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Effects of Voluntary and Involuntary Real Lab Situations on Personal Carbon Footprints of Private Households. Experiences From Germany

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This paper compares the carbon footprint effects of a voluntary real lab with those of the involuntary "real lab" provided by the lockdowns during the recent Corona crisis. In a voluntary real lab situation, 100 private households in Berlin (Germany) have tried to reduce their personal carbon footprints over 1 year (2018). The households have been equipped with a weekly carbon tracker, calculating their CO_{2e}[1] footprint in the domains housing energy, mobility on ground, air travel, food, other consumption, and public consumption. The households have been informed by various channels and supported by a network of "green" local enterprises and NGOs. It was also possible for them to make use of in-home energy advisors, identifying easy-to-accomplish saving potential. On average, the households managed to reduce their footprint by 11%, with individual savings of up to 40%. One of the major problems the households have been experiencing was refraining from air travel, e.g., by substituting it by train l. Others identified road safety as a major problem when switching from cars to bikes. With an annual reduction of 10%, carbon neutrality could be reached in or even before 2050. But political decisions are needed in order to change the collective boundary conditions. In 2020, Germany–as many other countries–has experienced a COVID-19 lockdown with substantial restrictions to all kinds of consumption activities (flying, international travel, consumption activities in the public etc.). This work compares the CO_2 reduction effects of these two "real labs," a voluntary and an imposed one, and ask what the relative quantitative effects are. Following that comparison, it reflect upon the similarities and differences of voluntary and imposed situations, and what there can be learned for the implementation of policies for more sustainable production and consumption patterns.

Keywords: carbon footprint, real lab, behavioral changes, corona crisis, voluntary reductions, involuntary reductions

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[1] In this paper CO_2 is meant as a synonym to CO_2 equivalent (CO_{2e}), comprising CO_2 and other important greenhouse gases such as methane (CH_4) or nitrous oxide (N_2O).

INTRODUCTION

Due to its huge environmental impact on the planetary ecosystems and flows, humankind has entered the era of the Anthropocene (Steffen et al., 2011). Significant evidence supports the suggestion that the ever growing ecological footprints about to transgress several planetary boundaries and thus is on its way to leave the safe operation space of planet Earth (Rockström et al., 2009). Next to the loss of biodiversity a very prominent and pressing example is anthropogenic climate change (IPCC, 2014, 2018). In 2015, the international community has adopted the Paris Agreement on limiting global warming at 1.5–2°C by 2100 above pre-industrial levels. But current climate policies are more in the range of 2.7–3.1°C global mean temperature increase (Schleussner et al., 2016; CAT, 2020). Would current climate policy pledges be realized, global warming could be limited to a range of 2.4–2.7°C, still falling short of the Paris goal[2]. Already under the current global warming level (about 1°C above pre-industrial), there can be observed an increase in weather related disasters, changing weather patterns, and human suffering, especially, but not exclusively, in the global South. Limiting global warming to the Paris goal level is therefore both an ethical obligation with respect to future generations and an imperative of prudence toward the present ones (World Bank World Bank Group, 2014; IPCC, 2018; Hoegh-Guldberg et al., 2019).

Aligning policies to the Paris Agreement goal would translate into a reduction of emissions from 36.4 gigatons of carbon dioxide in 2020 to 5 gigatons in 2050, and eventually reach a level of "net zero" by 2100 (IPCC, 2018). What is needed is a decadal halving of emissions until the middle of the century, and then the crossing of the line toward negative emissions measures until the end of the century (Fuss et al., 2014). A deep de-carbonization of the economy is a prerequisite (Geels et al., 2017), leading to a post-carbon society in the longer run. In a recent study (Akenji et al., 2019), per-capita consumption-based targets of GHG emissions scenarios compatible with the international climate policy goal (+1.5°C) have been calculated. According to the results, reductions to 2.5 t CO_2 in 2030 and to 0.7 t in 2050 have to be achieved - steep reductions if compared to current per capita levels of about 11 tons in countries like Germany or Finland.

Individuals can save immense amounts of carbon by mobilizing so-called "behavioral mitigation wedges," for example as much as 15 gigatons by 2060 simply by changing their diet to avoid meat, or by forgoing air travel (Cafaro, 2011). Changing diets alone would not only reduce carbon footprints, but also contribute to improved public health and a better protection of biodiversity (Springmann et al., 2018; Willett et al., 2019). Most studies point to plant-based diets, conserving energy, curtailing travel and living car-free as the most promising actions to reduce impact while enhancing human well-being (Gardner and Stern, 2008; Dietz et al., 2009; Girod et al., 2014; Westhoek et al., 2014; Sorrell, 2015; Ivanova et al., 2016; Schanes et al., 2016; Ahmad et al., 2017; Wynes and Nicholas, 2017; Duarte et al., 2018; Vita et al., 2019a). In a stakeholder-driven, scenario-based assessment of different lifestyle change choices (sufficiency and green consumption), a recent study finds that household choices supporting a local and sharing service economy have a maximum reduction potential of 18% of the European carbon footprint. Sharing and extending lifetimes of clothes and devices could diminish the carbon footprint by ∼3%. Reducing motorized transport by remote work and active travel could mitigate between 9 and 26%. Vegan diets could spare 4% of the land and reduce up to 14% of carbon footprint. Passive housing and decentralized renewable energy reduces carbon emissions up to 5 and 14%, respectively (Vita et al., 2019b).

The international climate policy debate has been fixated on technology and economic incentives and has often treated lifestyle and behavioral changes as secondary issues, if they have been considered at all. Production-based measures and negative emission technologies dominate the majority of existing emission scenarios for the 1.5°C target (Rogelj et al., 2015; Rockström et al., 2017), while the number of scenarios that incorporate demand-side reduction measures remain rather limited (Van Vuuren et al., 2018) – partly due to the resistance of most mainstream economists against non-growth oriented policies and the questioning of consumer demands treated as givens (Anderson and Bows, 2012). But it must become much more focused on changing consumption, or demand side options, in addition to emphasizing policy on the supply side (Creutzig et al., 2016; Alfredsson et al., 2018; Costa et al., 2021). Therefore, it must be considered to address lifestyles as targets of policies (and related research and modeling efforts), rather than a voluntary add-on by individuals (Capstick et al., 2014; Girod et al., 2014; Niamir et al., 2018).

The Corona crisis of 2020[3] came as a big surprise for societies across the globe, although there have been experienced other virus outbreaks earlier, and although scientists had been warning that pandemics can break out and spread more often in a globalized world. In order to contain the spreading of the virus, governments around the world have issued policies of confinement that, in the end, did reduce private and economic activity levels and related emissions significantly. Corona, it can be state, not only has been a stress test for the world's health systems and societies at large, it can also be regarded as a huge laboratory for behavioral change—and some unintended environmental benefits coming along with it.

In this paper, the authors want to compare the environmental effects of this huge involuntary and non-targeted behavior change "experiment" with results from small-scale voluntary and targeted experiments to reduce greenhouse gas emissions by

[2]Would the world revert current climate policies and move back to a "business-as-usual" world, global warming could reach 4.1–4.8°C levels, an unprecedented temperature increase since millions of years. The Paris Agreement has made this high-end climate change scenario much less likely (Hausfather and Peters, 2020a,b). But political regression is a possibility one cannot exclude, as former US president's intention to leave the Paris Agreement has shown. The pro-rainforest clearing policy of Brazil's president Bolsonaro is another example (Escobar, 2019; Fuchs et al., 2019).

[3]In this paper, the terms "Corona crisis" and "COVID-19" are used in the same meaning. COVID-19 is scientifically referred to as the severe acute respiratory syndrome–coronavirus 2 or SARS-CoV-2.

assisted individual action. It will look at the order of magnitude of CO_2 savings, ask for the motivational basis for behavioral change, and assess the persistence of the respective changes. For doing so this paper need to open up the "black box" of measured Corona-induced behavioral changes in order to get hold of individual and social processes underlying them. And, most importantly, it will try to answer the underlying question whether government-induced (involuntary) changes might be more effective and sustainable than voluntary ones. Given the massive amount of CO_2 saved during COVID-19—this numbers will be discussed in section An Involuntary Carbon Footprint Reduction Experiment: CO_2 Effects of the Corona Crisis—the evidence seems to clearly speak in favor of a government-led "mega-nudge" toward the Paris Agreement climate policy goals. In the final section the negative answer to this question will be justify, stating that there is no way around voluntary action by consumers as well as citizens in a (still) mostly democratic world. To provide this context this paper will start by a look at some results of a real lab experiment in the city of Berlin, performed 2 years ahead of Corona.

AN EXAMPLE OF VOLUNTARY CARBON FOOTPRINT REDUCTION: THE KLIB REAL LAB PROJECT

There have been numerous scientific attempts to reduce individual carbon footprints by some kind of interventions, tackling different barriers that prevent people from doing so. One of these barriers is knowledge and information. The "carbon literacy" of most people is limited: they misjudge the actual GHG potential of products and services—more or less independent of their environmental attitudes—, and they misjudge the global warming mitigation potential of their own actions (Truelove and Parks, 2012; van der Linden et al., 2015; Kause et al., 2019). In contexts for example, where relevant information is either not easy at hand (e.g., CO_2 content of products, services and activities; energy use of specific appliances and activities; less impact-intensive alternatives) or usually not available at all (e.g., energy/CO_2 use of others; normative viewpoints of others), providing consumers with *feedbacks* is a promising way to overcome information-deficit hurdles to behavior changes. Various studies have reported that energy savings due to feedback range from 3 to 20% (Abrahamse et al., 2005; Darby, 2006; Fischer, 2008; Ehrhardt-Martinez et al., 2010; Delmas et al., 2013; Harries et al., 2013). The reported variations may be attributable to differences in study design, as feedback has taken a variety of forms (e.g., marketing campaigns or electronic communications) using diverse study groups (ranging from self-selected volunteers to random population samples) (see for an overview (Steg, 2008; Steg et al., 2015; Stern et al., 2016). Near-real time feedbacks, social comparisons, and normative peer-group referencing can substantially increase simple energy use or CO_2 feedbacks (Schultz et al., 2007; Nolan et al., 2008; Allcott and Rogers, 2014; Buchanan et al., 2015; De Dominicis et al., 2019). An experiment with students at several schools in Taiwan has demonstrated that the repeated use of a personal carbon calculator has significant and positive short-term and relatively long-term effects on the reduction of the self-reported carbon footprint; the system significantly improved carbon footprint awareness, perceived behavioral control, and it also promoted behavioral subjective norms (Lin, 2016). If participants are not perceived as isolated individuals, but as socially embedded actors (e.g., group members), new elements of interventions come into play, e.g., group discussions that provide exchange and a space for justification and modification of beliefs (Werner and Stanley, 2011), or commitment making (Lokhorst et al., 2013). Near real-time feedbacks induced substantial energy conservation among participants who did not opt in, and in a context (hotel guests) where participants were not financially responsible for energy costs (Tiefenbeck et al., 2019).

