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Downscaling consumption to universal basic income level falls short of sustainable carbon footprint in Finland

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A R T I C L E I N F O

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A B S T R A C T

Human economic activities and following carbon emissions have been recognized to be a real threat to the environment. The current levels of consumption-based carbon footprints in all developed economies grossly exceed the sustainable level. Scientists have concluded that in addition to technological solutions, downscaling of consumption and far-reaching changes in lifestyles will be needed to achieve environmental sustainability. In this study, we provide a tangible real-world example that reveals the scale of the needed change from a perspective of a European welfare state citizen. Universal basic income (UBI) represents an income that is just enough to fulfil basic needs, such as food, shelter, and medication. In our case country, Finland, UBI is in practice at the same level as the income of the lowest income decile. The purpose of this study is to present and analyse the carbon footprints at a consumption level that corresponds to UBI. We compare the carbon footprints at this low-income level to average Finnish carbon footprints and discuss their sustainability in the light of global carbon budgets. We use an input-output approach based on the Finnish ENVIMAT model. The average carbon footprint at the UBI level is 4.8 tCO_2-eq and it focuses on necessities. It's significantly lower than the average carbon footprint in Finland, 9.4 tCO_2-eq, but still far from the level compatible with the current climate change mitigation targets. The results emphasize how challenging it is to find true low-carbon solutions for living in affluent countries. Lifestyle changes and technological leaps need to be combined and fostered by legislation.

1. Introduction

Human activities have been recognized to be a real threat to the environment and the regulating systems which enable comfortable living conditions on earth (IPCC, 2018; Rockström et al., 2009; Steffen et al., 2015). The Paris Agreement ratified in 2016 seeks to limit the global warming to 2 °C or even to 1.5 °C above the pre-industrial level. The goal requires massive greenhouse gas (GHG) emission reductions rapidly (IPCC, 2018).

Carbon budgets illustrate how much GHG emissions can still be emitted to limit global warming to a certain temperature. The remaining budget for a certain climate stabilization target refers to an estimation of the amount of global net CO_2 or GHG emissions which can still be emitted without exceeding the corresponding warming (IPCC, 2018). There are different methods and scales to examine the size of the budget and so the results also vary (Rogelj et al., 2018). The newest IPCC (2018) report encourages to limit warming to 1.5 °C which leads to a remaining carbon budget of 420 $GtCO_2$ until 2100 at 67 % confidence level. Budget for 2 °C is 1170 $GtCO_2$ at 67 % confidence level according to the same IPCC report. Currently we emit around 40 $GtCO_2$ per year (Le Quéré et al., 2018). If the emissions stayed at the same level, the 1.5 °C carbon budget would be reached in 10–15 years (Rogelj et al., 2018).

The carbon budget only shows the gross allowance over time for meeting a selected warming target. In order to operationalize it for decision making, the budget needs to be divided for countries, companies, individuals or other meaningful units. One such operationalization is the division of the carbon budget to per capita pathways from the current situation to zero without exceeding the budget (Raupach et al., 2014). The pathways work so that the later the GHG reductions begin, the steeper the curve becomes requiring faster and faster reductions (Raupach et al., 2014). According to Raupach et al.'s (2014) work, even reaching the 2-degree target would already now require annual reductions of 10 % until reaching zero around 2080. Postponing the mitigation with another 5–10 years would lead to a 30 % annual reduction requirement and reaching zero already around 2050. O'Neill et al. (2018) have calculated that the same 2-degree target would mean

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global per capita emissions of 1.6 tCO_2-eq over the period between 2011–2100. The current global average carbon footprint is around 5.7 tCO_2-eq per capita (Steen-Olsen et al., 2012).

Consumption-based carbon footprints reflect the consumption behaviour and lifestyles of consumers. They cover the lifecycle GHG emissions caused by the consumption of goods and services, and thus include the emissions embodied in trade (Baynes and Wiedmann, 2012; Wiedmann, 2009; Heinonen et al., 2020). Carbon footprint allocates the global GHG emissions to individual consumers, which makes it an effective tool to investigate the drivers of GHG emissions and plan mitigation actions (Peters et al., 2011; Ottelin et al., 2019a).

