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Authors: Peter Newman[1], Giles Thomson[1], Ville Helminen[2], Leo Kosonen[2], Emma Terämä[2]
[1]Sustainability Policy (CUSP) Institute, Curtin University, Australia
[2]Finnish Environment Institute (SYKE), Helsinki, Finland

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ABSTRACT

Sustainable cities: how urban fabrics theory can help sustainable development

This paper investigates how influential urban planning is in delivering sustainable cities. We discuss the impact of different urban fabrics – walking, transit and automobile urban fabric - on cities' ecological footprints and demonstrate it via case studies. We show significant advantages in terms of resource efficiency that walking and transit urban fabric offer over automobile fabric when it comes to urban metabolism. The basic raw material demand of walking fabric has the potential to improve urban efficiencies almost thirty times over the conventional automobile urban fabric in the same city. Also, combining urban fabrics with the Finnish national travel survey revealed clear differences in mobility patterns and related CO_2 emissions across urban areas and urban fabrics: walking and transit fabrics support and encourage least carbon intensive modes of mobility. In informal settlements across the globe, with many of the qualities of the walking urban fabric, community cohesion must be safeguarded when considering infrastructure development for effective urban metabolism and supporting the SDG's. The differences in urban metabolism with urban fabric suggest that cities can make major contributions to sustainable development through urban planning and design that respects and regenerates walking and transit urban fabrics. The paper also shows how this approach can assist the emerging regenerative cities agenda.

Keywords: sustainable cities, town planning, SDGs, urban fabrics, regenerative cities

TIIVISTELMÄ

Kestävät kaupungit: kaupunkikudosteorian vaikutus kestävään kehitykseen

Tässä julkaisussa tutkitaan kaupunkisuunnittelun vaikuttavuutta kestävien kaupunkien aikaansaamisessa. Pohdimme tapaustutkimusten kautta eri kaupunkikudosten vaikutuksia kaupunkien ekologiseen jalanjälkeen. Osoitamme, että autokaupunkiin verrattuna jalankulku- ja joukkoliikennekaupungin kudokset ovat resurssitehokkaita ja tällä on merkittävät myönteiset vaikutukset kaupungin metaboliaan. Tapaustutkimusten mukaan jalankulkukaupungin materiaalitehokkuus voi olla jopa kolmikymmenkertainen suhteessa saman kaupungin autokaupungin alueisiin. Samoin Suomen valtakunnallisen liikennetutkimuksen tarkastelu kaupunkikudoksittain osoitti, että kudokset poikkeavat selvästi toisistaan kulkukäyttäytymisen ja hiilidioksidipäästöjen osalta: jalankulku- ja joukkoliikennekaupungin kudokset tukevat ja kannustavat vähähiilisiin kulkutapoihin. Epävirallisella asutuksella, jota on runsaasti eri maiden kaupungeissa, on useita jalankulkukaupungin kudoksen ominaisuuksia. Näiden säilymisestä, erityisesti yhteisöllisyydestä, pitää huolehtia, kun harkitaan alueiden infrastruktuurin kehittämistä ja metabolian parantamista. Kaupunkikudosten metabolioiden erojen tunnistaminen tarjoaa kaupungeille mahdollisuuden merkittävästi vaikuttaa kestävään kehitykseen sellaisella kaupunkisuunnittelulla, joka arvostaa ja uudistaa jalankulku- ja joukkoliikennekaupungin kudoksia. Julkaisussa osoitetaan myös, kuinka tämä menetelmä voi tukea kaupunkien uusiutumista.

Asiasanat: kestävä kaupunki, kaupunkikudokset, SDGt, suunnittelu, uudistuvat kaupungit

SAMMANDRAG

Hållbara städer: hur teorin om stadsvävnader kan påverka hållbar utveckling

Denna artikel undersöker hur effektiv stadsplanering är att leverera hållbara städer. Vi diskuterar effekterna av olika stadsvävnader på städernas ekologiska fotavtryck och demonstrerar det genom fallstudier. Vi visar att, jämfört med bilstaden, är fotgängar- och kollektivtrafiksstaden mer resurseffektiva och det har betydande positiva effekter när det gäller stads metabolism. Enligt fallstudier har fotgängarstaden potential att förbättra stadens materialeffektivitetet nästan trettio gånger jämfört med bilstadsområdena. På liknande sätt visade en översyn av den finska nationella resvaneundersökningen att stadsvävnaderna skiljer sig markant vad gäller resebeteende och koldioxidutsläpp: fotgängar- och kollektivtrafikstaden uppmuntrar till mindre koldioxidintensiva sätt att röra sig. De informella bosättningar över hela världen underhåller många av de kvaliteterna av fotgängarstadsväv. Där måste gemenskapens sammanhållning säkerställas när man överväger infrastrukturutveckling för effektiv stadsmetabolism. Informella bosättningar, som finns i många städer i olika länder, har många fotgängarstadens kännetecken. Framtiden av den här typen av bosättningar, särskilt deras gemenskap, måste tas hand om när man överväger utveckling av infrastrukturen och förbättring av metabolismen i dessa områden. Att identifiera skillnaderna mellan metabolierna i stadsvävnaderna ger städerna möjlighet att bidra betydande till den hållbara utvecklingen. Det sker genom en stadsdesign som värderar och regenererar vävnaderna för fotgängare och kollektivtrafik. I artikeln visas också hur denna strategi kan mera allmänt stöda agendan för regenerativa städer.

Nyckelord: hållbar stad, planering, regenerativa städer, SDGs, stadsvävar

PREFACE

What could be a more timely topic to address than sustainable development and cities! With great pleasure we introduce this cross-cutting analysis with insights into urban planning, material efficiency, ecological footprint and the broad sustainability discourse. It is placed in specific country contexts from the global South as well as the global North, aiding its value in contributing meaningfully on the global scene.

This paper was originally written to support the knowledge gathering process around the 2019 Global Sustainable Development Report (GSDR) of the United Nations as a background report invited by the Independent Group of Scientists (IGS). The writing team consisted of scholars and practitioners from the North as well as the South, combining knowledge and insights around the complex area and the relentless question: What could in fact aid sustainable urban development going forward?

We hope you will be intrigued by the idea of urban fabrics as levering support for systemic change when we strive towards the future of global and local cities in the most sustainable way we can envision.

In Helsinki on Sep 2, 2019

Prof. Eeva Furman
Member of the Independent Group of Scientists (IGS)
Director, Environmental Policy Centre, SYKE

Dr. Emma Terämä
Director, Sustainable Urbanisation Programme, SYKE

CONTENTS

1 Introduction

Sustainable development of cities is fundamentally about the need to reduce the ecological footprint of cities whilst improving their livability. The concept of urban fabrics has developed based on a division of the city by different transport types or schemas (walking, transit, automobile) and can be used to motivate mobility-based zoning, planning and management (Newman et al., 2015). How the urban fabrics should be recognized, respected and regenerated, lies within the core of the practical implementation of sustainable development and environmental footprint reductions in cities. Furthermore, the Extended Metabolism Model first suggested in 1999 functions as a basis for understanding sustainability through material and (human) capital flows in cities (Newman, 1999; Newman & Kenworthy, 1999). As set out in Figure 1, this can now be applied to the three urban fabrics as outlined in this paper. This novel, but hopefully very practical approach could be most helpful in the day-to-day actions of planners and managers in making sustainable development meaningful in cities, where so much growth is now enabling opportunities for change. It also fits the global agenda being set by the UN's Sustainable Development Goals and the New Urban Agenda (2016), as well as fitting the climate change agenda and the emerging agenda of the Planetary Boundaries (Steffen et al. 2011).

The approach using urban fabric theory will be set out in the next section, but it is important to see why the division of cities into their three functional fabrics can offer significant new ways to address the complex issues of sustainable development. Cities can be categorized based on the combination of their urban fabrics (Newman & Kenworthy, 1989) using city level indicators to enable the comparisons of different city regions and motivate change. Adequate categorization should also include the identification of urban fabric areas and their overlaps. Although the city level categorizations are a powerful tool to motivate cities to change their policies, they do not always show how best to start the change towards sustainable development. As will be shown in this paper, to identify urban fabrics provides very clear steps to manage their potential to change, in strategic level planning and decision making alike. Urban fabrics can thus be used as a tool to set goals for the future as they provide: 1) a new way to structure urban form; 2) a way to recognize, respect and amend through planning their obvious shortcomings; 3) approaches to create solutions to tackle car dependency[1]; 4) a holistic viewpoint to assess urban sustainability and urban metabolism; and 5) how to acknowledge differences between cities based on the levels of each urban fabric. Urban fabrics theory does not distinguish between different administrative sectors but provides a good platform for consolidation of goals and planning procedures which are often missing in modernist planning. This paper seeks to pursue each of these perspectives and illustrate them with particular case studies.

In this paper we investigate how urban fabrics can provide pathways to more sustainable urban mobility and metabolism and to show how this can engage all the other key elements of sustainable development. We demonstrate how the urban fabrics have been used in different country contexts and can be related to the metabolism concept in practice. In this way, urban fabrics theory can target a simultaneous reduction in cities' ecological footprint whilst improving urban livability. We utilize the theory of urban fabrics to explain the relationships and to suggest how a city can respond to urban metabolism through new orientation of combined urban and transport planning by urban fabrics in order to contribute more

[1] To tackle car dependency and promote sustainable transport options, there is a need to build the principles of urban fabrics theory into city planning. This is achievable by developing methods and tools that are easy to apply in practical planning situations. The urban fabrics method is applicable to cities worldwide, although exact criteria and city typologies should be modified as appropriate to different cities.

significantly to sustainable development. To highlight possible development pathways we give examples of the links between the urban fabrics and transport/metabolism from urban areas across the globe.