The goal of the KliB ("Climate Neutral living in Berlin") project was to identify how much and how German households could reduce their carbon footprints by voluntary actions on the base of available technologies, and without any monetary or other material incentives. The approach was to combine a multitude of feedbacks in order to improve and stabilize the behavioral change intentions of the participants[4]. The project was designed as a real world lab[5]. The main goal of KliB was to find out whether private households could be supported in their intention to reduce their personal carbon footprint during the 1 year lab period by a multitude of interventions. Which interventions work, which ones do not? What factors influence the adoption of reduction strategies, what are the barriers to this adoption? At the same time, this gave the opportunity to learn more about the interplay between the respective roles of the consumer and the citizen, i.e., between what the individual household could do in terms of footprint reduction on the one hand, and what climate policy preferences individual household members would hold on the other.

After public advertising for the project, 208 Berlin households showed interest, but this number dropped once more detailed information about the experimental setting (1-year lab, weekly tracking) had been provided. So 170 households remained to fill out the baseline survey in late 2017 and were willing to participate on a voluntary basis.

The household size distribution differed slightly from the Berlin average distribution, with less one person households (32% in the project vs. 54.6% in the city) and more 4+ person households (21% in the project vs. 8.1% in the city). More families with children and more people living in shared flats have been participating in the project. With respect to income, KliB households did have a higher than average share of middle-income classes, as both the lower and the upper end of the Berlin household net income distribution is underrepresented. However, it is important to note that 19.4% low-income households had chosen to participate.

[4]The project was funded by the German Federal Ministry for the Environment (BMU) as a nationwide flagship project on innovative solutions for climate protection, running from 2017 to 2018, with a 1-year real-lab phase with private households participating as its core. Grant number: FKZ 03KF0062.

[5]The term "real world" refers to the fact that neither technological equipment nor (material or financial) incentives have been provided to participants. They had to operate under existing market and policy conditions.

The major intervention tool was the so-called Carbon Tracker, an online interface translating weekly consumption and behavior data into CO_2[6]. Baseline was the total annual 2017 emissions, serving as a comparison for the annual emissions of 2018, measured weekly. The following sectors have been covered: home energy (electricity, heating), mobility (differentiated according to ground mobility and aviation), food, other consumption, and public energy use (the latter was not altered during the project as it cannot be directly influenced by individuals).

To help these households to reduce their footprint, different interventions accompanied the real lab:

1. *The Baseline*: As a pre-condition for active participation, households did have to complete a first annual version of the carbon tracker in order to get their baseline values for the year 2017, the preceding year of the experiment. This feedback can be considered the first intervention tool, as it provided households with a first feedback on their behavior.
2. *Weekly tracking*: As mentioned, the main technical feedback tool however was the online Carbon Tracker, which had to be used on a weekly basis, with weekly reminders sent by e-mail. Households entered their consumption and other activities (such as car driving or eating less meat) and received their personal footprint together with a comparison with all other participants and with the German average footprint (11.6 tons per capita and year in 2018).
3. *Webpage*: The KliB team provided many practical low-carbon tips on the website in all domains under research, ranging from small (e.g., substitute exotic functional food items by more regional alternatives) to big points (e.g., alternatives to air travel trips and change to green energy providers). The sequence of these tips did follow a seasonal pattern, increasing the everyday life fit of this intervention tool. The website did also contain the (anonymized) weekly results for every household together with the comparisons mentioned.
4. *Closed forum*: On the same website, people could communicate on issues related to the project in a project-wide public discussion forum, one of the major peer-to-peer learning spaces.
5. *Facebook group*: A closed Facebook group has been established serving the same purpose but with a special offer to the preferred social media channel of KliB households.
6. *Newsletter*: The biweekly newsletter of KliB was distributed to all households, not only providing the seasonal tips but also addressing climate policy issues of the day, for example, articles on driving bans for diesel cars, technological alternatives to kerosene, or political debate about the shutdown of lignite power plants in Germany. This intervention tool was a key element in addressing the citizen, not only the consumer. A short version was sent to all participants via e-mail as a teaser, with longer versions provided at the website—another way of motivating people to repeatedly visit the website.
7. *Stakeholder services*: In addition to the website tips, the project actively offered products and services of the KliB stakeholder network, consisting of 20 Berlin-based businesses or NGOs. For example, a Berlin based environmental NGO offers household visits of trained energy advisors for free on a regular basis, and KliB households were invited to make an appointment. Or people could substitute conventional ice cream by low-carbon ice cream provided by a local green Berlin provider ("Florida Eis").
8. *Live Meetings*: During a couple of live meetings with the whole group information could be disseminated and questions asked, but the most important goal of these meetings has been community-building among participants. This intervention tool was especially important with respect to the social character of the innovation. As one workshop participant did put it: "For me it is important to know whether I am the only "crazy person" trying to systematically reduce my carbon footprint, or if there are others in my city too." This type of live peer-to-peer learning would have been impossible had the project taken place 2 years later.
9. *Mass Media*: The KliB project did receive a vivid and very positive response in the media—rather surprising that the project had a relatively small number of households. Two factors turned out to be crucial here: (a) Mass media were particularly attracted by the high degree of personalization in the project. While climate change mitigation usually comes along as a highly political and at the same time abstract issue, in KliB, it did have "a face"—people like you and me; (b) as most households wanted to reduce their footprints on a very concrete basis, mass media could report on success stories, not on the highly problematic side of climate change (such as disastrous impacts or failing policies). As all media activities have been reported on the website and as some households did actively cooperate with the media, this element can be seen as a final intervention "tool."

After 1 year of continuous interventions, and a lot of communication with the households, 72 of them ended up with a continuous track record. Others dropped out earlier. The analysis is based upon these 72 households with continuous tracking (**Figure 1**).

The sectoral comparison between KliB households and the German average reveals that the Berlin participants display lower initial (2017) emissions than their German counterparts—with the one exception of air travel. This exception can be attributed to the under-representation of low income households together with a higher share of very mobile (professional) backgrounds of the participants (scientists, executive staff members, migrant background).

The stark contrast between average German ground mobility per capita emissions (1,600 kg) and KliB participants (762 kg in the baseline) can be attributed to two biases of this sample of volunteers: (a) a self-selection bias, which led already interested

[6]The carbon footprint approach chosen in KliB follows a lifecycle emissions assessment method which counts all emissions along the value chain/lifecycle of a product or service. It is irrelevant for this method where (e.g., in which country) the emissions accrue. Carbon footprints of countries, which will be looked at later in this paper (section An Involuntary Carbon Footprint Reduction Experiment: CO_2 Effects of the Corona Crisis), follow a different (the so-called territorial) approach, listing only emissions that accrue within the legal boundaries of a given country. At the global level, both approaches should converge in total quantities.

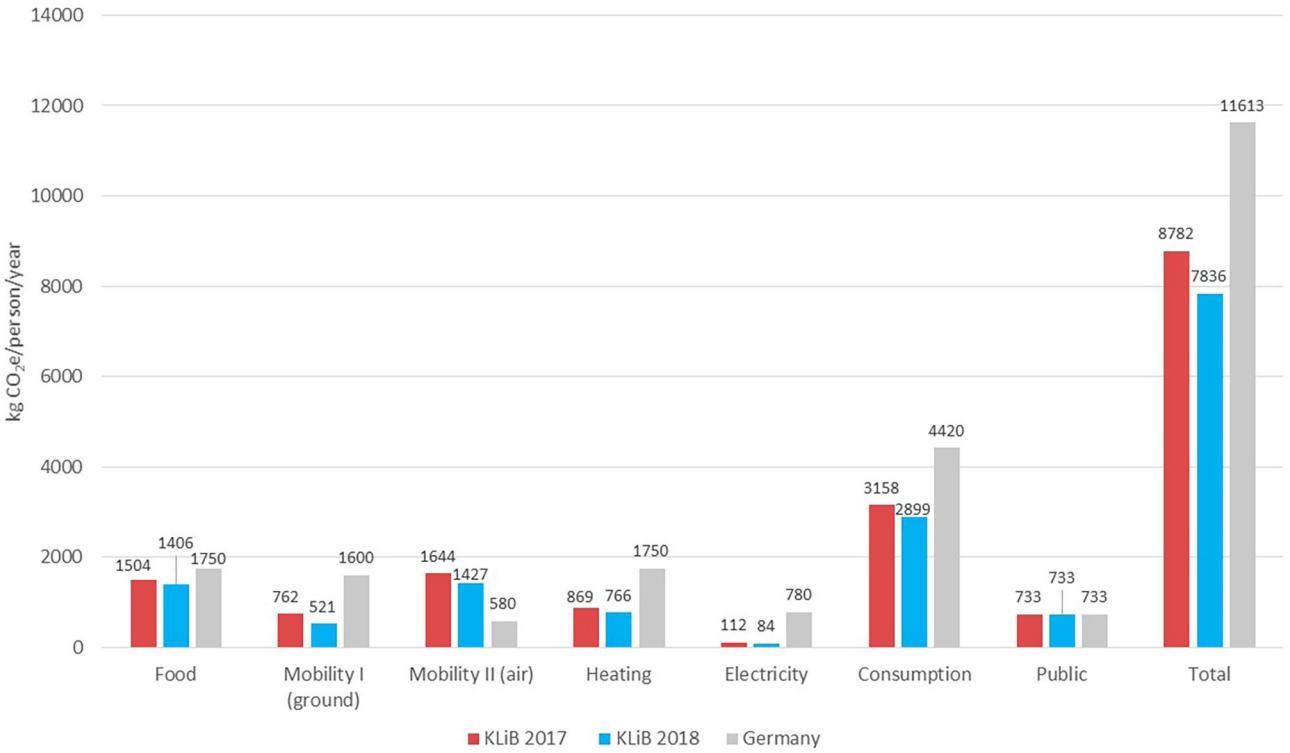

FIGURE 1 | Baseline (2017) (red) and real-lab sectoral performance (2018) results of KliB households (blue) in comparison with German average (gray) in total kg CO_2 per person and year. Source: Own data.

and engaged individuals to participate in a pro-climate project, and (b) an urban bias that allows city dwellers to access a much tighter and more dense network of public transport than in rural or semi-urban settings.

