Increasing positive climate impact by combining anti-consumption and consumption changes with impact investing

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DOI: 10.1002/sd.2117

INCREASING POSITIVE CLIMATE IMPACT BY COMBINING ANTI-CONSUMPTION AND CONSUMPTION CHANGES WITH IMPACT INVESTING

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ABSTRACT

Household consumption leads to global warming potential (GWP) impacts, for example, via energy consumption, production processes and transportation. 72 % of global greenhouse gas emissions are related to household consumption. Some of this consumption is nonessential and could therefore be reduced, leading to decreased greenhouse gas (GHG) emissions. There is, however, a risk of a rebound effect if money saved by reducing consumption is used or invested in a way that leads to GHG emissions elsewhere. Therefore, in efforts to further mitigate climate change via anti-consumption behavior or changes in consumption, it should be ensured that money saved is impact invested in climate change mitigating actions, thus creating a secondary impact. Previous studies have not considered the need to account for this double impact dynamic in climate change mitigation. An approach to calculate potential for double impacts is developed in this work. The paper also presents quantitative GHG emissions reduction potentials for some example anti-consumption actions and consumption changes as well as for possible impact investments.

Keywords: household consumption, anti-consumption, impact investing, global warming potential, climate change mitigation

INTRODUCTION

To stay within the planetary boundaries of the safe operational space for humanity presented by Rockström et al. (2009) and Steffen et al. (2015), global resource use has to be decreased to a more sustainable level. The IPCC report on limiting global warming to 1.5°C above pre-industrial levels demands action in all areas of human activity (IPCC, 2018). One of the actions needed is more responsible and sustainable consumption (Southerton & Welch, 2018). The majority of global greenhouse gas (GHG) emissions are related, directly or indirectly, to household consumption; the share of GHG emissions related to household consumption is estimated to be 72% of global emissions (Hertwich & Peters, 2009). Household consumption choices impact climate change, e.g., via goods and services production, energy usage, logistics and waste handling. According to World Bank (2018) figures, global consumption has increased constantly over the last decades. In the EU, production-based CO_2 emissions have decreased the targeted 20% to below 1990 levels (EEA, 2018), but if the simultaneous growth in imported carbon is considered, total emissions have remained almost at the same level as in 1990 (Buy Clean 2018). Based on the McKinsey Global Institute's report (2016), global consumption will continue to grow also in the near future. A dramatic change is that the main driver behind the growth is no longer population increase but greater spending by individuals (McKinsey Global Institute, 2016). According to Druckman & Jackson (2016), household greenhouse gas emissions are highly dependent on household consumption. In developed countries, a significant share of consumption can be regarded as nonessential and could be reduced without compromising basic human needs. Claudelin et al. (2018) show that Finnish households could, with rather simple changes, save total of €9 billion annually by reducing unessential consumption.

Anti-consumption can be seen as one option for households to reduce their sustainability impacts. Sustainability oriented anti-consumption is mainly driven by acts of reduction, rejection and reuse (Black & Cherrier 2010). Lee & Ahn (2016) review literature on anti-consumption and find that most anti-consumption research has been related to motivation. They further conclude that the consequences of anti-consumption have received less consideration. Sudbury-Riley and Kohlbacher (2018) surveyed 457 adults, and their work presents that social reasons are a greater driver for anti-consumption than ecological reasons, although both aspects are seen as important. According to Peyer et al. (2017), voluntary simplifiers, i.e. consumers who voluntarily reduce nonessential consumption, buy more green products and exhibit greater environmental and sustainability awareness than other consumer groups. The research reports that one-sixth of the German population can be considered simplifiers to a lesser and greater extent. In this paper, anti-consumption may refer also to changes in consumption behavior, e.g. substituting meat for plant based proteins. Our argument is that households can reduce their sustainability impact by reducing nonessential consumption through anti-consumption. This anti-consumption behavior can be an active and conscious lifestyle change or an unconscious change. This paper focuses on the potential impact of anti-consumption rather than motivations for anti-consumption and consumption changes, which have been studied e.g. by Rezvani et al. (2018), Gul Gilal et al. (2019), Hurth (2010) and Nguyen et al. (2018). As the paper focuses on GHG emissions, it does not cover all aspects of sustainability, but focuses on achieving the Sustainable Development Goal (SDG) number 13 (Climate action). Causal interactions among SDGs have been studied elsewhere, and the result of systematic compilation is illustrated in Global Sustainable Development Report (2019). Most of the papers have studied co-benefits to be harnessed, whereas trade-offs to be addressed have not been studied as much. The focus of the paper is on developed countries as the citizens of those have more opportunities to make consumption changes than citizens of developing countries.

Reducing consumption alone does not ensure a more sustainable future. In this work, we assume that as a result of reduction in consumption, households would have more money available. Money saved could be used either for investments or deposited in a bank account. In this case, money would typically be given as a loan by banks and directed to investments. Consequently, reduction in household consumption could lead to rebound effects via investments as banks might loan money for projects and companies contributing to climate change. The household savings rate in the EU currently varies from -1% (Cyprus) to 21 % (Luxembourg) with the EU average being 11 %. Households use their savings mainly for the purchase and renovation of dwellings (Eurostat 2018). Thus, money is channeled back to the consumption side and there is a risk that its use leads to additional sustainability impacts. However, sustainability impacts may also be positive, for example, through investment in energy efficient home improvement (Dobler et al. 2018, Claudelin et al. 2017). According to Statistics Finland (2018), Finnish household savings are allocated to the following categories: bank deposits 30%, other stocks and shares 27%, insurance 20%, quoted shares 12%, investment funds 7% and others 5%.

