Socioecological inequalities in European urban areas

A first exploration of incidences, causes, consequences and assessment methods

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1 Background and research questions

1.1 Context

The EU is increasingly recognizing that, even if the EU does not have any formal competence as to urban issues, the majority of EU policies have an urban dimension, directly or indirectly. An on-going intergovernmental process of more than two decades has led to an explicit European consensus on the principles of urban development, the 'Acquis Urbain'. The 2007 Leipzig Charter on Sustainable European Cities stresses the importance of an integrated approach to urban development and a focus on deprived neighbourhoods in order to remedy vicious circles of exclusion and deprivation (e.g., see EC, 2011). An Urban Agenda is currently being developed which is also likely to cover environmental challenges (EC, 2014), and hence also the EEA increasingly focuses on environmental challenges and possible responses in urban areas. The recent Action Plan for the Environment now also includes urban sustainability, including governance of the transition of the urban system. EEA is preparing a report on urban sustainability to further support the policy debate. Socioecological equality is considered relevant for such sustainability. In support of the urban areas in the 33 states falling under its remit, EEA would like to gain a better insight in the issue of socioecological inequality within and across these areas. More specifically, EEA would like to get an impression of the extent of socioecological inequality in terms of clustering of lack of or limited access to green open space, and/or bad air quality on the one hand, with socioeconomic deprivation on the other hand. It is important to note that socioecological inequality can also relate to other issues, such as climate risks (flooding, drought, heat stress, exposure to storms), drinking water quality, soil pollution, inadequate waste services, noise (air and or ground traffic), and environmental safety. This report however is limited to air quality and access to green open space. The argumentation for choosing these two environmental characteristics is that air quality is important for health (Hänninen & Knol, 2011). Satisfaction with green spaces both in the city and in neighbourhoods, is one of the features that show the highest correlation with the overall satisfaction of living in a city (EC, 2013).

EEA would like to know how cities compare with respect to such inequalities. In addition, EEA would like to see the contours of a conceptual framework including the different factors that influence the occurrence of such socioecological inequalities. At the moment the EEA is developing three typologies that contribute to the final Urban Sustainability report: Typology of cities, Typology of urban sprawl, and Typology of urban green infrastructures. EEA would like to gain an insight into the suitability of these typologies for capturing the issue of socioecological inequality. And finally EEA would like to be inspired by some good practices that might help counteracting socioecological inequality.

1.2 Discussion of terms

Several terms are being used to conceptualize socioecological inequality: environmental (in)justice; environmental racism (denotation of ethnic inequality); and environmental equity (Kruize, 2007). We use the term socioecological inequality in our study, as suggested by the EEA. Socioecological inequality is the combination of adverse environmental or ecological conditions with socioeconomic deprivation . We define socioeconomic deprivation as the occurrence of a situation in which people have a low income and/or a low level of education. With spatial clustering we refer to the combined occurrence within a spatially defined area. The study focusses on urban areas as 'unit of observation'. Urban areas can be defined in various ways, such as urban morphological zones (UMZ), as operationalised in the Urban Atlas, or as defined in terms of the CORINE land cover database, or Functional Urban Area, to name just a few important definitions. With green open spaces green areas are meant that have little or no soil sealing. Note that open here does not refer to accessibility for the general public. Furthermore green open space refers to green space inside and around cities (peri-urban area), including agricultural areas. It is should be noted that a quantitative analysis of socioecological inequality depends on these definitions. The results of a study focusing on access to public green space will lead to results different from a study focusing on green open space, and the same is true for analysis defining a city on the basis

of administrative boundaries rather than morphological or land-use characteristics. Also, in Mediterranean countries green open space actually isn't always green, it can also be barren land and then its ecosystem services may differ from vegetated areas. We don't pay special attention to this difference between regions.

1.3 Objective

Following the inception report and considering the results of the consultations with EEA, our study focusses on the spatial clustering of lack of, or poor access to, green open space and/or bad air quality (the major environmental factor adversely effecting health) on the one hand, with socioeconomic deprivation on the other. We focus on the level of neighbourhoods or streets, because this is the level at which socioecological inequality is most relevant.

The main objectives for this study are:

A. To gain insight in how to assess the specified socioecological inequalities at neighbourhood or street level in urban areas in the 33 'EEA states' and how to compare between cities or urban regions on these inequalities.
B. To gain insight in existing policies to counter socioecological inequality.

We reviewed key literature and data bases that provide insights on the presence and the causes of socioecological inequality for these ecological aspects within cities. We further reviewed key literature and case study reports on policies and practices countering such socioecological inequalities. It should be noted that the socioeconomic and ecological factors might be interrelated amongst themselves, e.g. green infrastructure and air quality, or education and income.

This report presents the results of a quick scan of the literature on socioecological inequality for air quality and access to green open space in Europe and the available information on indicators that could be used to describe and assess the situation in Europe. It is important to note that as a result of the limited time and resources available for the project, it is a quick scan that does not pretend to be fully comprehensive.

More specifically, this report addresses the following research questions:

1. Which existing English language literature provides knowledge and insight on socioecological inequalities in European urban areas?
2. Which databases are available at Eurostat and EEA on European cities that provide information on neighbourhood or street level on:
    a. presence of low income and/or low education
    b. air quality
    c. green areas in and around cities
3. How to interpret this information in relation to socioecological inequalities?
4. What are existing and implemented policies and practices that are directed at or help avoiding or reducing socioecological inequality?
5. What insights or data are missing that can help identify and understand the development of socioecological inequality within urban areas?
6. How to depict the different relations identified that could form the traits of an analytical framework?
7. Which indicators for the mentioned socioecological inequalities within urban areas are relevant and how can these be measured?
8. What is the meaning of the typologies of Cities, of Green Infrastructure (GI) and of Urban Sprawl for comparing between cities on these inequalities?

1.4 Outline of the report

Chapter 2 proposes a conceptual model on socioecological inequality in urban areas and answers the first research question on existing English language literature to provides knowledge and insight on socioecological inequalities in European urban areas. This question results in an understanding of the factors that influence the existence and extent of socioecological inequalities in urban areas.

Chapter 3 discusses the available data on indicators which can be relevant for the assessment of socioecological inequalities and answers research questions 2 and 3 about the availability of indicators relevant for socioecological inequality and their possible interpretation.

Chapter 4 analyses policies and practices to prevent or ameliorate socioecological inequalities by searching the literature, addressing research question 4. A wide range of policies may be relevant, such as environmental, green open space, air pollution, spatial planning, housing, transport, and health policies.

Chapter 5 summarizes the most important conclusions resulting from the answers of the research questions and tries to draw conclusions on how to move forward by answering research questions 5 to 8.

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2 Conceptual model on socioecological inequality in urban areas

2.1 The occurrence of socioecological inequality in European urban areas

In chapter 1 socioecological inequality has been defined as the spatial clustering of socioeconomic deprivation and adverse (physical) environmental circumstances. Therefore a first issue is to what extent both conditions co-occur in the same areas. With regard to the adverse environmental circumstances, the study is limited to poor air quality and/or poor access to green open space. Furthermore, following the majority of the literature, the focus is on socioecological inequality *within* cities, rather than inequalities between cities. The existing literature was scanned for information on the occurrence and extent of socioecological inequalities, especially in Europe.

First, it should be noted that not all research on socioecological inequality investigates this phenomenon at the same spatial scale. Sometimes it is investigated on a larger scale than that of an urban area, e.g. inequality between provinces or NUTS-2 areas (Richardson et al., 2013; Germani et al., 2014), or even that of countries (Braubach & Fairburn, 2010). It is questionable whether results at larger spatial scales also hold for smaller spatial scales. Braubach and Fairburn (2010), finding little inequality at the national level, suggest that if the data would have been broken down by income groups and urban-rural variation, inequalities may be much more expressed. For example, in rural areas green space is less scarce, and may also be readily available for low income groups, weakening a possible association between income and access to green open space that may exist in more urban areas. More in general, differences that do exist at small spatial scales will average out at larger spatial scales. However, if socioecological inequality (still) exists at higher spatial levels, it may also be expected to exist at lower spatial levels, and be more extreme. Furthermore, studies on socioecological inequalities do not always take air quality or access to green open space into account as environmental aspects.

The majority of studies detected in our quick scan conclude that spatial clustering of socioeconomic deprivation and adverse environmental conditions does occur: the presence of the one is generally associated with an increased likelihood of the presence of the other. In the UK, in 2008 20 per cent of the lowest income households lived in poor quality environments compared with 14 per cent of the highest income group. In this study, a poor quality environment was defined as one with (surveyor-assessed) significant problems in the neighbourhood with: the upkeep, management or misuse of the private and public space and buildings; road traffic and other forms of transport; or utilisation, that is abandonment or non-residential use of property (Randall, 2011). Pearson et al (2010) and Jephcote & Chen (2012) arrive at similar conclusions in UK-based studies. Naess et al (2007) observed an association between the concentration of fine particulates (PM 2.5) and socioeconomic deprivation in Oslo, Norway. And according to Kruize (2007), for rail traffic noise, combined traffic noise, and availability of public green space, in the Netherlands lower incomes are consistently worse off than higher incomes, in highly urbanized areas as well as in the country as a whole.[1] Moreover, low and minimum income categories have less access to an accumulation of environmental 'goods' compared to average and high income categories. In the two study regions with high spatial pressure – the Rijnmond region and the Amsterdam Airport region – the relatively large difference for the accumulation of all 'goods' is striking, with high incomes having ten times more access to this accumulation of 'goods' (e.g. amenities) than the minimum income categories. Also Bolte (2012, p. 87) concludes that socioeconomic differences in, among other things, exposure to air pollution and lack of access to green spaces have repeatedly been shown to exist in Europe, especially among children.