The current levels of carbon footprints in all developed economies grossly exceed the sustainable level suggested by O'Neill et al. (2018) and the current global average (e.g. Hertwich and Peters, 2009; Ivanova et al., 2016; Clarke et al., 2017), which is the starting point of the pathways of Raupach et al. (2014). Several different propositions have been made to target the emissions caused by (over)consumption, for example work time reductions (Schor, 2005; Pullinger, 2014; Nässén and Larsson, 2015; Buhl and Acosta, 2016; Zwickl et al., 2016; Wiedenhofer et al., 2018), aiming for work motivated by art and social good rather than profit (Mair et al., 2018), and supporting appropriate level and patterns of consumption (Lorek and Fuchs, 2013). However, downscaling of the income and consumption levels at national scale leads to a shrinking economy.

Economic growth typically measured by gross domestic product (GDP) is in the focus of current capitalist economies locally and globally. GDP has kept its position as the main measure of development, even though it is not necessarily beneficial for the well-being of people anymore (Kallis, 2011; Petridis et al., 2015; Wiedmann et al., 2020). Furthermore, the human caused GHG emissions are tightly coupled with GDP (Schneider et al., 2010; Kallis, 2011; Kallis et al., 2012, 2018; Mohmmed et al., 2019), especially when looked at from the consumption perspective (Wiedmann et al., 2020). Thus, new visions for more environmentally sustainable economies have been created. For example, steady-state economy (Daly, 2014) and degrowth (Schneider et al., 2010; Kallis, 2011) have been suggested as alternatives that could offer environmentally, economically and socially sustainable economies.

Wiedmann et al. (2020) highlight in their recent review that there is a lack of practical solutions and pathways to economies that would fill basic human needs but fit below the ecological ceiling, i.e. doughnut economies (Raworth, 2017). In the case of climate change, the challenges of providing such practical suggestions probably relate to the huge gap between the current state and the sustainable level of carbon footprints. The aim of this study is to provide a tangible starting point for the discussion on what it would mean in practice to downscale consumption to a sustainable level in affluent countries, European welfare states in particular.

We selected universal basic income (UBI) as our benchmark, since it represents an income that is just enough to fulfil basic needs regarding food, shelter, and medication, for example. In our case country, Finland, UBI is in practice at the same level as the income of the lowest income decile. The purpose of this study is to investigate the impact of downscaling consumption to UBI levels on household carbon footprints. The average carbon footprint in Finland is much higher than the global average (Hertwich and Peters, 2009; Ala-Mantila et al., 2014; Ivanova et al., 2016; Ottelin et al., 2019b) and the "fair share" of the remaining carbon budgets. We use the Finnish input-output model ENVIMAT (Seppälä et al., 2011), Statistics Finland's Household Budget Survey 2012, and data from the UBI experiment of Finland (Kangas and Pulkka, 2016) to assess the carbon footprints. We compare the size and composition of the UBI consumption level carbon footprints to the Finnish average carbon footprints, and the global average. In addition, the results are reflected against the remaining 1.5- and 2-degree carbon budgets and discussed in the contexts of downscaling consumption, sustainable economies, and welfare state.