In addition to consumption, another major challenge from the climate change perspective is transition from fossil energy to renewable energy sources. The transition requires huge investment in new energy infrastructure (Alfredsson et al., 2018). According to IEA (2014), investment totaling €35 trillion is needed by 2050 to enable the transition to a clean energy future. IPCC (2018b) estimated that global annual investment need in the energy system are approximately 2.38 trillion USD_{2010} between 2016 and 2035, which equals approximately €42 trillion over a 20 year period. The European Commission (2018) estimate that in the EU the annual gap in current emissions mitigation investments is €180 billion. To put this figure into context, EU households spend approximately €9.2 trillion on consumption annually (Eurostat, 2017).

Impact investing is a type of investing which generates social and environmental impact in addition to providing financial returns (Global Impact Investing Network, 2018). Mudaliar et al. (2018) conducted a survey of actors in the impact investment sector and, based on information from respondents, found that impact investing had grown to $228 billion. They also reported that most of the investors plan to increase their investments. Directing even a small share of household consumption to sustainability supporting investments could make a considerable contribution to sustainability transition. Additionally, increased impact investment would also ensure that reduction in consumption does not lead to GHG emissions through rebound effects generated in the investment sector.

The aim of this paper is to mitigate a lack of knowledge on household anti-consumption and consumption change impacts, and to develop a method to assess GHG emission reduction potential from combined anti-consumption or consumption change and impact investing. The method is tested using Finnish households as a case example, and the method is applicable for developed countries.

DEVELOPING THE DOUBLE IMPACT ASSESSMENT FRAMEWORK

In this work, the term “double impact” is used to describe the effects of the combination of anti-consumption or consumption behavior change and impact investing. Double impact thus includes both impacts from anti-consumption or consumption behavior change and impacts from impact investing. In theory, the methodology developed in this paper could be applied for analysis of many different sustainability impact categories but in this work only global warming potential (GWP) impacts through changes in GHG emissions are calculated. This work does not take into consideration how possible co-benefits and trade-offs related to other systems might alter the results, and therefore the method presents rather a potential for GHG reductions calculated with current knowledge.

First impact (Anti-consumption or consumption change impact). The primary possibility for consumers to decrease GHG emissions is to reduce consumption (quantitative change) or alter consumption patterns (qualitative change). Reduced levels of overall consumption influence overall demand, which affects levels of production. However, this impact is rather mid- or long-term, and GHG emission reductions will happen over time. Some qualitative changes, on the other hand, e.g. cycling instead of driving, have immediate effects in the short term through reduced fuel combustion. During the life cycle of goods, GHG emissions are generated in logistics, retail, use and dispose phases in addition to during production. Consequently, GHG emissions have to be taken into account from the whole life cycle perspective, i.e. life cycle assessment (LCA). Although GHG emissions vary considerably between different products and services, there is quite a lot of data already available on life cycle GHG emissions of different goods and services.

Second impact (Investment impact). Banks create money by loaning and investing the money that consumers have deposited, i.e. their savings. To ensure that savings from consumption lead to GHG emission reductions, it has to be ensured that money will not return to unsustainable consumption. A solution is that saved money is donated or impact invested to sustainability supporting actions. Such investments can, for example, be related to creation of carbon sinks or the production of renewable energy. GHG emission reductions through impact investing are challenging to evaluate as impacts typically happen over different time scales.

Tertiary impact (Reverse or additional impact). Investments usually gain interest over time. It is up to the consumer to decide what they wish to do with interests gained. If consumers use the interest for further investment, they may achieve additional GHG emission reductions. On the other hand, if the interest returns to the consumption side, it will likely cause GHG emissions. Also, if consumers withdraw their investments in the future, the withdrawn money will again have impacts on the consumption side. There are many consumer behavior aspects which affect the magnitude of impacts, and therefore there is considerable uncertainty regarding tertiary impacts.

Figure 1 presents typical consumer's money flows between consumption and investment sectors. To ensure that anti-consumption or consumption change actions do not lead to money flow to unsustainable investments in the investment side the money has to be directed to sustainability supporting impact investing.