[1] Note that this does not include access to agricultural areas, making up most of the Dutch countryside. With regard to well-being and health this access may be as important as access to public green space (De Vries et al, 2003; Maas et al, 2006, Maas et al, 2009)

However, there are exceptions to the general rule of the clustering of social and environmental deprivation, for air pollution (for an overview, see Deguen & Zmirou-Navier, 2010)[2] as well as for (access to) green (open) space. In a French study, Padilla et al (2014) found that the strength and direction of the association between deprivation and NO_2 estimates varied between cities. In Paris, census blocks with the higher social categories are exposed to higher mean concentrations of NO_2. However, in Lille and Marseille, the most deprived census blocks are the most exposed to NO_2. In Lyon, the census blocks in the middle social categories were more likely to have higher concentrations than in the lower social categories. Macintyre et al (2008) concluded that in Glasgow, Scotland, some local resources, (a.o. outdoor play areas, public sports centres, vacant and derelict land) were closer to or more common in , more deprived areas, whereas for other local resources (a.o. private schools, museums/art galleries) this was the other way round. Svastisalee et al. (2012) found that in Copenhagen neighbourhoods with a high proportion of residents with a low *education* were most likely to have public open space. On the other hand, mid-to-low *income* areas were less likely to contain public open space. As for green space, even if there are no, or 'reversed', differences in the amount of/access to green space, socioecological inequality may still exist in terms of the quality of the green space (Ellaway et al., 2007; Bolte, Pauli & Hornberg, 2011). We interpret quality here in terms of fitting the needs and desires of the local population.

2.2 Factors driving socioecological inequality

Socioecological inequality is about differences in environmental conditions between spatially segregated population segments. We will first consider spatial differences in socioeconomic status and in environmental conditions separately.

Spatial differences in socioeconomic status (segregation)

A main factor driving spatial clustering of socioeconomic deprivation seems to be the housing market and housing policies. Andersson & Magnusson-Turner (2014) studied changes to housing policy in Sweden. More specifically they studied the effects of allowing for local decision-making concerning giving public housing tenants the opportunity to buy their dwelling. Or, put differently, the conversion of public rental housing into market-based (cooperative) housing. They document increasing levels of socioeconomic segregation in Stockholm as the result of this right-to-buy policy.[3] In a similar vein of market development, Marcinczak et al. (2012), studying three Polish cities, concluded that despite the transition from socialist to more neoliberal policies, social segregation in terms of socio-occupational status, was (still) quite limited.

Besides housing, the job market is likely to be relevant, although this is less obvious for socioeconomic *segregation* within the wider urban area than for the socioeconomic conditions within *the city.* (see also Rink et al, 2011, p. 30). One of the reasons for shrinking cities is a decrease in the number of available jobs, leading to unemployment and (selective) out-migration, with the most qualified and youngest leaving first (Fol, 2012). This out-migration leads to an oversupply of inhabitable dwellings, lowering prices. As unemployment rises, the number of households needing public assistance increases while the city's tax revenues fall, leaving little capital available for investment. This has an impact on public infrastructures, including (maintenance of) green open space. According to Rink et al (2010), in Leipzig, Germany, socioeconomic segregation increased in the wake of the shrinking of the city. According to Fol (2012) the same happened in shrinking French cities. Interestingly, she attributes this to policies to stop or reverse the shrinkage, leading to gentrification.

[2] This may partially be due to different spatial scales, with inequalities being less common or less expressed at higher spatial levels.

[3] For more literature on segregation in Western cities, see Musterd and Ostendorf (2013).

Spatial differences in environmental conditions

Several European studies confirm the existence of meaningful differences in ambient air quality within cities, in terms of health impacts (Naess et al, 2007; Honold et al, 2012; Jephcote & Chen, 2012; Benmarhnia et al, 2013). Local differences in ambient air quality are primarily caused by the location of important emissions sources. Examples of such sources are road traffic, airplanes arriving at or departing from airports, some types of industry and power plants, and wood burning (for residential heating), as well as by prevailing wind directions (Baldasano et al, 2011; Gulliver & Briggs, 2011; Larsen et al, 2012; Minguillón et al, 2012; Beelen et al, 2013, Yim et al, 2013). Locations of emission sources are largely determined by the urban structure, while the amount of air pollution emitted depends on the type and intensity of use (of road, airports, industrial areas). The current urban structure is influenced by previous urban planning. Environmental regulations may also affect choice of location and amount of pollution emitted (see chapter 4).

The presence and distribution of green open spaces, small natural elements and access to the countryside is also determined by the urban (infra)structure. As was already mentioned with regard to air quality, the current urban structure is determined by urban planning in previous periods. According to Kabisch and Haase (2013), Western and Southern European cities experienced no decline in urban green open space between 2000 and 2006, whereas Eastern European cities did. Besides the amount and distribution of green open space, also its quality is important for wellbeing (see below). The level of maintenance and the redeveloping of 'outdated' green spaces is likely to depend on the wealth of the city and the room for action and motivation of citizens to maintain or even redevelop green open spaces themselves (Aalbers et al. 2014). Especially in times of crises, certain parts of the city may be favoured over others (Nogueira, 2010). A more extensive literature survey and/or more research is required to understand the reasons for this.

Spatial co-occurrence of socioeconomic deprivation and adverse environmental conditions

In the previous section (p. 6), it was already concluded that socioeconomic deprivation and adverse environmental conditions tend to be positively correlated. Adverse environmental conditions may lower housing prices. This has been documented for (perceived) air quality (Delucchi et al, 2002; Chasco & Gallo, 2013) as well as for access to green space (Gibbons et al, 2014; Nilsson, 2014). The reduced prices are likely to make such houses more attractive to people with lower incomes.
Similarly, Wolch et al (2014) argue on the basis of Anglo-American literature and cases in the US and China that while the creation of new green space to address environmental justice problems can make neighbourhoods healthier and more aesthetically attractive, it also can increase housing costs and property values. Ultimately, this can lead to gentrification and a displacement of the very residents whom the green space strategies were designed to help. Urban planners, designers, and ecologists, therefore, need to focus on urban green space strategies that are 'just green enough' (Wolch et al. 2014).

Brueckner et al. (2009) developed an amenity-based theory which demonstrates that the relative location of different income groups depends on the spatial pattern of exogenous amenities in a city. The analysis shows that when the centre has a strong advantage over the suburbs in exogenous[4] amenities, and when valuation of these amenities rises rapidly with income, the rich are likely to live at central locations. This conclusion applies regardless of whether or not endogenous[5] amenities, which depend on area's income level, are present. Brueckner considers green open space as an exogenous amenity. (2009) Green open space can be developed on hills, river beds or marshy areas, i.e. the natural elements or topography that hinder urban construction. Urban policy though, and political pressure by local residents on policy makers to maintain or even develop green open space, is of course a relevant

[4] Natural and historical amenities are generally exogenous amenities.
[5] Endogenous amenities and their levels depend on the current economic situation in a neighbourhood, especially the local income level.

factor that can change this situation in the long term. This may lead to additional greening. Similarly shrinkage and the demolition of empty buildings can lead to pocket park development, also in poorer neighbourhoods.

Glaeser et al (2008) argue that housing market explanations cannot explain all of the sorting of the poor into central cities where the employment opportunities are. They find that transportation mode plays a key role in explaining why the poor live in certain areas, close to where the work is, following Meijer et al (1965) and Le Roy and Sonstelie (1983). The marginal, but compared to the urban poor well-to-do, suburbanites would be able to commute from more attractive environment towards their work. Presence of older housing and in particular apartment buildings in central cities also helps explain the presence of poverty in the city center. (Glaeser et al. 2008)

The other way round, socioeconomically deprived neighbourhoods may have less 'voice' in trying to persuade local politicians to improve (or not deteriorate) their environmental conditions. They may be less aware of planned changes, less knowledgeable with regard to procedures, less inclined to be involved in participation (or legal) processes, and less successful when involved. Secondly, once environmental deterioration has taken place, socioeconomically weak population segments may have fewer opportunities to move out of the now less attractive neighbourhood. A recent multi-country European study showed that poorer people are less willing (or able) to pay much for clean air: net household income influenced the absolute Willingness-To-Pay (WTP) amount considerably, also after controlling for awareness of associated health risks and concern regarding air pollution (Istamto et al, 2014).

There is also the question of possible interrelationships between different environmental aspects. A bad air quality may not only influence the health of people, but also have a negative effect on the 'health' of the vegetation. An unhealthy appearance of the vegetation might lower its positive effects on well-being, but this issue has not been investigated much thus far. De Ruiter and Aalbers (2005) concluded on the basis of in-depth interviews with different user groups on green open space on the basis of photographs, that views with damaged green open space and unhealthy vegetation were discarded as presenting 'ugly places'. For instance: lawn with dry patches, barren spots in a vegetated bedding, not well maintained green open space, pebbles showing through the lawn, waste (p. 55-58), were found ugly and negative and reducing enjoyment. The other way round, green space may improve the local air quality, e.g. by filtering fine dust out of the air. However, although the filtering effect itself is not disputed (esp. for some types of coniferous trees), its contribution to the local air quality does not seem to be very strong. In their review, Wesseling et al. (2011) conclude that vegetation cannot improve the air quality in a city and could even make it worse, due to lowering wind speed in streets. Recently, a study by Vos et al (2013) reaffirmed this conclusion. Note that this does not imply that the presence of green space and air quality will not be related. Emission sources or air pollution (traffic, industry, power plants) may spatially coincide with an absence of green open space. It also does not imply that green space will not positively affect other environmental conditions, for instance by reducing heat stress (see e.g. Franck et al., 2013).

