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RESEARCH AND ANALYSIS

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Shifting expenditure on food, holidays, and furnishings could lower greenhouse gas emissions by almost 40%

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Abstract

This paper investigates how consumption-based greenhouse gas emissions from private households can be reduced. The aim is to quantify opportunities for mitigation through shifting expenditure on food, holidays, and furnishings to less carbon-intensive products and services that are available on the market but not yet mainstream. Two hundred and seventeen analyses of the greenhouse gas emissions/SEK for on-the-market products and services were used for estimating the consumption-based greenhouse gas emissions from an average person, an average single man and an average single woman. The consumption-based greenhouse gas emissions for these households were estimated to be 6.9, 10, and 8.5 tonnes per capita per year respectively; and food, holidays, and furnishings accounted for 56–59% of that. The alternatives to mainstream food, holidays, and furnishings include plant-based alternatives to meat and dairy products, locally produced vegetables, second-hand or repaired furnishings, holidaying abroad by train, and "staycations." Our results show that total greenhouse gas emissions can be lowered by 36–38% by shifting the expenditure on these products and services to less carbon-intensive alternatives without changing the total expenditure. The share of total emissions deriving from food, holidays, and furnishings is reduced to 30–35% after the change. The findings are discussed in the light of goals for reductions in greenhouse gas emissions, additional sustainability aspects, the limitations of the study and needs for further research. This article met the requirements for a silver–silver *JIE* data openness badge described at http://jie.click/badges.

KEYWORDS
carbon footprint, consumption based greenhouse gas (GHG) emissions, food, gender, holiday, mitigation

1 INTRODUCTION

Climate change is considered a major threat not only to human societies but also to ecosystems. It has been argued that humanity needs to take strong steps to cut emissions of greenhouse gases (GHG) by 45% before 2030 and reach net zero by 2050 (UN, 2019). There are numerous proposals for how such a cut could be achieved including using renewable energy, technologies for carbon dioxide removal, changing management practices and consumer behaviors (e.g., van Vuuren et al., 2018; UN, 2020).

While countries primarily report territorial greenhouse gas emissions from within their own borders, such as to the UNFCCC, alternative methods for estimating consumption-based greenhouse gas emissions have also emerged in recent decades (e.g., Peters, 2008; Peters & Hertwich, 2008; Palm et al, 2019). These methods look instead at what is purchased by a population or a household and then track the emissions for producing these products and services from their origins, thus attributing greenhouse gas emissions to consumers and not to producers. One area of use for such accounts is to explore to what extent greenhouse gas emissions might be lowered given changes to what is purchased. It has been argued that such analyses have advantages over the territorial-based ones for promoting change and that they can be used as the bases for policy interventions by politicians or companies (Peters & Herwich, 2008). Grubb et al (2020) argues that influencing consumer behavior is necessary to address emissions that have largely escaped influence up to now.

In this study, we present new estimates of lifecycle-based emissions intensities in kilograms of greenhouse gases per Swedish krona (kg GHG/SEK) for 217 products and services available on the consumer market today. The case study for this analysis is Sweden and we matched these intensities with data on Swedish households' expenditure in order to understand current levels of greenhouse gas emissions and the reductions that can be made through changed purchases. The household examples chosen are the average person, the average single man, and the average single woman and the explored areas of change are food, holidays, and furnishings. A large proportion of the population in affluent countries such as in the European Union (EU) live in single-person households and a few previous studies have shown differences in environmental impacts between men and women. The first two categories of consumption (food and holidays) are clearly important components of the overall carbon footprint of the household, whereas the third was chosen as an example of a product category where sharing and second-hand practices can make a difference (see further under *Background*). In each of these areas, we calculated the emissions intensities of alternatives to current products and services that emit less but that are available on the market and then matched them with appropriate expenditure to investigate the reduction in emissions of greenhouse gases. In short, the main research question of the paper is:

What is the greenhouse gas emissions reduction potential if household expenditure is shifted to low-emitting, affordable, and available alternatives in the areas of food, holidays, and furnishings?

The rationale for the study is to contribute with knowledge about how a swift transition to a society with low or no emissions of greenhouse gases could be achieved.

2 BACKGROUND

Official territorial-based statistics show that Sweden's greenhouse gas (GHG) emissions have decreased from 7.7 tCO_2e/cap in 2000 to 5.1 tCO_2e/cap in 2018 (SNV, 2019). Even though the present level is still far from what would be required by long-term climate targets, Sweden stands out as a low emitter in comparison to other affluent countries, primarily due to an almost complete de-carbonization of its heating and power production. These numbers, however, do not incorporate emissions from Sweden's growing imports of goods and services or the extensive international air travel undertaken by the Swedish population (Larsson et al., 2018). Studies have shown that the share of the Swedish carbon footprint arising from indirect foreign emissions is growing (Schmidt et al., 2019) and this share was the largest in a comparison of 23 countries (Ivanovna et al., 2016). Sweden's GHG emissions have been estimated at 8.1 tonnes in 2018 using a consumption-based perspective (that included private and public consumption as well as investments), which is 60% higher than the official territorial statistics (Statistics Sweden, 2020a).

In the last decade, there has been a trend towards slowly decreasing emissions from Swedish household consumption (−1.6%/year), since the reduction in the aggregated GHG intensity has been faster than the growth in consumption volume (Larsson & Nässén, 2019; Palm et al., 2019). The long-term climate targets will, most likely, entail a combination of reduced/reversed growth in consumption volume, a faster transition to less GHG-intensive products and services in combination with negative emissions.

A relatively large body of research has explored how the carbon footprint of individual households varies with sociodemographic variables. Clearly, the most important variable is the household's disposable income/total expenditure. Expenditure elasticities of total energy use and emissions have typically been estimated at between 0.5 and 1.1 for various countries, i.e., that increase in total expenditures by 1% is associated with increased emissions of 0.5–1.1% (e.g., Lenzen et al., 2006; Roca & Serrano, 2007; Shammin et al., 2010; Nässén, 2014; Steen-Olsen et al., 2016). These elasticities are the combined effects of many different consumption categories; food for example accounts for a larger share of the carbon footprint of low-income households whereas package holidays and air travel accounts for a larger share among high-income households (Hardadi et al., 2021). The latter also appears to be an example of a consumption category where there is no obvious point of saturation in demand. Ivanovna and Wood (2020b) found that among the 1% households with the highest carbon footprints in the EU (reaching 55 tCO_2e/cap/year), air travel accounts for as much as 41%, making it the most elastic consumption category in the study.