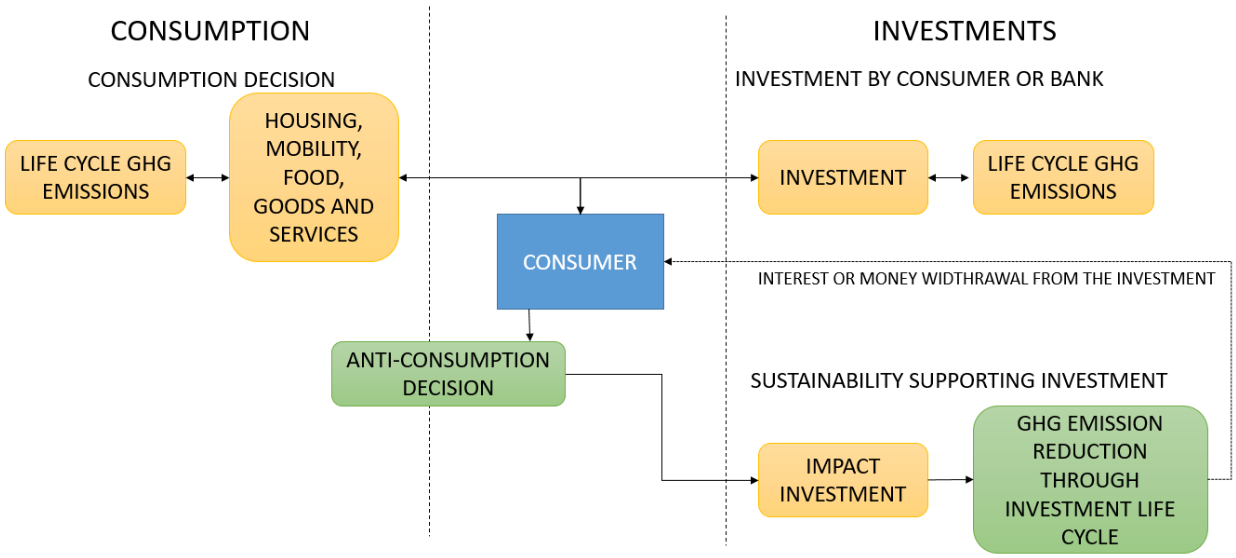

Figure 1. Money flows between consumption and investments and opportunity for double impact.

The following equation was developed to calculate the potential for the double impact from the GWP perspective:

$$D = \sum_{1}^{n} a_a \cdot g_a + \sum_{1}^{n} I \cdot g_I - \sum_{1}^{n} c_i \cdot g_i$$

, where D is the potential double impact (as GWP)

a_a is anti-consumption or consumption change choice [€]
g_a is life cycle GWP impact of anti-consumption goods or services [gCO_2eq $€^{-1}$]
I is investment or donation to GWP impact reduction actions [€]
g_I is life cycle GWP impact reduction by investment [gCO_2eq $€^{-1}$]
c_i is money from interest or from investments that is returned to consumption [€]
g_i is life cycle GWP impact of consumed goods or services [gCO_2eq $€^{-1}$]

DATA COLLECTION TO TEST DOUBLE IMPACT ASSESSMENT FOR A CASE STUDY OF FINNISH HOUSEHOLDS

There is a considerable body of research on household consumption in different consumption categories and comprehensive statistical data is available. Similar data is also available for consumer or household carbon footprints. The potential GWP impacts of overall consumption and different consumption categories and regions can be calculated using such data. Table 1 presents data on Finnish household consumption for different sectors and related average GHG emission reductions.

Table 1. Consumption and carbon footprints of Finnish households (Statistics Finland, Salo & Nissinen 2017).

Consumption category	Consumption (€/a)	Carbon footprint ($kgCO_2eq$)
Housing	4 973	4 500
Mobility	3 025	2 200
Food	2 641	1 800
Goods and services	7 068	3 000

Using data presented in Table 1, GHG emission reduction potential from anti-consumption choices in general can be calculated. The same data can be used if a consumer decides to use interest or withdraw money from the investment side and use it in the consumption side. However, these impacts are dependent on time and possible system changes. Claudelin et al. (2018) calculated the potential for Finnish households to reduce consumption with moderate changes in lifestyles. According to their calculations, households could annually, on average, save €150 from housing costs, €1 000 from mobility, €1 500 from food purchases and 450 € from goods and services. These results are utilized to calculate average annual GHG emission reduction potential and revenue of anti-consumption choices of different categories (Table 2). In addition to general categories related to anti-consumption impacts, also detailed examples of anti-consumption or consumption change impacts are calculated. Background data and assumptions for these calculations are presented in Appendix 1.

Table 2. Global warming potential impacts from Finnish consumer consumption choices (Statistics Finland, Finnish Environmental Institute).

Consumption category	Anti-consumption impacts [$kgCO_2eq$ $€^{-1}$]		Anti-consumption potential for Finnish households [$kgCO_2eq$ a^{-1}]
Housing	0.91		137
Mobility	0.73		730
Food	0.68		1020
Goods and services	0.42		198
Average	**0.62**	**Total**	**2085**

As noted earlier, the secondary impact is created through sustainable impact investments. There are several options related to these investments, and examples of investment options and related assumptions for the cases studied are presented in Table 3.

Table 3. Data and assumptions for secondary impact assessment of sustainable investments. (Hamrick & Gallant 2017; Suomen tuulivoimayhdistys 2017).

Sustainability supporting investment	Expected life time	Investment size of a unit	Other data needed	Life cycle GHG emissions from the investment	Life cycle GHG emissions from substituted investment
Solar PVs	25	1 000 € kW_p^{-1}	Operational period 800 h a^{-1}	55 $gCO_2eq\ kWh^{-1}$	Electricity production mix in Finland 200 $gCO_2eq\ kWh^{-1}$
Wind power	25	1 500 € kW_p^{-1}	Operational period 3 000 h a^{-1}	8 $gCO_2eq\ kWh^{-1}$	Electricity production mix in Finland 200 $gCO_2eq\ kWh^{-1}$
Biogas power	5	740 € plastic tank digester	Two cows' manure 3,6 GJ a^{-1} energy for cooking	No life cycle emissions included	Charcoal use 67 $gCO_2eq\ MJ^{-1}$
Carbon offsetting	n.a.	0.4-44 € tCO_2^{-1} (average 3 € tCO_2^{-1})			

RESULTS AND DISCUSSIONS

Table 2 presents potential for primary impacts for Finnish households for one anti-consumed € in different sectors and total anti-consumption potential based on the moderate scenario presented by Claudelin et al. (2018).