2. Research method and materials

2.1. Environmentally extended input-output analysis

The carbon footprints in this study were calculated based on an environmentally extended input output (EE IO) analysis. The method analyses economic activities and environmental impacts related to them. The EE IO analysis has become a widely applied method for assessing the GHG emissions caused by a certain type or group of consumers (e.g. Hertwich and Peters, 2009; Steen-Olsen et al., 2012; Ivanova et al., 2016; Ottelin et al., 2019b). In the EE IO analysis, the supply chains are organized in input-output matrices. The matrix displays the monetary flows between and within economic sectors and allows analysing the global impact of economic transaction in a certain location (Kitzes, 2013; Wiedmann, 2009). The environmental impacts related to each sector are collected in their own matrix (Kitzes, 2013). When these matrices, economic and environmental, are combined, the environmental impact entailed to a monetary purchase made by a consumer can be calculated (Kitzes, 2013; Wiedmann, 2009). The aim of the method is to determine the total upstream environmental impacts which are associated to the downstream consumption activities, including also the embodied impacts in internationally traded goods (Kitzes, 2013; Wiedmann and Lenzen, 2018). The upstream environmental impacts consist of all the impacts related to a product, or service, purchased by an individual end consumer with all the economic sectors participating the production and delivery chain involved (Kitzes, 2013). The EE IO method avoids truncation errors related to traditional process -based methods but assumes price, output, and emission homogeneity for one sector which causes uncertainty (Kitzes, 2013; Suh et al., 2004; Wiedmann, 2009). Hybrid models combining the EE IO and process LCA (life cycle assessment) can provide more accurate results (Suh et al., 2004; Heinonen et al., 2020).

2.2. The carbon footprint model of the study

The model applied in this study to determine the carbon footprints is a hybrid-LCA method based on a semi-multi-regional (MR) IO model called ENVIMAT. The ENVIMAT is an EE IO model created especially for the Finnish economy with the base year 2006 (Seppälä et al., 2011). It captures both domestic and international activities and their GHG emissions related to Finnish production and consumption excluding downstream impacts abroad caused by imported goods (Seppälä et al., 2011). The model has quite detailed input data as it consists of 151 industries with 918 domestic and 722 imported products and services. The model utilizes international COICOP categorization to classify final consumption into 50 categories. In this study the 2006 values were updated using the consumer price index of Statistics Finland. As the model combines IO analysis and process LCA, it is a hybrid method and aims to provide more accurate emission data. This means that part of the IO data was replaced by life-cycle inventory (LCI) information. The same hybrid model has been applied in e.g. Ottelin et al. (2018a, b) where it is also described in more detail.

2.3. Research materials

2.3.1. Household budget survey

The consumption data applied in this study is from Statistics Finland's Household Budget Survey (HBS) 2012. The HBS describes the expenditure of households in detail and it is complemented with demographic and socioeconomic information. A stratified sample of households was selected representing different regions in Finland. The final sample size was 3551 households when the response rate was 43.1 %. To correct the error caused by varying response rates between regions and socioeconomic groups, the HBS includes probability weight coefficients. The probability coefficient was used in the calculations of this study. The HBS data was gathered in 2012 by diaries and interviews, and by compiling register information. The expenditure data was organized according to the international COICOP system, which enables direct matching with the ENVIMAT model. A consumer price index provided by Statistics Finland was used to convert the monetary values from year 2012–2017, which is the base year of the study following the Finnish UBI experiment. The same index was used for all the categories because the value change had been small during that time period.

2.3.2. The universal basic income experiment in Finland

Universal basic income (UBI) is one proposed social policy in the quest of reaching a more sustainable economic system where the financial and natural resources are used sustainably and shared more equally (Kallis et al., 2012, 2018; Petridis et al., 2015; Jackson, 2017). UBI means an equal monthly payment to everyone by local or national governments (Van Parijs, 2004; Standing, 2017). The content is debated but the three words in the term clarify the meaning. Firstly, the payment should be universal meaning that everyone, usually adult members, who live or are part of a certain community or society should receive it (Van Parijs, 2004; Standing, 2017). There is no reason to deny the payment from someone for example due to age, activity, or gender. Basic means that the payment should be big enough to fulfil a person's basic needs like food, shelter, and medication, and so provide some financial security (Standing, 2017). As UBI is income it should be paid regularly without extra application or other actions (Standing, 2017).

