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Living sustainably in a Danish eco-community: how social and physical infrastructures affect carbon footprints

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The Self-Sustaining Village is a Danish eco-community whose mission is to develop communal sustainable living. This paper evaluates its sustainable living through a questionnaire survey of residents that measures their carbon footprint based on self-reported consumption. The survey also measures their life satisfaction. Results show that residents have a carbon footprint that is 60% below the national average and have a higher life satisfaction than the national average. Results from long-term participant observation explain the lower carbon footprints relating to energy, transport, food and other material items by the existence of particular physical and social infrastructures that shape life in the Self-Sustaining Village. Residents live more sustainably because their collective decisions make sustainable choices the standard or default options. They do so without having to make conscious choices individually and without sacrificing their private comfort for the environment and the climate. These villagers live up to their sustainable ideals and enjoy a richer social life that provides a higher life satisfaction than if they lived separately as independent households. The Self-Sustaining Village provides us with a model in which people live happier with less.

Global warming has become the most pressing issue of our time. According to the latest report from the Intergovernmental Panel on Climate Change (IPCC), addressing climate challenge and keeping global warming within 1.5 degrees Celsius as compared to pre-industrial levels requires that global carbon emissions be cut by 45% from 2010 levels by 2030 and reach zero net emissions by 2050[1]. While this target seems to be out of reach because of slow responses to climate change by national governments and the apathy of individual citizens, our paper argues that this reduction goal is indeed within reach, and in fact already exists in a Danish eco-community. In The Self-Sustaining Village in Hundstrup (referred to as the SSV in this paper), residents have an average carbon footprint that is 60% below the national Danish average. These residents are thus already living by the target that other Danish people, institutions, and policy makers are struggling to achieve.

Different studies suggest that material consumption is a key determinant of happiness[2–8]. This factor constitutes a major barrier to behavioural change since reducing consumption supposedly leads to lower levels of happiness. Other studies examine the difficulties and complexities of *individuals* having to make the right *choices* in their everyday life in order to reduce their carbon footprint or live more sustainably[9–13]. The problem with focusing on individual choices as the key to behavioural change is that this approach is blind to the material infrastructure that determines the form taken by daily practices[14]. Moreover, this focus places responsibility for change on *individuals*, which obscures the collective and political responsibility for both the environment and climate change[14]. Our study addresses these debates by showing first, that members of eco-communities can achieve lower carbon footprints while enjoying higher life satisfaction than average, and second, by explaining this as the result of *collective* choices[15–18] that unfold in physical and social infrastructures. This article demonstrates how the physical and social infrastructures found in the SSV lead to a lower carbon footprint without diminishing residents' life satisfaction.

Our focus on the key role of infrastructures is in line with practice theory and the work of by Elizabeth Shove and colleagues, which demonstrate that social practices are closely connected to material infrastructures[14,19,20]. On the one hand, physical infrastructures are 'material arrangements that enable and become integral to the enactment of specific practices'[19]. On the other hand, the spread of specific social practices creates a demand for a certain type of physical infrastructure: both infrastructures and practices mutually shape each other[20]. The physical infrastructure of the SSV includes common land and pastures, tractors, an ecological sewage system, roads, collective buildings with a common dining room, offices, guest rooms, laundrette, freezers, a swap room (where one can exchange

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things that are no longer used), a waste-sorting room, a do-it-yourself room, greenhouses, and shared cars, among others. As we will see below, this physical infrastructure plays an instrumental role in reducing the residents' carbon footprint.

Our study contributes to this theoretical focus on infrastructure by demonstrating that the development and management of a physical infrastructure requires a social infrastructure. Physical infrastructures are created and maintained to provide a community with goods and services. But physical infrastructures require legal and economic agreements about how to access goods or services, and at what price. Physical infrastructures also require consensus that imply that conflicting debates and political decisions are inevitable and necessary elements of communal living. Thus, physical infrastructures require social, economic, legal and political arrangements – what we call, in short, a 'social infrastructure'.

