

Analysis

How will we use our time in a future of sustainable wellbeing?

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ABSTRACT

Time use analysis is an accessible and intuitive method for building an understanding of the greenhouse gas emissions footprint of lifestyles, and the ways in which these lifestyles impact our enjoyment and wellbeing. This study develops a novel methodology to estimate the emissions footprint and experienced wellbeing of daily life in 2050 in three global north countries (Finland, France, and the UK) from a time use perspective. Our modelling utilises time use analysis, experienced wellbeing data, direct emissions data, environmentally extended multi-regional input-output analysis (MRIO), and scenario building. We first construct an ambitious 2050 scenario assuming a move to sufficiency-based household consumption of commodities and energy, dietary change, systemic changes to transport habits, technological change and cleaner production, and energy efficiency improvements. Despite modelling these ambitious changes out to 2050, we estimate that the emissions intensity of global north lifestyles will remain outside planetary boundaries. We then model experienced wellbeing and emissions in three time use scenarios, or 'lifestyles', for all three countries to understand how time use changes can improve wellbeing and lower lifestyle emissions. These scenarios are shaped by insights from functional time use theory (FTU), with further insights from the provisioning systems literature. We find that, though it is possible to improve our wellbeing and lower emissions through lifestyle change, further radical transformations are required to provisioning systems to bring emissions footprints within planetary boundaries. Moreover, without this transformation, some socially positive changes to time use may have unintended negative environmental effects.

1. Introduction

1.1. Time use and a post-growth future

The time horizon of 2050 is commonly used as a benchmark for achieving rapid decarbonisation and other ecological objectives to mitigate the worst effects of ecological crises (IPCC, 2022; European Commission, 2024). An influential and growing literature demands a move beyond growth-dependent economies in the global north to bring the resource and ecological footprints of these economies back within planetary boundaries (O'Neill et al., 2018; Wiedmann et al., 2020; Richardson et al., 2023). Post-growth economies should instead be based on the achievement of social outcomes, enhancing wellbeing, and sufficiency to ensure the universal satisfaction of basic needs while operating within planetary boundaries (Raworth, 2017; Hickel, 2020; Jackson, 2021).

Quantitative research related to this imperative, however, is often expressed in quantities and physical units of stocks and flows, such as energy, matter, waste, labour, and so on (Kallis et al., 2025; Mair, 2025). By contrast, time use studies, where they have intersected with methods and frameworks concerned with issues of sustainability, have offered an intuitive means of understanding the ecological pressures of global north lifestyles. In this paper, we extend time use and sustainability studies by further understanding an element of wellbeing derived from time use, now and in 2050. We also integrate time use sustainability studies into the post-growth literature which has operationalised the concept of planetary boundaries (O'Neill et al., 2018; Ala-Mantila et al., 2022), by demonstrating the degree to which global north lifestyles and time use in our case study countries transgress these boundaries.

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1.2. Research contributions and focus

This paper is primarily a contribution to a literature investigating the nature and conditions for a ‘good life within planetary boundaries’ (O'Neill et al., 2018; Fanning et al., 2020). The focus on time use helps bridge a gap between this analysis and accessible implications for daily life in global north countries in time use terms; in other words, what a good lifestyle within planetary boundaries may look like. In this context, this article seeks to address several research questions:

- To what extent did global north lifestyles (in Finland, France and the UK) in 2016 transgress planetary boundaries, and what are the drivers of this unsustainability in time use terms?
- What is the relationship between time use, emissions intensity, and experienced wellbeing?
- How can changes in global north lifestyles in a future based on post-growth assumptions of sufficiency reduce our emissions footprints and improve our experienced wellbeing?

To answer these questions, we develop a novel combination of methodologies to model the wellbeing and emissions footprint of lifestyles using time use analysis, activity-specific subjective wellbeing data, and total direct and indirect household emissions.¹ We first model the emissions footprint for 2016, the year in which the time use survey data utilised for this study was collected, for Finland, France, and the UK. We use this as a platform to estimate daily emissions footprints in our ‘2050 Sufficiency Baseline’, in which time use patterns are unchanged from 2016 data, but various other ambitious changes are assumed. Finally, we model three time use scenarios (‘Good Life’, ‘Caring Responsibilities’, and ‘Individualist’) in these hypothetical 2050 conditions to determine how changes to time use and our lifestyles might impact our wellbeing and emissions footprints. This is the first paper to model time use, sustainability, and subjective wellbeing relationships for multiple countries with various time use scenarios.

2. Background

2.1. Time use and sustainability

Time use studies are an increasingly important methodological tool in sustainability studies and have been used to model the energy and emissions footprints of lifestyles in a range of countries (Jalas, 2005; Druckman and Jackson, 2010; De Laet et al., 2017; Smetschka et al., 2019; Jiang et al., 2023; Long et al., 2024). By building concordance tables based on assumptions about the relationship between time use and consumption of goods, services and energy, these studies seek to quantify the energy or emissions footprint of individuals or households in time use terms. This is often expressed as a 24-h day (as this is the standard structure of time use surveys), or as specific activities which comprise a day. Typically, they concern one country at a fixed point in time, and do not involve multiple countries or alternative scenarios of household energy and commodity consumption or time use. By contrast, this article seeks to address a literature gap by understanding the impacts of time use in a more sustainable future, across multiple countries, using three time use scenarios (‘Good Life’, ‘Caring Responsibilities’ and ‘Individualist’).

2.2. Time use and wellbeing

Time use datasets sometimes record subjective wellbeing data from survey respondents (e.g. US Bureau of Labour Statistics, 2022; Statistics Canada, 2022). These are captured as activity-specific assessments of

‘experienced wellbeing’, for example, or in broader assessments of how life is ‘evaluated’ overall (Dolan et al., 2017). For example, evaluative wellbeing assessments investigate the general state of conditions like life satisfaction, pain, pleasure, enjoyment, and happiness (Miret et al., 2017).

Activity-specific wellbeing assessments, by their very nature, record a more focused assessment of experienced wellbeing, and have been in use for decades due to their policy and analytical applications (Krueger et al., 2009; Gershuny, 2011). They investigate the emotion and feeling of various states specifically derived from a range of activities and at close proximity to the time in which the activity took place (Miret et al., 2017). The Click and Drag Diary Initiative (CaDDI) time use dataset employed in our study collects activity-specific experienced wellbeing data in diary entries from nine countries ($n = 10,201$) by asking participants to provide ‘enjoyment ratings’ for each 10-min slot of activities carried out in a day (Sullivan et al., 2020).

We use data from diary entries from Finland, France and the UK in this study ($n = 3214$). This assessment of experienced wellbeing is an important but not entirely sufficient means of understanding the self-assessed subjective wellbeing of individuals. This is certainly the case when understood against broader theories of eudaimonic wellbeing (Lamb and Steinberger, 2017) or objective wellbeing which includes material dimensions and the satisfaction of needs (Max-Neef et al., 1989; Gough and Doyal, 1991; Sen, 1993). Therefore, while we acknowledge that analysis of experienced wellbeing is insufficient by itself to understand broader subjective wellbeing, we regard it to be a useful and necessary approach as part of a wider picture.

3. Methods

In this study we used a range of quantitative methods to explore emissions footprints and experienced wellbeing in 2050 from a time use perspective. The first set of methods establishes a baseline assessment of emissions footprints, the emissions intensity of time use (emissions per hour) and experienced wellbeing for our case study countries of Finland, France and the UK for 2016. This allows for an understanding of the emissions footprint and intensity of time-use within and between our case study countries, at the level of specific activities and groups of activities. It also offers an assessment of the experienced wellbeing derived from these activities.