Studies have also found that, when controlling for other factors in multivariate analyses, urban households tend to have a smaller carbon footprint than rural households; but on the other hand, an urban lifestyle correlates with a singularization of households, higher incomes, and greater consumption opportunities that operate in the opposite direction (Gill & Moeller, 2018; Ottelin et al., 2019). A few studies have investigated the difference in energy use between genders and found that single men use more consumption-related energy than single women even when differences in expenditure levels are considered (Räty & Carlsson Kanyama, 2010). Environmental impacts from food consumption among men and women have also been explored with the results of higher greenhouse gas emissions from men's consumption due to higher intakes of meat, even when adjusted for weight (Meier & Christen, 2012). Carlsson Kanyama et al. (1999) found that men's transportation patterns caused higher CO_2 emissions than those of women. Environmental psychology research has focused to a larger extent on attitudinal and motivational variables, but the dependent variable in these studies is usually more specific intent-oriented pro-environmental behaviors rather than aggregated GHG emissions from all consumption categories. Multivariate analyses in Nässén et al. (2015) and Enzler and Diekmann (2019), however, both showed that environmental concern had a significant negative correlation with carbon footprint, although much weaker than for income.

The focus of the present study is to quantify the potentials of different changes in consumer purchases to reduce aggregate GHG emissions from household consumption. Recent studies with a similar focus include Ivanova et al. (2020b) who synthesized the emission mitigation potential of a large set of options found in literature, Bjelle et al. (2017) who analyzed the potential to reduce carbon footprint for households in Norway, Moran et al. (2020) who quantified the potential for consumer-oriented policy in Europe, and Vita et al. (2019) who analyzed the environmental impact of lifestyle scenarios identified from back-casting workshops. Several of these studies highlight the importance of re-spending. Bjelle et al. (2017), for example, showed that while a large set of actions alone could reduce carbon footprint by 58%, when also accounting for re-spending, the potential dropped to 24–35%.

In this paper, we focused on three consumption categories: food, holidays, and furnishings. These categories were chosen based on being key sources of GHG emissions (particularly the first two categories, whereas the third was chosen as an example of a product category with potential for sharing and second-hand practices); that they have previously been subject to relatively little policy control; that they represent different frequencies of consumer decision-making; that they are subject to intensive efforts by industry and non-governmental organizations; and finally that the environmental motivations for changing behavior in these sectors can be supplemented by other factors such as concerns for health. Several previous studies have pointed to the GHG benefits of changing dietary choices from meat and dairy to plant-based protein sources as well as changes to different types of meat such as from beef to chicken (e.g., Carlsson-Kanyama, 1998; Carlsson-Kanyama & González, 2009; Scarborough et al., 2014; Willet et al., 2019; Broekema et al., 2020). There are fewer analyses of the effects of substituting different types of holidays, perhaps because the substitutability is not as straightforward as for different food types. The emissions generated by a holiday depend on many different factors including distance, mode of transport, and duration. Moreover, a holiday is not a necessity in the same way as food, where requirements for energy or protein can be clearly defined. Kamb et al. (2020), however, studied the GHG benefits of alternatives to air-travel based holidays for Sweden's population. Considering the purpose of different trips as well as people's stated willingness to accept a change in the mode of transport and substituting shorter trips for longer trips, they found a realistic potential for reducing GHG emissions by 26%.

The main contributions of the present study involve the presentation of new and rather detailed GHG intensities for 217 products and services covering all areas of consumption. In addition to traditional COICOPs (classification of individual consumption by purpose) these intensities also cover some available but not yet mainstream low-carbon alternatives in the consumption categories chosen for the study. Matching those intensities with expenditure data from households enables the quantification of the total GHG reduction potentials from a change in consumption patterns towards these low-carbon alternatives. Here, we also consider the differences in prices between the mainstream products and their alternatives, while assuming constant expenditures in each consumption category, meaning that the estimated potentials are not prone to the risk of rebound effects due to re-spending of saved money on other consumption (Alfredsson, 2004; Hertwich, 2005; Nässén & Holmberg, 2009; Druckman et al., 2011; Wood et al., 2018).

3 | METHODS AND MATERIALS

This study was conducted within the research program *Mistra Sustainable Consumption—from niche to mainstream* with the aim of stimulating a transition to sustainable consumption with a special focus on food, holidays, and furnishings. In this section, we describe the software that was used for the calculation of greenhouse gas emissions from products and services (EAP), the household expenditure data that were matched with these results, and the choices made when doing the analyses in EAP.

3.1 | The environmental analysis program

Many studies have been performed to determine the impact of household consumption. Most of these studies use a national, a multi-regional, or a hybrid input-output approach. Palm et al. (2019) is an example of such a hybrid top-down approach for Sweden. Castellani et al. (2019)

compared both methods for Europe, concluded with the pros of both methods and with a final call for efforts on hybridization bottom-up and top-down approaches. Such a hybrid method was developed in the nineties and is used in this paper and is described below.

The GHG emissions of products and services were analyzed by software called the Environmental Analysis Program (EAP). A thorough description of the program, the updates of the databases and the assumptions made for the calculations of each item are presented in Carlsson Kanyama et al. (2019), including four appendixes. Here, only a brief summary is provided.

The EAP tool was developed at the University of Groningen (the Netherlands) in the 1990s (Wilting, 1996). Originally, it was a tool to calculate direct and indirect energy consumption for the Netherlands. Later, GHG emissions as well as other emissions and land use were added (Benders et al., 2012). In the early 2000s, a Swedish version was developed in the context of an EU project and used for detailed study of households in the city of Stockholm (Carlsson-Kanyama et al., 2005). For the recent 2019 update, CO_2-equivalents were included.

The method used in the EAP is a hybrid approach, proposed by Bullard et al. (1978), in which process and input-output analyses are combined. Van Engelenburg et al. (1994) defined a method to operationalize this hybrid method in a step-by-step approach. The EAP is the result of the implementation of this approach into a user-friendly software tool with a set of databases that make analyzing a product almost a box-ticking exercise. Figure 1 shows which parts of a product's analysis are based on a process or input-output analysis. The results are presented as kg GHG emissions (GWP-100 in CO_2-eq.) per monetary unit, in this case Swedish kronor (SEK). The GWP factors used for CH_4 is 28 and 265 for N_2O, based on IPCC's fifth assessment report Myhre et al. (2013). The different steps necessary for calculating the environmental impacts of a product in the EAP are shown in the Supporting Information (EAP procedure). Residual goods are those materials in a product that are small or unknown and those that are not present in a product but were needed to produce it (e.g., office materials). See also Kok et al. (2006).