These two biases of the KliB sample can explain why participants did start the real lab with a baseline carbon footprint of about 25% below the German average. Still they managed to further reduce it by 10.8% during the 2018 real lab phase, leaving them with a result of 33% below German average. This value is well in the middle of the 3–20% range reported by meta-analyses of intervention studies (Abrahamse et al., 2005; Darby, 2006). Would it be able to reproduce this annual reduction rate every year, climate neutrality could be reached by 2050 (Akenji et al., 2019).

However, there are some considerable limits to a simple replication of the 1 year KliB result. One of the limits gets revealed by looking at the time development of emissions (**Figure 2**).

Ground, but especially air mobility have been heavily influenced by the public holidays in 2018. Given the high emission factor of air travel, travel behavior could compensate for successful reductions in other sectors, such as food.

This issue was addressed in the newsletter and on the website, e.g., by hinting at alternative modes of transport or holiday destinations. This led to vivid discussions about flying and possible behavioral and technological alternatives (e.g., fuels). But even highly committed persons cannot completely do away with flying—instead, they very often developed a kind of "flight guilt" feeling.

In order to find out more about the impact of the various interventions, two approaches have been followed. Next to comparing measurement data with intervention timing, the project used a subjective, but straightforward way to elucidate to the effects of these interventions: Participants were asked to assess them, distinguishing between effects on measurable behavior (carbon footprints), carbon consciousness, and social engagement (e.g., by trying to convince others to do something about climate change) (**Figure 3**).

It comes with little surprise that the intervention tools "baseline" and "tracking" did have a high impact on the carbon footprint—this was more or less the core design element of the project. Nevertheless, this outcome supports findings according to which a lack of reliable, tangible and timely information on the carbon footprint of products and services is a major hurdle when it comes to translating mitigation intentions into mitigation action (Truelove and Parks, 2012; van der Linden et al., 2015; Kause et al., 2019).

More surprisingly, it was found out that baseline and tracking did also—and even more intensely—affect the carbon consciousness of the participants, as both measuring tools have led households to repeatedly engage with the issue, think about it, and link it to everyday practices. Carbon footprint information can be a powerful tool to raise awareness. Interestingly, tracking has also been perceived as stimulating social engagement. It

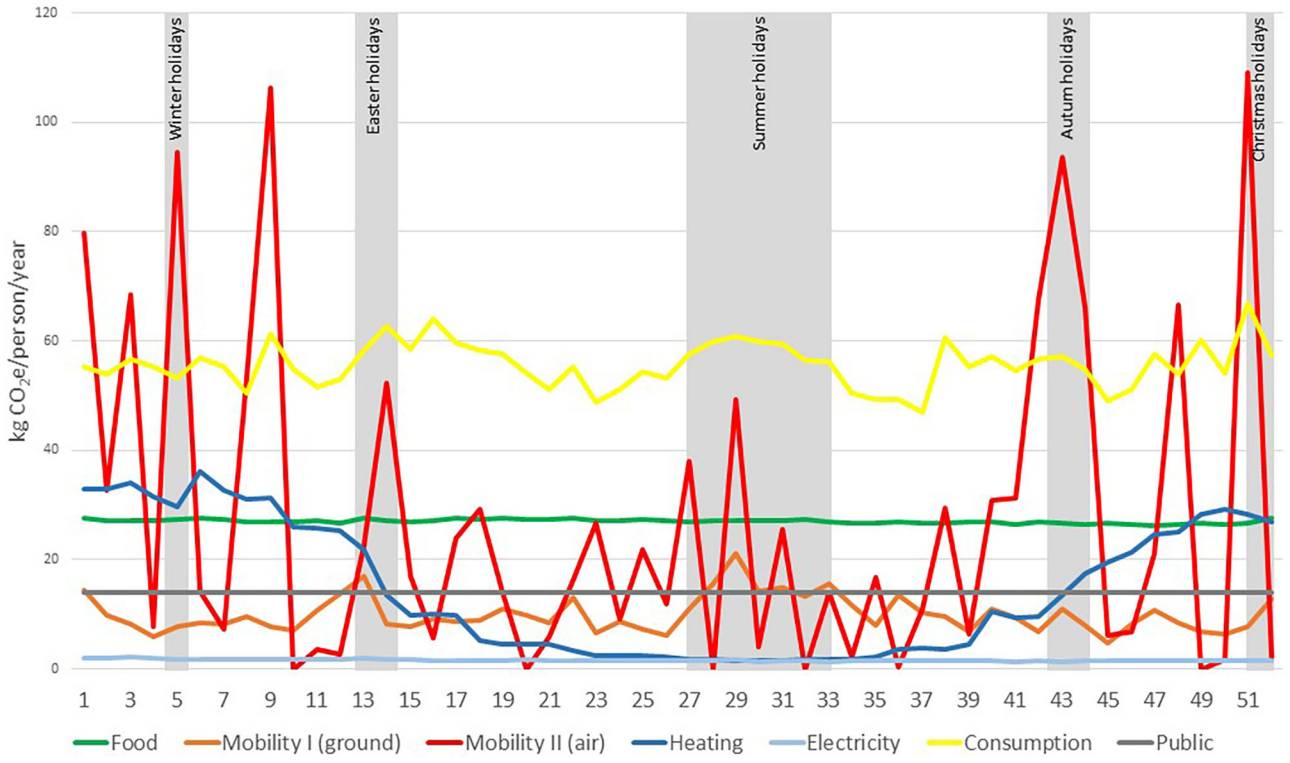

FIGURE 2 | Annual development of KliB households 2018 in kg CO_2 per person. Source: Own Data.

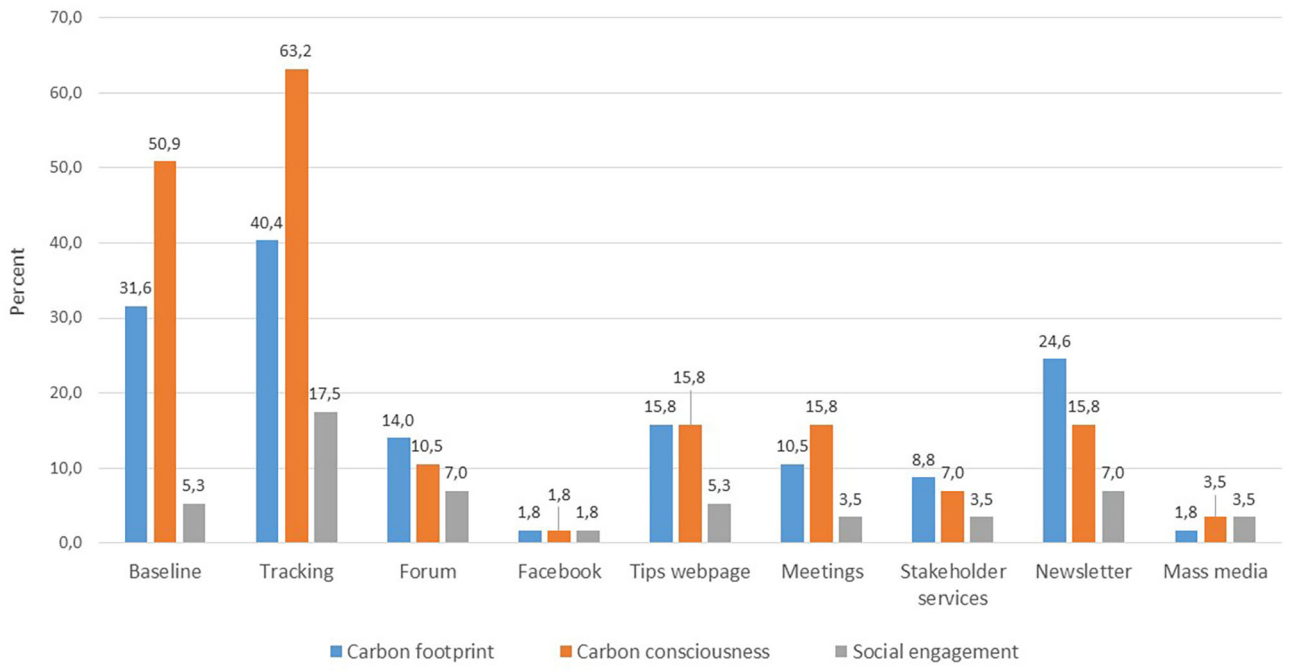

FIGURE 3 | Self-reported impact of intervention formats (x-axis) on participants' carbon footprint, climate consciousness, and social engagement (y-axis: percentage "agree"). Source: Own Data.

seems that dealing with concrete numbers from a reliable source can be a token around which people communicate about climate change and what could be done about it.

While the webpage was important when it comes to footprint and consciousness, the newsletter did have a substantial effect on the footprint. It cannot discern whether this can be attributed to the policy related pieces or to the more detailed individual tips on reducing individual footprints. However, a constant feedback not only on numbers, but also on arguments and context has been assessed to be very valuable.

Finally, live meetings are an important intervention tool when it comes to consciousness formation, less so when social engagement is at stake, while with the internal forum it is the other way around. Face-to-face interaction with like-minded people are more effective when it comes to consciousness formation than a web-based forum – probably because of the dense and physical interaction possible during live meetings.

The KliB project was interested not only in what individuals as *consumers* could achieve in direct (personal) carbon footprint reduction during 1 year, but also in the question of how this endeavor would relate to the attitudes and behaviors of individuals as *citizens*. In doing so, the project were guided by the idea of a holistic concept of "climate citizenship," including behaviors such as voting, participating in demonstrations, signing petitions, or simply voicing issues in private or professional contexts (Atkinson, 2015; de Moor, 2017).

One way of measuring the complex dimension of citizenship in this context was to ask for climate policy preferences of the participating households (**Figure 4**).