The concept of social infrastructure has been developed in the context of studies of both British and Danish eco-communities. Helen Jarvis talks about an invisible and immaterial 'social architecture', or 'soft infrastructure', when she refers to the organisation of labour, mutuality, and sharing, which is very different from the visible and material 'hard infrastructure'[21]. Thea Nguyen develops a similar conceptual distinction in her study of the Danish eco-community Munksøgaard when she creates a division between *physical* infrastructures and *social* infrastructures such as communal meals and working groups that are essential to the functioning of the community[22]. Likewise, Quentin Gausset refers to institutions that manage common activities and common goods as socio-political infrastructures because they represent basic structures that organise social interactions and manage conflicts in the community[15]. We define social infrastructure here as the set of social, economic, legal and political arrangements that organise access to resources and services within the community. These arrangements include bylaws, a regular meeting structure, direct democracy mechanisms, procedures for decision making and conflict resolution, a time bank for community work, cost-sharing arrangements, and the many working groups responsible for managing a collective good or service, including those provided by physical infrastructures.

The social infrastructure plays a double role in the sustainable transition: first it enables, manages, maintains, and determines the success of the physical infrastructure, and second, it transcribes the sustainable ideals of the community into practical collective action. When a community has a higher ideal of sustainability, as is the case of the SSV, then both physical and social infrastructures are geared towards achieving this ideal. Since every eco-community is organised differently according to history and context[23], the physical and social infrastructures found in the different eco-communities are the result of *collective* choices and negotiations.

By looking at the SSV from an infrastructural approach, we are able to understand how the relatively low carbon footprint of this community is achieved not just through physical infrastructures, but also because its social infrastructures design and manage access to collective goods and services in such a way that they are conducive to more sustainable lifestyles and higher life satisfaction.

Results

Our research in Denmark shows that the carbon footprint of 253 members of green communities in Denmark (eco-communities, food cooperatives, and urban gardening communities) is 27% below the national average, which is calculated on the basis of 1018 representative Danes who were also survey participants (equal variances not assumed, $t(679.7) = 7.5$, $p < 0.001$). This result is well in line with what has been reported by various studies of eco-communities that have emphasised sustainable advantages by living in co-housing, eco-communities, and other types of collective housing[21,24–34].

Among the green communities that participated in our survey, the SSV has the lowest carbon footprint per capita among. The total average carbon footprint of the residents of this community is 4.7 tonnes, which is 60% below the average carbon footprint of the Danish population (11.8 tonnes). An independent sample *t* test comparing the total carbon footprint of the 16 eco-community residents with the 1018 representative Danes (equal variances not assumed) shows that the difference is highly significant: $t(26.7) = 12.7$, $p < 0.001$. The SSV is a self-built eco-community established in 2004 by a small group of founders who bought an old farm and 15 hectares of surrounding fields and obtained a municipal permit to build 25 houses on the land. Today, the eco-community has 18 finished houses and four houses that are in the process of being built, with three empty plots still available for future settlers. The vision of the eco-community is to achieve a high degree of self-sufficiency in food, low-income living, a serious approach to community work, and the promotion of independent small enterprises. The land is owned by the community; each family unit rents a plot from the community where they build individual houses and can cultivate their own gardens. Villagers share a communal building, a 250-year old farmhouse with stables where collectively owned tools, freezers, and washing machines are stored. Likewise, facilities such as community gardens with collectively grown vegetables and cows, sheep, and chickens are raised collectively. While many families have their own private car, the community owns a shared car that can be used by members.

The SSV has around 50 large and small working groups that take care of different practical or organisational tasks such as trash sorting, bike repair, crop growing, taking care of the cows, lambs, and chickens, ordering groceries for the food coop, managing the collective launderette, the swap room, or the ecological system that filters used water, maintaining the gravel paths, and so on. All adult residents are expected to work four hours per week for the community in one or several working groups. Each group meets regularly to conduct its collective duties and presents its projects and their budgets for the coming year to a communal meeting that is held at the end of the year. The projects and proposed budgets are discussed at this meeting and adopted or rejected by a vote of the community. The eco-community is registered as a cooperative association headed by an elected board, but in practice, decisions concerning the entire community are discussed in monthly meetings and need a broad consensus to be adopted.

In the following sections we discuss the four subcategories of the carbon footprint survey (energy supply, transportation, food, and other consumption). We explain how this community achieves significantly lower carbon footprints than the general Danish population in all categories through a set of physical and social infrastructures.

Energy

A resident of the SSV emits in average 0.31 tonnes of CO_2 yearly based on his/her use of energy, which is more than 70% below the Danish average of 1.06 tonne. The difference is highly significant, as demonstrated by an independent sample *t* test comparing the energy-based carbon footprint of the 16 eco-community residents with 1018 representative Danes (equal variances not assumed): $t(32.8) = 12.6$, $p < 0.001$. Half of the eco-community energy consumption per capita is caused by the communal building, which is an old building with low energy efficiency.