3.2 | Data collection

Since the needed input-output data were only available for the year 2016, the other collected data were updated to 2016 whenever possible. The databases updated were:

- Basic goods (278 options)
- Packaging (11 options)
- Manufacturers (59 options)
- Transport (26 options)
- Trade and services (149 options)
- Households (direct) (5 options)
- Waste handling (22 options)

For the top-down data (IO), national input-output statistics, for manufacturing, wholesale and retail added values and GHG emissions are used. For the bottom-up emissions data, available databases like Ecoinvent, Agri-footprint, and Idemat were used for the production of various goods and transportation (for a full account, see Carlsson Kanyama, 2019, Appendix 1). For the prices of the basic goods and packaging materials international statistics about producer prices were used.

3.3 | Household expenditure survey

Data on household expenditure were provided by Statistics Sweden (SCB) who unfortunately had no data beyond 2012. We updated the data to 2016 with relevant consumer prices indices. The data covers average households (2.1 persons, N = 2871), the average single man household (N = 369), and the average single woman household (N = 251). The reason for choosing these average types of household was to get information about some household types that are very common and also to capture a gender dimension. Single households (without children) constitute over 50% of all households in Sweden and about a third in the EU (European Commission, 2020, figures for 2017). Being single could at least in theory make it relatively easier to change one's expenditure patterns. Only a few previous studies have attempted to capture the environmental impacts of consumption in relation to gender (Räty & Carlsson Kanyama, 2010; Meier & Christen, 2012) and we wanted to contribute with more data in this field.

The expenditure data from Statistics Sweden was organized in 11 main categories and the number of entries in each category ranged from 3 to 72 (average household). For details about the subgroups of the categories studied here, see the Supporting Information to this report.

1. Alcohol and tobacco
2. Clothes and shoes

3. Food and non-alcoholic drinks
4. Furnishings and routine care of the dwelling
5. Housing
6. Health care
7. Communication
8. Other products and services (including holiday homes)
9. Recreation and culture (including package tours)
10. Restaurants and hotels
11. Transport (including expenditures for car, bus and train tickets).

For the purpose of the study these expenditures were rearranged into the following 11 categories:

1. Tobacco
2. Clothes and shoes
3. Food and drink (including alcoholic drinks and restaurants)
4. Furnishings and routine care of the dwelling
5. Housing
6. Health care
7. Communication
8. Other products and services
9. Recreation and culture (excluding package tours)
10. Holiday (including package tours, hotels, and some car use, see below)
11. Transport (excluding part of car use, see below)

Data for calculating car use during holidays were derived from a survey carried out by Transport Analysis, a Swedish government agency (TRAFA, 2016). According to this survey, leisure travel by car constituted 48% of all kilometers traveled by car. Defining the share of kilometers driven for holidaying purposes out of total leisure travel is somewhat tricky but we estimated that 62% could be attributable to holidays (ibid). Thus, holiday trips by car are responsible for 30% of all kilometers traveled by car. This estimate includes kilometers traveled for the explicit purpose of holidays but also for car trips for visiting family and friends during holidays. The definition of a holiday varies but an example is "a time when someone does not go to work or school but is free to do what they want, such as travel or relax" (Cambridge Dictionary, 2021). In Sweden, visiting friends and relatives during holidays and weekends is very common (Vagabond, 2017). Visiting family and friends may be categorized as not belonging to holidays although it is something done partly during holidays according to Transport Analysis (TRAFA, personal communication with Andreas Holmström, February 12, 2020). No trips by car for visiting restaurants and other establishments for leisure were attributed to holidays, thus possibly underestimating car use during holidays.

3.4 | Choice of products and services to be analyzed

Products and services for our analyses of GHG emissions were chosen using the following exclusion/inclusion criteria:

1. Expenditure by the households should not be zero or very low. With no or little expenditures there was no point in investing time in an analysis
2. Products and services should be commonly available on the Swedish market and widely used. This applied to both mainstream and alternative products and services (see more below).
3. When it was understood (through prior knowledge) that some products under the same heading in the data on household expenditure may have very different GHG emissions, several analyses were made and an average was used (see more below).

Examples of commonly available foods chosen for the analyses were boneless meat of various types, as such meat is much more common than meat with bones in supermarkets. The alternatives to meat commonly available, and thus chosen for analyses, were frozen and packaged yellow pea and soy protein rich pieces. Commonly available alternatives to mainstream dairy products were soy and oat drinks as well as cheese based on coconut oil, so these were analyzed. For some fruits and vegetables, several analyses were done to take into consideration various transportation distances and indoor versus outdoor cultivation as it was known that greenhouse gas emissions vary due to these factors. An average was then used. Examples of mainstream services chosen for the analyses related to holidays were a charter trip to Spain as it is the most popular destination for Swedish holiday travelers. The alternative was a train-based package tour to Italy, as this was available through a Swedish travel agency.

For furnishings, we used data from, for example, IKEA and other low-cost large companies to the extent possible. For details about all products and services analyzed, see the Supporting Information.

A previous survey as part of *Mistra Sustainable Consumption—from niche to mainstream* was also used as a guide to what alternative products and services were available (Kamb et al., 2019; Thorsson et al., 2019; Lehner et al., 2019).

3.5 | Collection of data for the analyses

Performing an analysis in the EAP requires various data such as consumer price, country of origin, quantity and type of materials/ingredients used, packaging weight, and material and waste handling. We did analyses for 217 consumption items, including 17 of alternative products and services. A description of the assumptions made for the calculations of each item are presented in Carlsson Kanyama et al. (2019), including four appendixes.