Interestingly, a carbon tax (66.7%) receives more support than improved EU emission trading (47.4%), and natural carbon sinks (64.9%) are preferred over carbon capturing and storage (CCS) (7%). Although many households did complain about a lack of information on carbon footprints, this policy option (50.9%) was trumped by the support for an immediate coal exit (56.1%) and the removal of environmentally harmful subsidies (93.1%), the top priority in this sample. This choice reflects a mature assessment of existing policies by the KliB households. Next to the lack of internalized environmental losses, governments around the world grant industries and private households environmentally harmful subsidies, for example, for fossil fuels or non-sustainable agricultural practices—in Germany alone €57 billion in 2012 (UBA, 2017).

It is often highlighted that individual (consumer) action cannot "save the plant," but that governments have to step in and create incentives and regulatory environments that stimulate structural changes, e.g., due to investment in low-carbon technologies and infrastructure. This is a statement that can be fully subscribe to. But often enough proponents of such a policy-centered approach tend to forget that the political system is part of the social system at large, not an exterritorial "machine" to generate favorable boundary conditions. Especially in democracies, governments are frequently held responsible by elections in which policy proposals need to find the support of political majorities. This is exactly the point where consumers as citizens come back into play. The Corona crisis of 2020—although in a completely different context—offers a good example of the interplay between consumers and citizens.

AN INVOLUNTARY CARBON FOOTPRINT REDUCTION EXPERIMENT: CO_2 EFFECTS OF THE CORONA CRISIS

Accepting a certain degree of cynicism one can interpret the Corona crisis as a huge field experiment in enforced behavioral change with CO_2 reductions as an unintended side-effect. The cynical part hinges on the fact that human suffering as well as the economic and social costs of the pandemic have been huge. Governments did not have any intention to reduce carbon emissions when they decided to implement confinement measures, it was all about saving lives and protecting the health system from overload. Nevertheless, an *interpretation* of the Corona crisis as a "mega-nudging" experiment in massive behavior changes can ask about the effects it did have on people and the planet. After having done so with respect to CO_2 emissions (section Outside Corona: The CO_2 Effect of COVID-19 Induced Behavior Changes), this paper will try to open up the "black box" Corona and take a closer look at the motives of people to change their behavior (section Inside Corona: The Motives Behind Behavior Changes and Their Persistence). As CO_2 reductions were not intended by anti-Corona measures, and looking at the CO_2 effects from a purely aggregate, external observer perspective, one can term the first perspective "outside" Corona, while lifting the Corona black box for motives and behavioral intentions may be termed "inside" Corona.

Outside Corona: The CO_2 Effect of COVID-19 Induced Behavior Changes

The emergence of COVID-19 was first identified on 30 December 2019 and declared a global pandemic by the World Health Organization on 11 March 2020. Cases of infection rapidly spread, initially mainly in China during January, but quickly expanding to South Korea, Japan, Europe (mainly Italy, France and Spain) and the United States between late January and mid-February, before reaching global proportions by the time the pandemic was declared.

In the absence of a medical treatment or a vaccine, increasingly stringent measures were put in place by world governments in an effort, initially, to isolate cases and stop the transmission of the virus, and later to slow down its rate of spread. The measures imposed were started with the isolation of symptomatic individuals, but rapidly expanded to the ban of mass gatherings, mandatory closure of schools and even mandatory home confinement (often termed "lockdowns"). The two main orienting figures for both government action and public perception of the pandemic have been the number of newly infected people on the one hand, and the death toll of the virus—despite not easy to identify—on the other. As both indicators went down significantly following lockdown, the governments have gradually eased the restrictions during summer, but were forced to reintroduce the restrictions after the number of cases rose again in fall. While this paper has been

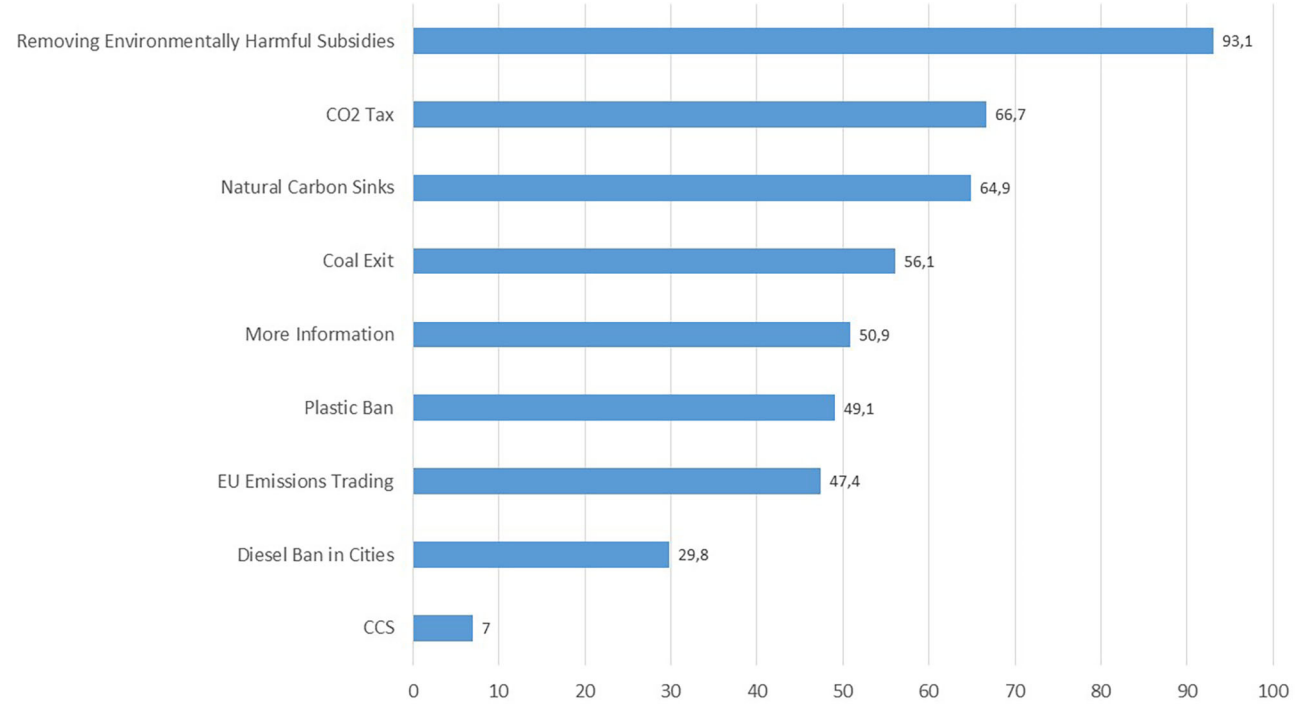

FIGURE 4 | Support of selected climate policy options by KliB households in percent. Source: Own Data.

written (December 2020), a second lockdown was in place in many countries, while first tests with newly developed vaccines have started.

The COVID-19 pandemic and the political attempts to contain it have led to greenhouse gas emission reductions as an unintended side-effect. The population confinement had been leading to drastic changes in everyday behavior, such as drastically reducing contacts with other people, flying and commuting less, more often staying at home, also for work (home office), home schooling, going out less (e.g., to restaurants, bars or cultural events), and substituting online for offline shopping. These government induced restrictions of individual behaviors have led to shifts in time and energy use: people staying at home use less energy at the workplace, for commuting or in restaurants, but increase their home energy use instead. As an effect, sectoral energy use reduced by various degrees (depending on substitution effects), and CO_2 emissions went down (depending on the carbon intensity of the sectors).

Early attempts to assess the CO_2 effect in the German case, undertaken in spring and summer 2020, range from 3.2 to 28.9 percent reductions (Agora, 2020; Alfeis et al., 2020). At the global level, this can meanwhile refer to solidified assessments, some of which use daily estimates and/or big data sources, such as mobile phone movement tracking or Google data (Forster et al., 2020; Friedlingstein et al., 2020; Le Quéré et al., 2020; Liu et al., 2020b). These studies converge in a global range of 4–7% decrease of CO_2 emissions. The Global Carbon Project for example assumes a reduction of 6.7%, while Carbon Monitor data suggest a reduction of 5.3%. Given the uncertainties of such an assessment—among other things by the fact that December data have not been available—the convergence of these assessments is quite high.

For the analysis, this paper refers to the daily, sector-specific, country-level CO_2 emissions from January 1st, 2019 to November 30th, 2020, based upon near-real-time activity data, provided by the international research initiative Carbon Monitor (Liu et al., 2020a). These estimates provide a picture of the daily, weekly, and seasonal dynamics of CO_2 emissions before and after the COVID-19 pandemic and the economic downturn that it has triggered.

According to these data, global CO_2 emissions have been reduced by 5.3% (1,653.6 Mt or 1.653 Gt CO_2) in 2020 (January-November) as compared to the same period in 2019. This is a substantial reduction considering that the growth of global CO_2 emissions between 2017 and 2018 has been 763 $MtCO_2$ (GCP 2020). Corona has thus "eaten up" more than 2 years of global CO_2 growth.