2.3 Consequences of socioecological inequalities

The negative effects of both socioeconomic deprivation and bad environmental conditions on well-being and health have been well established, although more so for ambient air quality than for lack of (access to) green open space. For recent overviews, see Deguen and Zmirou-Navier (2010) and Heal et al. (2012) on ambient air quality and Hartig et al. (2014) on green space and health. Whereas with regard to air quality the link with physical health, morbidity and (premature) mortality seem to be the focus of attention, with regard to access to green space also other aspects or indicators of well-being are frequently mentioned: residential satisfaction, quality of living, quality of life, emotional well-being, happiness, mental health. Some of these indicators are by definition linked to the residential situation, and therefore more likely to be influenced by (perceptions of) the physical characteristics of this situation. For example, satisfaction with green spaces and public spaces such as markets, squares and pedestrian zones, both in the city and in the respondent's neighbourhood, is one of the features that

show the highest correlation with the overall satisfaction of living in a city (European Union, 2013). The association with more distal health aspects is weaker, but has been shown to exist. As for the environmental aspects, a distinction can be made between objective assessments (e.g. by researchers using standardized methods) of such aspects and (subjective) perceptions regarding the same aspects. Some authors (see e.g. Okulicz-Kozaryn, 2013) plead for more attention being paid to perceptions, because they are more relevant than the 'actual' situation. However, environmental perceptions themselves are likely to be influenced by this actual (physical) environment.

Another question is what are the most important types of air pollution, as well as the most important types of green space with regard to health and well-being, since this may affect the choice of indicators. With regard to green space it may be noted that (access to) nearby agricultural areas, or the countryside, is not always included in studies on the relationship between green space and well-being. In a Dutch study that looked at different types of green space, including agricultural areas, these were shown to be at least as relevant as urban green space (De Vries et al, 2003). Also, many studies using objective assessments do not take small natural elements, such as street trees, home gardens, pocket parks, into account, usually because of a lack of available data. However, such small elements may be relevant for well-being and health as well (Van Herzele & De Vries, 2012; Van Dillen et al., 2012). The same holds for the quality of the green space. Van Dillen et al (2012) studied four Dutch cities and showed that the (objectively assessed) quality of the streetscape greenery was stronger related to health indicators than its quantity. Furthermore, different types of green space may be used differently and may have different types of effects on well-being and health, an issue that has hardly been explored thus far (De Vries, 2011).

Combined effect of socioeconomic deprivation and adverse environmental conditions

The attention for socioecological inequalities seems to driven by the assumption that the combination of adverse socioeconomic and environmental conditions is even more detrimental to human well-being and health than either of these conditions on its own. More in general, attention for multiple deprivation seems to be increasing, also in environmental health research in Europe, for instance demonstrated by the use of a multi-deprivation index, MEDIx, in the UK by Pearce et al (2010; see also Honold et al, 2012; Benmarhnia et al, 2013). Intuitively one might expect that the combined effect of socioeconomic deprivation and adverse environmental conditions will be at least the sum of their separate effects, or be 'super-additive'. However, there is little empirical research to support this assumption. In fact, the one study we came across suggests that it might be the other way round. In a UK-based study, Pearce et al (2010) observed that while area-level health progressively worsened as the multiple environmental deprivation increased, its effect on mortality was most pronounced in least income-deprived areas. Rather than considering socioeconomic deprivation and adverse environmental conditions independent causes of lower well-being and health, the one might also be considered to mediate the effect of the other. In an observational population study, Mitchell & Popham (2008) found that in England socioeconomic differences in health (in terms of mortality) were smaller in greener residential areas and concluded that green space may help to reduce the negative health effects of socioeconomic deprivation (see figure 1).[6] We propose that both are valid. Moreover, vice versa adverse environmental conditions may also be indirectly associated by lower well-being and health because of their effect on socioeconomic deprivation.

[6] It may be noted that in this study the reported results were corrected for air quality. It was not immediately obvious at which level of spatial detail this occurred, and whether air quality levels represented measurements or (more likely) model predictions.

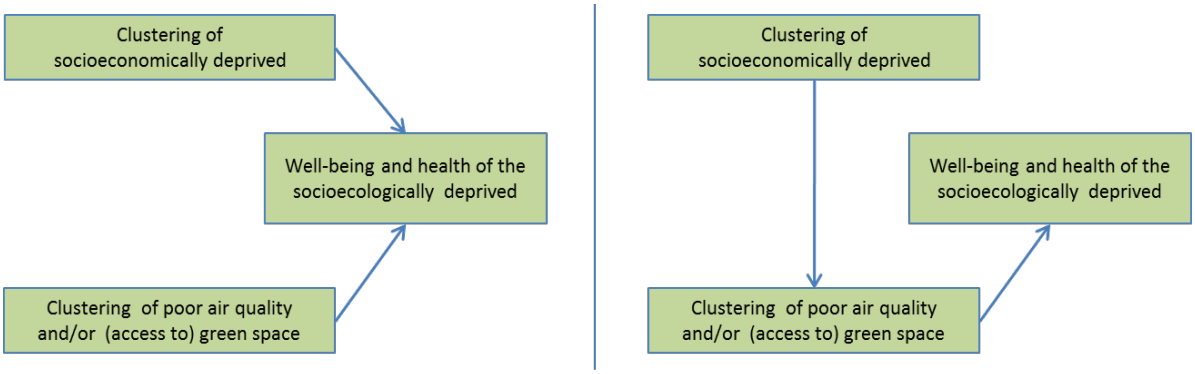

Figure 1: Different causal paths linking socioeconomic deprivation to well-being and health: directly versus indirectly

Even though subadditivity may generally be the case rather than super-additivity, the combination of both socio-economic deprivation and adverse environmental conditions is likely to leave people worse off than if only one of both applies, The (combined) effect of socioeconomic deprivation and adverse environmental conditions will also depend on the vulnerability of especially the socioecologically deprived people to such adverse conditions or their susceptibility to negative health impacts to which these conditions are conducive (WHO Europe, 2012, p. 19). Individual differences in physical and/or mental vulnerability are an issue that may be hard to influence by policy-making. However, to the extent that an increased sensitivity does exist within doubly deprived groups, it may affect the prioritization of reducing socioecological inequality as a policy goal.

Besides effects on health and wellbeing, socioecological inequality is said to also lead to a risk of social and political instability. Glaeser et al (2008) refer to the French decision to restructure the city of Paris after two urban revolutions that originated in the poor and polluted parts of the capital and had toppled two governments in 20 years' time. They engaged Baron Hausmann for the urban reconstruction. Also more recently riots in the suburbs of for instance Lyon, Toulouse and Clichy-sous-Bois, Paris have been associated with socioecological inequality, though there are disagreements between authors on whether the environmental and socioeconomic conditions were the real underlying cause. Dahrendorf (1959) argues that relative deprivation matters, not absolute deprivation. Rioters would compare their own situation with that of others and think about their own situation and what they think they deserve which may bring them into action (Dahrendorf in Stynen (year unknown)).

2.4 An integrated conceptual model for socioecological inequality

In the previous sections the issue of socioecological inequality has been approached from different angles. In this section we try to bring these different angles together in an integrated conceptual model, represented by a diagram (see figure 2). For the present situation, urban structure is highly important, as are housing supply and demand and current environmental policies (assuming that they have been in operation for some time). Urban structure describes how much green space is to be found where, as well as where the residential areas are located and how these are or are not spatially connected. Current housing stock, values and prices (rent or sale), together with housing preferences and household budget restrictions, determine who prefers and can afford to live where within these residential zones.

Environmental policies, also at levels higher than that of the urban region, may set acceptable levels for certain types of environmental conditions, maximum levels for environmental 'bads' and minimum levels for environmental 'goods'. Enforcement of such norms lowers the number of people living 'outside' such thresholds, thereby decreasing differences in environmental conditions[7].The job market influences how

[7] Deprivation may be defined in terms of finding oneself at the wrong side of absolute thresholds or in terms of relative differences. Whereas the first may be eradicated, the latter is more likely to always exist (unless there

many people have a paid job and how much they earn. It may also influence the housing supply, starting with housing (rental) prices. Indirectly, by way of tax revenues and expenditure on unemployment benefits, it may also influence the level of public amenities and facilities, starting with maintenance levels.

Besides environmental policies also other policies are included in the diagram, linked to the factor they are likely to influence most directly. Different levels of policy-making may be involved, from urban to regional, to national to the European Union. There are also other influences of economic, cultural, political or demographic nature at local as well as higher levels. Such drivers are for instance demographic trends, including international (labour)migration, globalization of the economy and its crises, the oil prices and the increasing power of international institutions and business. These longer term developments or trends may influence the scene within which socioecological inequality can develop in important ways, e.g. via the investments in the housing market, in social housing, or the demand of cheap housing by labour immigrants. Climate change (i.e., changes in temperature, precipitation and radiation) influences urban air quality. These drivers appear in the left side of the diagram.

Research question 1.
Which existing English language literature provides knowledge and insight on socioecological inequalities in European urban areas?

In our quick scan of the literature on socioecological inequalities in European urban areas, we have found that in a number of countries the existence of socioecological inequalities has indeed been confirmed, for a subset of the EEA member countries. This literature has been summarized in this chapter. For other countries, the issue may not have been analysed systematically or the results of analysis may not have been published in the English literature to which we have largely limited our literature survey, or we may have missed some publications in the quick scan performed for this preliminary study. Additional literature is available for other regions, such as the United States and developing countries, but the relevance of this literature for European conditions is yet to be assessed. We propose a relatively simple scheme that relates the environmental and socioeconomic components of socioecological inequality to a number of policy areas.

are no differences at all). For physical health absolute deprivation (e.g. of good air quality) is usually considered most relevant, whereas for mental health relative deprivation may (also) be of importance.