Our method then extends this analysis to model the emissions footprint and emissions intensity of time use for our 2050 Sufficiency Baseline. This scenario is developed based on important assumptions rooted in the postgrowth literature: sufficiency and radical energy transitions. These are operationalised as aggregate reductions in household final demand (based on the Minimum Income Standards (MIS) literature), and ambitious improvements in energy efficiency, widespread electrification and decarbonisation, technological progress, and systemic change to transport provision, alongside a shift to less meat-intensive diets. At this stage, we assume constant time use between 2016 and 2050, to assess the changing emissions intensities of time use activities by directly comparative means without lifestyle change.

Finally, we use results from the 2050 Sufficiency Baseline as new parameters of emissions intensity of time use activities to model three new time use scenarios to a) isolate and explore the effects of time use change on our emissions footprint and on experienced wellbeing, and b) determine which forms of time use contribute most to a lifestyle of sustainable wellbeing. A summary of our methodological approach is illustrated in Fig. 1 and is expanded upon in greater detail below. Further methodological detail is also provided in Supplementary Materials 1.

3.1. Time use and experienced wellbeing

The time use dataset used in this study is the Click and Drag Diary Initiative (CaDDI) time use survey carried out by the Centre for Time Use

¹ We use ‘emissions’ as shorthand for ‘greenhouse gas emissions’, measured as carbon dioxide equivalent (CO₂e).

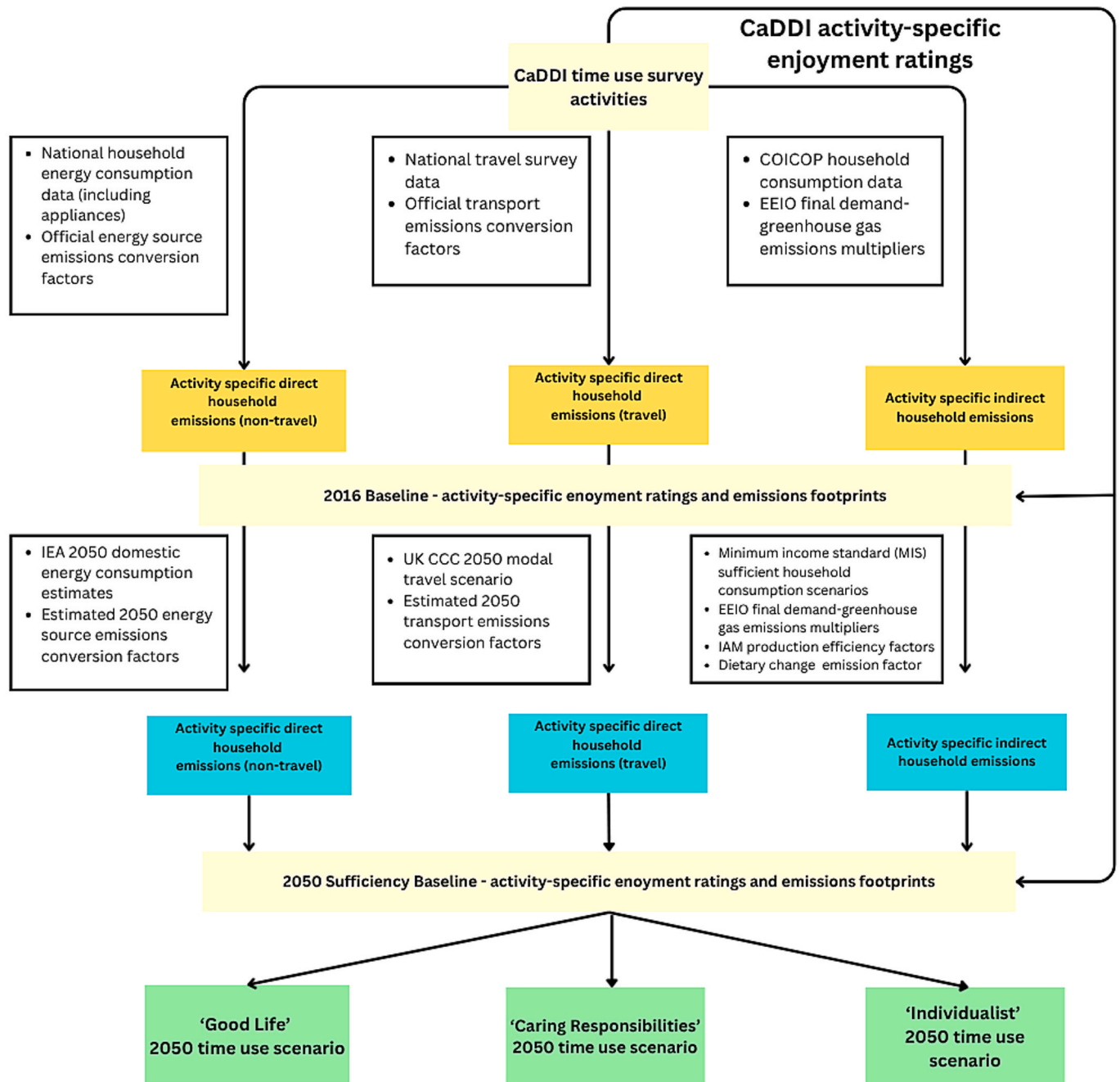


Fig. 1. Summary of methodology, outlining three main steps to produce 2050 time use scenarios. These include 2016 baseline footprints based on national average time use from time use data, our 2050 Sufficiency Baseline, and our three time use scenarios in 2050.

Research (CTUR) (Sullivan et al., 2020; Gershuny et al., 2022). This survey collected over 10,000 time use diary entries from about 6000 participants for nine countries in a 2016 wave (Sullivan et al., 2020). It is novel among standardised cross-national time use surveys as it instructs participants to enter *activity-specific enjoyment ratings* in electronic time use diaries (Sullivan et al., 2020). Therefore, CaDDI data offers comprehensive time use data for 37 pre-coded activities for 144 ten-minute periods in a day, each with their own enjoyment rating from 1 to 7 (where 7 represents the highest possible enjoyment).

To streamline analysis and results, these activities have been grouped into 16 larger categories where commonalities between activities exist (such as specific forms of care work or leisure). The mapping of the 37 original time use activities to 16 larger activity groups is included in Supplementary Materials 2. National average time use diaries were

calculated using this data to show a representative 24-h time use diary for the UK, France, and Finland. We also calculated national average enjoyment ratings for each of the 16 activity groups forming the average 24-h daily time use profile. These enjoyment ratings provide an understanding of the experienced subjective wellbeing derived from forms of time use.

3.2. Time use and sustainability

We model the relationship between time use and sustainability by determining the direct and indirect emissions associated with our 16 time use category groups. This is done in three stages: direct household emissions, travel related emissions (direct and indirect), and indirect (or embedded) emissions. Estimates at household level are converted from

national to per capita level using population estimates and projections for each case study country (in 2016 and 2050), obtained from Eurostat (for Finland and France) and the ONS for the UK.

Using methods developed in previous time use and sustainability research (Druckman and Jackson, 2010; Smetschka et al., 2019; Long et al., 2024), we estimate household direct emissions associated with time use categories by constructing concordances between our time use activity groups and household direct energy consumption. Using this approach, we estimate the total final household energy consumption associated with time use activities, including appliance-level estimates for household consumption of electricity. Household energy consumption data is drawn from Eurostat (for Finland and France) and from official UK sources (Eurostat, 2023; DESNZ, 2023). Using country-specific emissions conversion factors, we then estimate the direct emissions in CO₂ equivalent for 37 time use activities and 16 time use activity groups (Statistics Finland, 2016; ADEME, 2020; DESNZ, 2024; European Environment Agency (EEA), 2024). The concordances used to map direct energy consumption to forms of end-use energy consumption, and appliance-level mapping to time use, are presented in Supplementary Materials 2.

