189TH ANNUAL PACIFIC-RIM REAL ESTATE SOCIETY CONFERENCE

MELBOURNE AUSTRALIA, 13-16 JANUARY 2013

URBAN DENSITY AND LOCAL SUSTAINABILITY – A CASE STUDY IN FINLAND

EEVA SÄYNÄJOKI[1], JUKKA HEINONEN and SEPPO JUNNILA

Aalto University

ABSTRACT

According to the United Nations, cities are responsible for 75% of all energy consumption and for 80% of all greenhouse gas emissions globally. Urban planning and land use policies therefore play a major role in the mitigation of climate change. High urban density is often promoted as a sustainable land use policy. However, the environmental and social sustainability of dense urban structures can be challenged. Even though higher urban density may correlate with the increased carbon-efficiency of transportation and housing services, recent research has demonstrated that, in several cases, urban density is not a valid indicator for overall carbon-efficiency, let alone sustainability. The purpose of this study is to examine the extent to which local objectives for environmental and social sustainability can be achieved through the promotion of urban density in a predominantly rural case area. The analysis is conducted as a case study, where qualitative case-specific data is collected mainly from public proceedings. Quantitative data from multiple past case studies, some of which is case-specific, is used for carbon footprint calculations. The main finding of the study is that even though higher urban density is promoted in the case area as an environmentally-, socially- and economically sustainable use of land, increases in construction and consumption are actually likely to water down the potential carbon-efficiency gains. It is also found that the area's policies in pursuit of increased urban density have had negative social impacts.

Keywords: land economics, urban density, carbon footprint, sustainability aims, urban planning and land use policies.

INTRODUCTION

According to the United Nations, cities are responsible for 75% of all energy consumption and for 80% of all greenhouse gas (GHG) emissions globally. Given this, urban planning plays a major role in the mitigation of climate change (Ash et al. 2008). Where urban planning is used to promote economical, social and environmental sustainability, higher urban density is often seen as an effective land-use strategy (e.g. VandeWeghe and Kennedy 2007; Fields 2009). In regions that require space heating for part of the year, high-density residential areas with high-density buildings have an inherent advantage of lower energy use, in that they have a reduced area of external wall and less indoor space per person (Satterthwaite 2011). In addition, conventional wisdom holds that dense cities have great potential for limiting the use of motor vehicles and their associated GHG emissions (e.g. Ewing and Cervero 2010; Satterthwaite 2011). Thus there seems to be remarkable potential to reduce the carbon footprints of the many millions people moving to cities for the first time, who are able to live in well-built, energy-efficient apartments, with efficient appliances, that are well served by public transport (Satterthwaite 2011).

However, the environmental sustainability of high urban density can be challenged. Although higher urban density may correlate with the increased carbon-efficiency of transportation and housing services, consumption-centred lifestyles in the cities tend to repeal the benefits achieved. Recent research has demonstrated that, in several cases, management and planning strategies that aim to increase urban density seem to counteract environmental objectives for regional GHG emission reductions (Heinonen 2012). Cities and towns can be regarded as the demand and consumption centres of the global economy, and also as the hot spots of waste generation (Ramaswami et al. 2008; Grimm et al. 2008). Satterthwaite (2011) sums up that "in terms of future worries about resource constraints and GHG emissions, it is not the growth in population but the growth in consumption that is the primary concern".

When it comes to social sustainability, high urban density is not necessarily something that is desirable to populations. Dense urban structures do for example worsen the negative impacts of particle emissions on human health (Tainio et al. 2009; Apte et al. 2012). According to Bramley and Power (2009), compact urban areas worsen neighbourhood problems and dissatisfaction, despite improving access to services. In addition, a study by McCulloch (2012) shows a negative relationship between housing density and neighbourhood satisfaction that is largely independent of individual and household characteristics. Families with young children especially would prefer to live in neighbourhoods with lower housing densities (McCulloch, 2012). According to Vallance et al. (2005), density-centred urban planning is not

[1] eeva.saynajoki@aalto.fi, Aalto University School of Engineering, P.O. Box 11200, 00076 AALTO, Finland

always well received by local residents and can have unintended effects on everyday life and the symbolism of places and spaces.