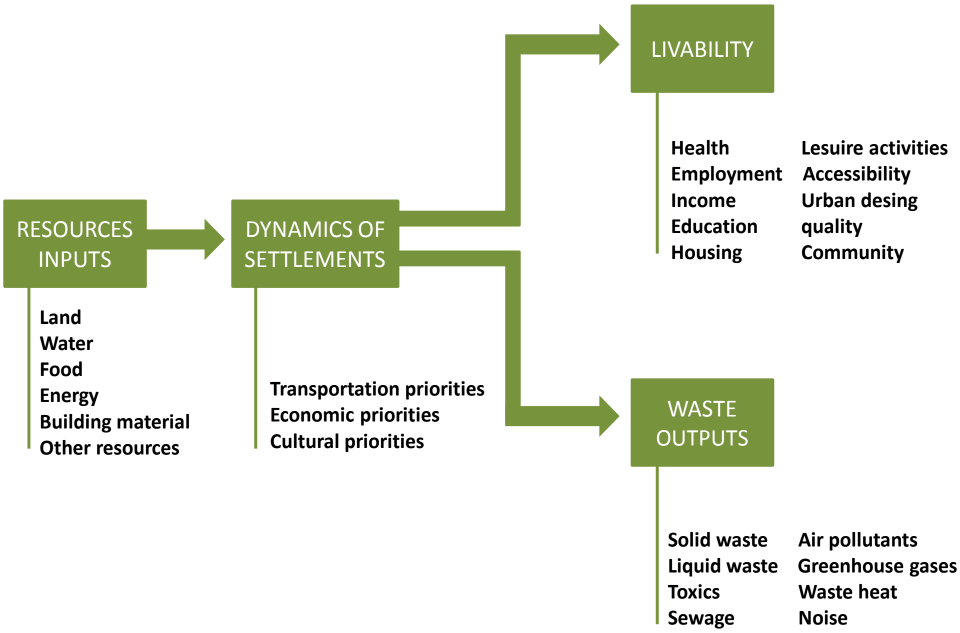

Figure 1. Extended metabolism model of human settlements, modified from Newman (1999)[2].

[2] This diagram shows how conventional approaches to city management just saw the metabolism of a city as a linear process. Much more is now being done to make this a more circular approach as outlined in the paper.

2 Characterizing three urban fabrics

The theory of urban fabrics was developed by Newman, Kenworthy and Kosonen (2015) after Australian researchers (Newman & Kenworthy, 1989; 1999; 2015) came together with Finnish planners and researchers (see e.g. urbanfabrics.fi, and Söderström et al., 2014). The aim of this theory-practice partnership was to help planners recognize, respect and regenerate the three urban fabrics, as opposed to just one as suggested by modernist city planning, and the schema behind that, since the 1940s[3]. The theory of the three urban fabrics within a city enables planners to create strategies for managing different urban areas, and especially to recognize that some urban fabrics have inherently more sustainable properties that need to be optimised and extended to other parts of the city, most probably because they were built in eras before modernist planning began to create highly unsustainable urban forms.

The original typologies of the three city types are set out in Figure 2 (Newman & Kenworthy, 1999). There are three city types from history that form the basis of urban fabric theory: walking cities, transit cities and automobile cities. Most cities today have a mixture of all three urban fabrics. The fundamental problem with 20th century town planning has been the belief that there is only one type of city: the automobile city. The need is to recognize, respect and regenerate each of the urban fabrics, but, as we will show, it is the automobile city that is the most resource consumptive type of urban fabric. The rediscovery of the other city types or fabrics has been a significant factor in the reduction of automobile dependence as a paradigm in town planning and thus focuses our ability to reduce and eventually regenerate urban footprints. The contemporary ‘biking city’ fits into all fabrics, however it largely falls within the realm of the intersection of walking and transit fabrics, and in many ways has replaced old ‘tram fabric’ in cities like Copenhagen. Thus bicycle infrastructure is reinforcing the sustainability of walking and transit fabric but the automobile city fabric remains largely unscathed by bicycle city endeavours as distances/times are too great. There are many signs of the transit city intersecting with automobile city fabric and creating significant potential to create sustainable development outcomes as outlined below.

Walking Cities have existed for most of settlement history since walking, or at best animal-powered transportation, was the only form of transportation available to enable people to get across their cities at walking speeds of around 3-4 km/h. Thus walking cities were dense, mixed-use areas of generally over 100 persons per ha with narrow streets, and were mostly no more than 3 to 4 kilometers across, or roughly 2 km in radius. The most intensive part is within a 1 km radius of some central point such as the main city square or plaza.

Walking cities were the major urban form for about 8,000 years, but substantial parts of old cities retain the character of a walking city, even though today they can be much larger than 4 km in diameter once mixed with intensive transit fabric. Kraców and Venice are, even today, mostly walking cities. In squatter settlements common to many Latin American, African and South Asian urban environments, the urban fabric is usually a walking city with narrow, winding and often unsealed streets suitable only for walking.

[3] For analysis on modernist planning, see e.g. Beauregard, 1991; Fuller & Moore 2017.

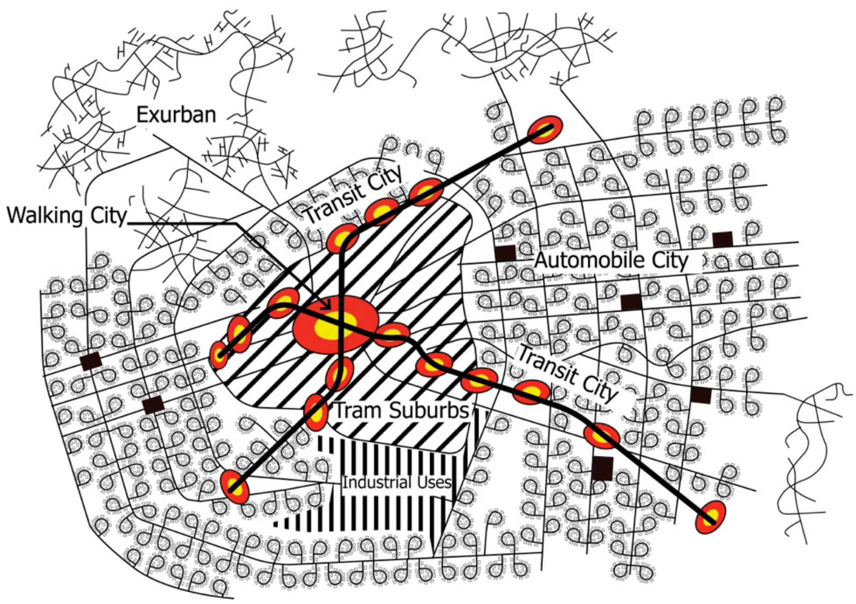

Figure 2. Automobile city, transit city and walking city, a mixture of three city types. Source: Newman & Kenworthy (1999).

Most contemporary cities have central areas that are predominantly walking cities in character, though they struggle to retain the walking urban fabric due to the competing automobile fabric which now overlaps with it. Many cities worldwide are trying to reclaim the fine-grained street patterns associated with walkability in their city centres and they find that they cannot do this unless they respect the qualities of the urban fabric of ancient walking cities (Gehl, 2011). Many modern cities are trying to create new urban centres and want to make them truly walkable but often don't have the tools to do it as modernist planning manuals rarely consider them. The new NACTO manuals are an exception (National Association of City Transportation Officials, 2016).

Transit Cities from about 1850–1950 were based on trains (from 1850 the steam train began to link cities and then became the basis of train-based suburbs) followed by trams (from the 1890's) that extended the old walking city. Both could travel faster than walking – trams at around 10-20 km/h and early trains at around 20 – 40 km/h. Such cities could now spread out forming the inner transit city 10-20 km across (5-10 km radius with an average around 8 km) and with trains forming the outer transit city at a distance of 20-40 kilometers (10-20 km radius).

Trams created linear development (trams, being slower and with closer spacing of stops, led to strips of walking urban fabric) and dense nodal centres along corridors (following faster heavy rail lines with walking urban fabric at stations like pearls along a string). Densities could be reduced to around 50 persons per ha as activities and housing could be spread out further, although they could also be significantly denser than 50 persons per ha. People still needed walking fabric around the stations.

Trains supplemented by buses are, up to this day, the basis of outer transit urban fabric. These can go out much further than the old tram and old subway networks and the fabric is based on corridors of dense sub-centres created by transit with an average speed of around 40 km/h. These developments go out 20 km or more from the city centre, depending on the speed of the trains. Busways and bus rapid transit (BRT) are now doing the same in newer areas of many cities wherever they are freed up from other traffic and Trackless Trams are potentially fitting into this urban fabric in the future (Newman et al, 2019).