- *Consumer prices* were collected from relevant retailers and the prices were converted to 2016 values using a relevant consumer price index. Whenever official statistics about consumer prices for the selected items were found, we used those. We collected prices for foods from the two main food retailers in Sweden and for traveling from the main package-holiday companies. For some goods such as furniture we used prices from large companies like IKEA. The aim was to find prices that represented items commonly purchased in Sweden.
- *Transportation weight* was calculated as the weight of the product plus the consumer packaging. Many consumer products were weighed on a scale if the product packaging did not show the weight or the producer could not provide information. For the weight of the packaging materials, see below.
- One of the most labor-intensive steps in the analyses was finding the types and weights of *basic goods* for the selected items. For some kinds of food (such as tomatoes and beef) this was easy, but most consumer products are made up of many materials or basic goods. To identify these, we used several methods: acquiring information from the producers; buying, disassembling, and weighing products by ourselves; or using data from various published studies, including various lifecycle assessments.
- *Packaging* (consumer packages) also required some substantial investigation and the same methods as for basic goods were used for collecting data.
- *Transport* was calculated using default assumptions about distances and transportation modes. Transport by air was not included as our understanding was that this was very rare for the analyzed goods.
- *Consumption emissions were not included*. This is because such emissions would be covered anyway when matching the EAP results (per SEK) with households' expenditures on electricity and fuel.
- *Waste handling* included the packaging and the products themselves, apart from items that are eaten, smoked, or drunk. Assumptions about waste handling options (such as recycle or burn) were based on what the researcher conducting the analysis considered to be a plausible option for their own consumption.

3.6 | Matching intensities with expenditure

Once the 217 intensities (kg GHG emissions/SEK) were calculated (see also Figure 1 and Supporting Information), they were matched with suitable expenditures to portray the total GHG emissions of the three selected household types. This calculation was done in two steps: the first was to match current expenditure with relevant emission intensities and the second was to match the same amount of expenditure to alternative products and services in the areas of food, holidays, and furnishings (see more below). In this latter endeavor, expenditure for all main categories of consumption were kept constant (see more below). Our approach for this scenario was estimating the mitigation potential from switching to already available low-carbon consumption options. This approach is something that Ivanova et al. (2020a) found to be relevant for a large majority of households. In contrast to Bjelle et al. (2017) we adopted an approach that did not cause any rebound effects. This is because prices for low-carbon options in the areas investigated here (food, holidays, and furniture) often were similar or higher than for conventional products.

4 | RESULTS

4.1 | 217 emissions intensities

A figure in the Supporting Information (Greenhouse gas intensities) shows the calculated emissions intensities (kg GHG/SEK) for the 217 products and services sorted from lowest to highest, where each dot is the result of an analysis. The highest intensity (lamb and goat meat) is 1792 times

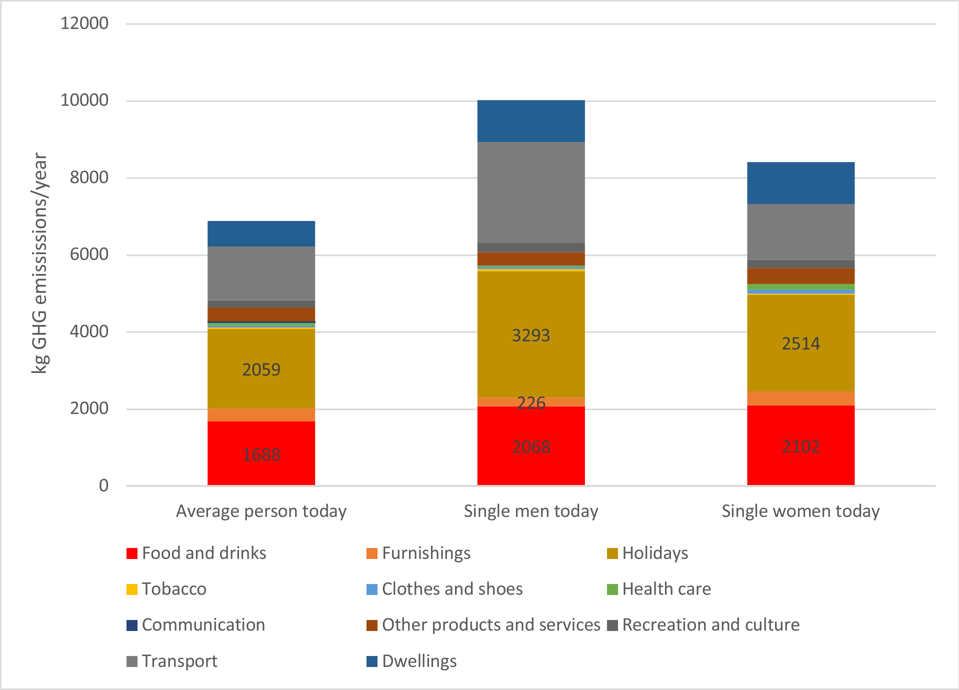


FIGURE 1 Total consumption-related GHG emissions/per year today (2016) from three types of household in Sweden (the average person, the average single man, and the average single women). Underlying data used to create this figure can be found in the Supporting Information (All em.&exp.)

more polluting than the lowest one (second-hand cars). This difference is of course much less interesting than the differences between products and services that can replace one another as presented below.

4.2 | Total consumption-related GHG emissions today

Figure 1 shows the consumption-related GHG emissions from the three types of household selected: the average person, the average single man, and the average single women. Total emissions range from just below 7000 kg per year (average person) to just above 10,000 kg per year (average single man). The average person has lower emissions than both the average single man and average single woman primarily because the average household also includes children and because expenditure for housing and transport is shared in households with several members. Food and drink account for between 21–25% of the total emissions while furnishings contributed 2–5% and holidays between 30–33% of the total.

The difference in men's and women's emissions is not due to differences in expenditure but rather to differences in expenditure patterns. Men spend only slightly more money than women, 2%, but emit 16% more greenhouse gases. This is due to number of factors such as more expenditure among women on low-emitting products and services such as health care, furnishings, and clothes while men spend a lot more money (70% more) on greenhouse gas intensive items such as fuel. These findings are in line with previous research on gender differences in energy use (Räty & Carlsson Kanyama, 2010) and seem to be relevant for number of countries. Thus, both transport and holidays have higher emissions among single men than among single women and this is due to car use. Emissions from package tours do not differ between the genders. Total spending on food and beverage is more or less the same between single men and single women as women spend only 9% less on these items than men.