Furthermore, authors such as Bloom et al. (2008) have challenged the notion that urbanisation fuels economic growth. It could also be the case that the application of a generic planning strategy to differing areas and regions does not always have the desired effects, given the unique characteristics of individual locations – be this in pursuit of environmental-, social- or economic sustainability or otherwise. Nevertheless, according to Roose et al. (2013), whose study addresses land use changes in the suburban zone of a mid-sized Estonian city, master planning is essential in order to preserve planning and construction rights for the future. Liberal land policies and loose planning controls may result in patchy and scattered suburban land allocations, characterized by vast discontinuity (Roose et al. 2013). It has been found recently that population density is not a primary determinant of vehicular travel once other variables, such as accessibility of destinations, transit and street network design, intersection density, and land use diversity, are controlled (Ewing and Cervero 2010).

The purpose of this study is to examine the extent to which local objectives for environmental and social sustainability have been and can be achieved through the promotion of urban density in a predominantly rural case area, located in Finland. The analysis is conducted as a case study, where case-specific data is collected from public proceedings and from earlier scientific publications. Firstly, we attempt to clarify the sustainability objectives that the administration of the case area is trying to achieve in their promotion of high urban density. Secondly, we investigate the potential effects of a higher level of urban density on the total carbon footprint of the case area. Finally, we assess the social impacts that density-centred urban planning has on the inhabitants of the case area.

The main finding of the study is that even though high urban density is promoted as an environmentally-, socially- and economically sustainable use of land, increases in construction and in the consumption habits of the area's inhabitants are actually likely to water down the carbon-efficiency gains that could possibly be achieved in the case area through density-centred policies. It is also found that the area's strategy of pursuing increased urban density has had negative social impacts. The paper is structured as follows: Chapter 2 introduces the research methods and the study design. Chapter 3 presents the findings that are discussed in Chapter 4. Finally, Chapter 5 concludes the paper.

METHODS AND STUDY DESIGN

A case study was conducted to examine the extent to which local objectives for environmental- and social sustainability can be achieved by targeting increased urban density in the Finnish municipality of Ylöjärvi, located just West of Tampere in Western Finland and consisting mainly of rural areas. Firstly, we conducted a brief review of official reports to understand the principal sustainability aims of the case area's land use strategy. Secondly, the relationships between urban density and regional carbon footprint were examined quantitatively. The per capita annual carbon footprint of the case area was compared to those of other areas and of other area types. Finally, we conducted a brief investigation into how the density-centred urban planning and land use policies could affect rural lifestyles in the area. The qualitative, case-specific data was collected mainly from public proceedings, while the quantitative data, part of which was case-specific, was taken from multiple past case studies.

Case Area Ylöjärvi, Finland

The Finnish municipality of Ylöjärvi was founded in 1869 and became a town in 2004. The municipality has a population of 31,000 and covers an area of 1,300km^2, of which 200km^2 consists of lakes and other bodies of water. The area has a population density of 28 inhabitants/km^2. Between 2007 and 2009 Ylöjärvi was merged with two surrounding rural municipalities – first with Viljakkala and then with Kuru. The area was selected as a case study because of its geographic diversity and because of its location. It is one of the fastest growing towns in Finland and consists not only of urban areas but also of rural landscape, multiple large lakes, and other natural areas, and is in fact one of the biggest towns in Finland in terms of area. Ylöjärvi is located in Western Finland and geographically is almost as equidistant from all of Finland's ten biggest cities as possible. The closest city Tampere is naturally the main commuting area for the inhabitants of Ylöjärvi.

Case Analysis of Urban Density, Carbon Footprint and Social Impacts

Firstly, two case-specific documents were analysed to understand the principal aims of the area's land use strategy. The *Operational Environment Analysis of Ylöjärvi* (Kirmula 2010) discusses the current circumstances and the future expectations of the town, and the *Town Strategy of Ylöjärvi* (City Council of Ylöjärvi 2010) consists of the reasoning, the aims and the execution of the town strategy. These two documents were the combined information source for identifying the aims and the forthcoming execution of the density-centred urban planning and land use policies in Ylöjärvi.