The reduction has been less marked in China (−0.5%, 49.8 $MtCO_2$), Russia (−3.6%, 50.0 $MtCO_2$), or the average of non-OECD countries (−3.9%, 350.2 $MtCO_2$). Other countries have seen more substantial CO_2 reductions, such as Brazil (−11.0%, 46.1 $MtCO_2$), the US (−14.6%, 633.4 $MtCO_2$) or Spain (−14.6%, 33.5 $MtCO_2$). In Germany, the focus country, the change was −9.8% (62.0 $MtCO_2$). The lion share of this reduction came from the power sector (−6.7%), followed by industry (−2.0%), the residential sector (−0.8%), ground mobility (−0.2%), and

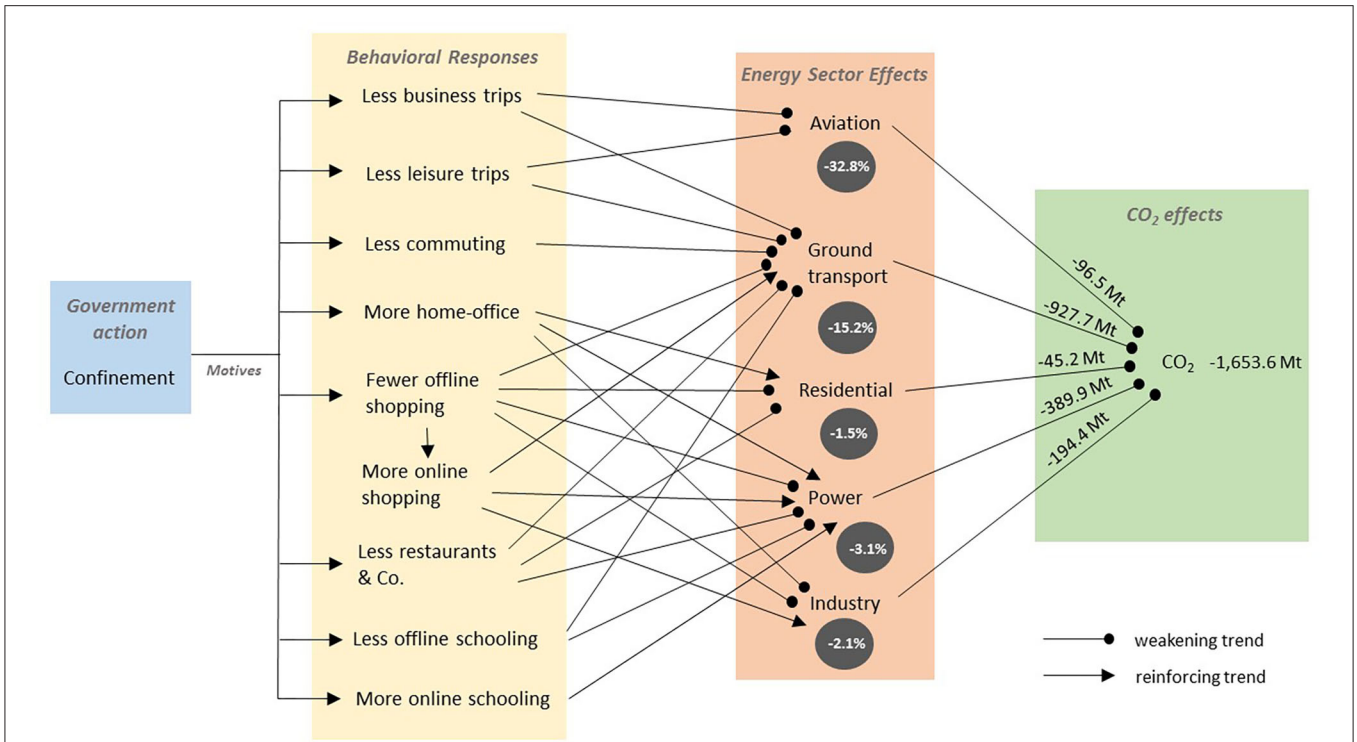

FIGURE 5 | Behavioral responses to government induced confinements, energy sector and global CO_2 effects. Source: own graph, data taken form Liu et al. (2020a).

domestic aviation (−0.1%)[7]. On a global level, the ground travel sector (−927.7 Mt, sector reduction rate: −15.2%) and the power sector (−389.9 Mt, −3.2%) have contributed most to the overall reduction of CO_2 emissions (−1,653.6 Mt), while industry (−194.4 Mt, −2.1%), aviation (−96.5 Mt, −32.8%) and the residential sector (−45.2 Mt; −45.2%) did contribute less (**Figure 5**).

Government policies did implement various confinement measures, and people showed behavioral responses, leading to reductions or sectoral shifts in activities. While one would be tempted to assume a direct link between imposed confinements to behavioral responses, a more careful assessment is necessary. This can be motivated by the fact that a certain portion of people did *not* follow the behavioral rules (e.g., in terms of social distancing or staying at home instead of gathering with others), which shows that this link is mediated by individual motives that make them follow-or obstruct rules instead. The next subsection (section Inside Corona: The Motives Behind Behavior Changes and Their Persistence) will come back to this point. These behavioral responses then translated into energy sector effects, e.g., in car related emissions or demand for electricity and heating at home. While some of these behavioral responses increased demand (e.g., more online shopping), others reduced it (e.g., less eating out in restaurants). The net effect of the corona crisis has been negative in terms of energy use and related GHG emissions[8].

While the net CO_2 effect of COVID-19 has been bigger than any economic downturn in the 20th century (IMF, 2020), it is by far not sufficient to stop global warming. The cuts in global emissions required per year from 2020 to 2030 are close to 3% for a 2°C target and more than 7% per year on average for the 1.5°C goal of the Paris Agreement. Depending on the rate, the timing and the character of recovery after the crisis, emissions could reach their pre-crisis growth path (0.9% per year, average of the years 2010–2019) after 1–2 years (Forster et al., 2020). Without structural changes, leading to a long-term de-carbonization of energy use sectors, the Corona emissions downturn of 2020 will be remembered as a singular event without any sustained effect. In addition, one can reasonably expect *enforced* behavior changes to be reverted to "normal" once the external barriers have been

[7]Looking at the sector reductions, i.e., the change of sectoral emissions between 2019 and 2020, there can be found domestic aviation (−50.8%) on top, followed by the power sector (−16.5%), industry (−11.5%), the residential sector (−4.0%), and ground mobility (−1.0%). These sectoral emission reductions translate into overall reductions according to the relative weight of the sector. Domestic flights for example have seen a dramatic drop, leaving airlines and airports in substantial economic trouble, but as domestic air travel emissions contribute less to the overall emission budget (−0.1%) than, say, ground travel, their substantial drop has a lower impact on total emissions than, say, the 1.0% drop of the ground transport sector, translating in a 0.2% reduction of total emissions in Germany.

[8]More online shopping for example increases the transport of goods, but decreases the transport of people. People shifting to home office use more energy at home, but the use of energy in the commercial building sector goes down. Both competing trends influence the residential sector, which covers both commercial buildings and private homes.

removed. This raises the question of the persistence of COVID-19 induced behavior changes, and here at the latest it is needed to open up the "black box" of observed behavior for questions of motivation and preferences.

Inside Corona: The Motives Behind Behavior Changes and Their Persistence

As mentioned before, it might look obvious to attribute the changes in people's behavior in the Corona crisis to the restrictions imposed by the government. But this is a short circuit, as not all people have adhered to the official behavioral guidelines. And those who did it may have done so for a variety of reasons. A Japanese study for example found that the government's requests to stay home was responsible for about one quarter of the decrease in outings in Tokyo, while the remaining three quarters are the result of information updating on the part of citizens through government announcements and the daily release of the number of infections (Watanabe and Yabu, 2020). The level of subjective motives thus cannot be skipped over.

A first indication of this indispensable subjective dimension can be derived from behavioral data itself. Bounie et al. (2020) for example use anonymized transaction and bank data from France to document the evolution of consumption and savings dynamics since the onset of the pandemic. They find that consumption has dropped very severely during the nation-wide lockdown but experienced a strong and steady rebound during summer, before faltering in late September[9]. But they also find that even after the end of the lockdown some expenditures did not reach pre-crisis (2019) levels (e.g., leisure, hotels, travel agency, restaurant, transport, clothing), while bouncing back was found for consumption items like automobiles, IT products, furniture, home appliances, or alcohol. Why would people abstain from bouncing back to "normal" once lockdown restrictions were lifted?

The key intermediate variable between government confinements and measurable consumer behavior are motives for behavioral change and, possibly, changes of preferences. If the government bans gatherings of people, people trust the government and are afraid of getting infected in case of joining gatherings, people will follow orders and stay home. But if people are less socially oriented and/or risk takers, or even adhere to some kind of conspiracy theory and/or are following populist discourse, they will not trust the government and join gatherings as before—or even more so in order to exhibit their protest against "government arbitrariness" (Bughin et al., 2021)[10].

A key question with respect to the environmental effect of Corona is whether private expenditures recover once social distancing restrictions are lifted or whether the COVID-19 crisis has a sustained impact on consumer confidence, preferences, and, hence, spending. Changes in consumer behavior may not be temporary, as they may reflect long-term changes in attitudes arising from the COVID-19 experience.

One of the core challenges of implementing pro-environmental behaviors is habit change. Habitual behavior allows us to avoid time and effort consuming deliberation processes in everyday situations. James (1890) claimed that "the more of the details of our daily life we can hand over to the effortless custody of automatism, the more our higher powers of mind will be set free for their own proper work." Following a habit helps people to manage their daily lives by freeing the mental capacities for other—more or less pressing—issues. To the degree that they have become habitual, overcoming non-sustainable practices can thus be very difficult. Before new, more sustainable habits can develop, long-living old and non-sustainable ones need to have been overcome. In a "functioning" social environment, this is difficult to achieve—as many intervention studies have shown (Gardner and Rebar, 2019).

Habits form as people pursue goals in daily life. When repeatedly performing a behavior in a particular context, people develop implicit associations in memory between contexts and responses, which involves various forms of learning processes (Wood and Rünger, 2016). Disruptive learning is a rather successful way of habit change. For example, Verplanken and Roy (2016) in a field experiment tested the habit discontinuity effect—habit change interventions are more effective during life course changes (e.g., moving house). Eight hundred households were randomly assigned to receive a sustainable behaviors intervention. The intervention was more effective for those who recently relocated, indicating that the removal of contexts that support habitual behavior is a key to change habits. The Corona crisis and government confinements have now done exactly this: They removed the legal and—to a wide extent—also the social environment contexts for pursuing well-established habits, such as driving cars or flying, and opened up—not on purpose, but factually—the window of opportunity for more sustainable practices. COVID-19 is leading to re-considering of existing behaviors with opportunities to embark on new designs for a sustainable future (Ramkissoon, 2020). The question is whether there is any empirical evidence to support this theoretical claim.

Hodbod et al. (2020) use data from a representative consumer survey in five European countries conducted in summer 2020, after the release of the first wave's lockdown restrictions. The survey documents the underlying reasons for households' reduction in consumption in five key sectors: tourism, hospitality, services, retail, and public transports. Based on the data, one can identify a large confidence shock in the

[9]This drop in consumption was met with a significant increase in aggregate households' net financial wealth. This excess savings is extremely heterogeneous across the income distribution: 50% of additional wealth accrued to the top decile. Households in the bottom decile of the income distribution experienced a severe decrease in consumption, a decrease in savings and an increase in debt (Bounie et al., 2020). Similar findings come from the US (Finck and Tillmann, 2020). The pandemic has thus increased consumption and savings inequalities.