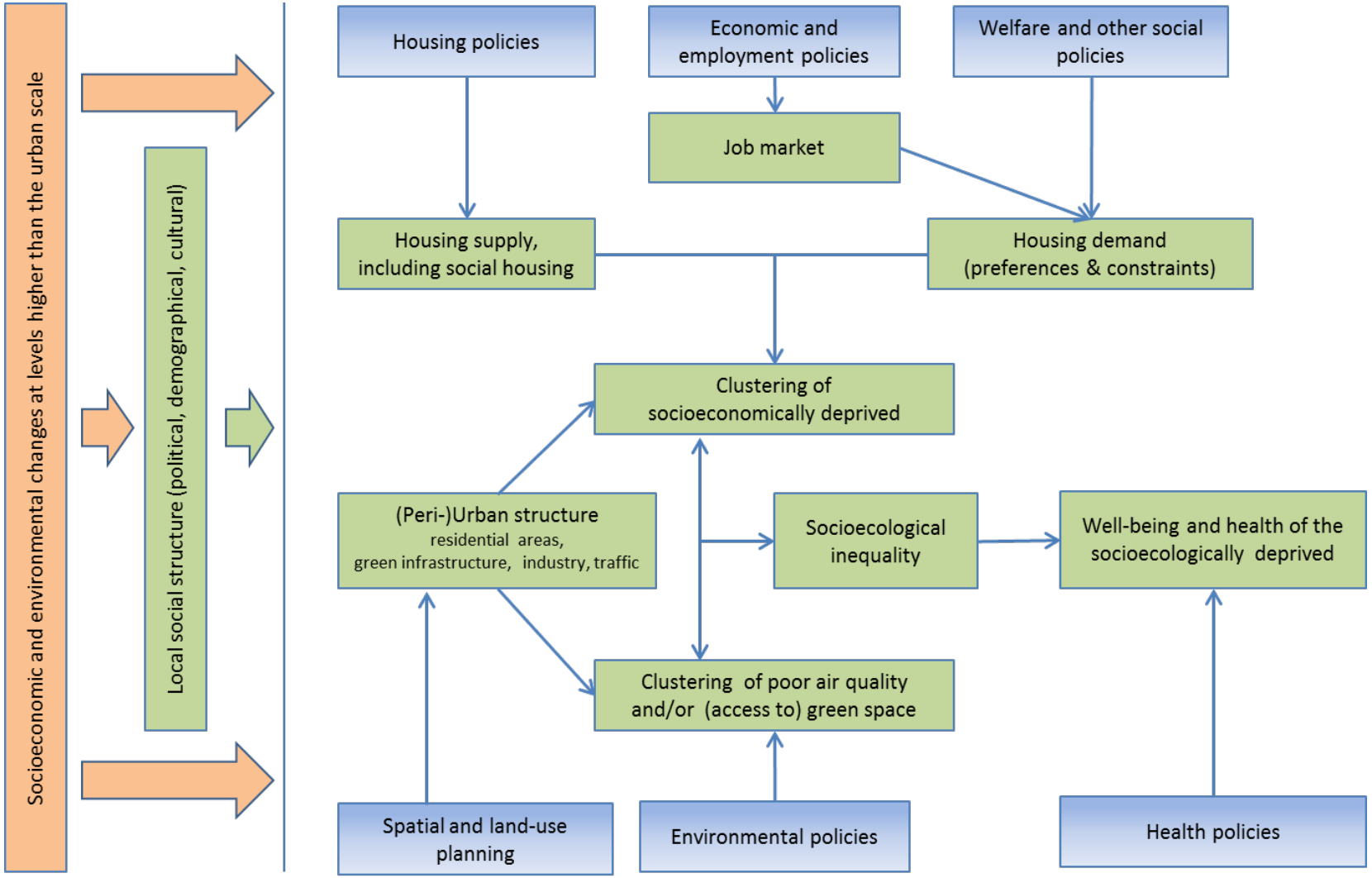

Figure 2: Diagram of the proposed conceptual model for socioecological inequality within an urban area, its causes and its consequences.

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3 Assessing the incidence of socioecological inequality: available data

In this chapter we provide an overview of socioeconomic and environmental data sources than can potentially be used as indicators to analyse and assess socioeconomic inequality. In addition to the name of the indicators, the coverage and resolution and source, we also included a tentative judgment as to the relevance of the indicator for the assessment of socioecological inequality, because the strength of the relationship between the indicators and the issue of socioecological inequality differs very much between the indicators, and is sometimes not well known. Because of the sometimes limited availability of meta-information on, or access to data sources and the limits of our assignment, the inventory may not be complete.

3.1 Socioeconomic data

For the availability of social and economic data and possible indicators that are relevant to the phenomena of socioecological deprivation we explored Eurostat data at national, NUTS 2, NUTS3, Cities and Greater Cities and LUZ level and thematically. LUZ and Cities and Greater Cities data are from the Urban Audit. (http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database). Table 1 summarizes our inventory.

Eurostat data for cities and greater cities contain data on persons (aged 25-64 years) with ISCED level 0, 1 or 2 as the highest *level of education*. (source: Eurostat Data Navigation Tree/General and Regional statistics/Urban audit/education) These data are available for 21 countries, though for different years. In combination with the population data per city these data can be used to provide an indication of the share of low-educated individuals in the city population. The data do not provide an insight into the clustering of these individuals in specific neighbourhoods. For information on this clustering other, additional indicators are needed.

Table 1: Socioeconomic data that may be used to assess socioecological inequality in urban areas

Data	**Level**	**Rele-vance**	**Coverage**	**Source**	**Remarks**
Population number per year, change	NUTS3	++	EU 28 plus CH, LI, NO and IS, ME, MK, TR	Eurostat, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_r_d3area&lang=en	Surface area in km^2.Population by sex and age groups 0-14; 15-64; and 65+ years
Regional gross domestic product (PPS per inhabitant)	NUTS 2	+	EU 28 plus CH, LI, NO and IS, ME, MK, TR	Eurostat, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_r_e2gdp&lang=en	by regions

Dispersion of regional GDP per inhabitant	NUTS3	+++	EU 28 plus CH, LI, NO and IS, ME, MK, TR	Eurostat, http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do	Indicator of lag of region compared to the nation, of risk of departure of better-of groups, of risk of poverty. Measured by the sum of the absolute differences between regional and national GDP per inhabitant, weighted with the share of population and expressed in percent of the national GDP per inhabitant. (economy)
Dispersion regional employment rate	NUTS2	++	EU 28 plus CH, LI, NO and IS, ME, MK, TR	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lfst_r_lmder&lang=en	The rate of dispersion of regional employment is zero when the employment rates in all regions are identical, and it will rise if there is an increase in the differences between employment rates among regions. (economy and employment policies)
Employment rate of the age group 20-64 - %	NUTS 2	+	EU 28 plus CH, LI, NO and IS, ME, MK, TR	http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do	excludes those living in collective households (where many deprived might actually be living)
Share long term unemployed	NUTS 2	++	EU 28 plus CH, LI, NO and IS, ME, MK, TR	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lfst_r_lfu2ltu&lang=en	Indicator occurrence of poverty. The share of long-term unemployment is the share of unemployed persons since 12 months or more in the total active population, expressed as a percentage.
Severely materially deprived or living in households with very low work intensity.	NUTS 2	+	EU 28 plus CH, LI, NO and IS, ME, MK, TR	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_mddd21&lang=en http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_lvhl21&lang=en	experience at least 4 out of 9 deprivations: cannot afford i) to pay rent or utility bills, ii) keep home adequately warm, iii) face unexpected expenses, iv) eat meat, fish or a protein equivalent every second day, v) a week holiday away from home, vi) a car, vii) a washing machine, viii) a colour TV, or ix) a telephone.

Average annual rent for housing per m² - EUR	Cities and greater cities	+++	BG (e), CZ, DK, DE (e), EE, ES, LV (e), LT, L, AT, PL, PT(e), SE(e)	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=urb_clivcon&lang=en	May be combined with income to indicate affordability of housing to low income groups
Cost of a combined monthly ticket (all modes of public transport) for 5-10 km in the central zone - EUR	Cities and greater cities	+++	all except DK, IE, EL,ES (rare),FR (rare), IT (rare),NL,AT,UK (rare),NO,TR	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=urb_ctran&lang=en	
Persons aged 25-64 with ISCED level 0, 1 or 2 as highest level of education	Cities and greater cities	+++	BG (e[8]), DK,DE (e),EE, IE,EL (e),ES(e),FR,LV,LT,HU,NL, AT,PL,PT,SI,SK ,SE,UK,NO,CH (21 out of 33)	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=urb_ceduc&lang=en	level 2 is lower secondary school, level 1 is primary school, level 0 is pre-school and childcare
Number of dwellings lacking basic amenities	Cities and greater cities	+++	BG,CZ,DK,EE,EL (e),ES(e), FR,LV(e), HU,MT,AT,PL,PT,SI,SE (15 out of 33)	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=urb_clivcon&lang=en	possibly an indicator for poverty and landlord practices not respect minimum standards
Number of empty dwellings	Cities and greater cities	++	BG,CZ,DE (incl. e, and partly), IE, EL(e), ES,FR,LT,HU(partly),NL (partly), PL,PT,SI,FI,SE (e),UK,CH.	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=urb_clivcon&lang=en	indicator for problems at the housing market or decreasing house prices. But can also be expensive houses for sale because of the crisis.
% of people severely materially deprived	Cities and greater cities	+	BG (e), CZ (e), EE,	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=urb_clivcon&lang=en	
Number of households in social housing	Cities and greater cities	+	DK, DE, IE, ES(e), FR, IT, LV (partly),LT,HU (partly),NE (partly), AU (partly), PT, SI, FI, UK	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=urb_clivcon&lang=en	

[8] e = estimate

National expenditure on social protection as % of GDP	National	+++	all, except MT and MK	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=spr_exp_sum&lang=en	
National expenditure on social protection per inhabitant	National	++	all, except MT and MK	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=spr_exp_sum&lang=en	
Public expenditure on labour market policies as % of GDP	National	+++	all except IC,LI,CH,MT,MK,TR,RS	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lmp_expsumm&lang=en	

The number of *households in social housing* indicates both the occurrence of social housing and its magnitude (source: Eurostat Data Navigation Tree/General and Regional statistics/Urban audit/living conditions). It is likely that this corresponds with clustering of socioeconomically lower income groups and thus also deprived (the lowest income) groups in certain areas, since housing corporations normally intervene area-wise or block-wise. Hence, for the existence of social housing policies this is a relevant indicator, that we expect to be positively related with clustering of socioeconomically deprived. In some Eastern European countries after the 80-ies social houses have been privatized. If housing corporations do not pay attention to environmental quality such as air quality or access to green open space, the locational factors become decisive for the relation between social housing and whether this occurs in areas with poor air quality and poor access to green open space. (see Housing Policies box in the diagram). But low income groups can also rent houses or apartments from landlords who provide below standard housing, for which available data on number of households living in rented houses is not a good indicator.