4.3 | Food and drink

Figure 2 shows the various emissions intensities for meat and dairy alternatives and locally produced vegetables as well as different types of meat, dairy products, and vegetables. Meat and dairy products have much higher emissions than all their replacements. Pork is five times more polluting than tofu and lamb is 25 times more polluting than tofu. Milk is five times as polluting as oat drink and cheese is four times as polluting as vegan cheese. Lettuce grown conventionally is 12 times as polluting as lettuce grown locally.

The prices of the meat and dairy replacements may be both higher and lower compared to the products that they replace. Oat drink may be up to 50% more expensive than milk, and meat replacements may be both more and less expensive than meat. Vegan cheese is generally more

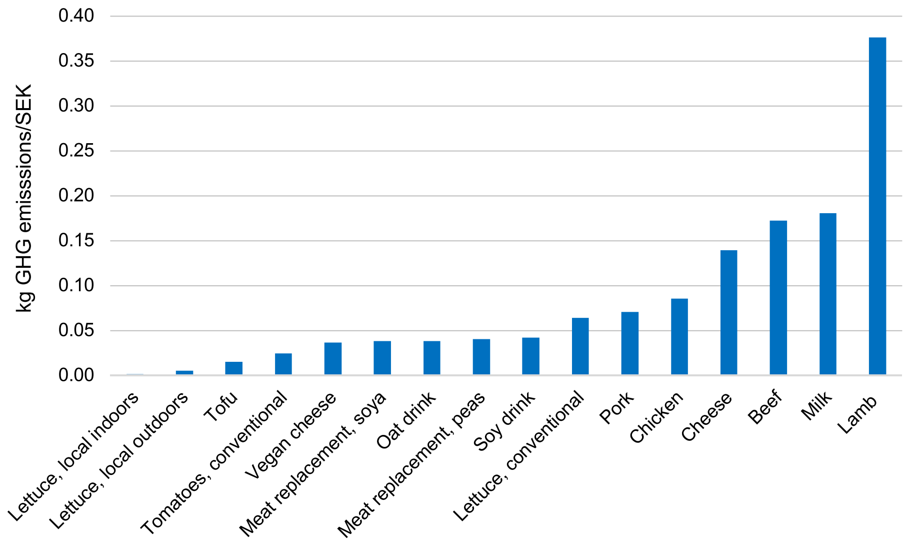


FIGURE 2 GHG emissions/SEK for meat, dairy products, and conventional vegetables and various replacements. Underlying data used to create this figure can be found in the Supporting Information (Food)

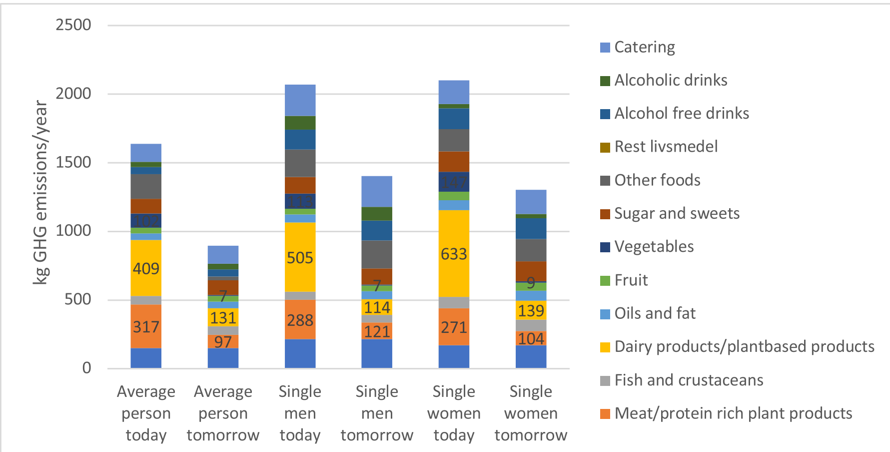
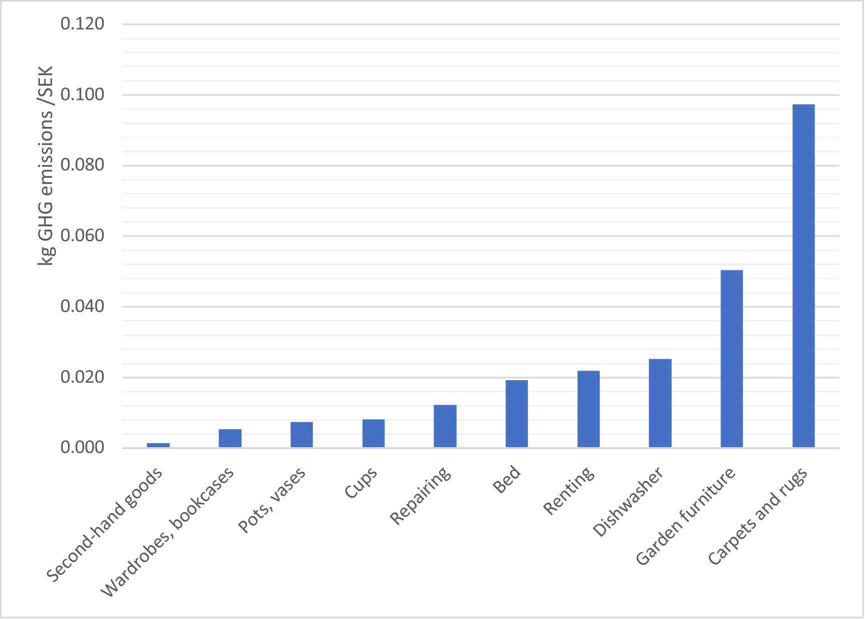


FIGURE 3 Consumption-related GHG emissions/per year today (2016) for food and drink after changed purchases for three types of household in Sweden (the average person, average single men, and average single women). Underlying data used to create this figure can be found in the Supporting Information (Food)

expensive than ordinary cheese, but the prices of cheese vary a lot depending on their quality. As a result, shifting the same amount of expenditure from meat and dairy products to their replacements will most certainly lower the intake of dairy-like products but not of meat-like products. This shift is not likely to have negative health consequences (see further under Section 5). The prices of locally produced vegetables vary a lot: some may come from community or privately owned gardens and can be acquired at a low cost; others may be bought at Farmers' Markets at higher prices than vegetables available at supermarkets. The local lettuce grown indoors in our calculation were sold at the same prices as the ones in supermarkets, but that production unit had not been established for commercial purposes. Thus, shifting expenditure from conventional to locally produced vegetables may result in lower vegetable consumption (see further under Section 5).