[10]Mellacher (2021) could show for Austria, that Corona skepticism was significantly higher in regions of high right-wing populism voter turnout, impacting even the death toll of Corona. On August 29, 2020, an anti-Corona demonstration in Berlin with estimated 18,000-38,000 "corona-truthers" participating escalated when far right activists attempted to storm the Reichstag, the German Parliament. The mix of motives that lead people to protest against government confinement policies ranges from economic needs to misinformation, anti-science and anti-vaccination attitudes, distrust in government or open extremist right-wing coup fantasies (Hotez, 2020). In any case these motives inhibit or at least complicate the link between government regulation and the individual compliance.

Southern European countries and a more permanent shift in consumer preferences in the Northern European countries. For reasons of comparability the focus will be on the German data.

The survey did offer five (six) categories to answer the question *why* (for what reason) people had changed their behaviors during COVID-19 confinements: (1) fear of infection risk, (2) inability to further afford consumption practices, (3) saving intentions, (4) preference changes ("I did not miss it"), (5) substitution by online alternatives (if applicable), and (6) other. While answer categories (2) and (3) would be important to differentiate with respect to the effect of income (inequalities) on consumer behavior, this is lumped together as "financial motives" due to the focus on the sustainability issue. The Results for Germany look as follows (**Figure 6**):

It can clearly be seen that the fear of an infection risk has been the main driver for people in changing their consumer behavior during lockdown. This especially holds for public transport (55.8%) and traveling abroad (49.5%), which supports the measured CO_2 effects on the ground transport and aviation sectors (see section Outside Corona: The CO_2 Effect of COVID-19 Induced Behavior Changes). But this motive of fear is also the dominant one when it comes to the hospitality sector (43.3%), offline shopping (41.9%) or personal services (such as haircutting) (39.1%). These results show that the confinement justification—preventing the further spread of the virus—has been accepted by many people and was the dominant motive behind behavioral changes during lockdown.

Overall, financial motives range second in leading people to behavioral changes, with the exception of public transport. It seems that personal services (19.2%), the hospitality sector (23.2%) and travel abroad (19.9%) are considered as dispensable luxury in these times.

Interestingly, the third most important motive is preference change: people have avoided the behavior not because they feared an infection or because they could not afford it any longer, but because they did not miss it, even though they were originally forced to do without. This is a clear case for a process of observing and learning, which is typical for the formation of new habits (Carden and Wood, 2018). It is clear that habit changes need time. The slow pace of habit learning was shown with a variety of health habits, such as exercising, that develop with weeks or months of repetition in stable contexts (Lally et al., 2010). When environments change, the cues activating habits may change also, with the result of disrupting habit performance. Without familiar habit cues, people are forced to make decisions about how to act. COVID-19 was such a large-scale habit disrupting event, and it took long enough to make people experience their "new normal," and evaluate their preferences.

Preference change was strongest in the offline shopping (20.9%) and the hospitality sector (20.8%), followed by personal services (19.2%), traveling abroad (15.3%) and public transport (14.5%). The availability of online alternatives was an important motivational factor to perform less offline shopping. This does not hold for the other activities.

If COVID-19 has led to preference changes in a range of10–20% of consumers surveyed, it would be wrong to expect aggregate consumption levels to simply bounce back once confinements are removed. At least some of those interviewees could have changed preferences persistently. Based on the dominant type of motives behind the perceived behavior change, one can consider different scenarios of future development (Hodbod et al., 2020), with different climate change outcomes (**Figure 7**).

If fear of infection dominates as a motive for behavior changes during confinement, a release of confinement (e.g., due to medical treatment widely available) will lead to a fast recovery in the business-as-usual sense (scenario A in **Figure 7**). In terms of climate change, this might lead to the resumption of an annual CO_2 growth rate of about 1%. If this recovery would additionally be fueled by government support for traditional, carbon-intensive industries, the world could end up with an increase of global warming in line with a high-end climate scenario lime RCP8.5[11]. A slow recovery scenario (B) would be driven by consumer preferences that are not based on fear of infection, but are more driven by the precaution principle, which translates into slow recovery and a certain level of additional savings to safeguard against future outbreaks. Under such a regime, emissions could lead to a slightly lower scenario (e.g., RCP6.5 or slightly above).

A sustainable reconfiguration, the last scenario considered here (C), would result from the dominance of consumer preference change for less mobility, cleaner production or more regional and seasonal products. If widely adopted, such preference changes could lead the world to a RCP2.6 climate scenario, compatible with the Paris Agreement goal of limiting global warming to 1.5–2°C levels.

In reality, these different motives do in fact coexist, the dominance of only one of them is highly unlikely, as the already mentioned survey has shown. Real future trends will most probably be a mix of heterogeneous motives—let alone of contrasting recovery policies. This leads to the question of social differentiation of consumer worlds during COVID-19.

SHORT AND LONG TERM EFFECTS OF THE CORONA CRISIS: FROM INVOLUNTARY TO VOLUNTARY CHANGES

While the Hodbod et al. (2020) paper provides many important insights with respect to the motivational plurality behind COVID-19 induced behavioral changes, it leaves open two important questions: (1) What consumer groups have a higher propensity for sustainable preference changes, and (2) how persistent might these changes be?

In a representative online survey, SINUS Market and Social Research (Heidelberg and Berlin, Germany) investigated how COVID-19 affects the everyday lives of Germans and influences their consumer behavior. The data were collected after the first

[11]RCP is the abbreviation for "Representative Concentration Pathway," measured in a triggered global warming potential of 8.5 Watt per square meter in 2100. RCP8.5 scenarios, often mistakenly termed "business as usual," refer to the upper end of possible emission pathways, with a very carbon-intensive economy (Riahi et al., 2011).

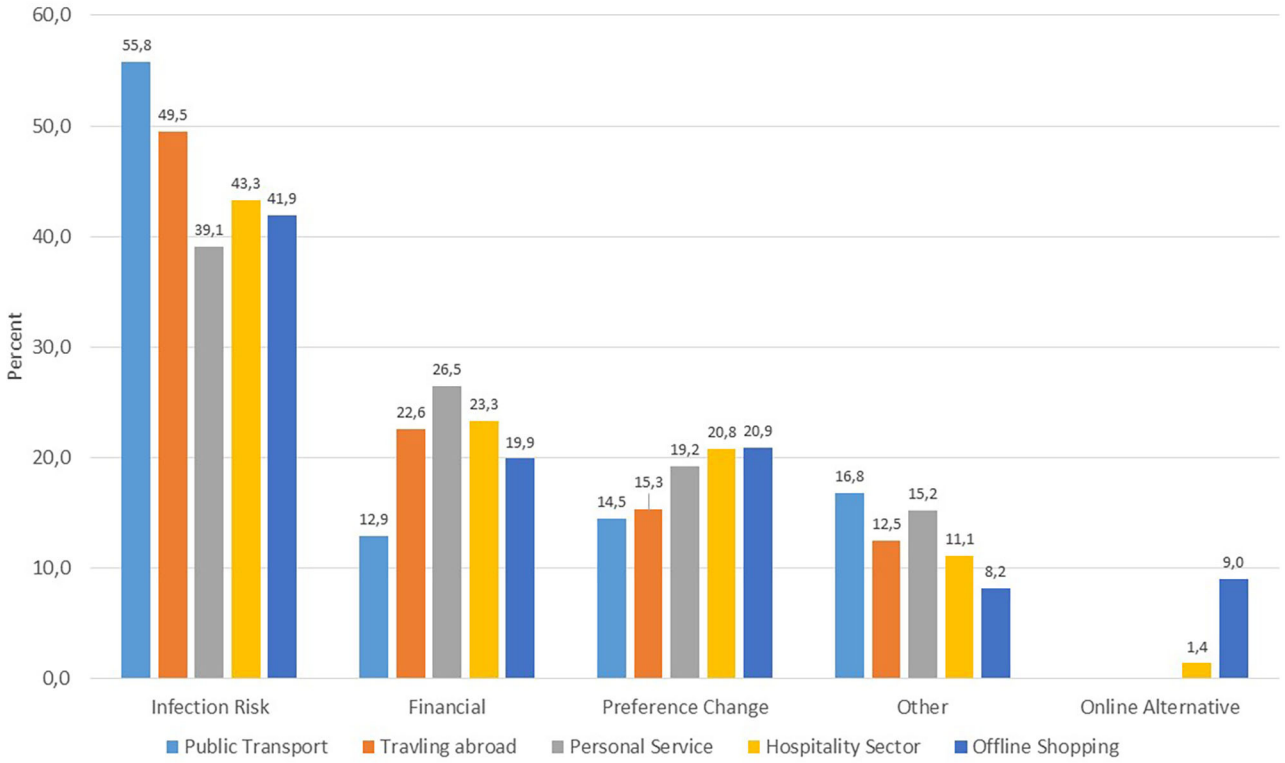

FIGURE 6 | Different reasons for reducing consumption during Corona lockdown in different domains of consumption. Source: own graph, data base: Hodbod et al. (2020).