Finland is the first country to run a large-scale UBI experiment. Finnish government added a universal basic income experiment as one item in its programme in 2015 (Kangas and Pulkka, 2016). The government chose to set a UBI experiment to investigate different possible models for a future social security system reform (Ministry of Social Affairs and Health, 2016). The main goal was to discover if UBI could promote employment. The UBI experiment began in January 2017 and lasted for two years. In the adopted model, the test group size was set at 2 000 individuals (Ministry of Justice, 2016). The participants were randomly selected among people who received the particular unemployment benefit called basic unemployment allowance (*peruspäiväraha*) or labour market subsidy (*työmarkkinatuki*) from the Social Insurance Institution of Finland, Kela, in November 2016 and were 25–58 years old on the 1st of December 2016. It was compulsory for the selected people to take part in the experiment. Participants for a control group were randomly selected among people who did not become selected into the experiment but fulfilled the requirements. Individuals in the test group received 560 euros per month tax free while people in the control group kept following the normal unemployment benefit scheme. The Act followed a principle that the benefit level of the participants could not drop when entering the experiment, so they were allowed to apply for other social benefits too. Also, the participants were able to work without losing the UBI payment. However, the earned incomes were taxed normally, and working may have had affected other benefits.

In this study, we used data from the UBI experiment to estimate the average consumption of the households living at the UBI level. Expenditure data from the actual participants of the UBI experiment has not been collected. Thus, we combined the income data from the UBI experiment with expenditure data from the Statistics Finland's HBS. It should be noted that there is unlikely any large differences in consumption behaviour between the randomly selected UBI experiment group, and other households with similar income levels in Finland. In the UBI experiment it was found that UBI had low impact on employment, but some impact on wellbeing (Kangas et al., 2019).

2.4. Research design

A two-phase research process was used to calculate the carbon footprints of households living at the UBI level. First, the data from the UBI experiment of Finland was used to define the income level of interest. Second, Statistics Finland's HBS was used to estimate the structure of consumption, meaning the division of expenditure into different consumption categories, at the UBI level. The savings rate (*(disposable income - expenditure) / disposable income*) of the households was taken into account. Furthermore, the HBS was used to estimate the GHG intensity of different consumption categories at the UBI level. Finally, the carbon footprints were calculated by multiplying the household type specific average income from the UBI experiment with the household type specific division of expenditure (%) and inflation corrected GHG intensities (CO_2-eq kg/€) that were estimated with the HBS.

In the first phase, the universal basic income experiment was analysed to estimate the final basic level of the UBI payment and how much money the participants of the experiment had for consuming if they received only the UBI payment and the allowed social benefits. The payment level was estimated based on social benefit payments in 2017 provided by the Social Insurance Institution of Finland, Kela (Kela, 2018). The respondents selected to the UBI experiment were receiving either basic unemployment allowance or labour market subsidy. Most of them were receiving labour market subsidy, so it was used in the calculations. General housing allowance was included as well because it is commonly paid for low-income households. In addition, child benefits and parental allowances were included when estimating the income levels of families. Taxation was ignored because the labour market subsidy was the only taxed benefit included. Moreover, the tax rate is very low at this income level. Working was not considered in the income estimation, since the aim of the study was to examine the consumption at the governmental payment level alone.

Based on the presented framing it was estimated that a person participating in the UBI experiment in 2017 received from 8 800 to 13 000 euros of annual income (Table 1). The UBI alone was 560 €/month per adult, which equals 6 720 €/year. The general housing allowance is around 3 800 €/year and child benefits around 1 100 €/year per child.

In the second phase, households with similar income levels were searched from the HBS data. In order to have large enough sample size, individuals consuming from 6 000–14 000 euros in year 2012 were selected from the HBS. They were classified into four household types matching with the UBI households presented in Table 1: singles, couples, single parents, and two-adult families (Table 2). The single-parents and the two-adult families have at least one child living at home who is younger than 25. Seniors (>65-year-olds) were excluded, since the main interest of the study lies in the population of working age who are potential receivers of UBI. In addition, a household type category called "others" was excluded, since it represents a heterogeneous group of various types of households, whose average carbon footprint is not very meaningful. It should be noted that these groups are missing also from the Finnish averages shown in this study. Furthermore, in the main figure (Fig. 1) an inflation correction has been made to change the euros from 2012 to 2017 to correspond with the year of the UBI experiment.

