



THE SOCIAL VALUE OF  
OFFSETS AND TEMPORARY  
CARBON REMOVALS

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The paper addresses a central problem in climate policy and carbon markets: how to value temporary and risky carbon offsets relative to permanent emissions reductions. Offsets—particularly nature-based solutions—are increasingly used in net-zero strategies, yet they are subject to impermanence, failure, and non-additionality.

**Authored by:**

Summary of Groom & Venmans (2023), *Nature* and Groom and Venmans (2025) *EEPE*.



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# The Social Value of Offsets and Temporary Carbon Removals

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## Research and policy question

The paper addresses a central problem in climate policy and carbon markets: how to value temporary and risky carbon offsets relative to permanent emissions reductions. Offsets—particularly nature-based solutions—are increasingly used in net-zero strategies, yet they are subject to impermanence, failure, and non-additionality. The core policy question is whether temporary or risky offsets have any value at all, and hence any place in a net-zero strategy. A subsidiary question then becomes whether there is any equivalence between temporary and permanent carbon storage or removal once these risks and time dimensions are taken into account. Resolving this question is critical for the credibility and efficiency of offset markets and net-zero commitments.

## Methodological approach

The authors introduce the concept of the Social Value of Offsets (SVO), defined as the present value of climate damages avoided by delaying emissions through temporary carbon storage. The approach is grounded in welfare economics and explicitly links physical climate dynamics to economic damages via the social cost of carbon (SCC). Unlike previous approaches that focus purely on physical metrics or abatement costs, the SVO framework accounts for the timing of emissions, the duration of storage, and the risks of failure and non-additionality. The methodology embeds these elements in a cost-benefit framework and derives equivalence factors that express the value of an offset as a fraction of the SCC.

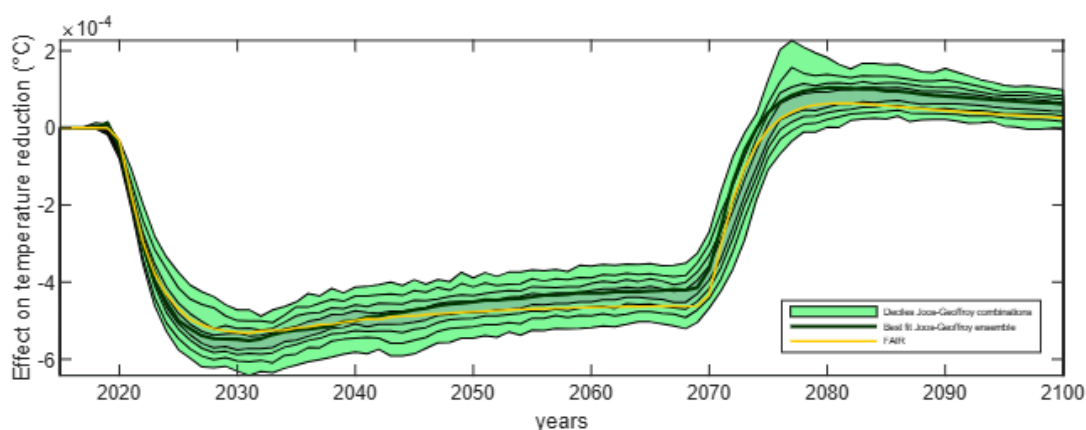
## Findings

The paper demonstrates that temporary offsets always have positive social value because delaying emissions delays climate damages via temporary reductions in temperature (Fig. 1). However, this value is generally well below that of permanent carbon removal. Calibration using plausible assumptions about failure and additionality risks yields a clear rule of thumb: a 50-year offset is typically worth between one-third and one-half of a permanent emissions reduction in welfare terms. This implies that two to three such offsets are required to compensate one ton of CO<sub>2</sub> emitted. The results also show that welfare equivalence varies systematically with offset duration, risk levels (physical risk and additionality risk. See Table 1), and future climate pathways. The approach provides a transparent way to compare offsets of differing quality.

## Policy implications

The SVO provides a coherent and policy-relevant metric for integrating offsets into net-zero strategies. It offers a principled basis for comparing offsets of different qualities, improving

integrity in voluntary and compliance carbon markets. The results also suggest that the use of shorter, more credible offset contracts, with the option of renewal, rather than unrealistic one-off perpetual commitments, would help with the incentives to provide long-lasting carbon removal. Properly calibrated (with more transparently available data), the SVO approach will help identify offsets that are too risky to be socially valuable. Beyond offsets, the framework can inform life-cycle analysis, the valuation of carbon debt, and comparisons between offsets and alternative mitigation technologies. The approach has already been central to the UK government's proposal to include carbon removals in the UK Emissions Trading Scheme in the future. Overall, the SVO shifts the debate from whether offsets have value to how much value they provide relative to their costs and risks.



**Fig. 1: The effect of a temporary emission reduction:** Panel a shows the background emissions and the temperature path of the IPCC's RCP 2.6. scenario. Panel b shows the effect of a temporary emission reduction (1 GtCO<sub>2</sub> absorbed in 2020, and re-emitted in 2070) on atmospheric carbon concentrations.

Failure and Additionality Risk ( $\varphi + \phi$ )	Permanence (Years)					Survival Probability
	10	25	50	100	$\infty$	
						P(t > 50yrs)
0%	10%	24%	44%	70%	100%	100%
0.2% (a)	10%	23%	42%	64%	85%	90%
0.5% (b)	10%	22%	39%	57%	70%	78%
1.4% (c)	9%	20%	31%	41%	44%	50%
4.6% (d)	7%	13%	17%	18%	18%	10%
6.0% (e)	7%	11%	13%	14%	14%	5%

Notes: Column 1 reports combined failure ( $\varphi$ ) and additionality ( $\phi$ ) risk. Sources: (a) Jayachandran et al. (2017); (b) Guizar-Coutino et al. (2022); (c) Acre study (see Groom & Venmans, 2023); (d) West et al. (2023); (e) additionality risk of 4.6% plus failure risk of 1.4%. Columns 2–6 report equivalence (SVTR/SCC) for permanence from 10 years to infinity. Final column shows probability of survival at 50 years. SCC values: \$109/tCO<sub>2</sub> (Howard & Sterner, 2017) and \$36/tCO<sub>2</sub> (Nordhaus, 2017). All referenced in Groom and Venmans (2025).

**Table 1. Equivalence of Temporary and Permanent Emissions Reductions.** Source: Groom and Venmans (2025).

## Links and materials

Groom, B. & Venmans, F. (2023). The social value of offsets. Nature.  
<https://doi.org/10.1038/s41586-023-06153-x>

Data and code repository:  
<https://doi.org/10.5281/zenodo.7848892>

Groom B and Venmans F (2026). [The Social Value of Temporary Carbon Removals and Delayed Emissions](https://www.journals.uchicago.edu/doi/abs/10.1086/733360). Environmental and Energy Policy and the Economy 2025 6:1, 169-212.  
<https://www.journals.uchicago.edu/doi/abs/10.1086/733360>.

SVO Policy tool: <https://svo-web-app.vercel.app>.

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