Indirect emissions are calculated using environmentally extended multi-regional input-output (EEMRIO) modelling. We use household final demand data (in COICOP categories, adjusted to 2016 US dollars from national currency units) from official sources in Finland, France and the UK (Statistics Finland, 2024; INSEE, 2024; ONS, 2025). Final demand-emissions multipliers are calculated from OECD Inter-Country Input-Output (ICIO) tables and greenhouse gas extensions derived from the GLORIA input-output database (hereafter referred to as EEMRIO multipliers) (Industrial Ecology Laboratory, 2025). This allows us to estimate embodied emissions throughout supply chains from a unit of final demand in each sector, and this method has been used in time use footprinting analyses in a range of studies (Druckman and Jackson, 2010; Smetschka et al., 2019). To connect these emissions estimates to time use categories, we use a series of equally-weighted concordance matrices developed for this study, linking CaDDI time use categories to COICOP classifications, a range of ISIC (International Standard Industrial Classification) sectors, and finally to the ICIO sectoral classifications in which our EEMRIO multipliers are organised. For the purposes of clarity and reproducibility, these matrices are included in Supplementary Materials 2. Further methodological detail relating to their utilisation and accompanying sensitivity analysis is included in Supplementary Materials 1.

We also estimate the total direct and indirect emissions related to time spent travelling, such as household car use and public transport. Using official national transport surveys for Finland, France and the UK (Traficom, 2016; CGDD, 2017; Department for Transport, 2017), and country-specific emissions conversion factors to estimate the emissions associated with travelling a given distance for a range of modes of transport (VR, 2019; ADEME, 2020; DESNZ, 2016), we also estimate transport emissions from various forms of travelling time use in the CaDDI survey. This is a simple concordance approach completed in one step, connecting emissions estimates calculated from transport surveys and emissions factors with corresponding time use categories in the CaDDI survey (see Supplementary Materials 1 for more detail).

Together, these methods – covering household direct, indirect, and transport emissions – allow us to estimate the total *annual* per capita emissions footprint of time use. From here, we also produce emissions footprint estimates for national average *daily* profiles of time use in Finland, France and the UK for 2016, and *hourly emissions intensity* parameters for all time use categories, i.e. what are the total emissions associated with an hour of bus travel in the UK, or two hours of unpaid care work in Finland? These inputs are instrumental for modelling our three time use scenarios in postgrowth 2050 conditions.

All energy consumption data, input output data and emissions extensions, household consumption data, transport survey data, and emissions conversion factors are from 2016 to match the year of the

CaDDI time use survey data.

3.3. 2050 sufficiency baseline

Based on our 2016 estimates of the emissions footprint of time use – measuring the emissions in kgCO₂e for an hour of time use for all activities – we model radically changed conditions of consumption and production in 2050. The core of the method remains the same as for 2016, but with a range of assumptions applied, including aggregate reduction in household demand, lower energy consumption, widespread electrification of energy use, lower emissions intensity of production in key sectors, a shift to less meat-intensive diets, and a modal shift in transport provision. These assumptions represent our ‘2050 Sufficiency Baseline’, simulating a more equitable and sustainable future of sufficient aggregate consumption, particularly of affluent lifestyles in the face of ecological limits (Oswald et al., 2020; Wiedmann et al., 2020; Millward-Hopkins and Oswald, 2023; Tian et al., 2024; Kallis et al., 2025; Tian et al., 2026). Expansive methodological detail relating to all scenario assumptions used for our 2050 Sufficiency Baseline is included in Supplementary Materials 1.

Firstly, we assume significant changes in household direct energy consumption. Using projections from the International Energy Agency (IEA) Net Zero Pathway, we assume that energy consumption in buildings in 2050 will be 68% of the 2020 total and will be characterised by a significant shift towards electrification of household energy use (IEA, 2021). We use Eurostat and official UK household energy consumption data for 2020 to model this overall reduction and change in fuel profile of end-use energy consumption (Eurostat, 2023; DESNZ, 2023).

For the UK, we use official electricity emissions factors projections for 2050 (DESNZ, 2023). French and Finnish electricity emissions factors for 2050 are estimated using official sources for estimates or scenarios of electricity grid fuel mixes in 2050, along with emissions intensities of those fuels (see Supplementary Materials 1). Emissions related to appliance-level electricity consumption estimates are calculated using these same country-specific electricity emissions factors for 2050. Emissions factors for fossil fuels consumed for direct household energy use are the same as the country-specific factors used for the 2016 baseline.

Assumptions are made for modal changes to transport systems and technologies. We model radical country-specific modal changes in transport consumption, using scenarios or projections from official sources in the UK, France, and Finland (Climate Change Committee, 2020; ADEME, 2022; Ministry of Transport and Communications, 2021). French and UK pathways utilised in this paper assume a reduction in overall transport kilometres per capita, with an ambitious modal shift to public transport and active travel at the expense of passenger car travel. The Finnish pathway assumes a no-growth in passenger car travel, but an increase in public transport consumption, resulting in a minor increase in per capita travel kilometres overall in 2050. We assume widespread electrification of public transport and the private car fleet and use the country-specific electricity emissions factors outlined above.

Indirect emissions for our 2050 scenario are modelled using the same EEMRIO multipliers used to produce our 2016 baseline. However, we simulate changes in the emissions intensity of production by adapting multipliers in key sectors based on CO₂ emission reductions pathways modelled in the IMAGE 3.2 Integrated Assessment Model (IAM) (van Vuuren et al., 2021; IIASA, 2022). Using the ‘Lifestyle and Renewables’ (LIRE) scenario developed in IMAGE 3.2 for the ambitious Shared Socioeconomic Pathway (SSP) 1.26, we calculate a change in the emissions intensity of production from 2015 to 2050 in key sectors and adjust the relevant EEMRIO multipliers in ICIO sectoral format by this factor (see Supplementary Materials 1 for detail). The LIRE scenario and SSP 1.26 is employed due to its conceptual alignment with the broader modelling assumptions made in this paper regarding a shift to less meat-intensive diets, electrification of key technologies, and overall

demand-side reductions in energy consumption, and so on.

We further assume significant changes to the level of household final demand based on sufficiency-related and postgrowth assumptions that, to achieve a sufficient level of decarbonisation in line with planetary boundaries, an aggregate reduction in overall consumption is required in global north countries (Gough, 2017; Hickel, 2021). To do this, we estimate a level of household consumption in line with the Decent Living Standards (DLS) literature, using population cohort-weighted reference budgets, or 'Minimum Income Standards' (MIS) (Deeming, 2020), specific to each country and mapped to COICOP categories to calculate indirect emissions of a sufficient household consumption scenario in 2050 (CRSP, 2023; Lehtinen, 2021, National Council for Policies to Combat Poverty and Social Exclusion, 2022).

Though preserving overall MIS demand levels for food (as not to reconstruct diets for each country), we simulate significantly less meat-intensive diets by applying an GHG emissions reduction factor to 'eating' related time use gathered from Springmann et al. (2018), which models food-related emissions reduction from 'flexitarian' diets of 52%.

3.4. Time use & wellbeing scenario changes

To produce the three scenarios ('Good Life', 'Caring Responsibilities' and 'Individualist'), time use is changed to represent stylised lifestyles in 2050 from which emissions footprints and experienced wellbeing assessments can be produced. These scenarios are heuristic devices used to explore experienced wellbeing and emissions intensities of alternative lifestyles in the future and are not predictions of time use in 2050. A detailed breakdown of the activity-specific daily time use profiles for our 2016 and 2050 baselines, and our three stylised time use scenarios in 2050, are described in Section 4.2.

The emissions intensity of each time use activity (kgCO₂e per hour) in 2050, estimated as described in Section 3.3, is used to estimate the emissions footprint for each new time use profile. To assess the experienced wellbeing effects of the different time use scenarios, we develop for a novel 'cumulative enjoyment rating' (CER). The CER is the sum product of the average enjoyment rating for a given activity and the total number of 10-min slots in a time use profile for that activity. Though this indicator is limited in its assumptions – such as the possible effect of declining marginal enjoyment beyond a certain level of time use – it is nonetheless a useful aggregate measure of states of experienced wellbeing, such as Kahneman and Krueger's (2006) 'U-Index'.