Figure 3 shows the GHG emissions from food and drink before and after expenditures for meat, dairy, and vegetables have been changed so that the same amount of expenditure on meat, for example, is now used for meat replacement, and so forth. All expenditures for meat, dairy, and vegetables for all households were switched to lower emitting alternatives and all other expenditure and emissions intensities remain the same. Emissions from food and drink is reduced by 32–38%, with single women lowering their food-related emissions the most, mainly because of lower emissions from dairy products. Emissions from vegetables remain low even before the change to local vegetables. Thus, it is the change to buying plant-based options instead of meat and dairy products that contributes most of the emissions reductions. The changes in expenditures affect men and women a bit differently as men spent more money on meat and meat products before the change (9%) and women spent more money on dairy products (23%). The changes contributed with 32–45% less greenhouse gas emissions from the food purchased.

FIGURE 4 GHG emissions/SEK for some examples of new furnishings and alternatives. Underlying data used to create this figure can be found in the Supporting Information (Furnishings)



4.4 | Furnishings

Figure 4 shows the various emissions intensities for some new furnishing products as well as emissions from alternatives such as repair, renting, and second-hand purchases. Second-hand products have clearly the lowest emissions of all alternatives in Figure 4. New furnishings products, however, have varied emissions and not all new products are more polluting than the alternatives. Cups, for example, are only six times more polluting than second-hand products while repairing is nine times more polluting and renting is 16 times more polluting than second-hand products. The reason why repairing gets such high emissions can probably be at least partly explained by this sector (the analyses were based on I/O data), also including activities such as car repair that may include using lubricants made from fossil fuels. That second-hand products get the lowest emissions is not surprising: these products are commonly of local origin and generally no retrofitting is done before sale.

The prices of alternatives such as second-hand goods, repairing and renting versus new furnishings products varies. Second-hand goods are cheaper than new ones, and a survey conducted in 2019 among a large number of second-hand stores showed that prices for clothes are about 90% lower than for the same new items. A search for a second-hand IKEA bed (Malm) showed a price of SEK 2500 while a new one was SEK 6000. Prices for repairing furniture may be higher than buying a new product, shown by a request for a quote for re-covering an armchair in one of the authors' homes. The lowest price offered was 56% higher than for buying a new armchair. Costs for renting were investigated by searching for companies that rent furniture in Sweden. Only high-quality furniture was available for renting and one example is an armchair for SEK 1000 per month, a price that most ordinary consumers would not be willing to pay given that all expenditure for furniture was between SEK 6500 and SEK 9700 per average person and year.

Due to the differences in price, shifting expenditures from new to second-hand furnishings will result in more products while using the same amount for repairing will result in fewer. Some furnishing products may be more suitable for repair than others: carpets, bookcases, beds may be more easily repaired than, for example, cups but that of course depends on the quality of the products and the services available. In our scenario of a future purchasing pattern we assumed that all furnishing products that the households buy new today can either be repaired or bought second-hand, an observation in line with our understanding of the Swedish market. In order for the households to acquire about the same number of products in the scenario as at present day we assumed that whatever money is used for furnishings today is spent on buying second-hand products (20% of the expenditures) and on repairing (80% of the expenditures). The total GHG emissions from furniture drop by 51–72% (see Figure 5). We then assumed that buying second-hand resulted in three times as many products as buying new ones and that repairing was twice as expensive as buying new stuff. All expenditures for furnishings for all households were switched in the same way. In this calculation, expenditure for maintenance is the same as before for all households, as it is difficult or impossible to buy second-hand dishrags, and so forth. The change is more pronounced for women than for men as women spend 50% more money on furnishings than men do.

4.5 | Holidays

Figure 6 shows the various emissions from different types of holidays today and some less carbon-intensive alternatives. As can be seen, the lowest emissions come from staycations and a package tour by train in Sweden. The staycation category includes activities such as concerts and massage,

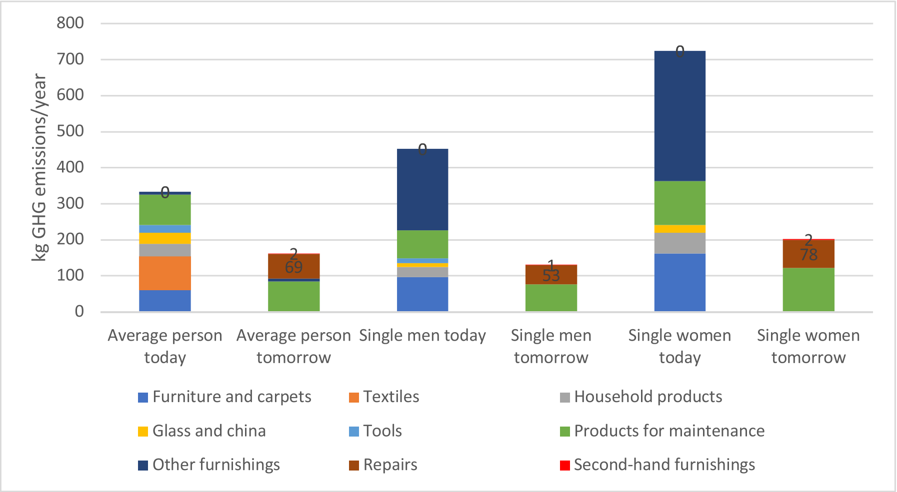


FIGURE 5 Consumption-related GHG emissions/per year today (2016) for furnishings and after changed purchases for three types of household in Sweden (the average person, average single men, and average single women). Underlying data used to create this figure can be found in the Supporting Information (Furnishings)

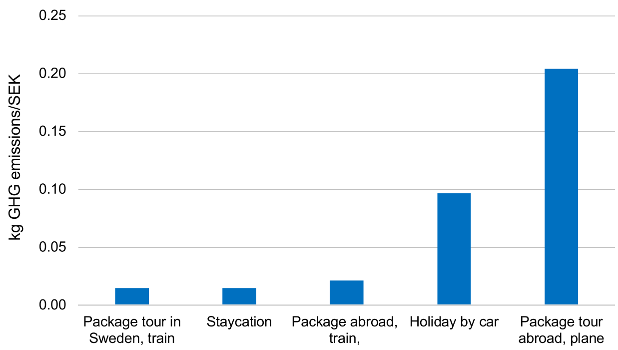


FIGURE 6 GHG emissions/SEK for various holiday options. Underlying data used to create this figure can be found in the Supporting Information (Holiday)

and the package tour by train in Sweden includes train and hotel accommodation. In Sweden, trains run on electricity and the state-owned rail company (SJ) buys only electricity generated from renewable sources for their trains (SJ, 2017, p. 11). The package tour abroad by train is assumed to go to Italy and include six nights. Such trips are available to Swedish consumers (Travel & climate, 2019). The package tour abroad by plane is assumed to last a week and go to the Canary Islands as Spain is the most popular destination for Swedish holiday travelers (Vagabond, 2017). The emissions for holidaying by car were calculated based on the average household's emissions from holidays by car divided by their matching expenditures. Traveling abroad by plane is almost 10 times more polluting than to travel abroad by train and taking a car-based holiday is six times more polluting than having a staycation or buying a package tour by train in Sweden.