Most old European and wealthy Asian cities retain this transit urban fabric, as do the inner cores and corridors even in newer cities that mostly developed in the automobile era. Many developing cities in Asia, Africa, and Latin America have the dense corridor form of a transit city, but they do not always have the transit systems to support them apart from buses stuck in traffic, so they become automobile-saturated or motorcycle saturated. Singapore, Hong Kong and Tokyo have high densities in centres based on mass rail public transit linkages and this dominates their transportation modal split. Many Chinese cities such as Shenzen, have quickly built metros to enable their dense corridors to become more functional. Cities such as Jakarta and Dhaka have grown extremely quickly with dense, mixed use transit urban fabric but the development is based predominantly on buses and paratransit; the resulting congestion shows that their activity intensity can only be properly serviced by mass public transit. Most of these emerging cities are now building the public transit systems that suit their urban form. China and India are building innumerable metro rail systems to support their dense transit urban fabric with significant sustainable development achievements (Newman et al., 2013; Gao & Newman, 2018).

Automobile cities that are looking to create transit options often are without reasonable densities around train stations and are finding that they need to build up the numbers of people and jobs near stations otherwise not enough activity is there to support such transportation options without extensive feeder systems and Park and Ride. Cities in Canada, Australia and parts of the USA are building transit urban fabric and walking urban fabric to support these modes with walk-on transit users (Newman and Kenworthy, 2015). New fast trains can extend the transit city way beyond the previous maximum distance of about 20 km radius and deep into automobile urban fabric (McIntosh et al., 2013). When fast trains averaging 80 km/h are built across big cities then a new kind of polycentric transit city fabric emerges around each of the main stations.

Automobile Cities from the 1950s onward spread beyond the 20 km radius to some 80 km in diameter (up to 40 km radius) in all directions, and at low density because automobiles can average 50-80 km/h while traffic levels are low. These cities spread out in every direction (where physically possible) due to the flexibility of automobiles and with zoning that separated activities.

Where buses were used as a supplementary service to the automobile, there was a missed opportunity to continue creating transit city corridors. Instead, these cities became subservient to automobiles in the new automobile urban fabric thus providing limited public transit, mostly unattractive and infrequent bus services to support their sprawling suburbs. Within a generation such areas became the basis of automobile dependence (Newman & Kenworthy, 1989) and automobility (Urry, 2004). Cities in the world from around 1950 have used their growth to build automobile dependent suburbs as their main urban fabric; it is not surprising that this growth has happened with significant increases in their urban metabolism and are hence the target of much focus for the sustainability agenda.

Many European and Asian cities are now building some suburbs around their old transit urban fabric, though the densities still tend to be higher than in the USA or Australia and access to transit services are often still feasible but distant and require car, bus or bike connections (Nilsson et al., 2014). In Asian cities especially, the use of private automobiles is often supplemented by large numbers of motorcycles that seem particularly to thrive in transit urban fabric due to the shorter distances needed. In cities and parts of cities that are built around the automobile there is a similar need to recognize the urban fabric and respect it for what it contributes to the urban economy just as was suggested above for walking and transit urban fabric. However, there is also a need to see that there are real issues associated with the dominance of such automobile urban fabric, especially where it extinguishes the best features of walking and transit fabric and expands the urban metabolism as well as the ecological footprint.

3 Urban Fabric Elements, Functions and Qualities

In Tables 1 to 4 we have set out the basic features of urban fabrics. They are based mainly on the practical experience of the City of Kuopio, Finland, a small regional city with an historic core and many new auto-based suburbs that needed to be given a new future as well as the older parts of the city needed to be respected and regenerated. Over the past 20 years the city planners applied the theory of urban fabrics in Kuopio's planning and then, as outlined below, other data from Finnish cities were collected and confirmed the patterns. The local experiences from Kuopio have been complemented by other, global experiences, especially in the city of Perth, a newer city but still one that demonstrates the three urban fabrics, though automobile urban fabric dominates. Perth provided much of the data on the metabolism data set out below on the three urban fabrics as well as other material from Newman and Kenworthy's Global Cities Database on energy (Newman and Kenworthy, 2015) and the data on informal cities is from Teferi & Newman (2017, 2018).

The tables show:

1. Urban fabric areas (spatial dimensions and boundaries for each urban fabric);
2. Urban fabric elements (physical components which are the working buildings and infrastructure that enable each urban fabric to function in its own way);
3. Urban fabric functions and lifestyles (the habits, ways of life and business functions of the users and providers in each fabric); and
4. Urban fabric qualities (the measurable outcomes in terms of urban form, transport, economic, social and environmental qualities in each urban fabric).

3.1 Using Urban Fabric to Reduce and Regenerate Urban Metabolism

Modernist urban planning is almost universally applied to cities. It creates predominantly an automobile city set of fabric areas and fabric qualities, with their associated metabolism. The dominance of this paradigm is what will be required to shift the current trajectory away from the local problems such as traffic congestion and the global agendas such as Planetary Boundary transgressions outlined by Steffen et al. (2011) and the agenda called for by the United Nation's New Urban Agenda (2016).

This transition has begun to occur as the world is witnessing 'peak car' and a dramatic growth in transit and walking city fabric (Newman and Kenworthy, 2015). The new era appears to be shifting away from automobile urban fabric. This demands that we have a more coherent set of planning norms that can more easily accommodate a reduction in metabolism and improved livability associated with less automobile urban fabric. To help analyse alternative structure and organization of (public) transit networks, as well as the accessibility and the level of service these networks provide, we can benefit from improved global data accessibility and options (Kujala et al., 2018). The town planning system is going to need support if the aim is to change away from its orientation to automobile urban fabric; its statutory regulations on densities, car parking, mixed use and other key regulations that still end up producing automobile urban fabric will need to be reviewed.

Table 1. Urban Fabric Areas

	WALKING CITY	TRANSIT CITY	AUTOMOBILE CITY
1. Dimensional radius	**0-2 km**	**0-8 km**	**0-20 km**
Outer dimension	1-2 km	8-20 km	20-40 km

Table 2. Urban Fabric Elements

	WALKING CITY	TRANSIT CITY	AUTOMOBILE CITY
1.Street widths	Narrow	Wide enough for transit	Wide enough for cars/trucks
2. Squares and public spaces	Frequent as very little private open space	Less frequent as more private open space	Infrequent as much greater private open space
3. Street furniture	High level for pedestrian activity	High level for transit activity (bus stops, shelters)	High level for car activity (signs, traffic lights)
4. Street networks	Permeable for easy access; enables good level of service for pedestrians	Permeable for pedestrians, networks to reach transit stops, corridors enable good levels of transit service	Permeability less important, enables high levels of service for cars on freeways, arterials and local roads. Bus circulation often restricted by cul-de-sac road structure.
5. Block scale	Short blocks	Medium blocks	Large blocks
6. Building typologies	High density minimum 100/ha usually	Medium density minimum 35/ha usually	Low density <35/ha, often much less than 20/ha
7. Building setbacks	Zero setbacks	Setbacks minimal, for transit noise protection and more space	Setbacks large for car noise protection and extra space
8. Building parking	Minimal for cars, seats for pedestrians, bike racks	Minimal for cars, seats for pedestrians, often good bicycle parking	Full parking in each building type
9. Level of service for transport mode	Pedestrian services allow large flows of pedestrians	Transit services allow large flows of transit users	Car capacity allows large flows of cars

Table 3. Urban Fabric Functions and Lifestyles

	WALKING CITY	TRANSIT CITY	AUTOMOBILE CITY
1. Movement / accessibility	High by walking	High by transit	High by car
- Across urban fabrics	Medium by transit	Medium by walking	Low by transit
	Low by car	Medium by car	Low by walking
2. Consumer services **- Shopping**	High local	High in corridors, especially sub centres	High, especially shopping centres, but dispersed
- personal services	Specialty niche services	Mostly shopping centres	All shopping centres
3. Large scale consumer services, e.g. hypermarkets, warehouse sales, car yards	Low	Medium	High
4. Industry functions	Small	Medium	Large
	- more white collar	- more labour intensive, e.g. hospitals, education	- more blue collar
5. Face-to-Face functions, e.g. finance, creative, knowledge exchange	High	Medium	Low (Medium)
6. Lifestyles by urban fabric			
- Walking city lifestyles	major	possible	not possible
- Transit city lifestyles	possible	major	difficult
- Automobile city lifestyles	possible	possible, common	major

Table 4. Urban Fabric qualities

	WALKING CITY	TRANSIT CITY	AUTOMOBILE CITY
1. Urban form qualities			
- Density	High	Medium	Low
- Mix	High	Medium	Low
2. Transport qualities			
- Car ownership	Low	Medium	High

- Level of service	High for pedestrians	High for transit users	High for car users
- Transport activity	High pedestrian activity	High transit activity	High car activity
3. Economic qualities			
- Development infrastructure, costs per capita	Low - Medium	Medium - Low	High
- GDP per capita	High	Medium	Low
- Labour intensity	High	Medium	Low
4. Social qualities			
- Difference between rich and poor	Low	Medium	High
- Ability to help car-less	High	Medium	Low
- Health due to walking	High	Medium	Low
- Social capital	High	Medium	Low
- Personal security	Variable	Variable	Variable
- Traffic fatalities	Low	Low	Medium to High
5. Environmental qualities			
- GHG per capita and Oil per capita	Low	Medium	High
- **Waste generated per capita in buildings and households**	Low	Medium	High
- Ecological footprint per capita	Low	Medium	High

Wherever possible when planning for greenfield and brownfield urban areas automobile fabric should be minimized in favour of higher density transit and walking fabric so as to maximise resource efficiency. In addition, new developments should seek infrastructure synergies at the energy, water and waste nexus (GIZ and ICLEI, 2014). Such integration of utilities can optimise efficiency between nexus elements through industrial ecology (see e.g. Ayres and Ayres, 2002), which is a strong global agenda but usually does not recognize the spatial agenda outlined in this paper.

