high and increasing nitrous oxide and methane emissions, especially due to nitrogen fertiliser use to increase dairy and beef production. Our scenarios, using the new GWP\* warming-equivalent method (Cain et al. 2019), are indicating that capping system fertiliser input and steady/permanent reduction in methane emissions (through cattle herd reduction), thereby enabling a cooling climate forcing (Fuglestvedt et al. 2018), could be essential to enable Paris Agreement -aligned mitigation for Ireland and reduced reliance on CDR.

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. By contrast, comparable NCQs and CO<sub>2</sub>-debt trajectories for developed nations starkly illustrate the urgency needed to achieve radical near-term action and show 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 CO<sub>2</sub> emissions within a *stated* overarching nett CO<sub>2</sub> cumulative quota constraint, supplemented by non-CO<sub>2</sub> mitigation, while limiting commitment to CO<sub>2</sub> debt and rigorously respecting a *nett* CO<sub>2</sub> 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 mitigation and adaptation policy failure.

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