3.5. Assumptions and limitations

As with any modelling study, assumptions are necessary and thus our study has limitations. Regarding indirect emissions estimates, modifying the multipliers from the EEMRIO model forward to 2050 involves assumptions about future technologies, sectoral interdependencies, and future trade patterns that are far beyond the scope of this paper. We have taken robust steps to address this limitation, however, by adapting EEMRIO multipliers in key sectors based on carbon emissions reduction pathways modelled in the IMAGE 3.2 IAM for SSP scenario 1.26 (van Vuuren et al., 2021). Whilst our GLORIA emissions extensions are expressed in CO₂ equivalent, the IAM SSP pathways adopted here are in CO₂ only, so we assume that other component gases in the CO₂ equivalent measure reduce at the same rate as CO₂.

Regarding time use, only primary time-use activity is modelled in this study, whereas secondary and even tertiary activities are often carried out simultaneously. Furthermore, we use enjoyment ratings as a proxy for wellbeing, but enjoyment ratings (or experienced wellbeing) are only one component of wellbeing and does not give an indication of eudaimonic wellbeing.

Similarly, due to the sparsity of any detailed or standardised time series data for activity-specific enjoyment ratings in the CaDDI, or other, time use datasets, it is assumed that time use enjoyment ratings remain constant between 2016 baseline and the 2050 Sufficiency Baseline.

Whilst it is reasonable to assume diminishing marginal enjoyment at the extremes, there is no available evidence base quantifying this dynamic for dozens of time use activities over time. For the reasons of transparency and analytical tractability, therefore, we do not make these unsubstantiated assumptions and hold enjoyment ratings constant.

We also acknowledge that analysing the sustainability and experienced wellbeing through national average time use profiles clouds significant heterogeneity that would emerge if our analysis focused on gender, class and socioeconomic status, employment status, caring responsibilities, and so on. Existing literature in relation to gender and class disparities in time use have made significant insights in this regard (Druckman et al., 2012; Vagni, 2020; García Román and Gracia, 2022; Osorio et al., 2024; Chidambaram and Scheiner, 2024; Zhou et al., 2025). We therefore welcome further research in this space to build on our approach by focusing on research gaps in relation to time use, sustainability and wellbeing, disaggregated by gender and income disparities, for example.

4. Results

4.1. Estimates of emissions footprints, emissions intensity, and experienced wellbeing for 2016 and 2050 sufficiency baseline

In this section, we present results of analysis of the basic relationships between time use, experienced wellbeing and emissions footprints in 2016, before looking at how the emissions footprint of time use might change in a sufficiency-based scenario in 2050. Crucially, for all results in this section, we assume that profiles of time use between 2016 and 2050 are constant. Section 4.2 then explores the specific additional changes to emissions footprints and experienced wellbeing from the range of lifestyle scenarios represented by three different time use profiles ('Good Life', 'Caring Responsibilities' and 'Individualist').

Based on our scenario assumptions without changes to time use, we see a significant drop in the emissions intensities of lifestyles in all three countries modelled for this study between 2016 and 2050. Total emissions fall by 63.2% in Finland, by 57.8% in France, and 66.7% in the UK. When expressed in units of tonnes of CO₂e per capita per year, annual emissions fall from 7.9 tCO₂e/cap to 2.63 tCO₂e/cap in Finland (−66.7%), from 6.82 tCO₂e/cap to 2.63 tCO₂e/cap in France (−61.4%), and from 7.38 tCO₂e/cap to 2.28 tCO₂e/cap in the UK (−69.1%).

O'Neill et al. (2018) estimate that 1.61tCO₂e/cap represents a planetary boundary consistent with 2 degrees of global heating. Therefore, despite the ambitious non-time use assumptions made in our methodology to construct a 2050 scenario, a continuation of current time use patterns in all three countries would see us fail to achieve emissions reduction consistent with planetary boundaries. Section 4.2 demonstrates how changes in time use might further reduce emissions footprints.

At the macro level, total transport-related emissions represent the largest share of emissions reduction for Finland, France and the UK, accounting for 42.9%, 52.3% and 39.5% of total emissions reductions respectively in 2050. Indirect emissions account for 28.4%, 25.6% and 31.1% of all emissions reduction in Finland, France and the UK respectively.

Our modelling assumptions regarding changes to the scale and nature of final direct energy consumption means direct emissions account for by 28.5% of total reductions between 2016 and 2050 in Finland, 22% in France, and 29.3% in the UK.

In gross terms, indirect emissions also fall significantly. With a move towards overall sufficiency-related levels of household consumption (represented by Minimum Income Standards), more emissions efficient production technologies (estimated from the LIRE SSP 1.26 emissions reduction pathways in key sectors), and a shift towards less meat-intensive diets, indirect emissions footprints fall by 22.6% in Finland, 19.5% in France, and 26.1% in the UK. These results are consistent with previous studies that have utilised reference budgets in input-output

modelling approaches (Druckman et al., 2012; McElroy and O'Neill, 2025).

At the activity-specific level, Fig. 2 shows emissions intensities (in kgCO₂e per hour) for 2016 and 2050 alongside estimates of daily emissions for all time use activity groups in our study averaged across all three countries, organised in descending order by the three-country average of activity enjoyment ratings. Total emissions change significantly between 2016 and 2050 across activities, and clear patterns exist as to which activities contribute most to daily lifestyle emissions. Higher emissions transport (dominated by private car travel), eating (driven by meat-intensive diets), and domestic work (due to various types of household energy consumption), on average across our three case study countries, produce the highest daily emissions of all time use activities in 2016. They represent a relatively small share of total time use, however, accounting for just 11.2%, 14.8% and 13.1% of daily time use in Finland, France and the UK respectively.

Based on the technological and behavioural changes modelled in this study, however, 2050 would see sharp emissions reductions in time use associated with eating and mobility. A shift towards less meat-intensive diets (Springmann et al., 2018), along with broader changes in direct emissions and emissions intensity of production, drives a reduction in 'eating' related emissions by an average of 59.5% across our three countries. Higher-carbon forms of travel emissions (such as private car transport) are estimated to fall by an average of 79.8%. Despite these changes, however, if 2016 time use profiles were maintained out to 2050, time spent eating, travelling and undertaking domestic labour in a day would still be sufficiently emissions-intensive to breach per capita planetary boundaries.

Fig. 3 maps out the relationship between the daily emissions related to, and the wellbeing derived from, time use activities. The bottom right-hand corner of this figure indicates activities which can contribute to high wellbeing and low emissions intensity lifestyles. Crucially from a postgrowth perspective, time spent doing care work and socially reproductive labour contributes to subjective wellbeing more than paid work. Active travel is also significantly less emissions intensive and contributes to higher wellbeing than all other forms of travel. The insights from these results are applied in the construction of our three alternative time use scenarios in 2050.

4.2. Modelling time use scenarios and wellbeing in 2050

Having established the basic relationships between time use activities, emissions intensity and wellbeing, and the change in emissions intensities based on our assumptions between 2016 and 2050, we are

able to address a core research question: How can changes in global north lifestyles in a more sufficiency-oriented future reduce our emissions footprints and improve our wellbeing?

To do this, we have constructed three time use scenarios, or hypothetical 'lifestyles'. A comparative summary of the hourly values for the 2016 time use profiles of our three countries (which are also used in our 2050 Sufficiency Baseline), and of the three alternative 2050 time use scenarios for all countries, are shown in Table 1. The time use profiles of these lifestyle scenarios (i.e. the composition of a 24-h day) are based on insights from functional time use (FTU) theory. Functional time use theory emerges from the 'material and energy flow analysis' framework (MEFA) developed by social ecologists and argues that time use is a system-level resource, shaped and constrained by social and individual systems which we produce and reproduce through systemic time use (Ringhofer, 2013; Ringhofer and Fischer-Kowalski, 2016). Ringhofer (2013) argues that four such systems exist, which we produce and reproduce through our collective time use: the personal system (where biological demands of sleep, eating, and washing place non-negotiable demands on a portion of our daily time), the domestic system (where dependents and needs for reproduction of the household place non-negotiable demands on time), the economic system (time required for work to secure an income), and the community system (time requirements to participate in social and community life). Transport time is understood as an 'enabling' time use system, which impacts the previous four core systems (Smetschka et al., 2019).