The emerging concept of regenerative cities seeks to optimise urban metabolism to mitigate adverse environmental impacts. Girardet (2010, 2015) has written extensively on the regenerative cities and in 2013, UN-Habitat's World Urban Campaign in the lead up to Habitat III called for a new urban paradigm in the publication *The Future We Want, The City We Need* which stated, “The city we need is a regenerative city” (UN-Habitat, 2013). Regenerative cities, with their circular metabolism, will need to create new urban metabolism outcomes in all three urban fabrics in all kinds of cities across the globe.

How then do we begin to practice town planning based on the theory of urban fabrics to advance sustainable development and even the regenerative city concept? How do planners manage cities in this rapidly changing set of factors outlined above and where the 20th century modernist certainties about automobile urban fabric are now losing their appeal? Transitioning to sustainable urban forms that support an efficient circular urban metabolism will require a new way of thinking, a schema that can be the framework to find optimal combinations of the right urban fabric, infrastructure integration, and technology.

To develop this integrated model of urban fabrics, infrastructure and technology, a series of case studies will be examined to see how the data on such cities can be used to illustrate.

Perth, Australia

Thomson and Newman (2018) have done a detailed analysis of the urban metabolism in Perth to demonstrate how it varies across the three urban fabrics. Tables 5 and 6 show the resources and wastes associated with the three fabrics. These data show the variations in energy, water, land, food, and basic raw materials in the three areas of the city as well as the wastes produced from this. There are very different metabolism flows in the three different fabrics.

The fundamental structural difference in the three urban fabrics dominates the differences between the three kinds of urban systems. Further analysis was done to show how technology and innovation in the construction industry could reduce this metabolism. Figure 3 shows how this reduces the quantities of resources and hence wastes considerably but there is still a very strong spatial element that underlies the differences in the metabolism. This highlights the importance of urban planning in sustainable development.

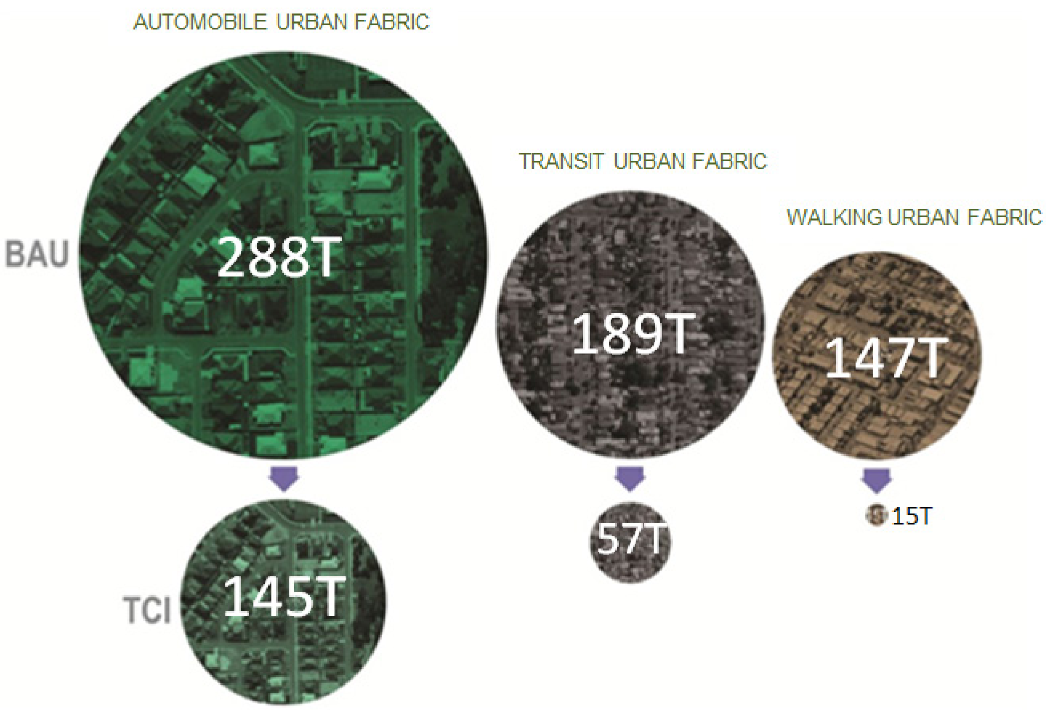

Figure 3. Variations in basic raw materials used for construction with urban fabric and with technology and construction innovation, in Perth, Australia. BAU is business as usual, TCI is technology and construction innovation. Source: Thomson and Newman, 2018.

Table 5. Resource input variations between urban forms. Source: Thomson and Newman, 2018.

INPUT (Per Person Per Year)	Automobile City	Transit City	Walking City
Resources			
Fuel in Megajoules (MJ)[1]	50 000	35 000	20 000
Power in Megajoules (MJ)[2]	9 240	9 240	9 240
Gas in Megajoules (MJ)[2]	4 900	2 940	2 940
Total Energy in Gigajoules (GJ)[2]	64.14	47.18	32.18
Water in Kilolitres (Kl)[2]	70	42	35
Food in Kilograms (kg)[3]	451	451	451
Land in Metres Squared (m^2)[4]	547	214	133
Urban Footprint in Hectares (ha)[5]	2.29	1.97	1.78
Basic Raw Materials (BRM) for New Building Types Per Person[6]			
BRM 1) Sand in Tonnes (T)	111	73	57
BRM 2) Limestone in Tonnes (T)	67	44	34
BRM 3) Clay in Tonnes (T)	44	29	23
BRM 4) Rock in Tonnes (T)	66	43	33
Total BRM in Tonnes (T)	288	189	147

Table 6. Waste output variations between urban form types. Source: Thomson and Newman, 2018.

OUTPUT (Per Person Per Year)	Automobile City	Transit City	Walking City
Waste			
Greenhouse Gas (Fuel, Power & Gas) in Tonnes (T)[1]	8.01	5.89	4.03
Waste Heat in Gigajoules (GJ)[2]	64.14	47.18	32.18
Sewage (incl. storm water) in Kilolitres (KL)[3]	80	80	80
Construction & Demolition (C&D) Waste in Tonnes (T)[4]	0.96	0.57	0.38
Household Waste in Tonnes (T)[5]	0.63	0.56	0.49

Finnish city regions

In Finland, the basic concepts of the theory of urban fabrics have been applied in several studies analysing the development of urban form since the Kuopio case (e.g. Ristimäki et al. 2017, 2013). The majority of Finnish cities have strong walking and transit urban fabric based on the historic eras when they were built; however the recent trend in urban form in Finland is wide-spread urban expansion or urban sprawl based on automobiles. Much of this has been in peri-urban areas within small villages that have become satellite areas for the cities. In the 2010s the sprawling development trend has halted, and even turned into densification policies. Similar trends were found in most developed cities (Newman & Kenworthy, 2015). The reasons for this reversal can be related to the global economic downturn but even in cities where this was minor there was a peak in car use associated with densities going up and significant growth in transit due to rail systems becoming significantly faster than traffic which grew into significant time barriers (Newman & Kenworthy, 2015).

In Finland, these new policies have been particularly taken up in urban centres, as well as in their immediate vicinity in cities over 100,000 inhabitants. However, the development varies greatly between urban regions, since the structural change of the economy is increasingly dividing the regions into high-growth and declining areas. While the largest growth areas invest in the development of public transport, the declining areas continue to spread out their already sparse structure (Ristimäki et al. 2013; 2017).

In one extensive research project, the urban form was analysed in 34 Finnish regions using the zonal approach based on two level areal definitions (Ristimäki et al., 2013). First, the urban regions were divided into urban, peri-urban and rural areas (Figure 4). Second, they were divided according to their urban fabric into pedestrian, transit and car-oriented zones following their location in the urban form and their public transport supply. The results show how remarkably in the pedestrian and transit zones the modal share of car-use and the related carbon dioxide emissions of transportation are lower compared to the car-oriented zone, mostly to be found in areas less densely populated.

In an analysis combining urban fabrics with the Finnish national travel survey, clear differences were found in mobility patterns and CO_2 emissions caused by passenger transport and mobility (Figures 6 and 7) (Ristimäki et al., 2013). The distance between e.g. home and work factors impacted greatly, still the availability of public transport and a walkable urban environment had a clear connection with transport choices.

In another detailed analysis the key factors affecting the future of the urban form in 14 Finnish city regions were identified (Ristimäki et al., 2017). Current development plans were used to assess what kind of urban form plans anticipate sustainable development outcomes. According to the results from these intermediate and small cities, the intensified development of the walking city will continue, and in many urban regions it is associated with a number of walking and cycling improvement projects (Ristimäki et al., 2017).

Except for the largest regions, the strengthening of the transit city is uncertain. In several urban regions the survival and the formation of the transit city would require much greater orientation of land use to support public transport as well as prioritizing for such services. Kuopio showed how to prioritize transit in a new corridor that had been highly car-based but a bus-only bridge transformed the possibilities for transit and enabled much more density near its route. Car city-orientated growth seems to continue on the basis of plans up to 2030, which is in many cases in contrast with the cities' own objectives. One key challenge is the supply of high-quality housing located in the walking and transit city, suitable for families with children. Otherwise, the demand of large apartments may again be realized in the car city areas, far away from jobs and services (Ristimäki et al., 2017).