Note that the actual carbon footprints of the low-income groups presented in Table 2 were not calculated here. The low-income groups were only used to estimate the structure of the consumption, meaning the division (%) of expenditure into various consumption categories and savings, at a low-income level, similar enough to the actual UBI

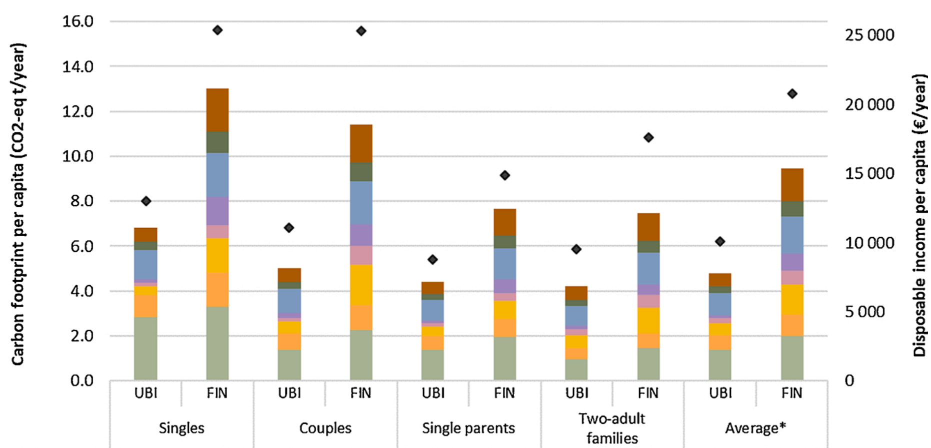
Table 1
Estimated UBI per capita for various household types. In addition to the allowances mentioned in the parentheses, all estimates include the general housing allowance and child benefits for families with children.

Studied UBI household types	Estimated UBI per capita (€/year)
Singles (UBI or labour market subsidy)	13 000
Couples (both have UBI or labour market subsidy)	11 100
Single parents (UBI or labour market subsidy)	8 800
Two-adult families (both have UBI or labour market subsidy or parental allowance)	9 500
UBI average (weighted per capita)	10 100

Table 2
Sample sizes and descriptive statistics on the studied groups derived from the Statistics Finland's Household Budget Survey 2012. The low-income group (from 6 000 to 14 000 €/year) was used to represent the consumption at the UBI level.

	Singles		Couples		Single parents		Two-adult families	
	Low-income	Avg. FIN	Low-income	Avg. FIN	Low-income	Avg. FIN	Low-income	Avg. FIN
Sample size (households)	115	541	158	709	53	117	421	911
Avg. household size	1	1	2	2	2.8	2.5	4.1	3.9
Avg. age of the reference person*	42	42	41	45	43	44	41	42
Avg. disposable income per household (€)	14 300	24 600	32 000	49 000	31 400	36 200	58 000	67 200
Avg. disposable income per capita (€)	14 300	24 600	16 000	24 500	11 400	14 400	14 000	17 100
Avg. living space per household (m2)	42	59	71	92	88	90	120	129
Avg. living space per capita (m2)	42	59	36	46	32	36	29	33
Share of car-owning households (%)	36 %	55 %	68 %	87 %	58 %	67 %	95 %	97 %
Share of owner-occupants (%)	18 %	42 %	38 %	65 %	43 %	59 %	82 %	86 %

* The main income provider of the household.



	Singles UBI	Singles FIN	Couples UBI	Couples FIN	Single parents UBI	Single parents FIN	Two-adult families UBI	Two-adult families FIN	Average* UBI	Average* FIN
Tangibles	0.6	1.9	0.6	1.7	0.6	1.2	0.6	1.2	0.6	1.5
Services	0.4	1.0	0.3	0.8	0.3	0.6	0.3	0.5	0.3	0.7
Food	1.3	1.9	1.1	1.9	0.9	1.4	0.9	1.4	1.0	1.6
Other travel	0.2	1.3	0.2	1.0	0.1	0.6	0.1	0.5	0.1	0.7
Private vehicles	0.1	0.6	0.2	0.8	0.1	0.4	0.3	0.6	0.2	0.6
Motor fuels	0.4	1.5	0.5	1.8	0.4	0.8	0.6	1.1	0.5	1.4
Housing other	1.0	1.5	0.7	1.1	0.6	0.8	0.5	0.7	0.7	0.9
Housing energy	2.8	3.3	1.4	2.2	1.4	1.9	1.0	1.4	1.4	2.0
◆ Income per capita	13 000	25 400	11 100	25 300	8 800	14 900	9 500	17 600	10 100	20 800