Secondly, quantitative data from multiple past case studies was used to examine the relationships between urban density and carbon footprint of the case area. The carbon footprint data examined in this paper was taken from three previously published studies (Heinonen et al. 2011; Heinonen and Junnila 2011a, 2011b). On top of this literature review, a new analysis was conducted to examine the results of the earlier studies in the context of promoting urban density in a predominantly rural case area. All quantitative data from these past studies has been generated using a single streamlined input-output-based hybrid life cycle assessment (LCA) model, which allocates the GHG emissions of all production and supply chains to the consumer or end user of each utility, regardless of the geographic occurrence of the emissions. The primary source for the statistical input data used for the calculations has been the most recent Finnish consumer survey (Statistics Finland 2007).

In order to provide a rough guideline for the relationships between urban density, lifestyles and regional carbon footprint, Finland was divided into three levels of urbanisation. A classification of the whole country into three area types and the related total carbon footprint calculations has already been published in a previous study (Heinonen and Junnila 2011a), and this data was used for our analysis. Municipalities with a population of less than 15,000 and where less than 60% of inhabitants live in urban areas, or where population is less than 4,000 and where 60–90% of the inhabitants live in urban areas, were categorized as rural areas. Municipalities with a population of between 4,000 and 15,000 and where 60–90% of the inhabitants live in urban areas were categorized as semi-urban areas. Municipalities with a population in excess of 15,000 or where more than 90% of the inhabitants live in urban areas were categorized as cities. The case area examined in the second past study (Heinonen and Junnila 2011b), from which the case-specific carbon footprint data was taken, was extended to incorporate the nearby rural towns of Kangasala, Orivesi and Vesilahti in order to achieve a sufficient sample size of statistical input data.

The average carbon footprint of an inhabitant of the extended case area was compared to the average carbon footprint of an inhabitant of each of the three types of area categorisations in Finland. Furthermore, to estimate the impact of a higher level of urbanisation on the carbon emissions of the case area, the extended case area was compared (in the context of an average consumption-based carbon footprint of an inhabitant) to three other areas of increasingly higher urban density than Ylöjärvi: the city of Tampere, which is located next to Ylöjärvi and is the third biggest city in Finland; the Helsinki metropolitan area, which is considered to be the only real metropolitan area in Finland; and Helsinki downtown core, which is the densest area in Finland. The population density in the city of Tampere is 340 inhabitants per km^2, in the Helsinki metropolitan area is 1,400 inhabitants per km^2, and in the Helsinki downtown core is 10,000 inhabitants per km^2. The carbon footprint data for the analysis, as mentioned previously, were taken from three previously published studies (Heinonen et al. 2011; Heinonen and Junnila 2011a, 2011b).

Finally, four case-specific documents were analysed to qualitatively examine how the density-centred urban planning and land use policies affect rural lifestyles in the case area: the *Report of the Common Volition of the Rural Villages in Kuru 2010-2012* (SVYE 2010), a study on the impacts of rural-urban municipality consolidations in Finland by a researcher from the University of Vaasa (Leinamo 2010), the *Consolidation Contract of Ylöjärvi and Kuru* (Municipalities of Ylöjärvi and Kuru 2007), and the *Report of the Impacts of the Considered Consolidation of Kuru with Ylöjärvi* (Elomaa et al. 2007).

FINDINGS

The main finding of the study is that even though higher urban density is promoted as an environmentally-, socially- and economically sustainable use of land, increases in construction and consumption are actually likely to water down the carbon-efficiency gains that could possibly be achieved in the case area by density-centred policies. It is also found that the area's strategy of pursuing increased urban density has had negative social impacts. The results of the case analysis are introduced in more detail below.

Land Use Strategy

According to the *Operational Environment Analysis of Ylöjärvi*, people, jobs and economic life will be concentrated around just a few dense areas in the future and municipalities will increasingly fall into two distinct categories: "healthy winners" and "regressive losers". In the municipality of Ylöjärvi, *increased land-use control*, *improved town centres* and *higher urban density* are three of the nine main urban planning objectives, along with *balance of growth*, *preparedness for population growth, construction of diverse apartments, support for economic growth, new ways of transportation*, and *improved services across municipality boundaries*. Housing will be concentrated around the town centre and close to the railway and public transport will be improved in these areas. In rural areas with high environmental value and natural beauty, "precautionary measures" will be taken. (Kirmula 2010)

According to the *Town Strategy of Ylöjärvi*, the three main aims of urban planning and land use policies in the area are (1) to promote balanced growth, supported by higher urban density; (2) to ensure the satisfaction of the inhabitants,

strengthened by diverse and high-quality housing and (3) to ensure a clean and diverse natural environment as a resource for the town. Between them, these objectives are targeting (1) economic sustainability, (2) social sustainability and (3) environmental sustainability. The reduction of regional GHG emissions (specifically the *Climate Strategy of Greater Tampere Area*) is also named as one of the key factors in directing land use and planning within the municipality (City Council of Ylöjärvi 2010).