As can be seen in Table 2, if Finnish consumers decided to save their money instead of consuming they would be able to reduce 0.62 $kgCO_2eq$ $€^{-1}$ on average, and the annual potential that could be relatively easily achieved would be 2086 $kgCO_2eq$. Higher reductions can be achieved if savings are focused on housing, mobility or food sectors. However, reductions in housing consumption may not be as easily obtained because they are limited by current housing and might require e.g. relocation. Reductions in goods and service consumption lead on average to lower global warming impact reductions than other categories. On the other hand, this category is the area that most likely includes some nonessential consumption and consumption which is more easily controlled by the consumer.

Figure 2 and Figure 3 present examples of consumption behavior changes and anti-consumption decisions and their potential economic and GHG emission changes. As can be seen in the figures, single GHG emission reduction actions vary considerably. However, it seems that mobility and housing related decisions bring the greatest economic savings and GHG emission reductions of the chosen examples. However, actions with the highest impacts may require investments and additional tasks e.g. purchase of a new car or moving to a smaller apartment. In general, most of the examples that led to GHG emission reductions also saved consumers money. Data from Figures 2 and 3 can be directly used for primary impact (anti-consumption and consumption change impact) assessment. Background data and assumptions for these calculations are presented in Appendix 1.

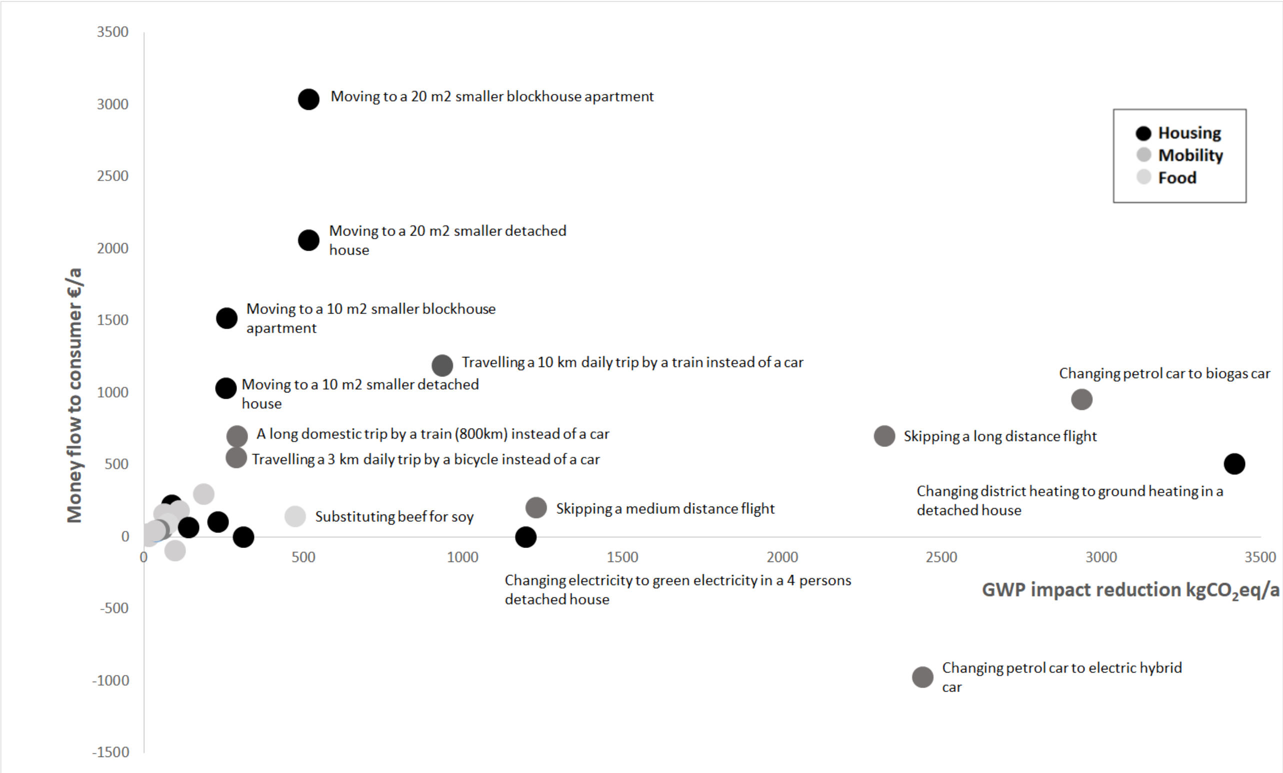

Figure 2. Global warming potential impacts and costs of anti-consumption or consumption change choices of Finnish households.