Fig. 1. Carbon footprints per capita at the UBI consumption level and in Finland on average.
*Average of the studied household types (excluding seniors, see the method section for details)

households. The estimated UBI payments, presented in Table 1, were used for calculating the carbon footprints at the UBI consumption level.

3. Results

The average carbon footprint at the UBI consumption level is 4.8 tCO_2-eq per capita, which is less than half of the Finnish average, 9.4 tCO_2-eq in the study (excluding seniors, see the method section for details). Single parents and two-adult families have the lowest carbon footprints per capita, 4.4 tCO_2-eq and 4.2 tCO_2-eq respectively at the UBI level, and 7.6 tCO_2-eq and 7.5 tCO_2-eq respectively in Finland on average. Singles have the highest carbon footprints per capita both at the UBI level and in Finland on average, 6.8 tCO_2-eq and 13.0 tCO_2-eq respectively. Couples fall in between with their 5.0 tCO_2-eq at the UBI level and 11.4 tCO_2-eq in Finland on average. The results reveal that the often-found economies-of-scale at the household level (Underwood and Zahran, 2015; Ala-Mantila et al., 2016), is less prominent at the UBI level than in Finland overall. Yet, it still remains. Economies-of-scale mean here the environmental benefits of intra-household sharing. Couples and families with children can share their living space and many other goods and services, which reduces their environmental footprints per capita. However, previous studies have found as well that focusing on specific income groups weakens the phenomenon compared to studies covering whole populations (e.g. Heinonen et al., 2013).

Looking at the composition of consumption, it is clear that basic income is largely spent on necessities. Housing and food compose over half of the carbon footprints at the UBI level regardless of the household type. In addition, the differences in absolute values between the UBI households and their Finnish average counterparts are relatively modest in these consumption categories. In contrast, the UBI households have significantly lower consumption and carbon footprints in the categories in which luxury goods dominate (instead of necessities): tangibles, services, private vehicles, motor fuels and other travel (i.e. public transport and holiday travel).

The share of housing related emissions of the total carbon footprint is particularly high for single UBI households as there is no sharing. Expenditure on rentals and imputed rentals takes a large share of their income, and thus they have little money to spend on other consumption categories. As Table 1 revealed, 82 % of them live in rental apartments and their average living space is 42 m^2. Due to intra-household sharing, the living space per capita decreases when the household size increases, and for UBI families with children the average living space is only 29 m^2

and 32 m^2 for two-adult families and single-parents respectively (Table 1). Families are also much more often owner-occupants, which reduces living costs in the long run. Even at the UBI consumption level, 82 % of the two-adult families are owner-occupants (Table 1). Thus, they spend a smaller share of their income on housing, and housing related emissions compose a smaller share of their carbon footprints.

When comparing the UBI level households to their Finnish average counterparts, the largest difference is in the couples group. UBI couples have 56 % smaller carbon footprints than average Finnish couples. The smallest difference, 42 %, is in the single-parents group, since they have a relatively low-income level on average as well.

4. Discussion

4.1. Comparison of UBI level footprints to carbon budgets

The UBI carbon footprint determined in this study, 4.8 tCO2-eq per capita, is notably smaller than the average carbon footprints for Finnish households in the comparison groups. Yet, they are still around three times as high as the long-term sustainable level suggested by O'Neill et al. (2018), but close to the global average. If the current global CO_2 emissions (Le Quéré et al., 2018) were shared equally among all the people, everyone would have approximately a carbon budget of 5.6 tCO_2 in 2017 following the IPCC (2018) 1.5-degree mitigation pathway. This number is quite close to the carbon footprint value estimated in this study for the UBI consumption level. However, this study only included the personal consumption component of carbon footprint excluding capital goods and governmental consumption, which have been shown to be significant globally and for European countries (e.g. Ivanova et al., 2016; Södersten et al., 2018; Heinonen et al., 2020).