Urban Density and Carbon Footprint

The average annual carbon footprint of an inhabitant of the extended case area was found to be approximately the same as an inhabitant of the city of Tampere or a general inhabitant of a city in Finland. However, people living in the extended case area were found on average to have a larger annual carbon footprint than an average citizen of Finland or an average inhabitant of a semi-urban area in Finland – and to be responsible of a remarkably larger share of annual GHG emissions than an average inhabitant of a rural area in Finland. Rather surprisingly, an average inhabitant of the Helsinki metropolitan area, where the population density is remarkably higher than in Tampere or Ylöjärvi, was found to have a far larger carbon footprint than the people living in Ylöjärvi and Tampere. Furthermore, inhabitants of Helsinki downtown core, which is the densest area in Finland, were found to have the largest annual carbon footprint of all. The results of the analysis are presented in more detail in Table 1.

Table 1: Carbon footprints

Area		Population	Density (per km^2)	Private consumption (annual per capita / €)	Carbon footprint (annual per capita)	Distribution of carbon footprint		
						Housing	Transport	Personal
1	Helsinki downtown core	165,000	10,000	20,200	14.7 t CO_2e [1)]	6.3 t	1.6 t	6.8 t
2	Helsinki metropolitan area	930,000	1,400	17,600	12.5 t CO_2e [2)]	6.6 t	1.6 t	4.3 t
3	**Extended case area**	**69,000**	**20**	**13,800**	**11.1 t CO_2e** [3)]	**6.5 t**	**1.9 t**	**2.7 t**
4	Tampere	206,000	340	15,000	10.9 t CO_2e [3)]	5.5 t	1.9 t	3.5 t
5	Cities in Finland	3,210,000	–	15,200	10.9 t CO_2e [2)]	5.9 t	1.8 t	3.2 t
6	Finland	5,400,000	20	14,300	10.2 t CO_2e [3)]	5.4 t	1.8 t	3.0 t
7	Semi-urban areas in Finland	860,000	–	13,800	9.9 t CO_2e [2)]	5.2 t	2.1 t	2.6 t
8	Rural areas in Finland	1,120,000	–	12,200	9.0 t CO_2e [2)]	4.7 t	2.1 t	2.2 t

1) Source: (Heinonen et al. 2011).
2) Source: (Heinonen and Junnila 2011a).
3) Source: (Heinonen and Junnila 2011b).

As well as presenting the total annual carbon footprints of an average inhabitant of various areas, Table 2 shows the distribution of the consumption-based carbon footprints across (1) housing, (2) transport, and (3) personal consumption. Here, "housing" refers not only to emissions relating to the construction of buildings but also to heating, electricity, furniture, appliances, and all maintenance services (e.g. cleaning, water supply and waste management). Similarly, the term "transport" refers to all ground transportation, including the construction of infrastructure, the manufacture of vehicles, all the maintenance operations, and the use of fuels. The term "personal consumption" is taken to exclude any personal expenditure related to housing or to ground transportation and includes all other expenditure on goods and services.

In the extended case area, the annual GHG emissions of housing per capita are remarkably high. Rather surprisingly, higher urban density in general seems to be associated with higher carbon emissions in the 'housing' category. The annual housing-related GHG emissions per capita in the extended case area could be decreased by 2.1 tonnes of carbon dioxide equivalents (t CO_2e) if they were to be reduced to the level of rural areas in Finland. Given that the emissions allocated to housing include the carbon footprint of new construction, higher rates of construction in denser areas could explain this association. Even if new buildings are more energy-efficient than older ones in the use phase, the efficiency gains in heating and electricity consumption cannot compensate for the annual emissions of new construction (Säynäjoki et al. 2012). Therefore, the most efficient policy in reducing the GHG emissions of housing seems to be the maximal utilisation of all existing buildings and infrastructure.