Understanding time use in systemic terms, therefore, allows us to map out time use scenarios where these systemic influences and constraints are modelled explicitly. The number of dependents directly increases our caring time responsibilities, for example. Physical infrastructure and provisioning systems also dictate the goods and services available for consumption which also impact our time use as individuals and at a system level (such as the scale and nature of public transport provision, for example). The indicative lifestyles we propose, therefore, reflect some core assumptions about these circumstances, constraints and characteristics. They are intended to demonstrate how the experienced wellbeing and emissions footprints of various lifestyles are impacted by systemic factors, and where the discretionary ability exists to meaningfully alter our time use in the absence of these constraints.

In the coming subsections, our scenario results illustrate the isolated effects of emissions reductions based on our modelling assumptions, and time use changes specifically, from 2016 to 2050 for each country. We use 2016 daily emissions estimates as a baseline for each country, apply direct and indirect emissions intensity changes for each time use activity

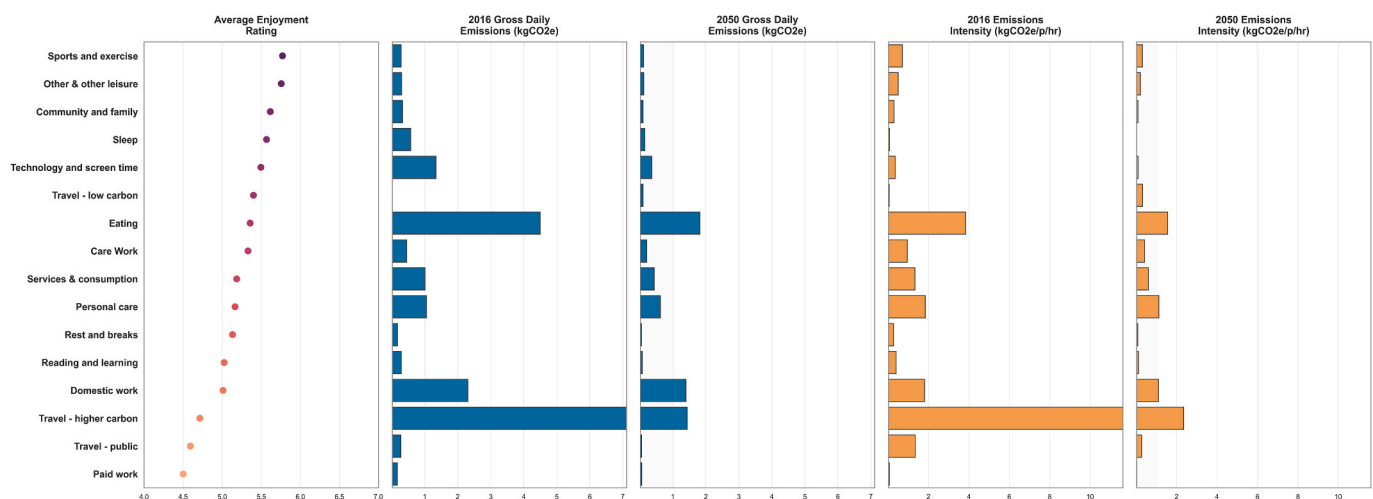


Fig. 2. Three-country average values summary of results of all time use activities, organised by enjoyment ratings. Results also include gross daily emissions and emissions intensity per hour for all activities, for 2016 and for our modelled 2050 scenario.

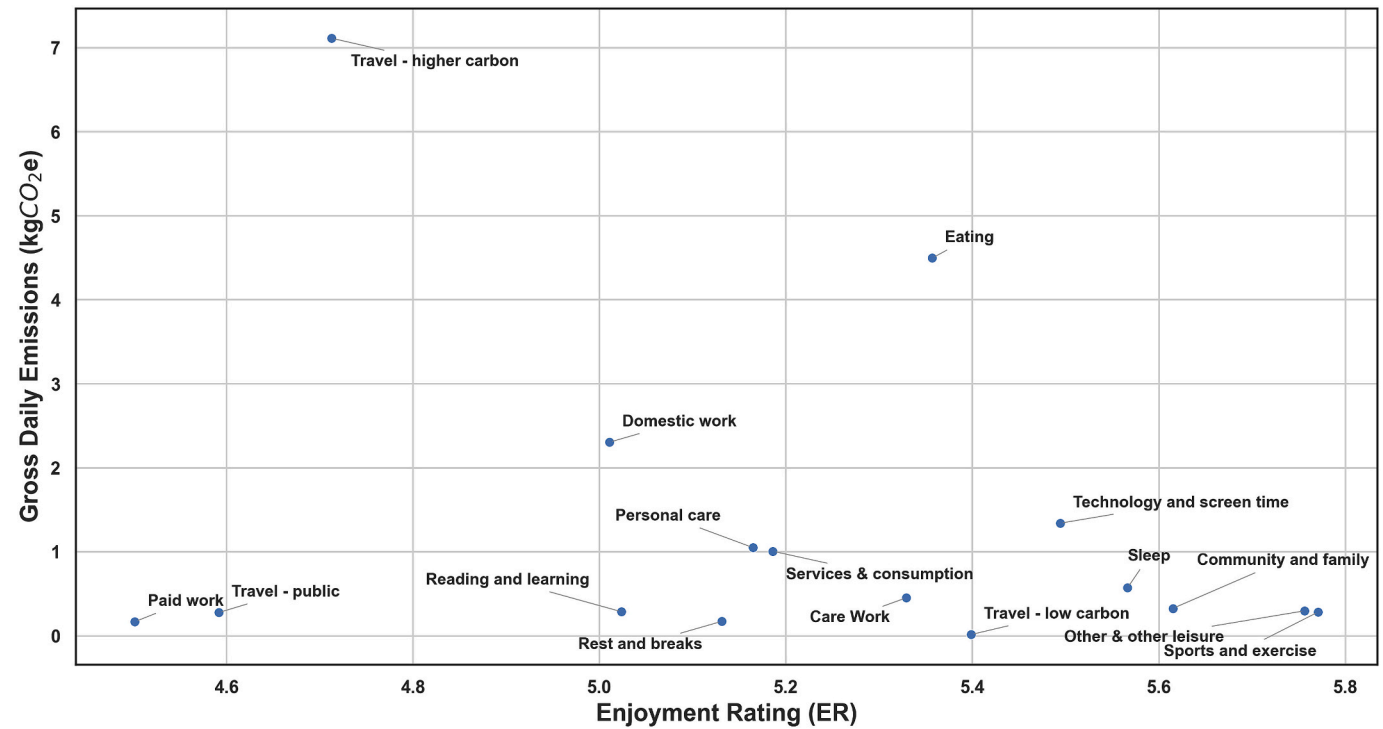


Fig. 3. Scatterplot showing the relationship between wellbeing and gross daily emissions of all time use activities (2016). The bottom right-hand corner points to the most sustainable activities which also contribute the most towards wellbeing.

Table 1
Comparative summary of number of hours per day spent on each time use activity for 2016 and the three time use scenarios for 2050. Note that the 2050 Sufficiency Baseline assumes time use as per 2016.