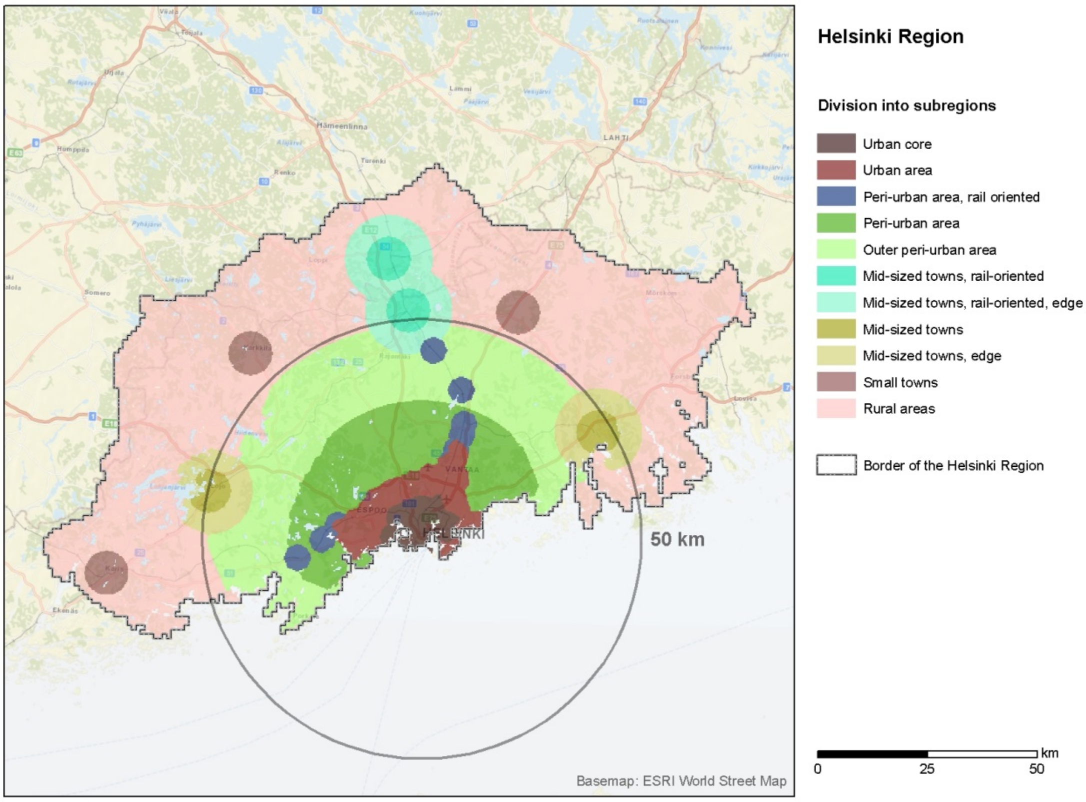

Figure 4. Example of areal definitions at the regional scale (source: Ristimäki et al., 2013).

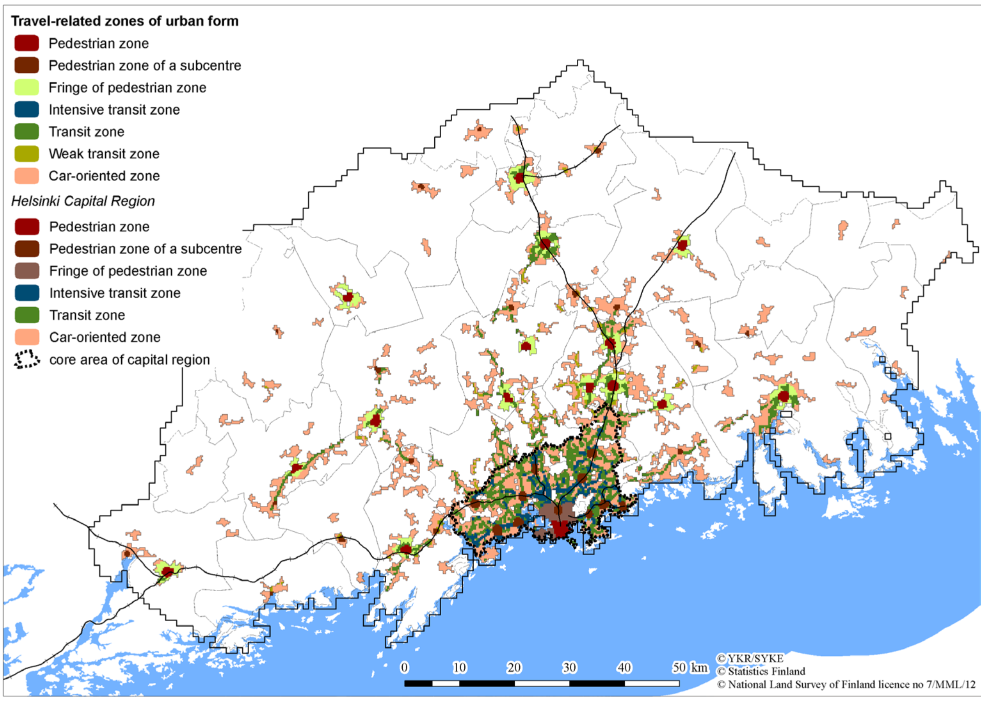

Figure 5. Example of areas divided into pedestrian, transit and car-oriented zones (source: Ristimäki et al., 2013).

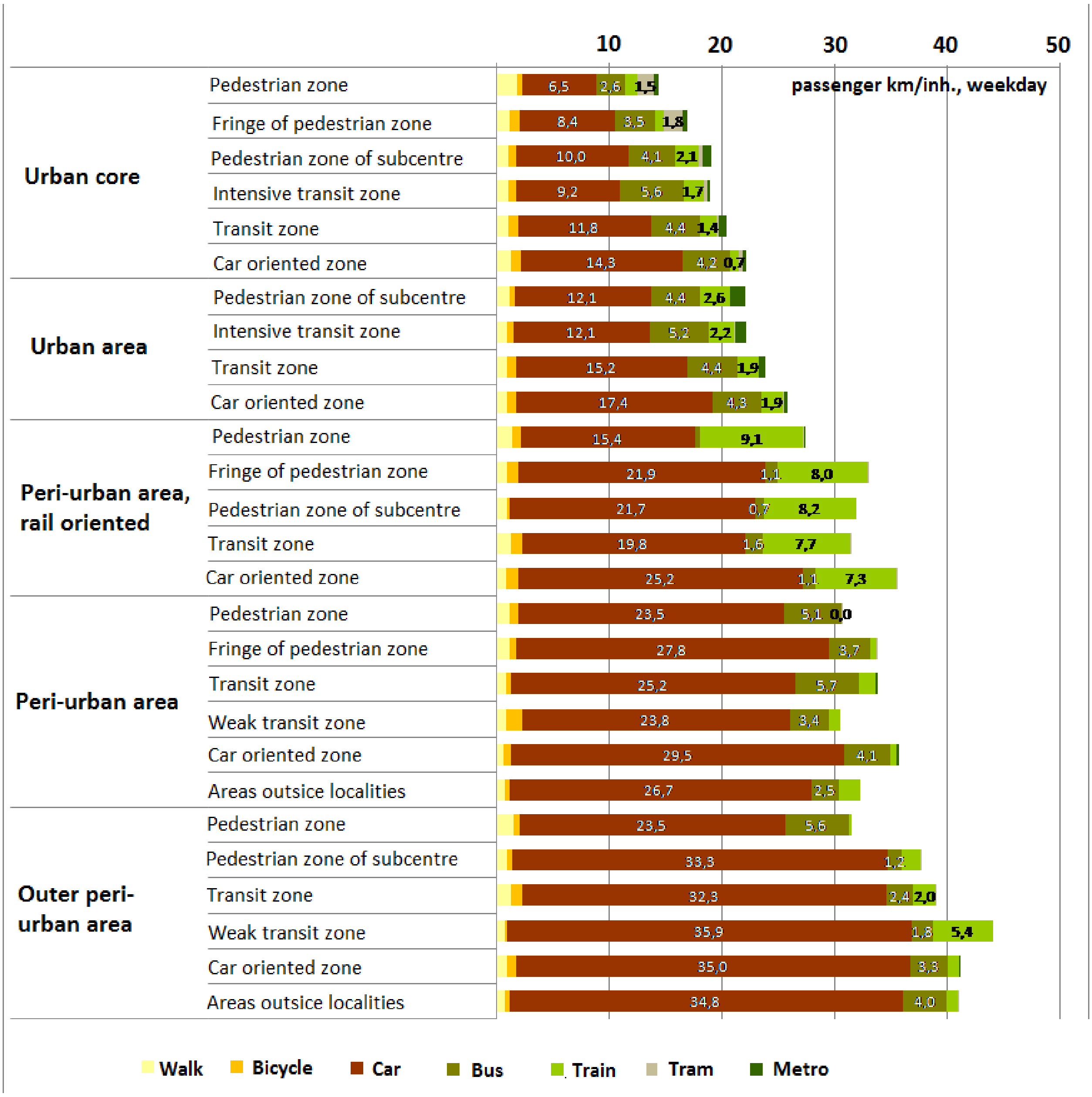

Figure 6. Daily mileage per transport mode (passenger km) for inhabitants in Helsinki functional metropolitan area 2010. (source: Ristimäki et al., 2013).