A valuable proxy for the presence of socioeconomically deprived people in a city might be the *number of dwellings lacking basic amenities* (source: Eurostat Data Navigation Tree/General and Regional statistics/Urban audit/living conditions). These data are available - but even if different years would be accepted - in terms of European coverage anot complete (see table). For 15 out of the 33 countries these data are available (e.g., 22,483 such dwellings in Halle an der Saale, DE in 2008; 65,454 in Prague, CZ in 2011; 30,819 in Copenhagen DK in 2011). Half (8 countries) of them are poorer states and here deprivation in cities is much wider spread which makes that rather than poverty, the presence of poor air quality and absence of accessible green open space is distinctive for the forms of socioecological inequality we are focusing on. Hence for the richer states this might be an even more valuable (+++) indicator. We expect these dwellings to be located in older neighbourhoods, hence spatially clustered, that are lagging in development, since modern building standards in the richer countries probably do not allow for such types of dwellings and those who can afford, prefer the dwellings that have basic amenities (see (peri)urban structure box and housing supply boxes in the diagram).

An important indicator of socioeconomic deprivation could have been the *% of severely materially deprived persons* but these data, though collected, are extremely rare at city level. At NUTS2 they are available but these areas can also be rural or urban and rural areas combined. People at risk of poverty, or severely materially deprived, experience at least 4 out of 9 deprivations: cannot afford i) to pay rent or utility bills, ii) keep home adequately warm, iii) face unexpected expenses, iv) eat meat, fish or a protein equivalent every second day, v) a week holiday away from home, vi) a car, vii) a washing

machine, viii) a colour TV, or ix) a telephone. So in terms of content they are very relevant, but they are not from the point of view of availability. Nevertheless, the fact that up to 43% of the population from Bulgaria belong to this group, gives an impression of the huge differences between European countries which we should take into account when considering socioecological inequality in a Europe-wide context.

The national expenditure on *social protection per inhabitant* (ranging between 700 euro per year in Bulgaria to 13,000 euro in Denmark per year) or in % of GDP provides an indication of the notion of social problems and need for policies to counter act. This might indicate willingness and ability (% of GDP) to counter spatial segregation as well. Expenditure on social protection contains: social benefits, which consist of transfers, in cash or in kind, to households and individuals to relieve them of the burden of a defined set of risks or needs; administration costs, which represent the costs charged to the scheme for its management and administration; and other expenditures, which consist of miscellaneous expenditures by social protection schemes (e.g., payment of property and income and other taxes). It is calculated in current prices. The functions (or risks) are: sickness/healthcare, disability, old age, survivors, family/children, unemployment, housing, social exclusion not elsewhere classified (n.e.c). These two types of data (social protection, social benefits) could be proxy indicators of the presence of policies to counteract deprivation and social segregation (+++) (see Welfare and other Social Policies box in the diagram).

If we look at a level higher: NUTS 3 and NUTS 2: *Dispersion of regional GDP per inhabitant* at NUTS3 level is of interest for identifying the risk of occurrence of socioeconomic inequality. The indicator is measured by the sum of the absolute differences between regional and national GDP per inhabitant, weighted with the share of population and expressed in percent of the national GDP per inhabitant (economy box in Figure 2). It is an indicator of the level to which a region lags behind other regions, and we think it can indicate the risk of departure of better-off groups to better areas and remaining behind of low-educated and poor groups (see table 1). Thus, it is a valuable indicator for signalling a negative economic trend and population shrinkage (interlinked), and the risk of migration and vacant housing which leads to decreasing house prices and influx and concentration of low-income groups. See Economic and Employment Policies box in the diagram.

Average annual rent for housing per m², in euros, is available at NUTS3 level for different cities but not all countries, and for different years. In combination with Gross Domestic Product (per person, average, and medium) it gives important indications on the housing market and affordability of houses. The data do however not indicate the occurrence of spatial clustering.

At national level, the *Public expenditure on labour market policies*, by type of action, is a meaningful indicator for the employment policies (see Figure 2). Expenditure on labour market policies (LMP) is limited to public interventions which are explicitly targeted at groups of persons with difficulties in the labour market: the unemployed, the employed at risk of involuntary job loss, and inactive persons who would like to enter the labour market. It includes a diversity of measures. They may be considered comprehensive measures of avoidance of poverty and exclusion, e.g. if minimum wages exist and are sufficiently high. However, this also depends on the content of the of policy.

3.2 Data on the distribution of (access to) green open space

Table 2 summarizes information on databases (with Europe-wide coverage) on green open (urban) space. Databases which may be relevant for an assessment of urban socioecological inequality at a European scale are discussed in the paragraphs below the table. The literature mostly uses the term green urban areas and not green open space. The definition of green open space as given in the introduction includes agricultural areas. Not all of the following indicators include agricultural land in their coverage, but mainly focus on green areas within built-up areas. The Urban Atlas has a separate indicator on agricultural areas, semi-natural areas and wetlands. Databases like these might also give the impression that there is a great amount of green space available in urban areas, but satellite imagery, on which these databases are often based, does not contain information on whether the green

space is publicly accessible or not. This type of information requires an additional step. However, also private green spaces may generate benefits to others than their owners.

Table 2: Data on green space that may be used to assess socioecological inequality in urban areas in Europe

Indicator	**Level**	**Rele-vance**	**Coverage**	**Source/Link**	**Remarks**
Green Urban areas	Street level (1:10000)	+++	EU27 (2012: EU31) 305 Large Urban zones	EEA, Urban Atlas http://www.eea.europa.eu/data-and-maps/data/urban-atlas	Input for "share of green urban areas" from ETC-SIA Urban GI database
Share of Green urban area	1 x 1 km	+++	EU27 (2012: EU31) indicators developed for 370 cities	ETC-SIA Urban GI database	Derived from "share of green urban areas" from Urban Atlas; the indicator presents the fraction of green spaces in European cities for two units (core city, fringes) [%]
Distribution of green urban area		++			The edge density per km² of edges/boundaries between green and red (built-up) areas of the cities
Mean effective green infrastructure		++			Potential green infrastructure areas minus the potential urban areas.
% of hotspots within the effective green infrastructure		+++			Areas where the potential green area and the potential urban area overlap
Green Infrastructure	10 x 10 km	+	EU32	EIONET, http://forum.eionet.europa.eu/etc-sia-consortium/library/2011_subvention/wa2_ludc/functionalities/green_infrastructure	Contains several indicators (8) of which JRC map on connectivity and Landscape fragmentation seem most relevant
Tree cover density	20 x 20 m	+++	Pan-European	EEA, Copernicus http://land.copernicus.eu/pan-european/high-resolution-layers	
Lawn cover	20 x 20 m	+++	Pan-European	EEA, Copernicus http://land.copernicus.eu/pan-european/high-resolution-layers	

The Urban Atlas is providing pan-European comparable land use and land cover data for Large Urban Zones with more than 100.000 inhabitants as defined by the Urban Audit (EEA, data list on Cities Typologies*)*. It is a data source with a high spatial resolution covering differences within cities at street level. It has a temporal coverage of 2005-2007 and is based on satellite imagery as a part of the local component of the GMES/Copernicus land monitoring services. The Urban Atlas is available for 305 large

urban zones. Because a large number of cities are included in the database, the Urban Atlas can be used for comparing between cities. To our understanding, the information is not regularly updated.

The Green Infrastructure indicator from the ETC-SIA Urban Green Infrastructure (GI) database consists of four different (sub-)indicators. Two indicators refer to inner city green infrastructure parameters; share of GUA (Green Urban Area) and distribution of GUA (represented by the edge density between "green" and "red"). The *share* of green urban area comes from the Urban Atlas database (EEA). It combines the entries: Discontinuous Low Density Urban Fabric (S.L. : 10% - 30%); Discontinuous Very Low Density Urban Fabric (S.L. < 10%); Urban green spaces; Sports and leisure facilities; Agricultural areas, semi-natural areas and wetlands; and Forests. The *distribution* of the green urban area is defined as follows: "The edge density provides an indication about the distribution of green urban areas such that one can interpret that a high edge density in a city indicates a relatively high number of green patches with borders to the sealed parts of the urban fabric made up of residential and commercial/industrial/public buildings" (ETC-SIA, 2013). It could be asserted that a high edge-density may enhance the access to urban green spaces, but also, that the edges with industrial land and (water) ways are not automatically enhancing accessibility of green open space.

In addition, the ETC-SIA Urban GI database includes two urban-fringe green infrastructure parameters: mean effective GI and % of hotspots within the effective GI. The *mean effective GI* follows from the potential GI according to land cover maps minus the potential cover of urban areas. The potential is derived from the Corine Land Cover data set based on Corilis-methodology (ETC-SIA, 2013). Corilis is a methodology for smoothing Corine Land Cover, obtaining a potentiality or intensity map for a certain land cover class within a defined radius. Each point of the territory is represented by a probability surface for the presence of a certain CLC class, varying from 0 to 100. Corilis results in one layer for each CLC class, which can be aggregated by simple addition to obtain an upper level (Corilis level 1) or a thematic group (GBLI, Wetlands, Dominant Land Types). This methodology is developed in the ETC-SIA report "LEAC methodology report 2011" (Martínez et al., 2011). This indicator might be less interesting for analysis of socioecological inequalities because it mainly maps green areas rather far away from cities. The *% of hotspots* are areas where the potential green area and the potential urban area overlap. The overlap areas or hotspots are interesting for this research because these areas indicate where green areas and cities meet. When reported on a more detailed level, this might give an indication of the local (lack of) access to green space.