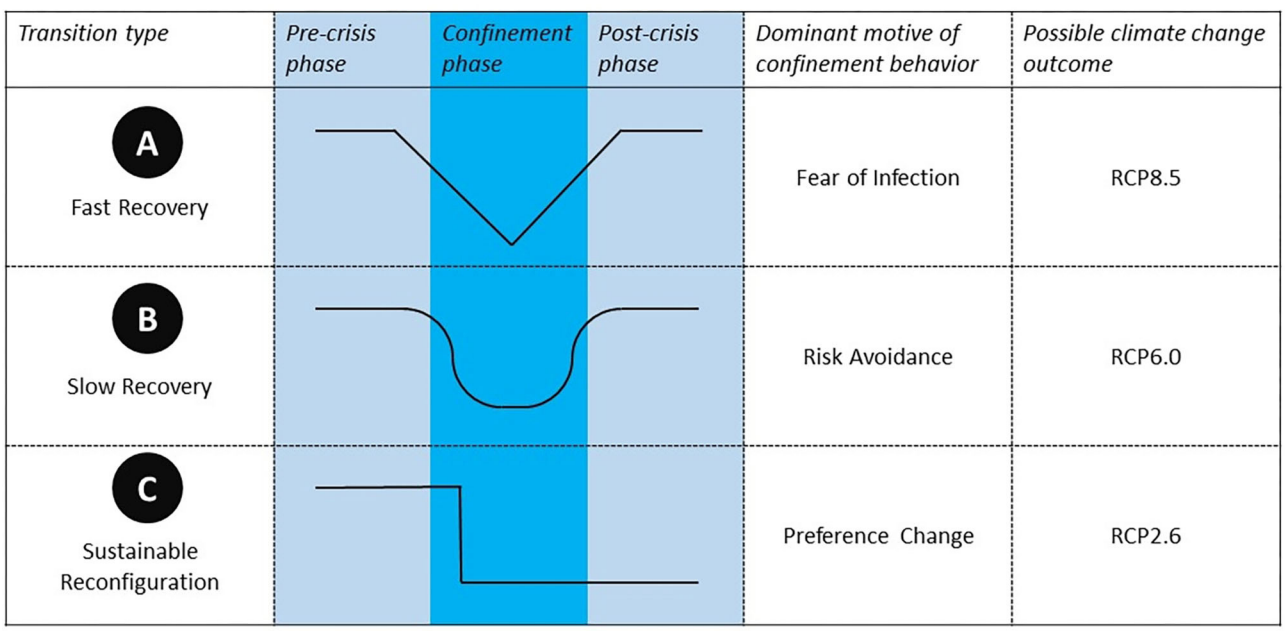

FIGURE 7 | Stylized transition types of pre- and post-Corona consumption levels and climate change outcomes, depending on the dominant motive of confinement behavior. Source: Own graph.

lockdowns in Germany had been gradually lifted[12]. Between May 14th and 22nd, 1,012 people aged 14 to 77 were surveyed. A representative quota sample was drawn according to age, gender and education.

In order to enable a differentiated analysis of behavioral changes in times of Corona, the Sinus-Milieus target group model was integrated into the research design. Through the differentiated evaluation of the data according to the milieu affiliation of the respondents, the analysis was supplemented by lifestyle and value components.

What is the Sinus-Milieus target group model? In brief, it is a social segmentation model based on an analysis of everyday life, developed over the course of four decades of mixed methods research. Sinus-Milieus group people with similar attitudes and lifestyles. The Sinus-Milieu model for Germany 2020 consists of ten different social milieus (see **Table 1** and **Figure 8**). The groups are differentiated based on the statistical analysis of response patterns to a standardized psychometric indicator containing questions on basic socio-cultural orientation, as well as attitudes to work, family, leisure, money and consumption. Socio-economic status (education and income) is also measured as a passive variable and incorporated into the description of the milieus (BMU/BfN, 2020).

The milieus can be situated on an axis system described by two axes: basic socio-cultural orientation (horizontal axis) and socio-economic status (vertical axis) (see Figure). The higher a milieu is located on this graph, the more elevated its socio-economic status (in terms of characteristics such as education, income or occupational group); the further to the right it is situated, the more "modern" its basic orientation in a socio-cultural sense (in terms of e.g., individualism and openness to change). The zones of overlap between milieus on the graph reflects the fact that the model is probabilistic rather than deterministic: the attributes that define each group tend to describe, but do not always match exactly, the characteristics of every individual to whom the group identity is assigned. The short profiles of the Sinus milieus are presented below (see **Table 1**).

Respondents in the SINUS Corona and consumption study have been segmented into these ten social milieus (see **Figure 8**). When asked how their environmental awareness has changed since the beginning of the Corona crisis, one in four respondents reported it to have changed for the better. Accounting for milieu, this was especially the case among the performance- and efficiency-oriented Performers (41 percent), and—to a lower degree—among the Hedonists (29 percent). In contrast, the Corona crisis has rarely had a positive impact on environmental awareness in the Traditional milieu (14 percent), and in the socially disadvantaged Precarious milieu (9 percent). Also, in the sustainability-oriented Socio-ecological milieu, in which skepticism about growth and globalization is firmly anchored, comparatively few respondents said that their environmental awareness had changed in times of Corona (18 percent). The interpretation of this latter results as an expression of self-confidence: members of the Socio-ecological milieu tend to see themselves as the green avant-garde of German society, and in their view there is hardly anything to be learnt from government restrictions on consumption, especially if these are not driven explicitly by sustainability concerns (**Figure 8**).

Furthermore, 40 percent of all respondents reported limiting private travel during the Corona crisis. Performers indicated this significantly more often (52 percent), the Traditionals and Precarious significantly less often (34 percent each). This must be seen against the background that in normal circumstances, Performers are more physically mobile than other groups for both business and private reasons.

A reduction in business travel in the future was predicted by 23 percent of professionals, including once again primarily the Performers (32 percent), but also the Liberal Intellectuals, who embody the enlightened educated elite with a liberal basic attitude and post-materialistic roots (31 percent). In contrast, the Social Ecologicals as well as the Adaptive Navigators – the well-educated, young middle of society – were significantly less likely to restrict their professional travel behavior (17 percent and 14 percent respectively). Again, this difference must be interpreted in relation to differences in business travel frequency under normal conditions.

Twenty eight percent said they would work from home more often during the crisis. This was especially the case for the Cosmopolitan Avant-gardes, who consider themselves psychologically and geographically mobile (42 percent), but also for the Performers (39 percent) and the Established (38 percent). In contrast, the down-to-earth Modern Mainstreamers (21 percent), the Traditionals (19 percent), the Precarious (20 percent) and the Social Ecologicals (9 percent) were significantly less likely to say they would work from home more often. In order to assess these findings, one has to consider the different professional background of these groups. The Precarious, for example, are characterized by a higher-than-average share of unemployed, which limits their business travel potential in the first place. On top of that, many occupations characteristic of this group (e.g., less-qualified blue collar or service jobs) allow much less for home-office substitution than, say, desktop work. The Social Ecologicals have a high share of employment in the education and social care sectors, which also allow less home-office substitution, even during times of lockdown.

In order to test for the perceived relevance of sustainability issues during a health crisis, interviewees were asked about their perception of climate change. More than 53 percent said that the issue of climate change should not be given less media coverage despite the Corona crisis. Climate change was named the most important issue other than Corona, followed by migration, right-wing extremism, war and the US presidential elections. The groups most likely to name climate change were the Performers (64 percent), the Cosmopolitan Avant-gardes (63 percent), the Established (61 percent), the Socio Ecologicals (61 percent) and the Hedonists (65 percent). In contrast, interest in the

[12]Strict restrictions on public life were imposed on a federal level in mid-March 2020, and were loosened gradually on a state-by-state level from late April to early May 2020. Rising infection rates did lead to a second lockdown in late fall 2020, and again at the beginning of a third wave of Corona in spring 2021. The focus of this paper is on 2020.

TABLE 1 | Short profiles of the Sinus Milieus.

Social leadership milieus	
Established – The classic establishment	Responsibility and success ethic; aspirations toward exclusivity and leadership vs. tendency toward withdrawal and seclusion; status-conscious; *entre nous* delimitation
Liberal intellectuals – The enlightened, educated elite	The fundamentally liberal, enlightened educational elite with post-materialistic roots and a critical world view; desire for self-determination; an array of intellectual interests
Performers – The efficient economic high-achievers	Multi-optional, efficiency-oriented high-achievers with a globalist economic mindset and a claim to avant-garde style; high level of IT and multi-media expertise; networkers and multitaskers
Cosmopolitan avant-gardes – The ambitious, creative cutting edge	The unconventional creative avant-garde: hyper-individualistic; psychologically and geographically mobile; digitally networked and always on the lookout for new challenges and change
Middle-class milieus	
Modern mainstreamers – The middle-class mainstream	The modern mainstream with the will to achieve and adapt: general proponents of the social order; striving to become established on a professional and social level; seeking to lead a secure and harmonious existence; among some, a growing fear of losing their social position and role
Adaptive navigators – The modern pragmatic youth	The ambitious young core of society with a markedly pragmatic outlook on life and sense of expedience: success oriented and prepared to compromise; hedonistic, yet conventional; flexible, yet security-driven; utilitarian approach to life; need for anchoring and affiliation
Social ecologicals – The committed socially critical milieu	Idealistic, discerning consumers with normative notions of the 'right' way to live: pronounced ecological and social conscience; globalization skeptics; strong advocates for non-discrimination and diversity; criticism of profit-oriented growth and consumer society
Underprivileged milieus	
Traditionals – Security- and order-oriented older generation	The security and order-loving wartime/post-war generation: rooted in the old world of the petty bourgeoisie or traditional blue-collar culture; homey, thrifty lifestyles; modest understanding of needs; increased feeling of social dislocation
Precarious – The underclass striving for direction and participation	The lower class in search of orientation and social inclusion, with strong anxieties about the future and a sense of resentment: keeping up with the consumer standards of the broad middle classes in an attempt to compensate for social disadvantages; scant prospects of social advancement; a tendency toward passive / reactive attitudes to life and withdrawal into familiar social environments
Hedonists – The fun and experience-oriented lower middle class	Living in the here and now; shunning convention and the behavioral expectations of an achievement-oriented society; cool and carefree image; spontaneous consumption style; leisure as an escape from modest economic circumstances

topic of climate change during times of Corona is much more restrained within the Modern Mainstreamers (32 percent) and the Precarious (36 percent).

Summarizing these findings, it can be conclude that a social milieu-sensitive look at modern societies can reveal more reliable, structured information about consumer preferences than isolated statements on an aggregate level. While these statements can help us to assess the overall "power" of a trend, a milieu-specific perspective can contribute significantly to this ability to ground aggregate data in the life-worlds of existing groups. In this context, it is a very interesting finding that a shift toward more environmental awareness can be observed in groups with a generally modern social orientation but without a history of clear environmental interest or commitment. While the traditionally environmentalist "core" milieus of Social Ecologicals and Liberal Intellectuals have experienced relatively little pro-environmental push impulses, and traditionally-oriented low-status milieus tend to bounce back once restrictions are removed, modern milieus across the horizontal range of society can imagine switching to longer-lasting behavioral changes. This finding aligns with the analysis provided in sections An Example of Voluntary Carbon Footprint Reduction: The KliB Real Lab Project and An Involuntary Carbon Footprint Reduction Experiment: CO_2 Effects Of the Corona Crisis of this paper.