The SSV has designed guidelines that list what is allowed in the community—buildings constructed primarily with natural material such as wood, hay bales, clay, and stone, or with second-hand material such as bricks, windows, and doors saved from destroyed houses. The guidelines advise residents on how to build houses that maximise passive solar heat, for example, by building taller facades that face the south and lower construction facing the north to maximise natural heating from the sun in the winter. Also, many village houses have floors made of clay that cool houses in the summer and keep them warmer during the winter. Houses are heated by mass ovens, or 'flex ovens', that burn firewood efficiently, which reduces the use of firewood (considered as carbon-neutral in our survey) and reduces pollution from solid particles. The ovens do not just heat the houses, they also heat the hot water tanks when there is not enough sun for the solar heater during the winter. Other houses are heated by geothermal heat. Some residents have solar panels, others use the national grid, which gets 52% of its electricity from renewable sources. All these solutions use less energy and use electricity rather than fossil fuel, which leads to lower carbon footprints.

The SSV communal buildings function as an extra, integrated part of the residents' everyday lives. This is where the communal dinner is cooked and served, where food is stored in common freezers and meetings are held, and also where the washing machine rooms, waste sorting systems, and reusable exchange rooms are located. Private guests can stay in the communal buildings' guest rooms, some residents use its rooms as office space, and many children play across ages and families in the living rooms of the communal building. All these communal features mean that the private homes are smaller than they would have been if they had to contain guest rooms, space for washing machines, an office, and playrooms, etc. As our survey shows, the numbers of residents per household are fairly similar (2.1 in the SSV against 2.2 in the reference group), whereas the average number of square metres per house is lower, with an average of 78 square metres in eco-community houses ($n = 16$) and an average of 117 square metres in conventional Danish houses ($n = 1018$). The difference is highly significantly, as shown by an independent sample t-test (equal variances not assumed): $t(14.2, N = 1034) = 4.7$, $p < 0.001$. This demonstrates how eco-communities can successfully influence relatively fixed social norms regarding housing size[35] and also demonstrates how the communal buildings solve some space issues that occur in every household.

Thus, the lower energy-related carbon footprint in the SSV can be explained in part by the physical collective infrastructure – the multi-use collective building allows smaller private houses and provides energy savings through its collective dining room. But this physical infrastructure is also the result of social infrastructures in the form of bylaws that define building guidelines to ensure that private buildings are smaller, well-insulated, heated by wood ovens or geothermal heat, and designed to maximise passive heat. The social infrastructures are managed by a number of working groups that specialise in building, energy supply, waste filtering, and other building issues, which ensures that both private and collective buildings are built to minimise energy consumption and environmental impact.

Food

The food-related carbon footprint of an average resident in the SSV is almost one-third of that of an average Dane (0.58 tonnes compared to 1.59 tonnes). An independent sample t-test comparing the food-based carbon footprint of the 16 eco-community residents with the 1018 representative Danes (equal variances not assumed) shows that the difference is highly significant: $t(16.8, N = 1034) = 16.8$, $p < 0.001$. Eco-community residents eat much less meat and more organic, seasonal, local, fresh and self-produced food than average Danes. The community produces almost half of the food it consumes in its own fields. Some vegetables are produced along permacultural principles, with a focus on perennial plants integrated in a food forest that capture more carbon than they release, but the community also relies on many annual crops (such as corn and other annual vegetables).

A central characteristic of the eco-community is its food store, where residents can freely access all the food produced in the community as well as other basic organic food products, including dairy and groceries, that are not produced by the community. One working group orders these products from a wholesale supplier, a second working group organises the storing in the communal food store and a third organises the baking of rye breads that are also part of the food cooperative's regular inventory. All residents pay a monthly fee of $165, with a reduced price for children, depending on their age. For that price, they can take from the food store whatever food they need in any amount, according to their needs. Every time a litre of milk, a loaf of rye bread, or tomatoes are needed in a private household, residents go to the communal building and pick up what they need. But this covers only basic food products and, as a rule, every private household supplements this basic food supply with food products that they buy themselves for their families in mainstream supermarkets, which is often determined by what their children like or dislike.