In a recent study on Finland, Ottelin et al. (2018a) estimated that the final demand of households causes 77 % of the carbon footprint of total final demand in Finland. If the government consumption (14 %) and investments (5%), and the final demand of non-profit institutions (4%) are added to the UBI carbon footprint estimated in this study by following Ottelin et al. (2018a), the average carbon footprint at the UBI level would be 6.2 tCO_2-eq per capita. However, Ottelin et al. show how the share of these emissions is larger in low-income than in high-income households. Thus, the UBI households probably use public services more than an average household, so the total average carbon footprint is likely to be more than 6.2 tCO_2-eq., and thus higher than the global 1.5-degree mitigation pathway level. Moreover, to stay on the pathway, the emissions would need to be cut by approximately 10 % annually in addition to first reaching the current pathway level. Similarly, previous studies on the interaction between environmental and social Sustainable Development Goals (SDGs) have shown that bringing the global population to a moderate expenditure level (still lower than the UBI level in this study), would lead to difficulties in achieving the climate targets unless additional mitigation measures are taken (Hubacek et al., 2017; Scherer et al., 2018).

4.2. Implications for downscaling consumption and degrowth

As shown above, even the carbon footprints determined at the UBI level excluding earned incomes are quite high considering the remaining global carbon budget. This is partly because low-income households don't have similar possibilities to make sustainable choices as higher income households. For example, the energy consumption per square meter was around 30 % lower in the highest income deciles compared to the lowest income decile in 2012 according to the HBS and the applied carbon footprint model. In vehicle efficiency there wasn't much difference though, since low-income households had older but smaller cars. In order to reach the climate targets, low-carbon housing, food, and mobility should be available and affordable to everyone. Considering middle- and high-income consumers who wish to reach their "fair share" of the global carbon budgets, they need additional mitigation solutions alongside downscaling consumption, given the current average GHG intensity (kg/€) of the economy. Ivanova et al. (2020) list in their recent review article renewable energy, sustainable diets, and shifting to public transport or electric vehicles as some of the most efficient sustainable consumption choices. Increased recycling and recovery of carbon (Shigetomi et al., 2019), and wooden construction (particularly in Nordic countries) (Amiri et al., 2020), could have significant impacts as well.

In practice, downscaling of consumption is usually linked to worktime reduction or work-sharing, which have been emphasized as important elements of degrowth (Schneider et al., 2010; Buhl and Acosta, 2016) and sustainable economies in general (Schor, 2005; Pullinger, 2014; Zwickl et al., 2016). Significant changes to the division between work- and leisure time could also have implications for expenditure shares (Buhl and Acosta, 2016), which we could not take into account in this study. However, among the studied low-income Finnish households, consumption behaviour is very similar between working and unemployed adult households. Among families with children, at least one of the parents is working in most cases. In general, it seems that as low-income households as studied here have very little latitude to make consumption choices, since housing and food take the majority of their income.

As discussed above, middle- and high-income households need additional (technological) solutions to reach sustainable carbon footprints. At the societal level, the reduction of the overall GHG intensity of the economy calls for innovation, which is typically driven by economic activity and profit seeking. This is a serious challenge for the degrowth concept. Tackling climate change and other environmental problems in a society where there is less money to share to different purposes is troublesome (Bailey, 2015). It raises a question on how the needed green investments would be financed. New technologies including renewable energy solutions and negative emission technologies, such as carbon capture and storage, are necessary in order to keep within the 1.5-degree pathway (van Vuuren et al., 2018). Yet, technological development (increasing efficiency in particular) is currently unable to overcome the impact of growing output (macro-economic rebound), which is one of the main arguments for the need of downscaling production and consumption in the first place (Wiedmann et al., 2020).