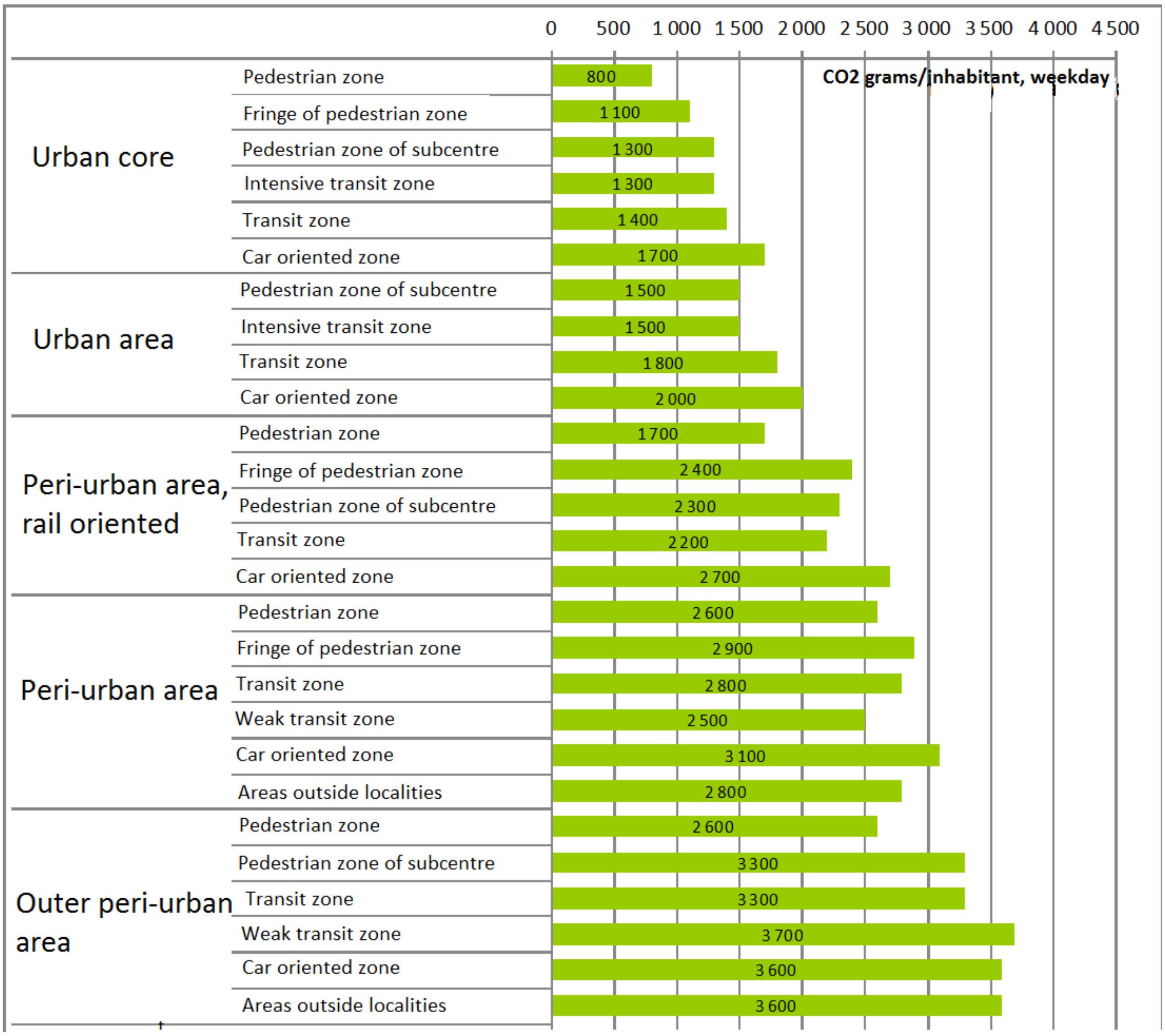

Figure 7 Carbon dioxide emissions of transport (g/inhabitants, weekday) in Helsinki functional metropolitan area 2010. (source: Ristimäki et al., 2013).

4 Informal settlements and urban metabolism

Urban metabolism modelling provides a tool for understanding and monitoring the performance of urban structures, not just in terms of GHG emissions but also as they relate to broader sustainability elements. These include water, waste, transport, and materials, as well as all the elements of livability in cities across the globe (Newman et al., 2017). As modelling of urban metabolism, and indeed of urban systems improves, there is growing evidence that human settlements everywhere have large untapped sustainability potential. Not only may cities potentially have no net (negative) impact, but they may even become regenerative in terms of energy, water, food and biodiversity. Each of these elements needs an understanding of urban stocks and flows, which can be provided through an urban metabolism analysis (Newman et al., 2017).

The Extended Metabolism Model can assist in understanding both the potential to create settlements that are 'zero carbon' but also evaluate whether they are achieving the SDGs at the same time (United Nations, 2016). There is little literature on the application of the Extended Metabolism Model to informal settlement improvement apart from Arief (1998) and now Teferi and Newman (2018). The latter examine whether the Extended Metabolism Model can illuminate good practice in informal settlement improvement as it pertains to urban planning policy and sustainability.

In the following, the work on two informal settlements by Teferi and Newman (2018) is described for two major developing cities: Jakarta, Indonesia and Addis Ababa, Ethiopia. Jakarta has a very different culture and climate to Addis Ababa, but they share the urban growth and economic issues faced by many emerging cities. The analyses benefit from the above theories of urban metabolism and urban form and indeed suggest that informal settlements have much of the character of walking urban fabric.

Jakarta, Indonesia

Jakarta is a mega city with a population of 10 million and a high proportion of informal dwellings (Aji, 2015). The area examined is called Ciliwung with an adjacent high-rise incorporating residents transferred from a slum clearance project. The results (Teferi & Newman, 2018) depict a small decrease in the metabolism of the residents in the high-rise housing in comparison to the informal river bank settlement dwellers. This is likely due to better technology and living conditions as well as having to pay for their energy and water as opposed to the informal settlements where formal energy and water provision are lacking and therefore unmetered. The wastes are much better managed in the high-rise, as is to be expected. The improved economic livability in the high-rise development is due to a reduction in poverty, but there is a striking difference in the social parameters: it is clear that the informal settlement has much better social capital. Teferi and Newman (2018) describe much higher levels of community trust and neighbourliness despite the poverty: "The residents like living there as they have a strong community that supports each other." Such settlements are highly dense with just small spaces between buildings and hence are walking urban fabric that should be respected and regenerated.

Addis Ababa, Ethiopia

Addis Ababa contains 30% of the country's urban inhabitants with a population of around 4 million. About 120,000 new residents are added to the city every year. Most of this takes place in the informal settlements where around 80% of Addis Ababa inhabitants live (Teferi & Newman, 2017). The settlement of Arat Kilo is an old, socially mixed slum, where formal and informal structures coincide (Teferi & Newman, 2018). It incorporates diverse housing typologies, ranging from single detached houses to poor dwellings. The age, construction quality, and infrastructural provision within the buildings are overall substandard. Comparing the informal settlement to a high-rise settlement with dwellers from a former slum nearby, Teferi and Newman (2018) show resource consumption of energy and water are very similar with only small GHG emissions by comparison with most households in most cities (Newman et al., 2017). The reduction in usage when people move to high-rise is probably due to them generally having to pay more than in the informal settlements for power and water which as in Jakarta are often not in formal supply. In terms of liquid and solid waste production, each of the slum groups were almost the same as the production of solid and liquid wastes from the high-rise condominiums. Though, there is a vast difference in how they are disposed (collected). This is because of the limitations of technology in the informal settlements. Despite the fact that the high-rise apartments produce a little fewer wastes, the amount generated is almost similar, which is consistent with the expected result from the metabolism model.

What is evident across the board in studies on people living in informal settlements compared to those transferred through slum improvements to high-rise settlements is that the metabolism is very similar though the community cohesion is not as strong as with the slum dwellers. The level of social interaction among the informal settlements is very high: they meet each other almost every day and generate strong levels of trust that leads to sharing of assets. There is clearly a strong community in slum settlements based not only on Teferi and Newman (2018) but others e.g. Baud et al. (2012), Nijman (2010) and Dhesi (2000) on India. The physical improvements that have been undertaken in the high-rise buildings compared to the slum settlement have often not brought about concomitant improvement of social conditions. “If the same level of physical infrastructure and access to the formal economy could be provided to the slum dwellers without removing their social structures, then it would obviously be a better way to improve such settlements” (Teferi & Newman, 2018).

As shown above, the efforts to capture information akin to the principles of urban metabolism or indeed urban fabric in informal settlement conditions is extremely difficult. Still, such early studies are suggestive of the need to respect local urban fabrics and regenerate them for improvement of infrastructure using small scale technologies such as solar, water tanks and small sewerage systems. The modernist planning approach of slum clearance followed by high-rise replacements, sometimes on the urban fringe, is similar to the problems with modernist planning now being found in developed cities (Newman et al., 2017).