An additional dataset called "Green infrastructure" is based on a calculation of a series of indicators from different European data sets which can be used for a description of GI at a spatial resolution of 10x10 km (EEA, data list on Cities Typologies). It consists of several indicators on green infrastructure of which in particular the JRC map on connectivity and landscape fragmentation may be relevant, although the relevance to urban environments is unclear, because the actual dataset was not accessible to the authors and insufficient meta-information was found. It is spatially very crude and therefore not very promising for assessing green space accessibility within cities or urban areas.

The Copernicus Land Monitoring Services includes a 'tree cover density' indicator giving a percentage of tree cover at a high spatial resolution of 20 x 20 m (Copernicus, 2014). A similar indicator is developed for 'lawn cover density'. The data are new and have not been validated yet and were not available for download, but may be very relevant to support an assessment of the availability of green space in the future.

In some countries, an attempt was made to develop operational indicators for the presence of small green elements within built-up areas, as a complement to the presence of green areas based on land use data. For example, in the Netherlands, first, the same land-use database that is used to identify green areas is used to identify built-up areas. Second, for the grid cells classified as built-up area the NDVI-score is determined. NDVI stands for Normalized Difference Vegetation Index and has been widely used in studies relating the presence of vegetation in residential areas to well-being and health (see e.g. Bell et al, 2008; Dadvand et al, 2012; Fan et al, 2011, Paquet et al, 2013). The NDVI is based on near

infrared light emitted when photosynthesis takes place and indicates the amount of green biomass. The methodology lends itself for Europe-wide application, since satellite data including the near infrared spectrum are available for the whole of Europe on a 20x20 m spatial resolution (SPOT[9], DMC[10]). By calculating this score only for areas classified as built-up area, it is expected that it indicates the presence of small green elements. However, the indicator has not been validated by field observations thus far. It should be noted that due to its dependency on photosynthesis taking place a) not all types of vegetation generate the same NDVI-score and b) the score for the same area may differ substantially between seasons. This may complicate its application at an European level.

Many European countries will have national databases with different scope, content, formats and levels of accessibility, which is at least partially reported to EUROSTAT in the context of the Urban Audit. For example, in the Netherlands an atlas of the environment has been developed which gives information on the availability of green and whether people are content with the green area in their neighbourhood (Ministry of Infrastructure and Environment, 2014). Statistics Netherlands (CBS, 2014) included the variables 'green space area (km^2)' and 'green space (in hectares) to which the public has access' in its most recent report to the Urban Audit for 2013. The Netherlands Environmental Assessment Agency (PBL) makes use of an even more sophisticated indicator, based on a normative model (AVANAR) that confronts the local demand for and supply of opportunities for recreational walks in a natural setting. Shortages in green recreational opportunities as calculated by AVANAR have been shown to be related to actual recreational behaviour (De Vries et al, 2014, p.192): people living in a neighbourhood in the highest shortage class generate 20% fewer recreational walks than those living in a neighbourhood without a shortage.[11]

It is important to note that, similar to the Dutch examples above, additional information for selected cities may be available as a result of specific European, national or local projects, but is not collected centrally at the European level and therefore it cannot be easily found. Nevertheless, they may still be of interest, for instance because they put the indicators that are available at the European level into perspective. One of the issues raised by the last example is whether it is the absolute amount of (accessible) green space that is important, or the amount of green space per capita (or both, but for different reasons). Even proposed standards for green space provision that have not (yet) been applied nationally (let alone Europe-wide) may offer relevant insights as to what is considered important and/or what would constitute a good indicator. An example of the latter is the Accessible Natural Greenspace Standard (ANGSt), adopted by Natural England (2010). One of the ANGSt-recommendations is e.g. that everyone should have accessible natural greenspace of at least 2 hectares in size, no more than 300 metres (5 minutes walk) from home. Especially when using beeline distances as an approximation, this is an indicator that might even be relative easy to calculate for all European urban areas. When 300 metres buffers around green areas that satisfy the required minimum size are drawn, residential areas within UMZs located outside any on these buffers may be considered green space deprived areas. Of course, the outcomes depend greatly on what is considered natural greenspace, e.g. whether agricultural areas are included or not.

[9] SPOT: Satellite Pour l'Observation de la Terre http://www.cnes.fr/web/CNES-en/1415-spot.php

[10] DMC: http://www.dmcii.com/

[11] People living in a neighbourhood with a high calculated shortage of opportunities for recreational walks in a natural setting also spend more holiday nights away from home, which might be construed as a kind of compensation behaviour (Sijtsma et al, 2012).

3.3 Data on the distribution of air quality

Table 3 gives information on which databases on air quality (with Europe-wide coverage) were identified. The potentially relevant air quality indicators are further discussed in the paragraphs below.

Table 3: Air quality data that may be used to assess socioecological inequality

Indicator	Level	Relevance	Coverage	Source	Remarks
AirBase	Point features	+++	EU39	EEA, ETC-ACM, http://www.eea.europa.eu/data-and-maps/data/airbase-the-european-air-quality-database-7	
Interpolated air quality data	10 x 10 km	+++	EU39	EEA, ETC-ACM, http://www.eea.europa.eu/data-and-maps/data/interpolated-air-quality-data-2	Derived from AirBase

AirBase is the primary and formal source for European scale information on air quality. An annual report is prepared every year presenting an overview and analysis of air quality in Europe from 2003 up to two years before (now until 2012), as well as estimates of urban population and ecosystem exposure to air pollution (EEA, AirBase). An additional annual report is published on ozone (EEA, 2013). Special attention is given to air quality in urban areas by combining air quality data with urban population exposure.

The air quality is measured at traffic stations and background stations. The population is then assigned proportionally to a measuring station to determine the exposure of the population to a certain pollutant. For every year and for each city in a certain country, the concentration of the pollutant is related to the urban percentage of the population (EEA, Exceedance of air quality limit values in urban areas). When using the interactive map for air quality from AirBase one can zoom in on a city and see which AirBase stations are available. For example, zooming in on the city of Amsterdam shows there are almost 20 stations where air quality is measured. This allows inner-city comparison of air quality (neighbourhood level), but also comparison between European cities. It is not clear how the location of these measuring stations was selected and if they are representative for highly polluted areas or not. Air quality is measured for several pollutants, including particulate matter (2.5 and 10), ozone, benzo(a)pyrene, nitrogen dioxide, sulphur dioxide, carbon monoxide, lead and benzene. Air quality is measured across 400 cities in Europe for multi-annual times series.

ESPON also has information on (interpreted) air quality which is derived from AirBase. Via the BRIDGE project 5 case studies have analysed several parameters including air quality of which some resulting datasets are available on the internet. For example, the city of Athens measures air pollution at different locations in the city at hourly rates. According to Frank de Leeuw (RIVM-ETC Air pollution and climate change mitigation; personal communication) AirBase data can be coupled to neighbourhood level socioeconomic data but this has not been done yet. EU countries have national systems to gauge air pollution, much of which is reported to the European Commission in the context of European air pollution policy. Also the Urban Audit has entries on air pollution. To really combine data of air quality with data on socioeconomic factors a much denser network that measures air quality would be needed than is usually available per city.

Research questions 2 and 3

Which databases are available at the EEA or Eurostat on European cities that provide information on neighbourhood or street level on the presence of low income and/or low education, air quality and green areas in and around cities? How to interpret this information in relation to socioecological inequalities?

Socioeconomic data sources

A number of socioeconomic data are especially relevant to the identification of the occurrence of socioecological inequality, notably *the number of persons aged 25-64 with ISCED level 0, 1 or 2 as highest level of education* and *the number of dwellings lacking basic amenities*. These data are available at city level for 21 and 15 out of the 33 EEA member countries, respectively, though for some regions only as estimations . Problematic for the ISCED level is that, in some countries, general education level is low anyway. In those cases, the indicator on dispersion of GDP per inhabitant is useful. It helps to identify serious imbalances which can indicate that, in relative terms, there certain groups are seriously lagging behind, which can then be expected to correlate positively with the size of the group of low-educated citizens. The number of dwellings without basic amenities to us seems a very meaningful proxy, yet more in richer countries (more distinguishing), for indicating the presence of socially deprived.

As for the factors that contribute to the risk of socioecological inequality, rather than measuring the inequality itself, the following four indicators are likely to be of interest relevant: *dispersion of regional GDP per inhabitant; cost of a combined monthly ticket for all modes of public transport for 5-10 km in the central zone; public expenditure on labour market policies as % of GDP; the national expenditure on social protection as % of GDP.* The first, if high, signals that serious inequalities within the region (NUTS3) exist, which can in addition lead to a pull of the better-off to the places where the money and the work is. The following indicator – if combined with income level - can indicate whether public transport is affordable to low income groups and enables them to find and keep work and income, if they do qualify for the job. National public expenditures on labour market policies are meaningful, because if these are high (and effective, which is of course not contained in the data) they reduce the chance of social deprivation. Finally, for those who can't make it to work, in different senses, the national expenditures on social protection indicate whether a culture and possibility of assisting the poor and increasing their income level exists, which reduces their deprivation. These different indicators relate to different boxes in Figure 2. Note that using the size of public expenditures on a certain problem as an indicator of smaller inequalities presumes that the problems themselves are similar in the different urban areas. To the extent that this is not the case, the size of the expenditure may also be seen as an indicator for the size of the problem.

Environmental data sources

As to databases on urban green open space, the Urban Atlas together with the Copernicus tree cover density and lawn database are the only databases that give information on neighbourhood and street level on green open space. Especially the information from the Urban Atlas is very useful for putting next to socioeconomic factors, but apparently it is not regularly updated. The Urban Audit also provides information on green urban infrastructure and is updated and extended periodically, but has a lower resolution. Additional databases are likely to be available at the national or urban level, but not as easily accessible at a Europe-wide scale. Like for socioeconomic data, it should be noted that a number of green space indicators may be relevant, but the strength of the relationship with socioecological inequality differs.