The cost of communal meals is covered by the $165 monthly subscription to the food store. Communal eating takes place seven days a week, but residents decide for themselves whether and when they feel like taking part in it. They are allowed to take the collectively prepared food back to their homes and eat in private if they prefer. Communal meals are always vegetarian, but some meat may be served once or twice per week under the condition that only meat from home-bred animals (chickens, pigs, sheep, cows) is prepared, which limits both the amount of meat available and the meat-related carbon footprint.

As we can see, producing, supplying, storing, and preparing food for the community requires different physical infrastructures, including agricultural land, pastures, a collective kitchen, dining rooms, food storerooms, and big refrigerators. But managing these physical infrastructures requires organisation, time and money. It requires a social infrastructure that establishes responsibility, plans the labour involved, and covers the cost of growing food, breeding animals, running the grocery store, preparing communal meals, and cleaning common rooms. Each activity is managed by a working group that meets regularly and devotes substantial time to discuss issues of quality, efficiency, ethics, and sustainability, produce a budget and defend it in the general assembly, organise access, booking, cost-sharing, and so on.

Transport

The average transport-related carbon footprint in the SSV is 70% below the national average: 2.0 tonnes compared to 6.73 tonnes ($t(30.0, N = 1034) = 9.5$, $p < 0.001$, equal variance not assumed). Transport-related emissions registered by the community's residents come mostly from plane and car travel. The average plane travel of eco-community residents is only 1.6 h annually while it is 13.7 h for an average Dane ($t(101, N = 1034) = 11.2$, $p < 0.001$, equal variance not assumed). Likewise, 68.8% of eco-community respondents did not fly in the past 12 months, which this proportion is only 41.7% in the Danish population (χ^2 (1, $N = 1034) = 4.7$, $p = .029$). Two factors explain this. On the one hand, there is a strong social norm in the eco-community that flying must be limited. This does not mean that a resident who flies is disapproved of, but there is a tacit agreement among residents that flying is bad for the climate. On the other hand, the average income of eco-community households is about 40 percent lower than in the reference group, which probably limits the frequency of spending holidays abroad.

When it comes to the car-related carbon footprint, the average for residents of the SSV is less than half the national average (1.22 tonnes compared to 2.63 tonnes; $t(19.5, N = 1034) = 3.6$, $p < 0.001$, equal variance not assumed). Most households have one car (usually a gasoline-efficient car), which can be explained in part by more resident families having children who need transportation for leisure activities. A few households have two cars and a few have no car at all. Some eco-community residents are committed to biking as much as they can and several residents have bought electric bikes as an alternative to a car.

The community has one shared car that can be used in cases of occasional need and that explains why many families have decided against buying a second car. Using a shared car limits emissions because the full cost of each trip must be paid up front and because the travel needs to be planned in advance to make sure that the car is available, which limits compulsive use. If the shared car is not available, it is a common practice for residents to borrow the car of a neighbour.

Social infrastructures and collective practices also influence car use. For example, it is common for residents to use the internal mailing list to ask other residents for a lift to work or to pick up their children on the way home from an activity. Thus, the lower transport-related carbon footprint can be explained by physical infrastructure (a shared car), by social infrastructure (a working group to organise the use of the shared car and an internal mailing list to organise carpooling), and by the collective norm that plane travel ought to be minimised.

Diverse consumption

When comparing the consumption of other items, the average carbon footprint of residents of the eco-community is 26% below the national average 1.82 tonnes compared to 2.49 tonnes, $t(16.7, N = 1034) = 5.9$, $p < 0.001$, equal variance not assumed. Eco-community residents spend

significantly less money on clothes, furniture, electronic equipment, hotels, restaurants, and leisure than average Danes.

One factor that helps explain this lower consumption is that households in the SSV have an average income that is approximately 40% below the national average. There are also physical infrastructures that motivate lower consumption. There is, for example, the swap room, where used garments, books, and other goods that are no longer of use to the owner can be left to be used by others. Family and friends from outside the eco-community also leave their used clothes in the community's clothes swap and pop by when they are visiting to see if there is anything of use to them. The community has also a waste-sorting room, in which items seen as non-reusable are disposed of in specific containers for plastic, metal, paper, cardboard, and electronics. There is also a collective working space with all kinds of do-it-yourself tools.