In areas with a high population density, the transport category represents a slightly lighter annual GHG emissions load than in the rural and semi-urban areas. The annual transport-related carbon emissions per capita in the extended case area would fall by 0.3 t CO_2e if they were reduced to the same level of per capita emissions as in the Helsinki downtown core. Even if higher urban density encourages people to walk, to ride bicycles, and to use public transportation, ownership of a car is normal, even for inhabitants of the densest cities in Finland. People living in the Finnish cities often own a second home or a summer cottage in the countryside, so even if high urban density encourages inhabitants to drive less in denser areas, increased emissions of city driving (per km) combined with long journeys for weekend and holiday trips associated with the Finnish lifestyle seem to decrease the benefits of higher urban density. Thus, there does seem to be some potential for reducing carbon emissions attributed to ground

transportation by promoting urban density, but this potential is relatively small (especially when compared to the potential benefits of reducing housing-related emissions by discouraging new construction).

In the extended case area, GHG emissions attributed to the personal consumption category were found to be remarkably small when compared to those in more urban areas. According to Table 1, higher urban density in general seems to be strongly associated with higher GHG emissions relating to personal consumption. Higher incomes and higher purchasing power per capita in denser areas could provide some explanation for this, but the easy accessibility of shopping malls, shopping streets, and other facilities may also encourage more consumption-centred lifestyles in the areas of high urban density. In the hypothetical scenario in which personal consumption in the case area were to rise to the same level as within the Helsinki downtown, core the annual per capita carbon emissions relating to personal consumption would increase by a massive 4.1 t CO_2e. Our analysis indicates that promoting higher urban density as an environmental land-use strategy in rural areas carries a risk of encouraging environmentally unsustainable, consumption-centred behaviour, so, far from helping facilitate sustainability improvements in this area, density-centred carbon mitigation strategies are actually likely to do more harm than good when it comes to personal consumption.

Nevertheless, a carbon footprint comparison of the extended case area to the city of Tampere, the closest city to Ylöjärvi, estimates that even if higher urban density may increase private consumption in the area, reductions in other emissions categories are likely to offset this. According to Table 1, the population density in Tampere is 17 times that of the case area. Annual private consumption per capita is 9% higher in Tampere than in the case area, but Tampere's overall per capita carbon footprint per capita is 2% lower. Therefore, if the case area were to be developed in such a way that the urban structures, the related lifestyles, and the volumes of new construction became similar to those in Tampere, both higher urban density and higher private consumption could be achieved with no net increase in regional carbon footprint. In this scenario, the annual GHG emissions of housing per capita would fall by approximately the same amount as personal consumption related emissions would rise, thereby resulting in net effect of close to zero.

Social Impacts

As well as assessing the environmental impacts of a land-use strategy that promotes urban density, we found it important to consider the associated social impacts. The results of a brief investigation indicate that the rural population in the case area has been negatively impacted by new policies resulting from the pursuit of such a strategy in Ylöjärvi.

According to Leinamo (2010), the anticipated social benefits for the municipalities of Kuru and Viljakkala of their amalgamation with Ylöjärvi have not materialised. Inhabitants of rural villages in Kuru are concerned about the increased land-use control and housing restrictions in rural areas – new policies in Ylöjärvi seem to limit inhabitants' rights to choose where they want to live. The inhabitants of these rural villages organised a public workshop for the discussion of these concerns and for the preparation of a written statement, but the City Council of Ylöjärvi ignored the statement in the land-use framework negotiations for the greater Tampere area (SVYE 2010).

A condition of the consolidation of Kuru and Ylöjärvi was the closure of three of the four schools in Kuru in pursuit of economic efficiency gains (Municipalities of Ylöjärvi and Kuru 2007). The schools in Ylöjärvi were markedly bigger than those in the rural villages of former Kuru, and the consolidation decreased the municipal costs per schoolchild, with one teacher now responsible for more children (Elomaa et al. 2007). However, it was understood that daily public services would not be moved from Kuru and into central Ylöjärvi. The three schools were closed at the end of the 2009–2010 semester but contrary to the contract, the old school buildings were sold and were therefore unable to be utilised as a community resource. In both Kuru and in Viljakkala, services (in particular healthcare in Viljakkala) have deteriorated following the consolidation (Leinamo 2010).