What would be further interesting, is mapping such informality as part of a mega city within the logic of the three urban fabrics, and extending the analysis to evaluating more precisely the accessibility options and their emissions impacts with suggested pathways forward. Whilst it is undisputed that the housing conditions form an important part of the metabolism analysis, further examination of access options and their metabolism effects would warrant more detailed investigation. In order to engage with the formal economy, people still need mobility, and the urban fabric thinking can assist in finding sustainable development pathways that support both sustainable urban mobility solutions while improving the economic conditions of those in informal settlements (Hernandez & Dávila, 2016; Hernandez & Titheridge, 2016).

5 Designing urban fabric to optimise and regenerate urban metabolism

At any stage in a city's history the patterns of land use can be changed and the opportunities taken to enable a regenerative approach. If cities are shaped by their transportation systems which in turn have a major impact upon urban metabolism and equal access, then the most important policy and planning direction to reduce the ecological footprint and increase equal mobility opportunities, is for the city to restrict the development of a car-based urban fabric in favour of the transit and walking fabric. However, when redeveloping existing urban areas it will be necessary to carefully co-ordinate land use intensity concurrently with the imposition of new transportation systems over the urban fabric, or else risk a mismatch which may render them largely dysfunctional.

Creating new, or regenerating old, urban areas for sustainability requires first a consideration of the transport mode and building typologies as these shape and define the urban fabric. An integrated approach offers greater opportunities for optimization of urban metabolism (Bunning et al., 2013; GIZ & ICLEI, 2014; Newman, 1999; Newton et al., 2012a; Newman et al., 2017).

An individual building can, and should be optimised in terms of its metabolism. However, development needs to address at least the neighborhood or city district scale to benefit from the additional opportunities for optimization offered by the urban fabric including district utility and community services. Integrated design has the potential to deliver transitional, decentralised, sustainable neighborhoods that cumulatively work toward delivering a regenerative (or in the least more sustainable) city. The city district is likely an optimal scale to trial innovative processes and technologies. Successful prototypes can in turn inform urban policies or guide institutionalised financial incentives to ultimately mainstream the type of sustainable urbanism needed to reduce the ecological footprint of entire cities or city regions through the optimisation of their urban metabolism. An example of such a process is the WGV precinct in Fremantle, Australia where 100 units of development have been able to show not just a zero carbon outcome but to have fulfilled all 17 of the Sustainable Development Goals (Wiktorowicz et al, 2018).

Particular strategies will be needed for each component of an urban footprint to collectively reduce a city's urban metabolism and work toward the delivery of a regenerative city. For example:

1. Energy can become regenerative if the fuel used to build and operate buildings and build and run transport, is renewable, and the amount of renewables greater than is actually being consumed by the city. The rest can be used to help power and fuel the surrounding bioregion. This is likely to include highly energy efficient buildings and maximising the available sites to create renewable energy from sun, wind and geothermal sources to power electric systems in buildings and transport as well as renewably-powered gas such as hydrogen (Droege, 2008; Newman & Kenworthy, 2015; Terama et al., 2017, 2018). Such innovations will vary across the three urban fabrics especially in the ability to use roof-top solar (Newton and Newman, 2013).
2. Water can become regenerative if there is a big emphasis on water efficiency as well as collecting rain water and ground water, and recycling waste water and any excess is used to help regenerate aquifers and water bodies in the bioregion. This can be done with current technologies and can relate to all three urban fabrics with different techniques depending on the space available for water sensitive urban design.

3. Biodiversity can become regenerative if it is built into every part of the urban fabric (Paloniemi et al., 2017). Such nature-based urbanism approaches may include green roofs and green walls, the so-called biophilic urbanism approach that works best in high density walking fabric where whole new urban habitat is possible to create as in Singapore (Newman, 2014). Also water retention parklands and other water sensitive designs need to be used to create more resilience to natural events and increase habitat opportunities (Beatley, 2009; Kellert et al., 2011; Newman, 2014; Newman and Matan, 2013) which can occur in less dense urban fabrics. The greening of degraded urban land is a common theme in best practice urban regeneration, for example where hardscape such as roads can be retrofitted or surface parking redeveloped and revegetated (Dunham-Jones & Williamson, 2008; Gehl & Rogers, 2013; Newton et al., 2012b).
4. Solid waste can be reduced to very small amounts (as outlined above in the urban fabrics discussion) but can only be regenerated if new systems of waste management are created. However the return of carbon, phosphorus, nitrogen and other trace elements to surrounding soils can be done through recycling presently being demonstrated in many cities. Nutrient recycling can also provide rich growing mediums for urban agriculture (Newman & Jennings, 2008).

The transformation of automobile fabric would appear to offer the greatest opportunities for sustainability improvements. This is good news for the sprawled cities of the USA, Australia and Canada with their high ecological footprint but also large areas of automobile fabric that may be regenerated. This is not to say there is no place for automobile fabric in low-density areas as lower density automobile fabric does offer some advantages, namely:

- Greater space for activities involving freight and recycling, as well as space for roof-top solar
- Space for private gardens that can also be used for local food, including deep rooted planting for trees
- Opportunities to incorporate ecosystem services such as biodiversity habitats, carbon sequestration and urban community-based agriculture.

However, the aggregate benefits to a city, and its surrounding hinterland, are increased with the higher population density of transit and walking urban fabric because they offer:

- Viable catchments to meet business cases for improved public transport, distributed utilities, and greater service, job and retail density
- Greater proximity to services, shops and jobs to reduce vehicle kilometers travelled and to support a vibrant walking, cycling and transit community
- Reduced embodied energy through lower material requirements, e.g., shared walls, or shorter infrastructure lengths with much lower per capita cost
- Reduced encroachment upon adjoining productive land or valuable ecosystems.

In addition to optimizing urban fabric, a regenerative design overlay can further drive down the ecological footprint of an area. An integrated approach to the provision of urban systems, and monitoring by an urban metabolism analysis, can offer city makers a powerful tool for further environmental gains and build a powerful narrative of positive change. Regenerative design considerations might include:

- Urban applications of industrial ecology, e.g. seeking synergies between, and productive uses for, solid and liquid waste which might be used to create biogas or fertilizer for urban food production
- Technology and construction innovation to reduce material inputs and improve building performance e.g. prefabrication
- Substitution of centralized (and usually hydrocarbon powered) energy, water and waste management systems with distributed infrastructure e.g. solar photovoltaics, trigeneration (combined cooling, heat and power), water sensitive urban design, grey water, black water and nutrient harvesting
- Provision of infrastructure for sustainable mobility solutions and services, e.g. charging stations and parking reserved for shared vehicles
- Seeking to understand and enhance the bioregional qualities of the subject urban area, and reflecting this in the built form and public space, as opposed to the conventional practice of homogenous application of modernist planning principles that have facilitated the global spread of automobile urban fabric.

6 Conclusions

This paper demonstrates that city planning decisions are highly influential in delivering sustainable cities because different urban fabrics have different impacts on the cities' livability as well as ecological footprints, not least due to their urban metabolisms. This is demonstrated in the Perth case study that shows the significant advantages in terms of resource efficiency that walking and transit fabric offer over automobile fabric in most resource and waste cases of urban metabolism. The basic raw material demand of walking fabric with a technology and construction innovation (e.g. application of regenerative design principles) has the potential to improve urban efficiencies almost thirty times over the conventional automobile urban fabric in the same city. Combining urban fabrics with the Finnish national travel survey revealed clear differences in mobility patterns and related CO_2 emissions across urban areas and fabrics: walking and transit fabrics support and encourage least carbon intensive modes of mobility. What can be learnt from informal settlements is twofold. Despite improvements to housing and infrastructure, community cohesion in high-rise slum clearance areas are not as strong as within the old, informal settlements that have many of the qualities of walking urban fabric. The level of social interaction among the dwellers is very high in informal settlements as their various daily needs are dependent on everyday interactions between close neighbours, generating strong levels of trust. This becomes a basis of a local sharing economy that supports its members from tangible to intangible resources. The need to respect such urban fabrics and build with it rather than just clearing it, seems to be a major conclusion from all the studies that cross the divide between developed and developing cities. The idea that modernist planning can just clear such historic fabric is no longer acceptable in any city, and the need to achieve sustainable development goals, including its social dimensions, now makes this even more of an imperative. Further studies need to be conducted in different cities to show how urban fabric can be respected and regenerated to enable cities to achieve more sustainable development. The size of the differences in urban metabolism with urban fabric suggests that cities can indeed make major contributions to sustainable development, not to mention zero carbon and zero waste strategies, through town planning and design that respects and regenerates urban fabrics. The regenerative city offers the potential for a whole new era of city planning and building. This agenda has been shown to work within the urban fabrics approach to designing sustainable cities of the future.

REFERENCES

Aji, P. (2015). Summary of Indonesia's poverty analysis. Mandaluyong: Asian Development Bank.

Ayres, R. U., & Ayres, L. (Eds.). (2002). A handbook of industrial ecology. Edward Elgar Publishing, Cheltenham, UK.

Baud, I., Sridharan, N. & Pfeffer, K. (2012). Mapping urban poverty for local governance in Delhi in Pouw, N. & Baud, I. (Eds) Local Governance and Poverty in Developing Nations. Routledge, New York. Pp 139-171.

Beatley, T. (2009). Biophilic Urbanism: Inviting Nature Back to Our Communities and Into our Lives. William & Mary Environmental Law & Policy Review, 34(1), 209–238.

Beauregard, R. A. (1991). Without a net: Modernist planning and the postmodern abyss. Journal of Planning Education and Research, 10(3), 189-194.