From a social perspective, downscaling is a very difficult concept for European welfare states. Maintaining the current level of social security in a shrinking economy would be hard if not impossible, since social benefits and welfare services are funded mainly with income and consumption related taxes that rely on strong economy. Thus, shifting taxation from labour and low-carbon consumption to carbon intensive sectors combined with strong public and private sustainable investments would be socially more acceptable approach to transforming current welfare states into eco-states (Ottelin et al., 2018a). In addition, fossil-based energy should be phased-out by regulation (Le Quéré et al., 2019) to avoid leakage effects. The policies should also cover the imported emissions to avoid so-called "low-carbon" illusion, meaning that the domestic energy production is clean, but GHG intensive products are imported from elsewhere (Clarke et al., 2017; Ottelin et al., 2019a).

4.3. Limitations of the study

There are several limitations in this study. First of all, it was not possible to study the consumption of the actual people taking part in the UBI experiment. Instead, similar households (with similar income and consumption level) were identified in the Finnish HBS. Secondly, there were no exact information about the income level of the participants of the UBI experiment, but that needed to be estimated from different sources for this study. However, the governmental actions are recorded and documented clearly, and the information is widely available. A preliminary report presenting the sums of benefits paid by the Social Insurance Institution of Finland, Kela, and earnings and income from self-employment of the experiment participants and the control group came out after this study was conducted (Kangas et al., 2019). It reveals that the actual income level of the UBI participants and the control group was very close to the level estimated and applied in this study. Thus, the very small difference in the income do not affect the main findings of this study. Third, we could not estimate the actual emissions from using public services and from investments overall, as there is no data available for such an analysis for this sample (see also Ottelin et al., 2018a, for a more detailed discussion about the problems in estimating these components for a given sample of consumers).

The applied method and utilized data have their own limitations and uncertainties. The Finnish HBS data utilized in this study is from year 2012 and doesn't necessarily represent the consumption behaviour of year 2017 accurately. The consumer habits change over the years and so do the prices. To correct the error of changed prices, a consumer price index was used. Moreover, the information for the ENVIMAT model applied in the carbon footprint calculations is from year 2006, and the Finnish economy and production technologies have evolved since. A more detailed description of the method and its limitations can be found from Ottelin et al. (2018a, b). In addition, this study focused only on GHGs and other environmental pressures were excluded.

5. Conclusions

The carbon footprint at the UBI consumption level is on average 4.8 tCO_2-eq, which is 49 % lower than the average carbon footprint in Finland. However, adding the governmental consumption and investments components to the UBI carbon footprint increases it to around 6.2 tCO_2-eq, which is higher than the global average or "fair share". Furthermore, the results illustrate that even a cutdown in the consumption levels in Finland down to the UBI level would not be enough to reach sustainable lifestyles considering the 1.5- or 2-degree climate targets in the long run. Innovations to decrease the GHG-intensity of consumption are needed as well. The results emphasize the need for low-carbon solutions for housing, nutrition, and travelling for all income classes.

Economic growth has been and still is based on extensive utilization of fossil fuels. This has led to suggestions to build an alternative economic system based on degrowth. However, the results of our study raise the question on how to run a welfare state like Finland, with a large public sector and a wide variety of public goods and heavily subsidized semi-public goods, and have funding for new technologies to tackle the climate change in a degrowth economy. Nonetheless, in the light of the results of the study, it is equally difficult to see how continuous economic growth could be reconciled with 1.5- or 2-degree climate targets.

Finally, this study provides a consumption-based carbon footprint benchmark for future studies elsewhere on the GHG impacts of downscaling strategies. It is possible that for example in warmer countries the UBI consumption level would lead to lower carbon footprints, due to less need of heating energy and possibility for year-round local food production.

CRediT authorship contribution statement

Salla Kalaniemi: Conceptualization, Formal analysis, Investigation, Visualization, Writing - original draft. **Juudit Ottelin:** Conceptualization, Methodology, Formal analysis, Investigation, Visualization, Supervision, Writing - review & editing. **Jukka Heinonen:** Conceptualization, Writing - review & editing, Supervision. **Seppo Junnila:** Conceptualization, Writing - review & editing, Supervision.

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 paper.

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