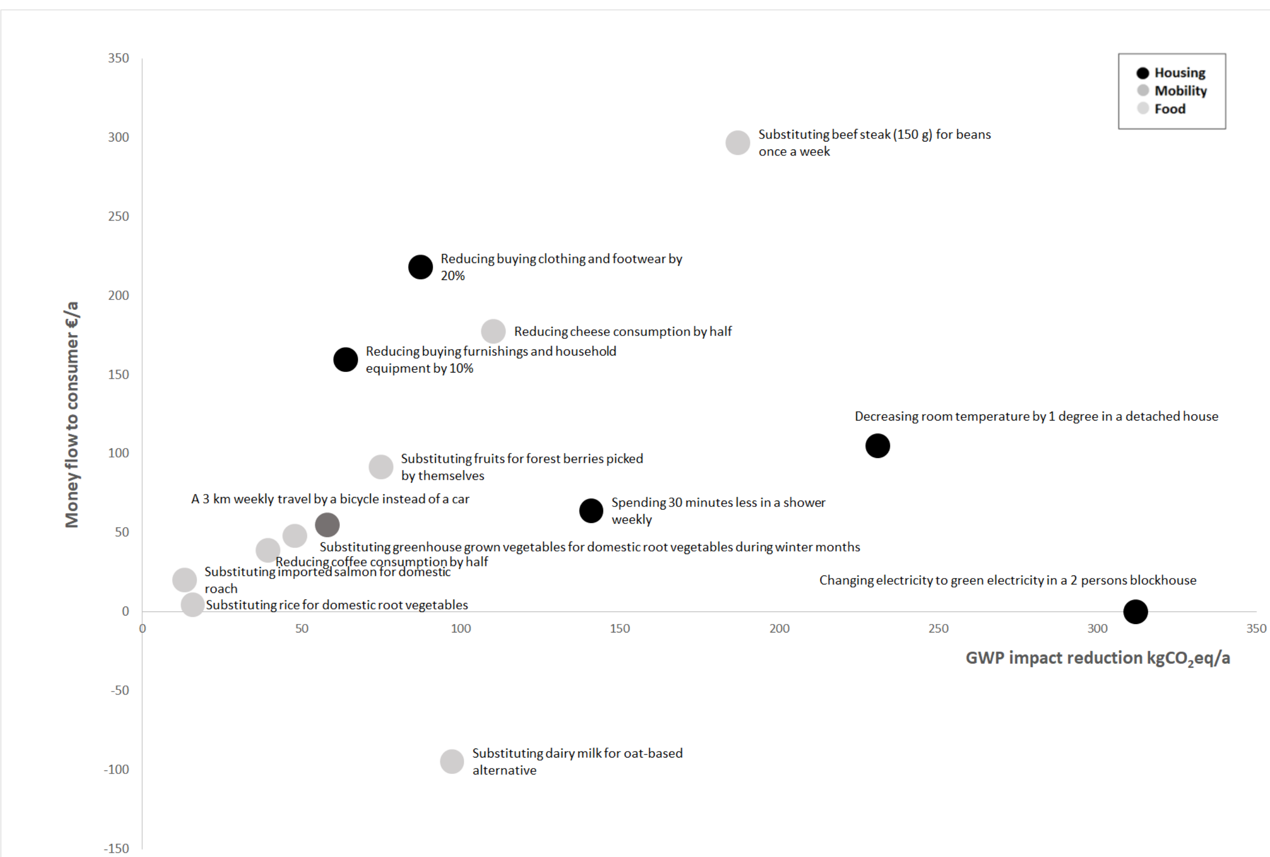

Figure 3. Global warming potential impacts and costs of anti-consumption or consumption change choices of Finnish households for examples with lower potential.

Changing a petrol car to a hybrid electric car and substituting dairy milk for an oat-based alternative seems lead to reductions in GHG emissions but they also increase costs for the consumer. However, the calculations are made for only certain car models, and the calculations include also car depreciation, which is higher for electric hybrid cars. Therefore, depending on the models, the money flow to the customer could be either more negative, closer to zero or positive. On the other hand, as the fixed costs of a car are included in the calculations, living without a car would be needed to achieve the full calculated money flows. The gasoline costs of driving a kilometer would be approximately 0.11 € whereas the costs per kilometer would be 0.33 € if the fixed costs were considered. If only gasoline costs were considered, it would actually be cheaper to drive the 10km daily trip instead of taking a train. Also, changing to ground source heating might, depending on details of the house and location, cause negative money flow to the customer. However, most of the anti-consumption and consumption change choices studied for this work clearly have positive effects on both GHG emission reductions and money flow to the consumer.

Some of the choices, e.g. changing to green electricity, are relatively easily done and do not require familiarization or changes in everyday behavior. Choices related to changing a heating system and changing a car to a biogas or electric hybrid car require both familiarization and possibly large investments, but they do not require daily behavioral changes. Some choices, e.g. skipping a flight or using public transportation or a bicycle instead of a car, require changes in behavior. Over half of the example changes are relatively small and result annually in less than €350 of savings and 350 kg CO_2eq of GHG emission reductions. Most of these changes require changes in behavior to some extent. The achievable reductions and savings are not significant by themselves but combined they will have significant impact.

The results of secondary impacts through impact investing are presented in Table 4. Relatively high variation in potential GHG reductions from chosen energy infrastructure investments as well as from carbon sequestration options can be seen.

Table 4. Global warming potential impact mitigation through life cycle of investment from example impact investments when €1 000 is invested.

Impact investment	GWP reduction [kgCO_2eq 1 000 €$^{-1}$]
Solar PV in Finland	2 900
Wind power in Finland	9 600
Biogas in Africa	1 600
Carbon sequestration	400–44 000

Table 5 presents example cases of potential double impacts by combining anti-consumption or consumption change and impact investing. It also presents tertiary impact through use of interest. The total potential double impact is calculated based on these three impacts.