Daily Time Use Profiles (Hours) - 2016 Countries and 2050 Scenarios																	
	Paid Work	Travel - Public	Travel - Higher Carbon	Rests and Breaks	Domestic Work	Personal Care	Reading and Learning	Eating	Travel - Low Carbon	Sleep	Services and Consumption	Care Work	Technology and Screen Time	Community and Family	Other and Other Leisure	Sports and Exercise	Total
Finland (2016)	2.6	0.2	0.5	0.6	1.1	0.5	0.9	1.0	0.3	8.5	0.8	0.4	4.0	1.4	0.6	0.5	24.0
France (2016)	3.1	0.2	0.6	0.6	1.4	0.6	0.7	1.5	0.3	8.3	0.6	0.5	3.7	0.9	0.6	0.4	24.0
UK (2016)	2.8	0.2	0.7	0.7	1.3	0.6	0.6	1.1	0.3	8.5	0.9	0.5	3.7	1.0	0.6	0.4	24.0
Good Life (2050)	2.0	0.5	0.0	0.5	1.2	1.0	1.0	1.2	1.0	8.0	1.0	1.0	2.0	2.5	0.0	1.0	24.0
Caring Responsibilities (2050)	3.0	1.0	0.5	0.5	3.0	0.5	0.2	1.0	0.0	8.0	0.5	4.0	1.0	0.5	0.0	0.2	24.0
Individualist (2050)	5.0	0.0	2.0	0.5	0.5	1.0	0.5	1.0	0.0	6.0	1.0	0.0	5.0	0.5	0.0	1.0	24.0

group based on assumptions in our 2050 Sufficiency Baseline, and then isolate the impact of how a change in time use for each scenario would affect daily emissions estimates in the future. Specifically, this includes direct emissions reductions based on our assumptions, indirect emissions reductions (driven by changes in emissions intensity of production and adoption of less meat-intensive diets), reductions in transport emissions, and the further effect of changes in time use for each country for each scenario. All of these scenarios in emissions terms are expressed alongside a comparison of per capita planetary boundaries.

4.2.1. ‘Good life’ scenario

The ‘Good Life’ scenario represents a way of living most in line with

the aims and likely consequences of sufficiency-oriented and postgrowth policy (Kallis et al., 2025). These include modest worktime reduction (Soper, 2020; Lukács and Antal, 2022) which can facilitate increased leisure time and greater time spent on socially reproductive labour such as volunteering and care work (Jackson, 2017). It also assumes more socialised and sustainable transport habits, with all private car transport replaced with active travel and public transport. The nature of leisure also reverses time trends (Harvey et al., 2022) to move away from screen time with electronic devices, and more towards activities with clear physical and eudaimonic subjective wellbeing co-benefits (such as exercise, reading, spending time with loved ones) (Ryu et al., 2022; Brand-Correa and Steinberger, 2017). This profile also deviates from

national time use averages in 2016 by including more time for personal care, to highlight the importance of personal hygiene and health.

In sustainability terms, gross daily emissions decline for Finland, France and the UK when compared against the 2050 Sufficiency Baseline for each individual country. As is evidenced in Fig. 4, even though the Good Life scenario complements the ambitious and even transformative scenario building with further ambitious changes to our time use, all lifestyles are estimated to continue to exceed planetary boundaries. Rescaling O'Neill et al.'s (2018) per capita emissions boundary estimate of 1.61 tCO₂e per capita per annum to 4.41 kgCO₂e per capita per day, this threshold is still surpassed by Good Life scenario daily emissions totals of 8.02 kgCO₂e for Finland (where a marginal increase in total daily per capita emissions is evidenced), 6.6 kgCO₂e for France, and 6.2 kgCO₂e for the UK (or 2.93, 2.41, 2.26 tCO₂e per capita per annum, respectively).

Even in the context of this continued overshoot, for people to live in a manner closer to a Good Life scenario design – to participate more in the community, to travel only by low emission modes, to work less – requisite provisioning systems must be in place to facilitate this. Whilst changes in our lifestyles can drive further decarbonisation and improved subjective wellbeing, particularly in comparison to the other scenarios in this section, they are not in themselves sufficient to bring lifestyles within ecological limits.

In experienced wellbeing terms, this lifestyle is estimated to give the highest cumulative enjoyment rating (CER) of our three scenarios (CER = 772.4 for Finland, 765.5 for France, and 770.7 for the UK), increasing versus the 2016 time use profile for France (CER = 756.15) and the UK (CER = 762.7), and declining marginally for Finland where cumulative enjoyment is the highest of the three countries in 2016 (CER = 775.1) (see inset panel in Fig. 4).

4.2.2. 'Caring responsibilities' scenario

This scenario foregrounds the impacts on an individual's time use where the demands of the household time use system – the time required to care for dependents, such as children or the infirm, and the additional household labour associated with this care – are priority. The time

scarcity created by these demands, notably in care work and in additional domestic labour, are reflected elsewhere. Time for reading, screen time, and sports and exercise is reduced. Active travel is replaced by a combination of public and private transport also due to time constraints of the household time use system. There is also an assumption of a small increase in paid work, given that support for dependents and the higher costs associated with this may require additional income.

Fig. 5 shows significant emissions increases driven by time use changes (2.89 kgCO₂e in Finland, 2.57 kgCO₂e in France, and 1.15 kgCO₂e in the UK), and an overall reduction in cumulative enjoyment ratings, across the three case study countries in this scenario compared to their 2050 Sufficiency Baseline. In contrast to the 'Individualist' scenario (see Section 4.2.3), where a much greater degree of discretionary time use is assumed, conceptually this scenario demonstrates the lock-in to higher emissions forms of time use due to unavoidable time system constraints. Regarding wellbeing, scenario CER values fall in all three countries (to CER = 759.5 for Finland, 750.9 for France, and 749.4 for the UK), due to higher-enjoyment leisure time (such as technology and screentime) being substituted for some of the least enjoyed activities such as domestic work and public travel (see inset panel in Fig. 5).

This scenario demonstrates the impacts on household emissions placed on lifestyles where there are unavoidable domestic demands on their time. From a postgrowth perspective, care work ought to be the foundation of a new care-based economy (Dengler and Lang, 2022; Jackson, 2025). Without the provisioning systems and infrastructure in place to support this care work – either through state provided care to free up discretionary time use, or accessible public and active travel infrastructure – there may be unintended second order effects for emissions.

4.2.3. 'Individualist' scenario

The 'Individualist' scenario represents a lifestyle distinguished by two primary features. First, this scenario assumes no dependents and therefore limited household time demands from a functional time use perspective beyond time needed for individual care and reproduction. In starkest contrast to the 'Good Life' scenario, the 'Individualist' scenario