DISCUSSION

The purpose of this study was to examine the extent to which local objectives for environmental- and social sustainability can be achieved through the promotion of urban density in a predominantly rural case area. It is clear that the land use strategy of the case area, Ylöjärvi, is to promote urban density and to concentrate people, services and economic life in areas around the town centre and close to the railway. This strategy of high urban density aims to achieve economic-, social- and environmental goals. The results of the carbon footprint analysis indicate that both higher urban density (that can be associated with economic savings) and higher private consumption (that can be associated with higher quality of life) could be achieved in the case area without any net increase in annual per capita GHG emissions. This is exhibited by Tampere, the closest city to the case area, where urban density and private consumption are higher, but the overall regional carbon footprint is slightly smaller than that of Ylöjärvi.

However, rather surprisingly, it was found that the potential of a high urban density strategy to reduce carbon emissions attributed to ground transportation is small and that given the high carbon intensity and long carbon payback times of

new construction (Säynäjoki et al. 2012), higher urban density in general is actually associated with higher carbon emissions in the 'housing' category. The findings of the carbon footprint analysis also estimate that promoting denser structures in municipalities that consist predominantly of rural areas carries a risk of encouraging unsustainable, consumption-centred lifestyles. Therefore, increases in construction and in consumption are actually likely to water down the carbon-efficiency gains that could possibly be achieved in the case area by density-centred policies. Finally, rural lifestyles were found to be on the whole less carbon-intensive than urban lifestyles. For example in the downtown core of Helsinki, the capital of Finland, the annual per capita carbon footprint is more than 30% higher than that of the case area, with per capita GHG emissions relating to lifestyles and personal consumption more than 150% higher than in the case area.

It was found to be a strong belief in Ylöjärvi that in the future people, jobs and economic life will concentrate in a few dense areas and that each municipality will become either a "healthy winner" or a "regressive loser". If this development is supported on a national level and if populations are encouraged to abandon the countryside of Finland, there will most likely be need for massive construction of houses and infrastructure in the cities. Nevertheless, the findings of the carbon footprint analysis suggest that it would be highly important to utilise all existing housing units and infrastructure not only in cities but also in the countryside. From the environmental point of view, concentrating people, services and economic life into towns and cities could be seen as a waste of housing stock and infrastructure in the countryside and as an unnecessary creator of demand for new construction in cities, an activity that is associated with massive greenhouse gas emissions (Säynäjoki et al. 2012). In addition to that, according to McCulloch (2012) especially families with young children would prefer to live in neighbourhoods with lower housing densities.

In Ylöjärvi, the inhabitants of the rural areas were found to be concerned about increased local land-use control and housing restrictions, as these seem to limit the inhabitants' rights to choose where they want to live. The reported deterioration of services (in particular healthcare) in the rural areas may also, unintentionally or purposefully, push people into the denser town area. In countries like Finland, many families living in cities own a second home or a summer cottage – often a relatively spacious detached house in the countryside that might even be heated all year round. Encouraging increased utilisation of these rural properties and promoting full-time rural lifestyles would reduce the need for new construction in cities, freeing up apartments for those who prefer city dwelling. Despite a possible increase in the use of private vehicles, the environmental benefits of the efficient use of the existing housing stock and of the possible changes towards less consumption-centred lifestyles could be significant. This alternative sustainability strategy to the promotion of urban density could be promoted by reduced working hours and improving possibilities to work from home. This could not only encourage some people to move permanently from their city apartments to their second homes in the countryside, but also support increased overall employment. If increased rural habitation were to occur, the tax contributions and daily consumption behaviour of increased rural populations could support services and create jobs in rural and semi-rural areas, further increasing rural quality of life and providing further incentive for migration to rural areas.