As to data bases on air quality, AirBase, managed by the EEA, includes annually updated Europe-wide information on key air pollutant concentrations. For urban analyses, the traffic-related measurement stations are of particular importance. Additional information for selected cities may be available as a result of local programmes, projects or campaigns, but is not collected centrally at the European level. To our understanding, the information from AirBase could in theory be overlaid with data reflecting socioeconomic deprivation at urban and neighbourhood level, but this has not been done yet in practice.

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4 Policies and practices reducing socioecological inequalities

Chapter 4 on policies and practices that prevent or reduce socioecological inequalities summarizes the literature for existing and implemented policies and practices that are directed at avoiding or reducing socioecological inequality. As illustrated in Figure 1, a wide range of policies can be relevant: environmental, green open space, air pollution, spatial planning, housing, transport, health and other policies. Our findings are illustrated by three case descriptions.

4.1 Spatial, social and housing policies in relation to socioecological inequality

Spatial policies

Spatial planning in general is not regulated on a European scale, i.e. the European Commission does not have specific legislation on green space or spatial planning. It is the responsibility of national and local governments. Many EU-investments (such as the Structural Funds, e.g URBACT, ERDF but also LIFE+) do however co-direct urban developments. In the introduction, we mentioned the Leipzig Declaration and the Urban Agenda. But other, non-urban, European policies can also have a spatial or urban component. For example, recently the European Commission has adopted a Clean Air Policy Package (EC, 2014) to limit national emission of six main air pollutants. Countries have to uphold the European rules and legislation on emission ceilings of air pollutants. National spatial planning policies therefore automatically have to take air pollution into account avoiding exposure of people to pollutants. Another example is the European Green Capital Award (EGCA), a policy tool that the European Commission uses to recognise and reward local efforts to improve the environment, economy and the quality of life in cities (EC, 2014). Although concrete, specific spatial policies aiming at decreasing socioecological inequality at the urban level may be almost absent in Europe, various scholars have addressed the need for such policies and provide suggestions.

Looking at spatial planning approaches in relation to socioecological inequality we now present insights from different countries and continents. Theys (2002), referring to cases of socioecological inequality across the globe and on the basis of European research literature, promotes a territorial approach to sustainability in order to reduce socioecological inequality and pay due attention to social issues. He discusses the neglect of the social dimensions in economic and environmental policies. He observes a distinction between the culture of ecologists being more technologically, and of urbanists being more socially oriented. Most economists neglect growing socioecological inequalities at the urban level. Environmental policies have not made a major point of resolving socioecological inequality (Theys, 2002). Stronger, he argues that the technological approach to economic and environmental development even reinforces this tendency to neglect the socioecological inequality. And then there is the gentrification effect of urban reconstruction and eco-quartiers, instead of the expected contribution to increased social mixing. Similar processes of gentrification as result of reconstruction- or transit-oriented development are observed by Arbaci (2008), the Richmond Equitable Development Initiative (http://reimaginerpe.org/research/richmond/docs), Anthony (2010) and others. According to Theys, the environmental measures like increased tax on fuel, reduced subsidies for public transport, and restrictions of car use, disproportionately affect poor peri-urban dwellers, who would have to spend a large part of their monthly income on public transport.

Theys calls for a sustainable development approach that relates, or better, weaves links between the local and the global, the sectors and the spatial dimensions. Theys demands a strategic vision and first of all a vision at space, referring to Emelianoff (1999), that is inspired by the local "topology", to integrate local with global sustainable development challenges and to pay attention to local uniqueness, both geographically and in terms of local capacities. Theys calls for a territorial approach that links social urbanism with ecology in order to solve daily life problems and needs. Developing supportive financial mechanisms like taxations, much larger investments in urban reconstruction and making sure that cities have access to the necessary means for such reconstructions, is required. This would also demand an

institutional reform, allowing each territory to define its own ways of action, transparency and value based public action.

Remarkable of this French exposé on a territorial approach is how it aligns with the urbanist vision by Bernard Reichen and Alfred Peter (see box 1) used for the scheme of Territorial Cohesion for the Montpellier Agglomeration and other French regions. Their spatial planning approach also imagines functional and spatial inter linkages between environment and urban structure. The functional dimensions connect environment to society. To further this reflection on the relation between spatial planning and social dimensions of the environment we can also refer to Newman et al. (2009). Newman bases his insights on experiences and lessons from the US and Australia. Newman et al. distinguish the walking city, the transit city and the automobile city. These different urban fabrics influence developments and possibilities. Newman (2009) describes urban planning that combines appreciation for local places with global responsibility: Present heavy car dependency of cities is inequitable to the elderly, the young and the poor. This will be reduced by greater walkability of cities and transit access. At the same time noise, loss of public safety, aggressive behaviour by car drivers and neighbourhood severance will be reduced, as well as (costs of) pollution.

Danish architect Gehl, with a long standing experience as urban planner, similarly draws attention to the fact that the human scale of cities has been forgotten in urban planning. After the car invasion in the sixties it is now time for a lively, liveable, sustainable and – again – healthy city.' Looking carefully after people in city planning will efficiently address all three issues', Gehl states (see his power point presentation 'Cities for People' www.Gehlarchitects.dk). He refers to examples of walkable and cycleable areas developed in Copenhagen, Melbourne, Helsinki, Tokyo, Vienne, Zurich, Stockholm, Munich, Sydney and Oakland. Hence from different corners of Europe and the world strong argumentations for a more inclusive form of spatial planning, linking social dimensions to ecological dimensions are made that would be beneficial in terms of air quality, green open space health, and social equality. Involvement of the public in institutional reform to support this new urban development is mentioned by Theys solely.

Where Theys, Reichen, Peter and Gehl pay due attention to the social dimensions of urban development we remind that the paradigm of a compact city brings with it a city with much less green open space and the risk that those who can afford it settle down in the more scarce green open spaces or depart for the countryside or urban fringe, while the low income groups stay behind in the deprived areas. The more inclusive vision of a green veined urbanization at least provides a structure that reduces this risk (for which the edge density noted in the previous chapter may be a suitable indicator). This resembles the spatial planning strategy of the Two Networks (Tjallingii, 1995). This strategy distinguishes the slow networks of ecosystems along the watercourses which should be coupled to housing areas, and the rapid network of traffic which should be coupled to business and high urban dynamics. Such a strategy separates air pollution sources from housing areas and couples green open space with residential areas, a vision that might help to prevent future areas of socioecological deprivation (see also Aalbers and Jonkhof, 2005).

Social policies

We expect social policies like employment promotion, income policies, differential taxation and education programmes to make a substantial difference in terms of reducing socioeconomic deprivation, but an in-depth investigation of this relationship is beyond the scope of this report. An inspiring Dutch example is the social policy of the National Programme Rotterdam-Zuid. It focuses on districts with high unemployment levels and many young immigrants. The national and local authorities, schools, care organizations and companies have joined forces to counteract social deprivation and enhance the actual integration of the local inhabitants in the labour market and improve the quality of life. Both the national minister for social affairs and the a local alderman were responsible for the programme. The Alderman engaged in close consultation with schools for professional and higher education to ascertain that they would not advise students to choose a study that would be unlikely to lead to a future job. Also he engaged in talks with companies to obtain confirmations that they would actually engage successful students. Applicants received training to prepare a c.v. and anticipate the job interview.

(http://www.rotterdam.nl/nprz). The programme has not yet been evaluated but the approach seems focused on solving real problems, very interactive, and promising. Simultaneously, the widely available green open space is partly built with houses for higher income groups in order to enhance the social mix of residents and raise the quality of life. Higher income groups bring with them the endogenous amenities (Brueckner et al. 1999).

We did find numerous examples of community initiatives to self-organize and fight socioecological inequality. Following the earlier suggestions for institutional reforms above (and see also references to Nijkamp's condition of participation below), the Richmond Equitable Development Initiative (REDI, US) also refers to the need for greater community ownership. They ran a multi-year campaign aimed at influencing Richmond decision-makers to adopt equity principles in planning processes on focus areas which include equitable land use and planning, quality jobs and workforce training, affordable, safe and reliable public transit, greater community ownership and creating a healthy environment. Similar examples of social policies, often developed by Civil Society Organizations, can be found in the American Journal on Race, Poverty and the Environment. Local residents, including youth, are invited to workshops and trained to understand their local situation in global perspective, and to be made aware of both the social and environmental dimensions of community development (e.g. Brooks, 2001, Gibbs, 2002). So, activism to enhance the access of local residents to decision making as well as awareness raising activities among local residents do exist. These American examples are paralleled by European local initiatives in which local residents develop urban agriculture initiatives, engaging neighbourhoods. Generally these initiatives seem organized rather by higher educated individuals and networks than by socioeconomically deprived people. But we are not aware of any studies on the involvement of deprived groups in these actions.

Housing policies

Glendinnings (2009), in his review of Swenarton's review (2008) of urban architecture of 1900-1930, writes that the domain of public housing policies has been under researched. He concludes that very diverse issues, related to different departments, sectors or disciplines have been studied. Our own scan of the literature did not reveal reviews, let alone systematic reviews, of (the integration of) environmental aspects in public housing policies e.g. concerning green open space and clean air, and their relevance for the health and wellbeing of public housing residents in Europe. This might be indicative of the neglect of the environmental issues related to housing in urban areas, especially when it comes to the more vulnerable groups. (see also Theys, 2002) Whereas scholars have not paid much attention to these issues, practitioners have. The early twentieth century garden city concept and work of urban planners like Ebenezer Howard is a social approach to housing and the environment which is famous. In the post WWII urban lay-out these ideas were copied into large scale public housing interventions. These have not always been successful (e.g. Le Corbusier district in Marseille, Bijlmermeer in Amsterdam). In Rotterdam Zuid, the post-war urban development plan led to discussion in the fifties about investment in quality. 50 years later the National Programme Rotterdam Zuid is instigated to readdress problems in the very same area. In West Amsterdam the neighbourhoods by van Eesteren have recently been reconstructed because of multiple problems. Private houses are built in the previously widely available but (over time?) little used green open space. The outdoor space in the neighbourhoods constructed following the 'light, fresh air and space'-concept of van Eesteren) had become anonymous, due to lack of adequate management which includes the keeping up with developments and wishes of the residents (Aalbers and Bezemer, 2005). Without proper research on social housing in relation to the outdoor environment, important requirements for the successful and sustainable development of new social housing areas may be neglected.