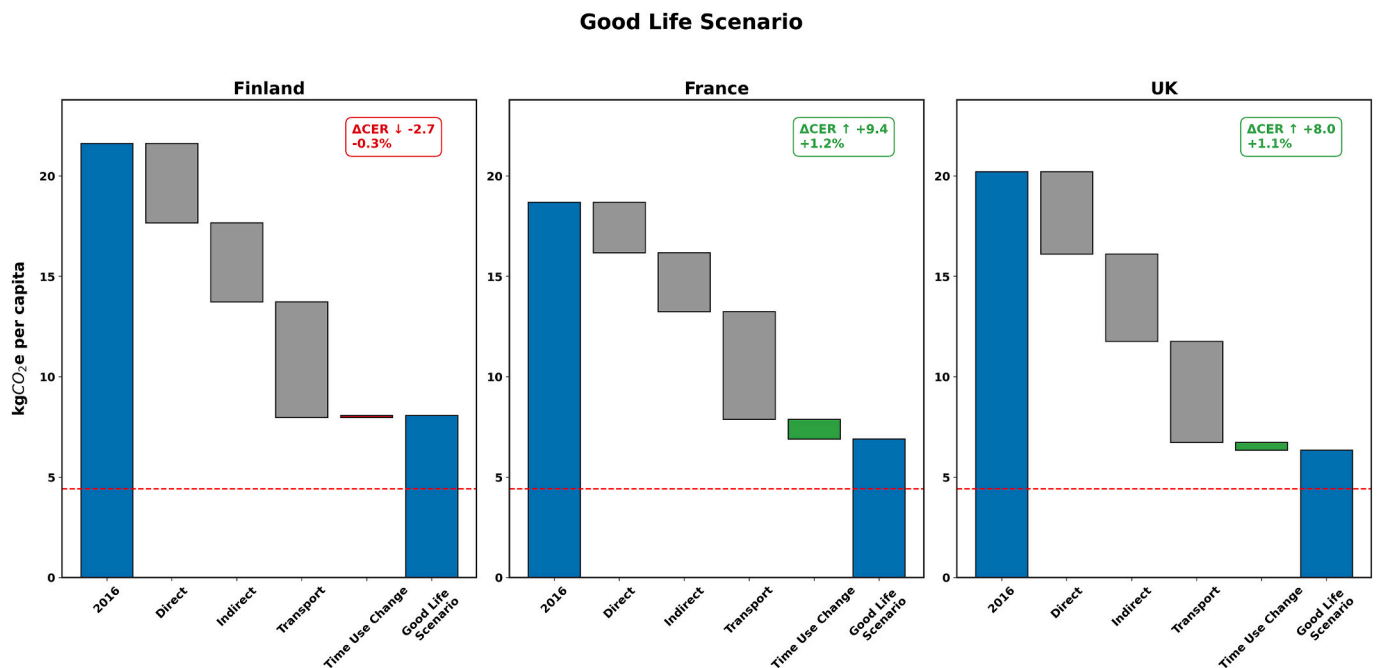


Fig. 4. Waterfall chart showing emissions reductions for each case study country between 2016 and 2050, disaggregated by direct, indirect, and transport emissions, and the specific effects of time use changes in the 'Good Life' scenario. The dotted line represents the per capita planetary boundary for emissions, based on O'Neill et al. (2018). Cumulative Experienced Wellbeing (CER) values represent the increase or decrease in aggregate experienced wellbeing in each country in each scenario (see Section 3.4).

Caring Responsibilities Scenario

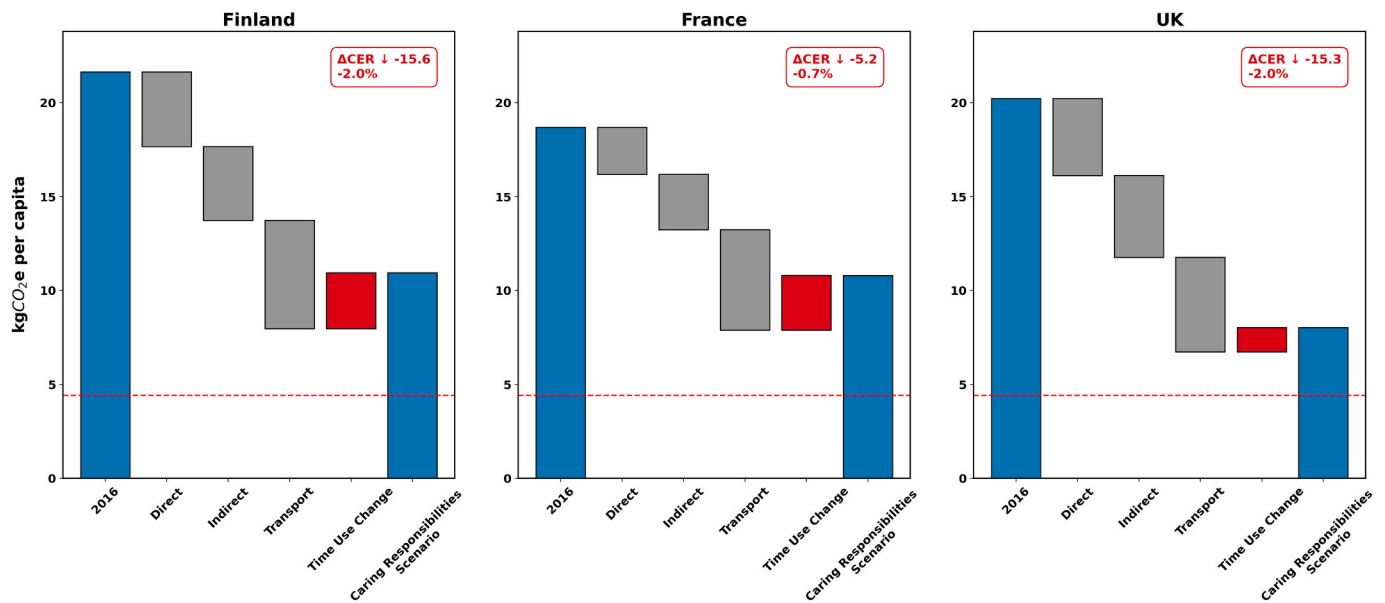


Fig. 5. Waterfall chart showing emissions reductions for each case study country between 2016 and 2050, disaggregated by direct, indirect, and transport emissions, and the specific effects of time use changes in the 'Care Responsibilities' scenario. The dotted line represents the per capita planetary boundary for emissions, based on O'Neill et al. (2018). Cumulative Experienced Wellbeing (CER) values represent the increase or decrease in aggregate experienced wellbeing in each country in each scenario (see Section 3.4).

further assumes a work-intensive lifestyle with a correspondingly high level of income (which we assume is used to hire domestic help to lower the time spent on domestic work). With sharply increased time expended on working and forms of leisure linked to screen time and technology, we also assume a lower quantity of sleep. There is no time afforded to care work, for dependents in the household or for the wider community. Active and public transport is replaced entirely by private

transport.

The 'Individualist' scenario is the highest emissions and lowest wellbeing scenario modelled in this paper. As evidenced in Fig. 6, CER falls to 758.9 for Finland, 741.4 for France, and 743.8 for the UK from CER values based on 2016 national average time use profiles. Furthermore, daily lifestyle emissions driven by time use changes increase by 3.77 kgCO₂e in Finland, 2.02 kgCO₂e in France, and 1.89 kgCO₂e in the

Individualist Scenario

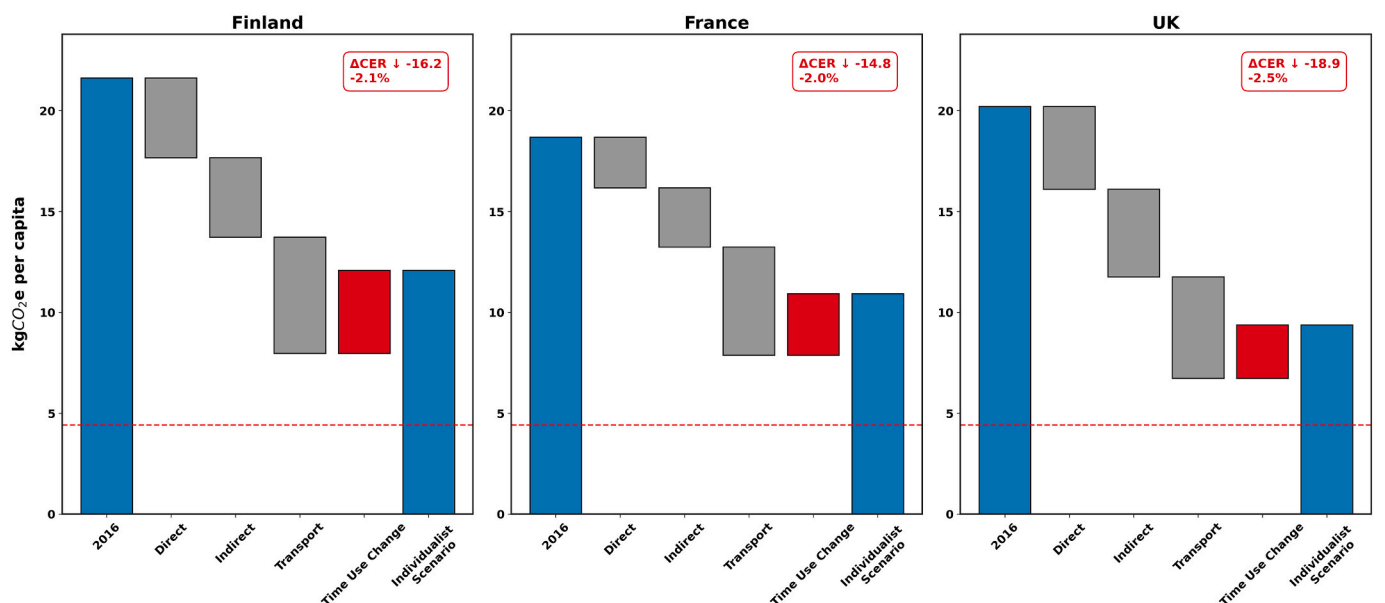


Fig. 6. Waterfall chart showing emissions reductions for each case study country between 2016 and 2050, disaggregated by direct, indirect, and transport emissions, and the specific effects of time use changes in the 'Individualist' scenario. The dotted line represents the per capita planetary boundary for emissions, based on O'Neill et al. (2018). Cumulative Experienced Wellbeing (CER) values represent the increase or decrease in aggregate experienced wellbeing in each country in each scenario (see Section 3.4).