All these physical infrastructures are managed by a social infrastructure in the form of the aforementioned working groups, who meet regularly to discuss how to organise the service, how to avoid free riding (when someone uses a service without sharing the cost), and so on. Additionally, there is a high degree of sharing of equipment, such as freezers, washing machines, and tumble dryers, trailers, tools, crafting tables, lawn mower and kitchen accessories, which motivates less individual consumption., There is also a common practice of borrowing almost everything from neighbours, which is accomplished either through direct contact between neighbours or by using the internal mailing list.

Another significant factor influencing the degree of reduced consumption is the common ethic among the residents to live a simple, low-income, low-consuming life. A resident of the SSV does not improve his or her social status by buying the newest car or biggest flat screen TV. Instead, social status is achieved and maintained by being able to use your hands to construct a beautiful house, grow vegetables or build the nicest chicken house from re-used materials. Eco-community residents mutually reinforce that ethic by shopping at flea markets and second-hand shops. Material values are not unimportant, but higher social recognition is achieved by demonstrating sustainable and climate-friendly achievements rather than by purchasing goods that are new, big, or flashy.

Life satisfaction

Living more sustainably requires a lower carbon footprint and therefore, a lower consumption of goods, among other factors. The question here is whether people can live happier with less[27,34,36–40]. Higher income usually translates into more happiness, even though this correlation tends to disappear over time or beyond a certain threshold of income[5,41]. Our survey did not measure 'happiness' as such, but we asked respondents to state whether they agree with the statement 'I am satisfied with my present life'. As predicted by the income-happiness theory, our survey shows that among the 1018 representative Danes, a higher income correlates with a higher life satisfaction. Remember that our survey shows that the average income in SSV households is approximately 40% below the national average. According to the income-happiness theory, eco-community residents should be less satisfied with their life than the rest of the population. But contrary to this expectation, our survey shows that eco-community residents are even more satisfied with their life than the average in Denmark. Among the 16 eco-community respondents, 88% declare to be very satisfied or satisfied with their life. Among the 1018 representative Danes, 67% report the same. When performing a Pearson chi-square test of independence, the difference is weakly significant at the 10% level: χ^2 (1, N = 1034) = 3.08, p = 0.079.

Because eco-community residents are better educated than the average Dane, their lower income cannot be explained by a lack of skills or income opportunities, but rather as the result of choice residents make about how they wish to live. However, more likely and more in line with the general thesis of this paper, residents' lower income is also the result of their community's social and physical infrastructures. Eco-community residents have access to self-grown food and organic food supplies through their shared-payer food cooperative, shared home appliances, shared cars, and re-used clothes and books, which makes it possible for them to live comfortably on a much lower income than does the average Dane. In other words, residents of this eco-community are under less pressure to make more money because their living situation provides more goods and services than are available outside the community. Working less for wages outside the community also goes hand-in-hand with working more for the community itself (in various working groups or by building and maintaining one's house). Thus, despite being poorer than average, eco-community residents do not necessarily perceive or feel themselves as such. They generally have white-collar jobs and they enjoy a generally normal life in which they can afford most of the things that other Danes can afford (albeit in more limited quantity) because they save every day on costs related to housing, energy, food, and other goods.

Residents of the SSV often declare that they do not think of themselves as reflecting that much on their carbon footprint. As a resident put it: 'We do not wake up in the morning thinking about CO_2'. It is by spending their energy on making the SSV's social and physical infrastructure work that they achieve major reductions in their carbon footprint – without thinking much about it and without being aware that well-functioning infrastructures *are* the source of more sustainable practices. Because their lower material consumption and lower carbon footprint derive more from collective infrastructures than from private choices, their lifestyle choices come naturally; residents do not feel that they sacrifice their private comfort to live more sustainably.

In this way, infrastructures are instrumental in shielding residents from the lower life satisfaction that accompanies lower income and consumption in the general Danish population. Social infrastructures also create regular social interactions, and they free up time for members who are not involved in a specific task and can enjoy a service provided by others. This means that residents have a social life that is richer than average around common meals and other collective activities. They also enjoy more leisure time to do things that appear to be more important for their life satisfaction than income and material consumption. The SSV residents' collective engagement in a sustainable initiative can also contribute in and of itself to a meaningful life and to psychological well-being, which can also lead to a higher life satisfaction, as has been documented elsewhere[34,42,43].

Ours results show that a lower carbon footprint can go hand-in-hand with a higher life satisfaction. The SSV and other intentional communities or environmental grassroots collective initiatives[34,44–46] seem to support the degrowth argument that another, better, and happier world is possible with lower levels of consumption and resource exploitation.