According to Satterthwaite (2011), cities concentrate so much of what contributes to high quality life that people living in cities can entertain themselves without implying high material consumption levels (and thus high GHG emissions). However, cities tend to offer also more possibilities for shopping and consumption than rural environments typically do. This study has shown increased lifestyle-related personal consumption to be one of the biggest threats to local environmental sustainability and to be strongly associated with high urban density. Therefore, the potential to reduce regional carbon footprints through the promotion of urban density can be seen as largely limited, specifically because of the associated changes in consumption habits and lifestyle sustainability. Furthermore, the potential to reduce GHG emissions of ground transportation in predominantly rural areas by promoting urban density was found to be relatively small. Given this, and given the uncertainties with the benefits of high urban density discussed above, alternative approaches to tackling sustainability, such as technical improvements and strong political support for environmental innovations in the vehicle market, for example next-generation hybrid cars, or innovative transit and street network design solutions might be a more effective and more sustainable attempt to reduce the carbon emissions of ground transportation (Quill 2008; Ewing and Cervero 2010).

We argue that sustainable lifestyles can potentially be created not only within dense urban structures but also in the countryside. Instead of applying a generic planning strategy to differing areas, it is important to categorise regions into certain types, each with different sustainability characteristics, and to tackle sustainability challenges in these region types differently. For example, small but relatively dense rural villages that are well served by regional public transport and consist of energy-efficient, renovated buildings (i.e. not new builds) and good basic services could be carbon-efficient, especially if supplied by local energy production from renewable sources. This study agrees with Satterthwaite's (2011) statement that "It is not cities or urbanization but high consumption lifestyles that underpin unsustainable or potentially unsustainable levels of resource use, waste and greenhouse gas emissions – whether or not those who have such lifestyles live in cities or other urban centres or rural areas. It is the resource use and waste

generation implications of income levels and consumption choices that need consideration much more than the proportion of people living in cities."

CONCLUSIONS

Urban planning and land use policies play a major role in both the mitigation of climate change – one of the hottest topics of environmental sustainability – and in affecting the satisfaction of an area's inhabitants, a clear indicator of social sustainability. The results of this study show that the promotion of high urban density as a generic planning strategy to differing areas and regions may not be as beneficial for the environment and for an area's inhabitants as is often thought. The implementation of density-centred land policies in areas that are predominantly rural could result in carbon spikes from increased construction, as well as increased greenhouse gas emissions from personal consumption habits, as shopping for goods and services becomes more readily accessible. On top of this, side effects of these policies such as increased land use control and the centralisation of essential services can result in negative social impacts, especially for those living in rural areas. We argue that, from the environmental point of view, minimising the need for new construction by maintaining and upgrading existing buildings and infrastructure, not only in cities but also in the countryside, is essential. Furthermore, we conclude that sustainable lifestyles can be encouraged not only within dense urban structures but also in the countryside.

REFERENCES

Apte, J., E. Bombrun, J. Marshall and W. Nazaroff (2012) Global Intraurban Intake Fractions for Primary Air Pollutants from Vehicles and Other Distributed Sources. Environmental Science and Technology, 46: 3415-3423.

Bloom, D. E., D. Canning and F. Günther (2008) Urbanization and the Wealth of Nations. Science, 319: 772-775. DOI: 10.1126/science.1153057

Bramley, G. and S. Power (2009) Urban form and social sustainability: the role of density and housing type. Environment and Planning B: Planning and Design, 36 (1): 30-48.

City Council of Ylöjärvi (2010) *Town Strategy of Ylöjärvi* (translated to English). Ylöjärvi 2020 – hyvässä kunnossa: Ylöjärven kaupunkistrategia. December 2010.

Elomaa, A., M. Menlös, V. Hanhilahti, H. Koskinen, R. Lamminen, M. Hursti, M. Kaario, S. Yli-Pihlaja and R. Koskinen (2007) *Report of the Impacts of the Considered Consolidation of Kuru with Ylöjärvi* (translated to English). Kurun – Ylöjärven kuntaliitosselvitys. Raportti ohjausryhmälle. Sivistyspalvelut. April 2007.