UK. Though this scenario differs significantly from others and acts as a formal contrast to the radical changes towards sufficiency assumed within the 'Good Life' scenario, it is not extreme or based on unrealistic assumptions. Screen time and technology is already the most popular form of leisure in the CaDDI time use survey, and large sections of the population struggle with sleep quality (Peng et al., 2023). Overtime working is also common across a range of industries (Anxo and Karlsson, 2019). This scenario also endeavours to show a 'time rebound' effect through an application of functional time use theory. With little systemic constraints on time and with an assumed higher income to afford time substitution (such as paying for domestic work), greater discretionary time can be used in emissions intensive activities such as private transport.

5. Discussion

To model stylised lifestyles in 2050, we have made radical assumptions regarding more sufficient ways of living, energy efficiency, technological progress, widespread electrification and decarbonisation, systemic changes to transport provision and consumption, a move towards less meat-intensive diets, and, ultimately, three scenarios exploring time use changes. Our 'Good Life' scenario demonstrates forms of time use which can bring us closer to planetary boundaries. Despite this, however, we find that the combination of social and technological change we have modelled, alongside time use changes in all our scenarios, is not sufficient in any case to bring emissions footprints within ecological limits (O'Neill et al., 2018; Ala-Mantila et al., 2022).

Our primary conclusion, then, is clear: systemic and transformational changes are also needed to the ways in which we provision energy, goods, and services through biophysical resources to bring global north lifestyles within ecological limits. These changes must accompany aggregate reduction in energy and resource use, to meet required rates of decoupling of resource use from economic production (Haberl et al., 2020; Vogel and Hickel, 2023; Slameršak et al., 2024; Mair, 2025).

The method used in this study and the nature of our results offers an opportunity to contribute to time use-sustainability analysis. Seeking to understand drivers and consequences of profound unsustainability solely based on individual habits and lifestyles, or that of households, is at best a partial and incomplete means of analysis. Using functional time use theory, we have argued that we must understand our time use in the context of a broader range of time systems which dictate our time use and have real impacts on our emissions and wellbeing (Ringhofer, 2013; Wiedenhofer et al., 2018).

On the other hand, the provisioning systems literature argues for a transformation in how physical and social systems translate resource use into social outcomes, to guarantee a good life for all within planetary boundaries (Fanning et al., 2020). Specifically, the ways in which we produce, distribute, and exchange goods and services, through immaterial systems such as markets or through physical infrastructure, combine to govern the relationship between the resources we use and the waste we produce, and important wellbeing indicators. Using a conceptual framework which combines the insights of functional time use theory and the provisioning systems literature, we further argue that time systems which constrain and influence our time expenditure are in turn shaped by the broader physical and non-material systems of provisioning in society.

This is evident from our scenario results, in several ways. Firstly, before we explore the effects of time use and lifestyle changes on emissions, we modelled widespread and radical shifts in terms of energy and goods consumption, dietary change, technological change, electrification, and modal shifts in how we travel, which was ultimately insufficient to reach planetary boundaries. In essence, these simulate significant changes in provisioning systems, and despite their broad scope and ambitious parameterisation they are insufficient when

measured against objective ecological limits.

Secondly, we have shown how some time use changes can contribute towards greater wellbeing and lower emissions footprints, in our 'Good Life' scenario, but it is clear that the assumptions made for this scenario – including work time reduction, care-based forms of labour, and more eudaimonic forms of leisure – will require further radical changes to systems of provisioning to allow a critical mass of the population to achieve a time use profile such as this. Despite the wholesale nature of the changes required, and the failure to reach the ultimate objective of a per capita emissions footprint which is within planetary boundaries, the 'Good Life' scenario is an example of how changes to provisioning systems modelled in this paper can further reduce emissions and improve wellbeing. To achieve this, we need changes to time systems, as conceptualised by functional time use theory, which ultimately requires fundamental changes to provisioning systems.

Finally, the 'Care Responsibilities' scenario creates a clear conflict between what is expected of people in future scenario based on sufficiency-oriented or postgrowth assumptions, where care-based work ought to proliferate due to its lower ecological intensity and links with physical and mental wellbeing, and what is possible in the absence of systemic change to support this way of life. We have modelled significant time constraints on the individual time profile in this scenario, which has second order effects on the ability to spend time on meaningful leisure or take slower but less emissions intensive forms of transport. Provisioning systems can improve indicators for lifestyles of this nature by creating social contributions to the care burden (by way of public provision of childcare, or enhanced social care, for example), which can free up discretionary time for lower emissions, higher wellbeing activities. In contrast, the 'Individualist' lifestyle demonstrates that, even in the absence of excessive time use constraints from a range of time systems, lock-in to forms of time use which have high emissions intensity and low wellbeing might persist. This demands broader cultural change, and policy measures to curb the ecological effects, by way of increased energy consumption and emissions footprint, of the 'time rebound' effect (Mizobuchi and Yamagami, 2022) when relatively unhindered by systemic time constraints.

6. Conclusion

Time use analysis is an accessible and intuitive means of assessing the transition to a good life for all within planetary boundaries. Indeed, our study is the first of its kind to develop a modelling approach to investigate the ecological and wellbeing effects of time use and lifestyle changes for multiple scenarios across multiple countries. Through the novel methodology developed for this study, we have demonstrated activities in our lives which can reduce our resource consumption and improve our wellbeing. More specifically, we have shown through our scenario construction and analysis that lifestyle changes (our 'Good Life' scenario) based on these activities can also have a positive impact on our wellbeing and emissions footprint.

Though this is an important finding in our paper, we have also shown the real constraints on lifestyle changes as a means of bringing the emissions footprint of our societies within ecological limits. Time use is necessarily constrained by social and economic systems, which also fundamentally limit the ecological gains attainable from mere lifestyle change. This is evidenced clearly in the results of our 'Caring Responsibilities' scenario, where time use when reallocated towards high wellbeing and socially useful care can, without broader systemic change, increase emissions.

This reinforces the systemic analysis at the heart of this paper – wholesale changes are needed to provisioning systems to a) facilitate more sustainable and high wellbeing time use, and b) to reduce the ecological intensity of our current time use. Our scenario results demonstrate that the gap between final emissions in our 'Caring Responsibilities' and 'Individualist' scenarios and ecological limits are considerable. Therefore, whilst we can conclude that improvements to

our wellbeing and sustainability are possible through lifestyle change, even in the context of widespread and radical technological, social and economic change assumed in our 2050 Sufficiency Baseline, this is not sufficient in and of itself. To achieve higher wellbeing within ecological limits global north countries must pursue fundamental changes to provisioning systems.

CRediT authorship contribution statement

Seán Fearon: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Ben Gallant:** Writing – review & editing, Validation, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Angela Druckman:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Formal analysis, Conceptualization. **Simon Mair:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Formal analysis, Conceptualization. **Lirong Liu:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ecolecon.2026.109221>.

Data availability

Data will be made available on request.

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