Table 5. Example cases for double impact calculations.

Case	Primary impact (anti consumption)	Secondary impact (impact investment)	Tertiary impact (Reverse or additional impact)	Double impact (total impact)
Person saves 200 € by skipping a medium distance flight and donates money for carbon sequestration project.	1230 $kgCO_2eq$	800 $kgCO_2eq$ (4€ $kgCO_2eq^{-1}$ price)	-	2030 $kgCO_2eq$
Person substitutes his weekly steak with beans and invests savings (300 €) for solar energy projects. Also 2% interest is invested to the same target.	187 $kgCO_2eq$	861 $kgCO_2eq$	17 $kgCO_2eq$	1065 $kgCO_2eq$
Person decreases room temperature by one degree in a detached house and invests savings (105 €) for a biogas project in Africa. 1 % interest returns to consumption.	231 $kgCO_2eq$	171 $kgCO_2eq$	-0.7 $kgCO_2eq$ (0.6 $kgCO_2eq$ $€^{-1}$ average consumption)	401 $kgCO_2eq$

Other environmental impact categories could be assessed similarly but there may be more limitations in data availability and accuracy related to impacts from different consumption categories. Tables 4 and 5 indicate that the total impact varies mainly depending on the primary and secondary impacts. The tertiary impact is relatively insignificant compared to the other two impacts. If a household anti-consumed the €3100 Claudelin et al. (2018) calculated, the interest rate was 2 %, and savings and interests were invested in solar PV in Finland, the impact achieved via interest would be 180 $kgCO_2eq$ while the primary impact would be 2085 $kgCO_2eq$ and the secondary impact 8 990 $kgCO_2eq$.

There is a lot of discussion about consumers' possibilities to mitigate global warming. Anti-consumption or consumption changes have been seen as a potential method to reduce consumption related GWP impacts. However, consumption change alone does not ensure that anti-consumed money is not directed back to consumption as investments via bank loans. Therefore, to ensure that there really are positive impacts from the GWP perspective, money has to be invested in sustainability supporting actions. There are however many uncertainties related to exact numbers because this approach combines consumer level actions and wider perspective system changes e.g. through changed consumption patterns.

It is likely that some consumers will, at some point, withdraw their invested money to use it for consumption. Consequently, whether the total impact of anti-consumption is negative or positive can vary considerably. For example, if the investments and interests are withdrawn and used for energy efficiency improvements of current dwellings, further reductions in GHG emissions may be achieved. From the point of GHG emissions reduction, the worst option would be to anti-consume on something that has high economic saving potential but low GHG emission reduction potential, and then later use the saved money e.g. on a long distance flight.

The calculations are based on LCA which is a microeconomic tool, and therefore macroeconomic changes are not considered in the calculations. The results might not be as straightforward as displayed in the double impact method and the method merely presents potential with the current knowledge. Especially time affects both the amount of money saved and GHG emissions reduced, and also e.g. global situations have effects on all levels creating uncertainty for quantified assessment. For example, a positive side of the current Covid-19 virus has been that is has temporarily decreased GHG emissions (Le Quéré et al. 2020). As a negative side effect, it has affected the economies making it harder to invest money in climate change mitigation and adaptation. Lack of mitigative actions increases GHG emissions possibly leading to increased occurrences of natural hazards such as cyclones and droughts that are further burdens for economies. Already in 2007 it was pointed out by the Stern Review that without investing approximately 1% of yearly GDP into climate change mitigation the costs and risks caused by climate change will cause a loss of at least 5% of global GDP each year.

CONCLUSIONS

Anti-consumption or consumption changes of households have potential to reduce greenhouse gas (GHG) emissions. The scale of GHG reductions varies considerably depending on the actions undertaken, and the behavior may provide savings or additional costs for households. To ensure that saved money from anti-consumption or consumption changes does not lead to additional GHG emissions via rebound effects, the money should be impact invested to provide additional GHG reductions. For this purpose of assessing additional impacts, a double impact calculation method was created. Double impact calculation combines potential sustainability impacts that are achieved through anti-consumption or consumption behavior change, impact investment and the use of interest from investments. Households in developed countries have huge potential to reduce consumption related GHG emissions and, through impact investing, to e.g. promote sustainable energy transition. The double impact method is created based on the current standards of LCA (International Organization for Standardization 2006 & 2018) which do not necessarily take systemic changes into consideration. The changes might alter the results for both GHG reductions and monetary savings. Therefore, further research to evaluate co-benefits and trade-offs related e.g. to SDGs are needed. Future research should also focus on how to technically ensure that saved money from consumption is directed to impact investing. Despite the limitations of the double impact method, it is a good tool for assessing the combined impact of anti-consumption or consumption changes and the additional impacts.