Discussion

Based on the above results, we suggest that the lower carbon footprint found in the SSV is the result of different physical and social infrastructures. The different aspects of these infrastructures are worth discussing here, which enriches our understanding of them.

Firstly, social and physical infrastructures are interdependent. Communal land, buildings, machines, furniture, and cars are all crucial to the community and help explain the lower carbon footprint of its residents. But these physical infrastructures require collective management, i.e., social infrastructures that often take the form of working groups that organise community aspects relating to maintenance, responsibility, labour, or economy. A good physical infrastructure requires a well-functioning social infrastructure because 'When the social infrastructure breaks down, so does the physical'[22].

Secondly, both physical and social infrastructures are constantly in the making. While some infrastructures laid the foundation of the SSV from the very beginning, others have been under continuous construction over the years and are the result of striking a pragmatic balance between ambitious values and considerations of the reasonability of practice[47]. This continuous process is in line with Tim Ingold's theory of *dwelling*. Tim Ingold[48] postulates that people everywhere are not just passively adapting to previously existing environment, nor are they creating their environment out of their imagination. Rather, they are shaping their environment by dwelling in it

and engaging actively with it, which is a continuous process. This is also a never-ending process: Physical and social infrastructures are always in the making.

Thirdly, an important aspect of the social infrastructure is the specialisation of working groups. Each adult in the SSV participates in 2 or 3 working groups that specialise in one aspect of community organisation (waste sorting, bees, shared cars, compost, food supply, vegetables, poultry farming, communal building, cattle, etc.). Members of a working group dedicate their time to make each group work and are committed to applying the sustainable values principles of the eco-community. In the general Danish population individuals make choices regarding all aspects of consumption – which prevents them from dealing in depth with any of them. People in the SSV only work with a limited number of issues, which means that they have time to delve in depth into each issue and make the most sustainable choices for the entire community. The result is that the choices made collectively by the community through its different working groups are much more sustainable than the choices that might be made by each individual working alone. And because the decisions made by the different working groups apply to all members of the community, residents end up following a more sustainable trajectory without thinking much about it and without feeling that they are making a personal sacrifice.

A crucial point in the development of infrastructures conducive to lower carbon footprint is that sustainability must be an explicit goal of the community, which is certainly the case for the SSV (as stated in its very name). Sustainability is a determining factor when working groups make decisions that apply collectively to other residents, even though compromises might be made regarding cost and efficiency. Sustainable ideals can also lead to a lower carbon footprint independently of infrastructures, such as by spreading a kind of 'flygskam' (flight shame) to discourage plane travel or by giving high value and social recognition of do-it-yourself solutions made out of recycled material rather than prioritising high-tech solutions. The role that infrastructures can play in the green transition depends on the core values guiding their design and management.

Our research shows that the residents of the SSV have a carbon footprint that is 60% below the Danish national average, and enjoy a higher life satisfaction. We explain this by the existence of physical and social infrastructures that are conducive to more sustainable practices and a richer social life. Our paper contributes to the understanding of the role played by infrastructures in the sustainable transition by showing that social infrastructures are indispensable for the good working of physical infrastructures and are the result of collective choices that lead to more sustainable lifestyles. Sustainable practices are not seen as deriving from conscious individual efforts to live more sustainably. They are perceived instead as a by-product of a strong collective engagement in making the social and physical infrastructures work, which explains why a lower carbon footprint and material consumption can go hand-in-hand with higher life satisfaction. Our research demonstrates that the members of this eco-community, by collectively creating and managing their community's physical and social infrastructures, have found a way to drastically reduce their carbon footprint while at the same time enhancing their life satisfaction.

Methods

General approach

This paper builds on research and reflections produced in the COMPASS research project (Collective Movements and Pathways to Sustainable Societies) in which both authors participated (http://compass.ku.dk). This project was financed by the Velux Foundation and was based on a close collaboration between academic researchers from Copenhagen University and practitioners from different green communities. Its objective was to study the influence of collective action within green communities on environmental behaviour and social norms. This article focuses specifically on the SSV because this green community reported the lowest carbon footprint in our quantitative survey (see below). The data used in this article come from qualitative and quantitative methods.