The prices of alternative ways to spend a holiday vary. Concert tickets may vary greatly in price (from a few hundred to several thousand SEK) as do other staycation activities. A package tour in Sweden by train can be very cheap if the ticket is bought early and an example of this is that a train ticket between Stockholm and Gothenburg (a large city in western Sweden) can cost anything from SEK 185 to SEK1500 one way.[1] A train package tour to Italy cost SEK 11,000 at the travel agency offering it. This may be contrasted with the price of a package tour by plane to the Canary Islands that can range between SEK 6000 and SEK 17,0000.[2]

Shifting expenditure from high-emitting options such as holidays by plane and car to train travel and staycations may or may not mean that travel is reduced. When we assume that all the money spent on a package tour by plane and car trips is instead spent on a train trip to Italy (SEK 11,000) and the rest on a staycation, the drop in emissions from holidays is substantial: 85–90% in the three analyzed households (see Figure 7). All expenditures for holidays for all households were switched in the same way. We assumed that expenditure on hotels and holiday cottages remains the same for all households. The proposed changes affect women and men differently: after paying for the train trip to Italy men remain with 4.6 times as much money for staycation than women do. This is because men spend more money on holiday (35% more) than women do, mainly due to more car use.

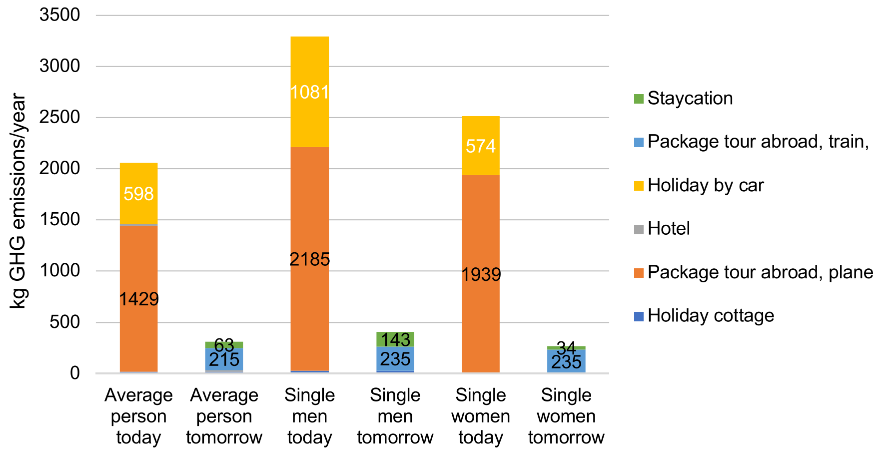


FIGURE 7 Greenhouse gas emissions per year for holidays after changed expenditure for three types of household in Sweden (the average person, average single men, and average single women). Underlying data used to create this figure can be found in the Supporting Information (Holiday)

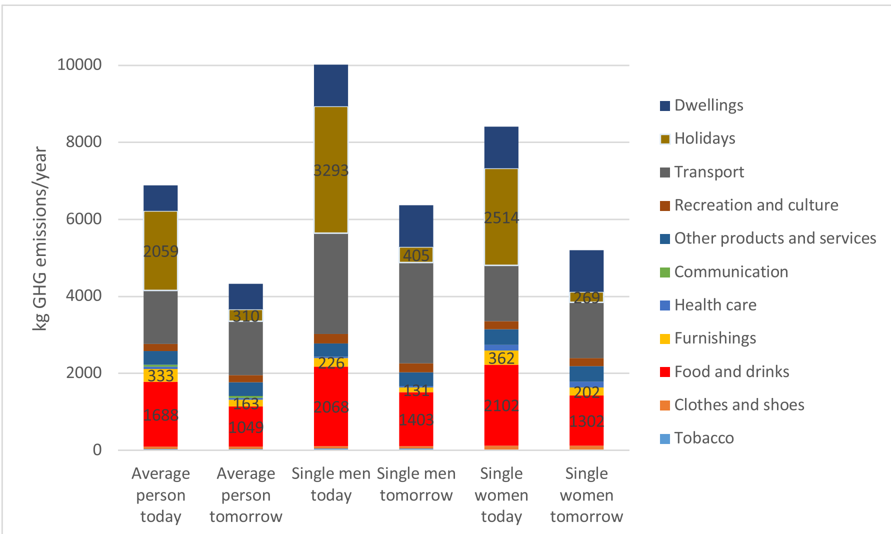


FIGURE 8 Total consumption-related GHG emissions/per year today (2016) and after changed expenditure for three types of household in Sweden (the average person, the average single man, and the average single women). Underlying data used to create this figure can be found in the Supporting Information (All em.&exp.)

4.6 | Total consumption-related greenhouse gas emissions

The total consumption-related GHG emissions for the average person, the average single man, and the average single woman when purchases changed in the areas of food, furnishings, and holidays are shown in Figure 8 together with today's emissions (see also Figure 1). The total reduction in emissions is similar for all household types, from 36–38%. Total GHG emissions still vary, ranging from 4300 kg/year (average person), to 6400 kg/year (average single man), and 5200 kg/year for single women. Even with reduced emissions, single men emit 18% more greenhouse gases than single women do. With reduced emissions, food and drink accounts for between 13% and 25% of the total while furnishings contribute 1–4% and holidays between 4% and 7% of the total.