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APPENDIX 1

Mobility category	GWP impact data	Economic data	Other assumptions	References
Skipping a long distance flight	Direct emissions 114 gCO_2eq pkm^{-1} Plane manufacturing emissions 7 gCO_2eq pkm^{-1} Jet fuel production 15 gCO_2eq MJ^{-1}	700 € back and forth trip	Fuel consumption 3.5 MJ pkm^{-1}	Technical research center Finland 2018 Chester & Horvath 2009 Travel agencies
Skipping a medium distance flight	Direct emissions 165 gCO_2eq pkm^{-1} Plane manufacturing emissions 7 gCO_2eq pkm^{-1} Jet fuel production 15 gCO_2eq MJ^{-1}	200 € back and forth trip	Fuel consumption 2.2 MJ pkm^{-1}	Technical research center Finland 2018 Chester & Horvath 2009 Travel agencies
Travelling a 3 km daily trip by a bicycle instead of a car	Direct emissions 135 gCO_2eq pkm^{-1} Car manufacturing emissions 20 gCO_2eq pkm^{-1} Petrol production 15 gCO_2eq MJ^{-1}	Car use costs 0.33 € km^{-1}	Fuel consumption of a car 2.3 MJ pkm^{-1} Bicycle driving is assumed to have no GWP impacts or costs 5 days a week	Technical research center Finland 2018 Chester & Horvath 2009 YLE 2018
Travelling a 10 km daily trip by a train instead of a car	Direct emissions from a car 135 gCO_2eq pkm^{-1} Car manufacturing emissions 20 gCO_2eq pkm^{-1} Petrol production 15 gCO_2eq MJ^{-1} Train manufacturing emissions 20 gCO_2eq pkm^{-1} Electricity production 17.4 gCO_2eq MJ^{-1}	Car use costs 0.33 € km^{-1} A monthly train ticket is 54 €	Fuel consumption of a car 2.3 MJ pkm^{-1} Electricity consumption of a train 0.30 MJ pkm^{-1} Train are using 70% hydro and 30% grid mix electricity 5 days a week	Technical research center Finland 2018 Chester & Horvath 2009 YLE 2018 HSL ticket prices
Changing petrol car to electric hybrid car	Direct emissions from a petrol car 135 gCO_2eq pkm^{-1} Petrol car manufacturing emissions 20 gCO_2eq pkm^{-1} Petrol production 15 gCO_2eq MJ^{-1} Electric car manufacturing emissions 35 gCO_2eq pkm^{-1} Electricity production 48.6 gCO_2eq MJ^{-1}	Petrol car use costs 0.33 € km^{-1} Electric car use costs 0.41 € km^{-1}	18 000 km annual driving Fuel consumption of a petrol car 2.3 MJ pkm^{-1} Electricity consumption of an electric car 0.7 MJ pkm^{-1}	Technical research center Finland 2018 Chester & Horvath 2009 YLE 2018
Changing petrol car to biogas car	Direct emissions from a petrol car 135 gCO_2eq pkm^{-1} Petrol and gas car manufacturing emissions 20 gCO_2eq pkm^{-1} Petrol production 15 gCO_2eq MJ^{-1} Gas production 12 gCO_2eq MJ^{-1}		18 000 km annual driving Fuel consumption of a petrol car 2.3 MJ pkm^{-1} Fuel consumption of a gas car 1.9 MJ pkm^{-1}	Technical research center Finland 2018 Chester & Horvath 2009 YLE 2018
A long domestic trip by a train (800km) instead of a car	Direct emissions from a car 135 gCO_2eq pkm^{-1} Car manufacturing emissions 20 gCO_2eq pkm^{-1} Petrol production 15 gCO_2eq MJ^{-1} Train manufacturing emissions 20 gCO_2eq pkm^{-1} Electricity production production 17,4 gCO_2eq MJ^{-1}	Car use costs 0.33 € km^{-1} One way train ticket is 80 €	Fuel consumption of a car 2.3 MJ pkm^{-1} Electricity consumption of a train 0.30 MJ pkm^{-1} Train are using 70% hydro and 30% grid mix electricity 5 days a week	Technical research center Finland 2018 Chester & Horvath 2009 YLE 2018
A 3 km weekly travel by a bicycle instead of a car	Direct emissions 135 gCO_2eq pkm^{-1} Car manufacturing emissions 20 gCO_2eq pkm^{-1} Petrol production 15 gCO_2eq MJ^{-1}	Car use costs 0.33 € km^{-1}	Bicycle driving is assumed to have no GWP impacts or costs	Technical research center Finland 2018 Chester & Horvath 2009 YLE 2018