Quantitative data

The questionnaire survey comparing members of green communities and the general Danish population estimates the carbon footprint of each respondent. Following the calculation method suggested by www.carbonindependent.org, we quantified the carbon footprint of energy (yearly consumption of electricity and heating), transport (kilometres driven in trains, buses, or private cars and hours travelled in planes and on ferries), and food (percentage of meat-free, fresh, organic, and seasonal food). We added a fourth category for other items that reflect people's daily lives and activities, i.e., the amount of money spent yearly on clothes, electronics, furniture, hobbies/sports, restaurants/hotels, medicines/cosmetics, and bottled drinks/cigarettes. Each kilowatt hour (kWh) of electricity or of heating from a specific energy source, each kilometre on a bus or train, each litre of fuel consumed in a private car (weighted by the percentage of car travel made alone or shared with other passengers), each hour spent on an airplane, each answer on food habits or on the consumption of clothes, electronic, or another category was then given a specific carbon footprint found either on carbonindependent.org or from a variety of official Danish sources such as the Danish Energy Agency, Statistics Denmark or HOFOR (a major Danish energy supplier).

The total carbon footprint derived from this survey is based on self-reported consumption, and the survey rests on the assumption that people are able to estimate their annual consumption. When respondents did not know their yearly consumption of electricity or heating energy, we made an estimate based on their housing size, the number of people in the household, and their self-reported efforts to save on energy. We recognise the limitations of this approach, but it was the best option available given the limited time and resources of our project. The most important point here is that the same method was used for measuring the carbon footprint of both average Danes and members of green communities.

We have chosen in our survey to focus exclusively on aspects of daily consumption that people control and can choose to reduce as individuals. The incompressible carbon footprint of the national infrastructure of hospitals, schools, army, education, and so on, is not included in our research, except for the road infrastructure, which we have included in our calculation of the car-related carbon footprint.

The questionnaire was administered online in May 2019 by YouGov to 1018 representative Danish respondents and to 258 respondents purposefully chosen because of their participation in green communities such as food cooperatives and eco-communities. A total of 16 of the 258 respondents were residents of the SSV, which constitutes 72% of the 22 households living in that specific community. Given the wealth of different ways to calculate carbon footprint[49] and the limitations of our methods (see above), we cannot directly compare our results with those of other studies that use different calculation methods. Instead, we compare the carbon footprint of the 16 SSV respondents with the average calculated from the 1018 representative Danish respondents. While some studies have tried to estimate the carbon footprint of eco-communities and have concluded that their residents enjoy significantly lower carbon footprints than the national average[24,27], few studies have compared, as ours does, the carbon footprint of an eco-community to a national baseline calculated with the same method.

The results and correlations of the quantitative surveys are explained by insights that originate in qualitative methods. The first author of this paper visited the SSV four times to conduct three interviews with residents, to test and collect data for the survey, and to organise one of the research meetings of the COMPASS project taking place in the community.

Qualitative data

The second author is one of the first residents of the SSV and lived in the community for 12 years. She and her husband moved there and lived in a mobile home with their first son in 2007, just a few years after the first residents had begun to establish the SSV. Over the next five years, the couple built their straw bale house by themselves. When the house was completed in 2012, the family, now with two more sons, moved into their new home.

Throughout her years of residency in the SSV, which can be seen as long-term participant observation, the second author took part in the community's working groups, cultivated crops, prepared collective meals, fed and milked cows and conducted monthly tours of visitors who came to experience the eco-community. She is also a former board member of LØS, the national association of eco-communities in Denmark. In addition, she has run a company called 'Sustainable Everyday', in which she used her reflections on daily life in eco-communities to promote and spread this model. Her many years of engagement in building and managing the SSV and facilitating the spread of eco-communities in Denmark has provided her with first-hand knowledge of the daily organisation of eco-communities.

The importance of social infrastructure as an analytical focus emerged from the authors' discussions with the COMPASS project's team of researchers over the course of three years[15,50,51]. Quantitative results were produced at the end of the project and were interpreted in this pre-existing analytical frame. This paper explains these quantitative results by describing how the design and management of infrastructures in the community influence transport, the consumption of energy, food, or other material goods, as well as life satisfaction.

Data availability

The quantitative data that support the findings of this study are available in the Open Science Framework (OSF) at https://osf.io/8g6pd, reference number 8g6pd.

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Author contributions

The first author has mainly contributed with the collection and analysis of quantitative data, while the second author has mainly contributed with the collection and analysis of qualitative data. Both authors have contributed equally on the structure and argument of the paper. All authors read and approved the final manuscript.

Competing interests

The authors declare no competing interests.

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