5 | DISCUSSION

In this paper, we have shown that consumption-based GHG emissions can be lowered by almost 40% given changed purchases for food, holidays, and furnishings with examples from three household types. Overall expenditure levels remained the same. Emissions intensities were estimated for 217 categories of products and services available on the market, both mainstream options and options considered to be new low-carbon alternatives. Prices and expenditure for these items were considered when modelling the possible changes so that the amounts of alternative products purchased remained realistic compared with the amounts purchased before the change. It is also worth noting that the reduction potentials shown in this study do not require costly investments as is the case for buying an electric car or installing solar panels, which are other options for climate-aware households. Therefore, our examples are easy to comply with from an economic point of view. Below we discuss how our findings relate to goals for GHG emissions reductions and how they can be used, some possible impacts resulting from our proposed changes on aspects of sustainability other than climate change, and finally the limitations of our study and needs for further research.

As pointed out in Section 1, leading organizations such as the United Nations (2019) have stated that a strong reduction (45%) in global greenhouse gas emissions is needed over the next 10 years. In Sweden, the goal for 2030 is for emissions to be 63% lower than 1990 (*Klimatlag* (2017:720), Sweden's Climate Act.). For consumption-related GHG emissions, there is no reduction goal set in Sweden but the Swedish Environmental Protection Agency has stated that "Traveling less by air, changing our eating habits and buying second-hand instead of new, creates great climate gains, and it can reduce your carbon footprint by several tonnes per year" (Swedish EPA, 2020). The Swedish EPA relies on data about consumption emissions of greenhouse gases calculated by Statistics Sweden, which uses a multiregional input-output database for calculating the environmental impacts of consumption. For 2018, the average consumption-based emissions were estimated at 8.1 tonnes per capita (Statistics Sweden, 2020a). However, since both private consumption (5.0 tonnes) and public consumption (0.9 tonnes) as well as investments (2.2 tonnes) are included in this figure, it is not directly comparable to the almost 7 tonnes of consumption-related greenhouse gas emissions resulting from private consumption by the average person presented in this study. In our study, investments were included for manufacturing and wholesale and retail. However, if the investments emissions from Statistics Sweden (SCB, 2018) are proportionally distributed between private and public consumption, the resulting emissions for private consumption are 7.33 tonnes per person, which is close to our results. An advantage of the EAP-based results compared to those presented by Statistics Sweden is that the EAP results are much more detailed. An example is Food, which has 11 analyses in the calculations presented by Statistics Sweden (Statistics Sweden, 2020a) while we had 60 analyses for food. In total, the calculations made by Statistics Sweden are based on less than half as many products and services as the ones presented here (ibid). Also, the EAP can be used to analyze an unlimited number of new products and services as they appear on the market, something that is not possible with the input/output data. Previous research has shown that a bottom-up approach, such as ours, gives similar results as a top-down approach, based on environmentally extended input-output tables when it comes to consumption-based greenhouse gas emissions (Castelani et al., 2019) and our results confirm this.

The Sustainable Development Goals (UN, 2020) cover a large range of aspects including good health, climate action, and the protection of biodiversity. There is a lot of evidence that plant-based diets with no or only small amounts of animal products are healthier than diets with large or moderate amounts of animal products (e.g., Westhoek et al., 2014, Springmann et al., 2018; EAT Lancet Commission, 2019). Meat production also contributes to the emergence and amplification of infectious diseases such as COVID-19 (Espinosa et al., 2020). Thus, changing purchases away from animal products as proposed in our study have a potentially positive effect on health. Regarding the protection of biodiversity, a shift away from meat would reduce the need for growing protein-rich fodder crops such as soybeans, which is a driver for deforestation in the Amazonas (Barona et al., 2010). At a national level, however, there may be some disadvantages if the breeding of ruminants such as cows and sheep ceases. In Sweden, there are currently about 440,000 ha of semi-natural grazing land that should be grazed by ruminants for reasons of biodiversity conservation. In a scenario using pure suckler herds for grazing, the amount of beef produced was estimated at 40 g per week and person in Sweden. This assumed that the cows had a calf every year that was slaughtered and that no milk was produced (Röös et al., 2016). It should also be noted that cattle may be kept for the sole purpose of grazing in a system where each cow only gives birth to the number of calves necessary for maintaining the size of the herd and where the livestock is allowed to pass away in a natural manner.

There are several limitations in this study and thus scope for future research. One obvious limitation is the outdated expenditure data that we used. As explained in Section 3, this is because no more recent data were available from Statistics Sweden. No further update is planned (Statistics Sweden, 2020b). The only solution for more recent data presently seems to be collecting data as part of a research project, an endeavor that would require substantial resources for the results to be generalizable. If such data, which are usually organized in COICOP categories, were to be collected, a limitation would be that those categories currently do not differentiate between all plant-based products offered as an alternative to dairy products, and actual animal-based dairy products (milk is the only one where there is a non-animal drink category). Also, it is not possible to differentiate between protein-rich meat substitutes in the COICOP categories, nor locally produced versus regular commercially produced vegetables. Furthermore, there is no category for second-hand goods, or package tours that differentiate between transportation modes (United Nations, 2018). This means that even with a more up-to-date expenditure survey, it would be impossible to spot the adoption of alternative expenditure patterns as proposed in this study. Another limitation is the choice of car travel's share being attributed to holidays. Here, we assumed that 50% of the total kilometers traveled by car for visiting friends and relatives were undertaken during holidays. This is a very arbitrary assumption and should be substantiated in further research. The EAP could also be further developed to include emissions intensities for manufacturing from number of different countries. The differences in prices of items purchased could also be further explored in the EAP analyses. In this study we tried to find prices of commonly purchased items, not too expensive and not too cheap. However, previous checks of EAP results showed that price differences have only a minor effect on the emission intensities (Wilting, 1996), but this result needs to be reaffirmed.

As in the few previous studies of the environmental impacts of gender-related consumption (Carlsson Kanyama et al., 1999; Räty & Carlsson Kanyama, 2010), our results show significant differences in environmental impacts between single men and women both before and after changing expenditures. However, unlike the study by Meier et al. (2012), greenhouse gas emissions from foods did not differ much between the two genders. Further research could explore tailor-based policy instruments according to gender in the quest for climate change mitigation. The results from our research show that the choice of holiday and transport are areas for which this may be most relevant.

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NOTES

[1] Prices checked at SJ 27 August 2020.

[2] Prices checked on 28 August 2020 at allacharterresor.se. The search done for November 2020.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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