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Food category	GWP impact data	Consumer price data	Other data	References
Substituting beef for soy	Beef: 25 kgCO_2eq/kg[1] Soy: 0.49 kgCO_2eq/kg[2]	Beef: 12.97 €/kg Soy: 5.66 €/kg	Beef consumption per person 19.4 kg/a	Clune et al. 2017 Statistics Finland 2018 Finnish grocery stores Natural Resources Institute Finland 2018
Reducing cheese consumption by half	Cheese: 8.655 kgCO_2eq/kg[2]	Cheese: 13.75 €/kg	Cheese consumption per person 25.8 kg/a	Clune et al. 2017 Statistics Finland 2018 Natural Resources Institute Finland 2018
Substituting imported salmon for domestic roach	Salmon: 4.5 kgCO_2eq/kg Roach: 0.72 kgCO_2eq/kg	Salmon: 12.22 €/kg Roach: 22.5 €/a[3]	Salmon consumption per person 3.5 kg/a	Silvenius 2014 Metsähallitus 2015 Natural Resources Institute Finland 2018
Substituting rice for domestic root vegetables	Rice: 2.8 kgCO_2eq/kg Root vegetables: 0.13 kgCO_2eq/kg	Rice price: 2.09 €/kg Root vegetables: 1.33 €/kg	Rice consumption per person 6 kg/a	Saarinen et al. 2011 Finnish grocery stores Statistics Finland 2018 Natural Resources Institute Finland 2018
Substituting beef steak (150 g) for beans once a week	Beef: 25 kgCO_2eq/kg[1] Beans: 0.51 kgCO_2eq/kg[2]	Beef tenderloin: 50.4 €/kg Beans: 6.49 €/kg	Protein content of beef: 57% Protein content of beans: 30%	Clune et al. 2017 Finnish grocery stores National Institute for Health and Welfare 2018
Reducing coffee consumption by half	Coffee: 8.0 kgCO_2eq/kg	Coffee: 7.84 €/kg	Coffee consumption per person 9.9 kg/a	Wallén et al. 2004 Finnish grocery stores Natural Resources Institute Finland 2018
Substituting fruits for forest berries picked by themselves	Fruits: 1.3 kgCO_2eq/kg Forest berries: 0 kgCO_2eq/kg	Fruits: 1.56 €/kg Berries: 0 €/kg	Fruit consumption per person 58.8 kg/a	Clune et al. 2017 Statistics Finland 2018 Natural Resources Institute Finland 2018
Substituting greenhouse grown vegetables for domestic root vegetables during winter months (December, January, February)	Greenhouse vegetables: 3.1 kgCO_2eq/kg Root vegetables 0.13 kgCO_2eq/kg	Salad, cucumber and tomato: 2.17 €/kg Root vegetables: 1.33 €/kg	Greenhouse vegetable consumption per person: 15.95 kg/winter months (consumption doesn't vary between different months)	Saarinen et al. 2011 Finnish grocery stores Statistics Finland 2018 Natural Resources Institute Finland 2018
Substituting dairy milk for oat-based alternative	Dairy milk: 1.3 kgCO_2eq/kg[1] Oat drink: 0.45 kgCO_2eq/kg	Dairy milk: 0.99 €/l Oat drink: 1.82 €/l	Milk consumption per person: 114.4 l/a	Clune et al. 2017 Florén et al. 2013 Finnish grocery stores Natural Resources Institute Finland 2018

[1]EU median value, [2]median value, [3]average: fisheries management fee 45 €/a, angling 0 €/a, [4]median value for field grown fruits 0.42 kgCO2-eq/kg, median value for greenhouse grown fruits 2.13 kgCO2-eq/kg, [5]average value (beef 25, pork 5.4, chicken 3.7 and salmon 4.5 kgCO2-eq/kg), [6]average value (greenhouse vegetables 3.1 and root vegetables 0.13 kgCO2-eq/kg), [7]meat casserole

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Other consumption category	**GWP impact data**	**Consumer price data**	**Other data**	**References**
Clothing and footwear	0.4 $kgCO_2eq$ €$^{-1}$	Average annual consumption 720 € a^{-1}	20% reduction	Claudelin et al. 2018 Seppälä et al. 2009
Furnishing and household equipment	0.4 $kgCO_2eq$ €$^{-1}$	Average annual consumption 1062 € a^{-1}	10% reduction	Claudelin et al. 2018 Seppälä et al. 2009

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Housing category	**GWP impact data**	**Consumer price data**	**Other data**	**References**
Moving from 80 m^2 apartment to 60 m^2 apartment	District heating 188 gCO_2eq kWh^{-1}	District heating costs 85 € MWh^{-1} Price for a sqm 2500 €	Need for heating 55 kWh/m^3, house built in the 80's Loan for 20 years, interest 2 %	Motiva 2018 Finnish energy 2018 Motiva 2016
Moving from 150 m^2 house to 130 m^2 house	District heating 188 gCO_2eq kWh^{-1}	District heating costs 85 € MWh^{-1} Price for a sqm 1500 €	Heating energy consumption 24625 kWh/a for 150 m^2 and 21875 for 130 m^2 Loan for 20 years, interest 2 %	Motiva 2018 Finnish energy 2018 Motiva 2017
Changing to green electricity in an apartment	Electricity production 164 gCO_2eq kWh^{-1}	Approx. same prices	One person living in an apartment, electricity consumption 1400 kWh/a	Motiva 2018 Adato Energia 2013
Changing to green electricity in an detached house	Electricity production 164 gCO_2eq kWh^{-1}	Approx. same prices	Four persons living in a detached house, electricity consumption 7300 kWh/a	Motiva 2018 Adato Energia 2013
Changing district heating to a ground source heat pump	District heating 188 gCO_2eq kWh^{-1} Electricity production 164 gCO_2eq kWh^{-1} Ground-source heat pump manufacturing, transport and borehole 7.7 $kgCO_2eq$ GJ^{-1}	District heating costs 85 € MWh^{-1} Electricity cost 13,4 c/kWh Investment 15 000 €, no interest	Detached house 150 m^2, heating energy consumption 24625 kWh/a Life expectancy 20 a	Finnish energy 2018 Motiva 2017 Saner et al. 2010
Lowering room temperature by 1 C (detached house)	District heating 188 gCO_2eq kWh^{-1}	District heating costs 85 € MWh^{-1}	Detached house 150 m^2, heating energy consumption 24625 kWh/a Lowering room temperature by 1 C lowers energy consumption by 5%	Motiva 2018 Finnish energy 2018
Spending 30 mins less in a shower/week	District heating 188 gCO_2eq kWh^{-1}	District heating costs 85 € MWh^{-1}	Shower uses water 12 l/min Energy needed for heating 0.4 kWh/l	Verto D-mat Oy 2018

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