Bunning, J., Beattie, C., Rauland, V., & Newman, P. (2013). Low-Carbon Sustainable Precincts: An Australian Perspective. Sustainability, 5(6), 2305–2326. https://doi.org/10.3390/su5062305

Dhesi, A. S. (2000). Social capital and community development. Community Development Journal, 35(3), 199-214.

Droege, P. (2008). Urban Energy Transition: An Introduction. Elsevier Science, 1-14. https://doi.org/10.1016/B978-0-08-045341-5.00029-3

Dunham-Jones, E., & Williamson, J. (2008). Retrofitting Suburbia: Urban Design Solutions for Redesigning Suburbs. John Wiley & Sons, Hoboken, NJ.

Fuller, M., & Moore, R. (2017). The death and life of great American cities. Macat Library, London.

Gardner, H., & Newman, P. (2013). Reducing the materials and resource intensity of the built form in the Perth and Peel regions. Australian Government, Department of Sustainability, Environment, Water, Population and Communities. Perth, Australia.

Gehl, J., & Rogers, R. (2010). Cities for People. Island Press, Washington, D.C.

Gehl, J., & Svarre, B. (2013). How to Study Public Life. Island Press, Washington D.C.

Girardet, H. (2015). Creating Regenerative Cities, Routledge, Abingdon, UK.

Girardet, H. (2010). Regenerative cities. World Futures Council. Hamburg, Germany. Available at: https://www.worldfuturecouncil.org/regenerative-cities/

GIZ and ICLEI. (2014). Operationalizing the Urban NEXUS: towards resource efficient and integrated cities and metropolitan regions. Eschborn, Germany.

Hernandez, D.O. and Dávila, J.D. (2016). Transport, urban development and the peripheral poor in Colombia—Placing splintering urbanism in the context of transport networks. Journal of Transport Geography, 51, 180-192.

Hernandez, D.O. and Titheridge, H. (2016). Mobilities of the periphery: Informality, access and social exclusion in the urban fringe in Colombia. Journal of transport geography, 55, 152-164.

Kellert, S. R., Heerwagen, J., & Mador, M. (2011). Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life. Wiley, New York.

Kujala, R., Weckström, C., Darst, R. K., Mladenović, M. N., & Saramäki, J. (2018). A collection of public transport network data sets for 25 cities. Scientific Data, 5, 180089. http://doi.org/10.1038/sdata.2018.89

McIntosh, J., Newman, P., & Glazebrook, G. (2013). Why Fast Trains Work: An assessment of a fast regional rail system in Perth, Australia. Journal of Transportation Technologies, 3(2A), 37–47.

NACTO. (2016). Global Street Design Guide. NACTO, National Association of City Transportation Officials (U.S). Island Press, Washington D.C.

Newman, P. (1999). Sustainability and cities: Extending the metabolism model. Landscape and Urban Planning, 44, 219–226. https://doi.org/10.1016/S0169-2046(99)00009-2

Newman P (2014) Biophilic Urbanism: A Case Study of Singapore, Australian Planner, 51:47-65.

Newman P , Beatley T and Boyer, H (2017) Resilient Cities: Overcoming Fossil Fuel Dependence, Island Press, Washington DC.

Newman, P., & Kenworthy, J. (1989). Cities and Automobile Dependence: An International Sourcebook. Gower Publishing, Aldershot, UK.

Newman, P., & Kenworthy, J. (1999). Sustainability and Cities: Overcoming Automobile Dependence. Island Press, Washington, D.C.

Newman, P., & Kenworthy, J. (2015). The End of Automobile Dependence: How Cities are Moving Beyond Car-Based Planning. Island Press, Washington, D.C.

Newman, P., Kenworthy, J., & Glazebrook, G. (2013). Peak Car Use and the Rise of Global Rail: Why this is happening and what it means for large and small cities. Journal of Transportation Technologies, 3(4), 272–287. https://doi.org/10.4236/jtts.2013.34029

Newman, P., Kosonen, L., & Kenworthy, J. (2016). The Theory of Urban Fabrics: Planning the Walking, Transit and Automobile Cities for Reduced Automobile Dependence. Town Planning Reviews, 87(4), 429-458. https://doi.org/10.3828/tpr.2016.28

Newman, P., & Matan, A. (2013). Green Urbanism in Asia: The Emerging Green Tigers. World Scientific Publishing, Singapore.

Newman Peter, Karlson Hargroves, Sebastian Davies-Slate, Daniel Conley, Marie Verschuer, Mike Mouritz, Dorji Yangka and Garry Glazebrook (2019) The Trackless Tram: Is it the Transit and City Shaping Catalyst we have been waiting for? J. Transportation Technologies, 9, 31-55. doi: 10.4236/jtts.2019.91003.

Newton P and Newman P (2013) The Geography of Solar PV and a New Low Carbon Urban Transition Theory, Sustainability 5(6): 2537-2556;

Newton, P., Murray, S., Wakefield, R., Murphy, C., Khor, L., & Morgan, T. (2012a). How do we regenerate middle suburban 'greyfield'areas?. AHURI Research & Policy Bulletin, (150). Melbourne, Australia.

Newton, P., Newman, P., Glackin, S., & Trubka, R. (2012b). Greening the Greyfields : Unlocking the Redevelopment Potential of the Middle Suburbs in Australian Cities. World Academy of Science, Engineering and Technology, 71(11), 658–677.

Nijman, J. (2010). A study of space in Mumbai's slums. Tijdschrift voor economische en sociale geografie, 101(1), 4-17.

Nilsson, K., Nielsen, T. S., Aalbers, C., Bell, S., Boitier, B., Chery, J. P., Fertner, C., Groschowski M., Haase D., Loibl W., Pauleit, S., Pintar, M., Piorr, A., Ravetz J., Ristimäki, M., Rounsevell, M., Tosics, I., Westerink, J., Zasada, I. (2014). Strategies for Sustainable Urban Development and Urban-Rural Linkages. European Journal of Spatial Development, 1–26. Retrieved from http://www.nordregio.se/Global/EJSD/Research briefings/article4.pdf

Paloniemi, R; Tiitu, M; Viinikka, A; Vikström, S; Furman, E. (2017). Promoting health through interaction with nature in urban areas. SYKE Policy Briefs. http://hdl.handle.net/10138/215210.

Ristimäki, M., Tiitu, M., Kalenoja, H., Helminen, V., Söderström, P. (2013). Yhdyskuntarakenteen vyöhykkeet Suomessa. Suomen ympäristökeskuksen raportteja 32/2013. Finnish Environment Institute, Helsinki. [In Finnish, Abstract in English] http://hdl.handle.net/10138/41574

Ristimäki, M., Tiitu, M., Helminen, V., Nieminen, H., Rosengren, K., Vihanninjoki, V., Rehunen, A., Strandell, A., Kotilainen, A., Kosonen, L., Kalenoja, H., Nieminen, J., Niskanen, S., Söderström, P.(2017). Yhdyskuntarakenteen tulevaisuus kaupunkiseuduilla, kaupunkikudokset ja vyöhykkeet. Suomen ympäristökeskuksen raportteja 4/2017. Finnish Environment Institute, Helsinki. [In Finnish, Abstract in English] http://hdl.handle.net/10138/176782

Söderström, P., Schulman, H., & Ristimäki, M. (2015). Urban Form in the Helsinki and Stockholm City Regions. Papers of the Finnish Environment Institute 16/2015. Finnish Environment institute. Helsinki. http://hdl.handle.net/10138/155224

Steffen, W., Persson, Å., Deutsch, L., Zalasiewicz, J., Williams, M., Richardson, K., Crumley, C., Crutzen P., Folke C., Gordon L., Molina M., Ramanathan, V. Rockström J., Scheffer M., Schellnhuber H. J., Svedin U. (2011). The Anthropocene : From Global Change to Planetary Stewardship. Ambio, 40(7), 739–761.

Terama, E., Peltomaa, J., Rolim, C., Baptista, P. (2018). The Contribution of Car Sharing to the Sustainable Mobility Transition. Transfers, 8(2), 113-121, https://doi.org/10.3167/TRANS.2018.080207.

Terämä, E., Peltomaa, J., Lyytimäki, J. (2017). Sustainable mobility solutions are created locally. SYKE Policy Brief, http://hdl.handle.net/10138/183657.

Thomson, G., & Newman, P. (2018). Urban fabrics and urban metabolism - from sustainable to regenerative cities. Resources, Conservation and Recycling. 132, 218-229. https://doi.org/10.1016/j.resconrec.2017.01.010

UN-Habitat. (2013). The Future we Want, the City we Need. Nairobi. https://unhabitat.org/wp-content/uploads/2016/03/The_Future_We_Want.The-City-We-Need.pdf

United Nations. (2016). Habitat III New Urban Agenda. Draft outcome document for adoption in Quito, October 2016. Online at: http://habitat3.org/the-new-urban-agenda.

Urry, J. (2004). The system of automobility. Theory, Culture and Society, 21(4/5), 25–39.

Wiktorowicz J., Babaeff, T., Breadsell, J., Byrne, J., Eggleston, J., Newman, P. (2018). WGV: An Australian Urban Precinct Case Study to Demonstrate the 1.5 °C Agenda Including Multiple SDGs. Urban Planning, 3(2), 64–81. DOI: 10.17645/up.v3i2.1245.

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