CONCLUSION AND OUTLOOK

This paper has considered the COVID-19 crisis as an involuntary world-wide "real lab" experiment in behavior changes and did focus on consumption changes and related CO_2 effects. According to still preliminary assessments, the Corona crisis can be hold responsible for a 4–7% reduction in global emissions, the largest annual cut ever so far. This involuntary "experiment" was compared with a small-scale voluntary experiment in the city of Berlin, Germany, with about 100 households reducing their individual carbon footprints in a 1 year intervention and feedback period. Opening up the "black box" of only observed behavioral changes in order to have a closer look at the heterogeneous motives that people have in following government rules, and by analyzing the influence of the specific motive of preference changes, as the latter are a good indicator for updating and learning during the confinement period and might also be interpreted as predictors of sustained behavioral change. Finally it was referred to a Sinus study on the effects of Corona on different social milieus in order to refine the understanding of preference changes in the light of Corona-independent consumer segments. The findings of this work can be summarized as followed:

- Voluntary real lab experiments in reducing personal carbon footprints can result in 3–20% reduction rates. The Berlin KliB

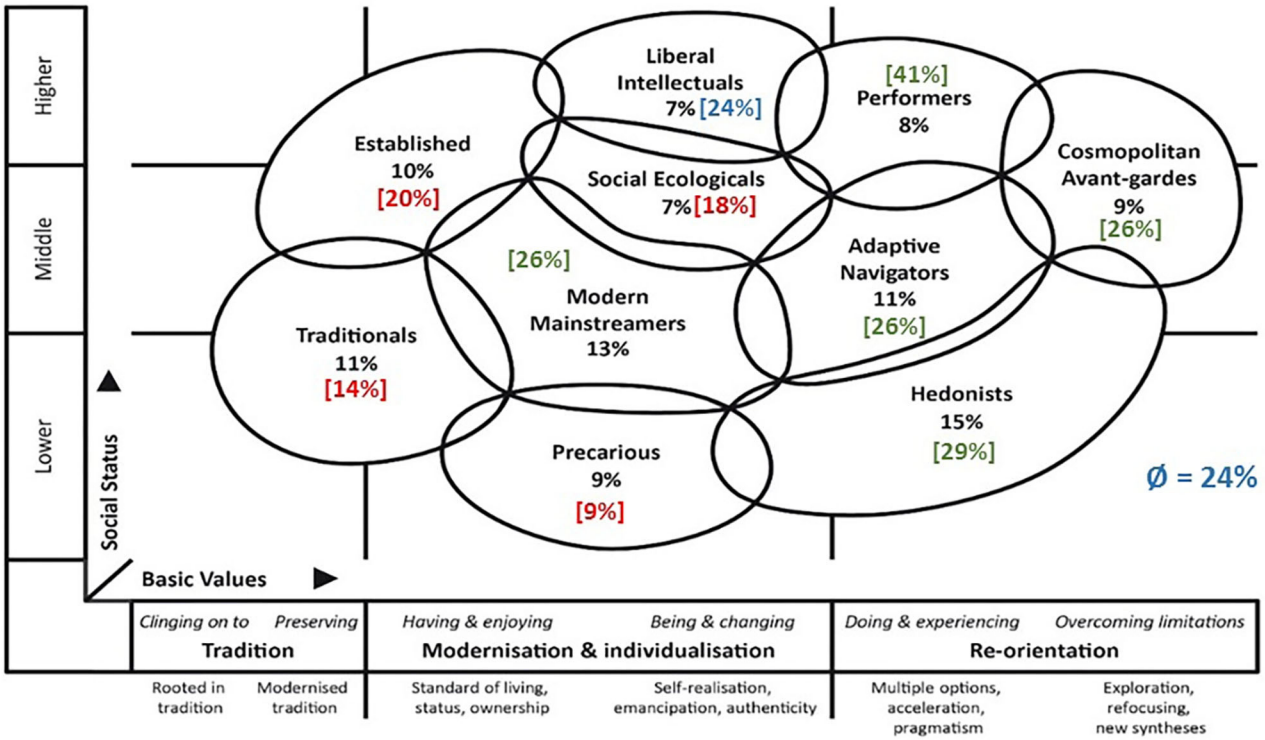

FIGURE 8 | Sinus-Milieus in Germany 2020 and their percentage of the adult population (percentage points in black). In color and in bracket: share of respondents stating that Corona restrictions have improved their environmental awareness; blue: average value, green: above average value, red: below average value. Source: Own Data and BMU/BfN (2020).

real lab with about 100 households ended up with an average reduction of 11%, with maximum reductions of 40% reached by a few very "stringent" participants.

- If the society would manage to reproduce this annual average reduction rate every year until 2050, it would be able to meet the Paris Agreement goals of limiting global warming to 1.5–2°C (in 2100). But current policies are lacking behind that goal and will most probably leave the planet with a warming of about 3°C. KliB has underlined the fact that consumers as citizens can help to support de-carbonization policies that transcend the scope of their individual consumption decisions.
- The COVID-19 crisis in 2020 can be regarded as a planetary-scale "real lab," leading to massive behavioral changes that summed up to a global annual CO_2 emissions reduction of about 4–7%, in Germany of about 10%.
- While this reduction was the biggest downturn of emissions ever since in 1 year, its global climate effect is very limited, given the fact that cumulative and not individual annual emissions trigger global warming. Due to the involuntary and non-targeted character of anti-COVID-19 confinement measures, a large portion of the 2020 reduction effect could largely fizzle out during recovery.
- In order to assess the possible persistence of COVID-19 carbon footprint reductions it is needed to transcend purely observational data ("black box" Corona) for the subjective level of behavioral motives and intentions. Various motives can be discern to follow government confinements.
- In the German case, the motive "fear of infections" can explain for 40–55% of behavioral changes, the biggest driver identified. Once a medical treatment for COVID-19 will be found, consumer behavior driven by this motive will most probably bounce back to "normal" (i.e., consumption levels before the crisis and their growth path).
- However, 10–20% (depending on consumption domain) of behavior changes can be explained by preference changes that the crisis has induced. Changed preferences are an expression of individual deliberation processes and thus display at least a high share of voluntary decision making. There is a realistic chance that they will persist even after confinement removal and thus lead to medium-range sustained behavioral changes.
- A closer look at the consumption and consumption preference effects of COVID-19 against the background of the social milieu structure of Germany (as an example that can be transferred to other countries) reveals that confinement did positively influence other milieus than the "usual suspects," i.e., the pro-environmental avant-garde.
- It seems that Corona confinements did not trigger much pro-environmental preference changes and sustainability learning in milieus already affine to climate and sustainability issues, mainly due to their non-targeted and involuntary character. But for less climate-sensitive social milieus, this "external"

character of the learning stimulus seems to have been a window of opportunity, and a quasi-experimentation space, for reflecting existing preferences and habits. Given the fact that these milieus are status high and influential, a social imitation effect could be expected additional to the "intrinsic" effect of milieu-specific behavioral changes.

- The character of the post-Corona recovery will depend upon the strength of motives that have been driving behavioral changes during the crisis. While infection and risk related motives dominate, the preference change share of motives should not be forgotten or underestimated when designing recovery policies. It seems that existing or planned recovery schemes neglect the potential of a more sustainable design of the future economy—despite calls for a Green Deal at the EU level.

These findings must be seen in a preliminary character. Therefore, some limitations should be highlighted. Although the arguments have been developed based on a variety of sources and studies (and at least related to KliB) in a pre-Corona context, more coherent studies and a broader basis would be needed. Especially when it comes to compare voluntary to non-voluntary interventions and their longer-term effects. It would also be necessary for further studies to include the debate for and against nudging (Barton and Grüne-Yanoff, 2015; Sunstein, 2015), which has gained some prominence in the environmental debate, but had to be excluded for reasons of focus and brevity in this paper.

In just a few months, the COVID-19 pandemic has driven a health crisis that has transformed life as we knew it and has plunged the world into the worst economic downturn since the 1930's (IMF, 2020). Following the onset of the COVID-19 crisis, governments have initially responded with massive fiscal stimulus to address the prevailing uncertainty, keep employers afloat and households solvent.

However, as the extended duration of the crisis is becoming clear, governments are facing critical questions on how best to design their continuing support to the economy. Economists assume an almost full (98%) recovery of the global economy by 2023 if there will be no more restrictions comparable to those in the first half of 2020 (which is still open), and under the assumption that around half of the disturbances specific to customer-facing service industries persist until mid-2023 (Rees, 2020). Consumer preference changes are not included in this scenario.

The results suggest that a simple recovery process without taking into account preference changes risks creating zombie firms and would hinder necessary structural changes to the economy. The argument is made plausible that there is an untapped potential for policy induced sustainability oriented behavioral changes, and a need to align recovery policies with climate policy (and other sustainability) goals. If this point will be missed, recovery policies will re-establish carbon intensive lock-ins of the (even recent) past (Tong et al., 2019). Looking at consumer and citizen preferences—and COVID-19 induced preference changes—can help to design more appropriate policies. The KliB experiment has shown that people *as citizens* would support more stringent climate policies, even if their own performance as low-carbon *consumers* displays a lack of coherence and/or persistence. This is an important finding, as policy makers in democracies need to get regular support and approval by the political sovereign, the majority of the people.

The recent climate discourse in the German society has experienced a high degree of fragmentation and polarization, with groups such as Fridays for Future on the one hand and right-wing populists on the other as drivers (Reusswig et al., 2020). This makes it more difficult than before to develop climate policies that find majority support. All the more important it will be to better merge top-down to bottom-up approaches in policy design (Schäfer et al., 2018). Policy makers should be better coordinated with the innovative impulses from the "eco-avantgarde," and learning effects of the Corona crisis can be used to broaden the social basis of more sustainable consumption behaviors. While COVID-19 has triggered much larger CO_2 effects than small-scale experiments such as KliB, the latter can help in designing more appropriate climate policies due to the fact that they demonstrate the feasibility of voluntary carbon footprint reductions. The processes of deliberate reflection upon existing habits and the search for new ones have been side-effects of the "mega nudge" Corona as well. This should encourage to design more stringent policies that express the will of both the consumers and the citizens. At the end of the day, people may be able to "nudge" others, but humankind as a whole cannot "nudge" itself without deliberately and voluntarily change its own behavior.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the Corresponding author.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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