Ewing, R. and R. Cervero (2010) Travel and the Built Environment – A Meta-Analysis. Journal of the American Planning Association, 76 (3): 265-294. DOI: 10.1080/01944361003766766

Fields, B. (2009) From Green Dots to Greenways: Planning in the Age of Climate Change in Post-Katrina New Orleans. Journal of Urban Design, 14 (3): 325-344. DOI: 10.1080/13574800903056515

Grimm, N. B., S. H. Faeth, N. E. Golubiewski, C. L. Redman, J. Wu, X. Bai and J. M. Briggs (2008) Global Change and the Ecology of Cities. Science, 319: 756. DOI: 10.1126/science.1150195

Heinonen, J. and S. Junnila (2011a) A Carbon Consumption Comparison of Rural and Urban Lifestyles. Sustainability, 3: 1234-1249. DOI: 10.3390/su3081234

Heinonen, J. and S. Junnila (2011b) Implications of urban structure on carbon consumption in metropolitan areas. Environmental Research Letters, 6: 014018. DOI: 10.1088/1748-9326/6/1/014018

Heinonen, J., R. Kyrö and S. Junnila (2011) Dense downtown living more carbon intense due to higher consumption: a case study of Helsinki. Environmental Research Letters, 6: 034034. DOI: 10.1088/1748-9326/6/3/034034

Heinonen, J. (2012) The Impacts of Urban Structure and the Related Consumption Patterns on the Carbon Emissions of an Average Consumer. Dissertation - Aalto University, Finland. ISSN 1799-4934.

Kirmula, T. (2010) *Operational Environment Analysis of Ylöjärvi* (translated to English). Ylöjärven kaupungin Toimintaympäristöanalyysi. March 2010.

Leinamo, K. (2010) *A study on the impacts of rural-urban municipality consolidations in Finland* (translated to English). Yhdeksän hyvää ja kymmenen kaunista: Vuosina 2001–2009 toteutettujen maaseutu-kaupunki -kuntaliitosten tarkastelua. Levón Institute, University of Vaasa, Finland.

McCulloch, A (2012) Housing Density as a Predictor of Neighbourhood Satisfaction among Families with Young Children in Urban England. Population, Space and Place, 18: 85-99. DOI: 10.1002/psp.650

Municipalities of Ylöjärvi and Kuru (2007) The consolidation contract of Ylöjärvi and Kuru 30.8.2007.

Quill, E. (2008) From Gasoline Alleys to Electric Avenues. Science, 319: 750-751.

Ramaswami, A., T. Hillman, B. Janson, M. Reiner and G. Thomas (2008) A Demand-Centered, Hybrid Life-Cycle Methodology for City-Scale Greenhouse Gas Inventories. Environmental Science & Technology, 42(17): 6455-6461. DOI: 10.1021/es702992q

Roose, A., A. Kull, M. Gauk and T. Tali (2013) Land use policy shocks in the post-communist urban fringe: A case study of Estonia. Land Use Policy, 30: 76-83. DOI: 10.1016/j.landusepol.2012.02.008

Satterthwaite, D. (2011) How urban societies can adapt to resource shortage and climate change. Phil. Trans. R. Soc. A 2011, 369: 1762-1783. DOI: 10.1098/rsta.2010.0350

Statistics Finland (2007) The Finnish Consumer Survey 2006. http://www.stat.fi. Accessed 15 December 2009.

SVYE (2010) *Report of the Common Volition of the Rural Villages in Kuru 2010-2012* (translated to English). Maaseudun kehittämissuunnitelma: Kylien tahtotila 2010-2012. Samassa veneessä yhdessä eteenpäin –hanke.

Säynäjoki, A., J. Heinonen and S. Junnila (2012) A scenario analysis of the life cycle greenhouse gas emissions of a new residential area. Environmental Research Letters, 7: 034037. DOI: 10.1088/1748-9326/7/3/034037

Tainio, M., M. Sofiev, M. Hujo, J. Tuomisto, M. Loh, M. Jantunen, A. Karppinen, L. Kangas, N. Karvosenoja, K. Kupiainen, P. Porvari and J. Kukkonen (2009) Evaluation of the European population intake fractions for European and Finnish anthropogenic primary fine particulate matter emissions. Atmospheric Environment, 43, 3052-3059.

Vallance, S., H. C. Perkins and K. Moore (2005) The results of making a city more compact: neighbours' interpretation of urban infill. Environment and Planning B: Planning and Design, 32: 715-733.

VandeWeghe, J. R. and C. Kennedy (2007) A Spatial Analysis of Residential Greenhouse Gas Emissions in the Toronto Census Metropolitan Area. Journal of Industrial Ecology, 11 (2): 133-144. DOI: 10.1162/jie.2007.1220