Turning to American literature: also Newman (1997) states that neighbourhood quality has not obtained much attention in public housing policies of the HUD (US). Bratt (2010) explores key connections between housing and family well-being, based on a review of a large number of studies and analyses. She examines the specific ways in which improved housing conditions and less onerous housing cost burdens promote healthier, more productive families. 'Housing is the foundation of family life, without which all other activities are severely challenged or rendered impossible to carry out: a decent place for a

family to live becomes a platform for dignity and self-respect and a base for hope and improvement. A decent home allows people to take advantage of opportunities in education, health and employment—the means to get ahead in our society. A decent home is the important beginning point for growth into the mainstream of American life' (National Housing Task Force, 1988, p. 3). Bratt concludes with a proposal that would involve a significantly increased commitment to housing based on all recipients of housing subsidies entering into a reciprocal relationship with the government which would involve fulfilling a basic set of responsibilities.

Bratt gives detailed figures on the housing woes in the US, originating from the US Department of Housing and Urban Development (HUD). The reasons for the problems are multi-faceted: loss of both private low-cost units as well as HUD-assisted units; rents rising faster than the rate of general inflation and incomes; and decreases in the rate of new additions to the inventory of assisted housing, as well as decreases in federal funding for HUD. Her article makes clear what the basic role of social housing can be to counter socioeconomic deprivation . Very low-income people are challenged in a number of ways and, although each of the factors discussed has disproportionately large impacts on poor people, but she has not distinguished between poor versus non-poor residents. She refers to the work of British researcher James R. Dunn on the relationship and pathways between housing, socioeconomic status, and health (see Dunn, 2000).

Her proposal includes a series of deep housing subsidy programmes instituted through an initiative based on a new social contract between government and individuals. The essence of this new contract would involve government provision or direct support of decent, affordable housing in exchange for individuals meeting their core responsibilities: working toward family well-being and optimal productivity (see figure 3).

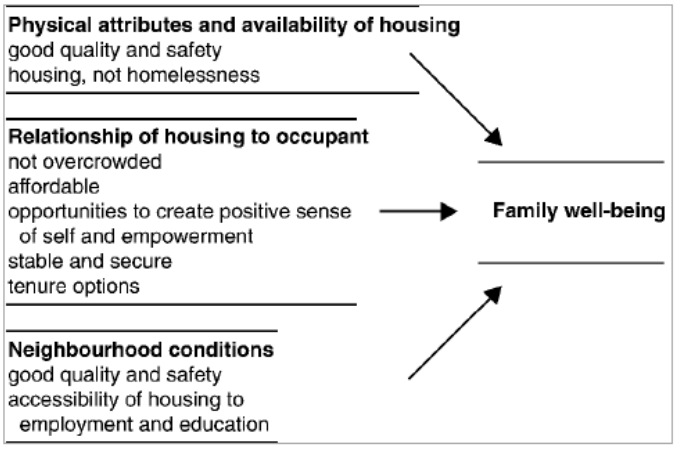

Figure 3: The connection between housing and family wellbeing (Bratt, 2010)

Patterson (2014) describes the development in terms of relocation of social housing residents by means of vouchers (coupons) in West New York. He uses a spatial and statistical analysis and the data provided by the office that emits the vouchers. His study reveals that part of the African Americans use the vouchers to move out from impoverished hyper-segregated areas into historically white neighbourhoods, whereas another part moves into areas of re-ghettoization. More research is needed, but vouchers might offer a housing policy instrument to counteract socioecological inequality.

Freeman & Li (2012) studied another housing instrument to counter segregation, the law against discrimination on Source of Income (SOI laws). They investigate whether it facilitates access to less disadvantaged neighbourhoods. They find found substantively important reductions in neighbourhood poverty rates associated with the implementation of SOI laws and small but statistically significant reductions in minority concentration as well. They also looked at the impact on concentration of voucher recipients in neighbourhoods. This does not appear to be related to SOI law implementation. According

to Bolt et al. (2010) desegregation and mixing policies are not very effective. See also Gibson et al (2011).

4.2 Environmental policies in relation to socioecological inequality.

In this report, we focus on ambient air quality and access to green space as two main environmental factors related to socioecological inequality in Europe. We acknowledge the existence and relevance of other environmental factors, such as noise, exposure to climate risks, indoor air quality, closeness to polluting industries and water and sanitation. Studies are available also about these issues, and in general we can say that policies addressing these issues in general will also reduce the negative effects on socioeconomically deprived populations. to reduce the observed inequalities. WHO (2012) suggests six general recommendations for action, which can be tailored to the respective national situation:

- action 1: general improvement of environmental conditions, assuring healthy environments for all;
- action 2: mitigation and reduction of risk exposure in the most affected population groups, focusing on the most exposed and/or most vulnerable subpopulations;
- action 3: national environmental health inequality assessments to assess or confirm inequalities based on national, more detailed data;
- action 4: sharing experiences and case studies on successful interventions tackling environmental health inequalities;
- action 5: review and modification of national intersectoral policies in relation to environmental health inequalities;
- action 6: monitoring of environmental health inequalities using a standard set of inequality indicators.

The last four actions relate to research, assessment, monitoring and exchange of information. Below we elaborate the first two, i.e. what is known about the role of environmental policies to address socioecological inequalities, focusing on air quality and access to green open space.

Policies addressing ambient air quality

The literature confirms that there is significant inequality in the exposure to air pollution and the related health risk in Europe and elsewhere. Air pollution combined with other aspects of the social and physical environment, generally create disproportional disease burden in populations with limited incomes and with minimal local resources to take action (WHO, 2012). Because there are many exceptions to the general rule, such as polluted city centres where only wealthy citizens can pay the high housing costs, or suburban areas in northern countries where people with high incomes have large numbers of wood burning stoves, local policies have to account for locally specific circumstances.

For air pollution, over the last few decades an extensive system of legislative instruments has been developed to regulate and reduce emissions and concentrations of air pollutants (see Table below). Member States have transferred this European legislation to national levels, which generally reduces the levels of background air pollution in urban areas. The EEA annually reports about the status of air quality in Europe (EEA, 2014), with an additional annual report on ozone (EEA, 2013). The information in this reports compare the actual situation with the air quality and emissions targets and the status of policy implementation, and are supported by more detailed information in country fact sheets and indicators on the EEA website. The European Commission has proposed a new Clean Air Policy Package in 2013 updates existing legislation that controls harmful emissions from industry, traffic, energy plants and agriculture, with a view to reducing their impact on human health and the environment. Because air pollution impacts in cities are most severe, reducing air pollution gets special emphasis in the new proposals, but no attention is given to the specific problem of differentiated exposure for groups with different socioeconomic status. However, according to the Commission, "all EU citizens will benefit from improved air quality, but children, the elderly and citizens suffering from asthma and respiratory

conditions will benefit the most", while one may argue that the latter categories of citizens are overrepresented in socioeconomically deprived neighbourhoods.

The national and sub-national authorities are very important actors in implementing EU legislation and can adopt additional measures to further protect their populations and the environment (EEA, 2014), and specific air quality and traffic policies in many European cities will specifically address the situation in poor air quality hotspots. However, no overview is available of such policies in the member states, and also no systematic inventory of policies that address inequalities in exposure to poor air quality. Although clear evidence of city-specific environmental inequalities (that relate to the historical socioeconomic make-up of the cities and its evolution) and the relationship between poor air quality and socioeconomic deprivation has been established in several places in Europe for some time (e.g., see Padella et al., 2014), the issue does not seem to have entered the policy agenda, neither at national or international, nor at local level. In the UK, recognition of the importance of environmental equality has been reflected by increasing political and government attention in this area (Netcen/AEA Technology, 2006), but this attention seems to be focus mainly on more research rather than developing and implementing targeted policies. It should be noted though that an up-to-date inventory of national and local policy developments is not available in the literature, and consequently some recent developments may have been missed. According to WHO (2010), policies aimed at reducing the root causes of these inequalities could be based on urban multi-polarity and diversity, requiring long term urban planning (see Box 1). Urban transformation towards more compact cities, as suggested by EC (2011) could reduce travel distances for commuting and as a side-effect reduce background air pollution, but may increase local peak levels of air pollutants in the more concentrated city centres, with higher risks for neighbourhoods near highly trafficked streets.

Box 1: Urban multi-polarity and diversity

"Urban planning policies that would look for 'spatial multi-polarity and social diversity' might play at the very roots of these inequalities. Multi-polarity refers to the structure of our large metropolitan areas. Currently, with some variation across and within countries, European cities tend to be laid out in a concentric pattern: historical and cultural areas concentrated in the centre, with also a high proportion of businesses and expensive housing, while low cost residential areas are progressively expelled to the outskirts, where also industrial activities are located. In contrast to this concentric structure, 'multi-polarity' calls for urban poles that provide a range of amenities (housing, workplaces, commercial, cultural or leisure sites) tending to reduce the need for long distance commuting in polluted environments. Diversity is a complementary principle of multi-polarity, where each pole would provide the widest possible variety of activities and, most importantly, of housing profiles, places for the rich being intermingled with council residence. This diversity scheme would prevent the formation of peripheral clusters of poor housing, which is typically associated with lack of access to good education and other cultural amenities: the further they are from the city centres, the more likely they are to be let in a marginal status."

Source: Deguen and Zmirou-Navier (2010)

Examples of policies that address local air pollution in city centres, which may implicitly or explicitly contribute to reducing socioecological inequalities, are the special zones on which air pollution abatement focuses, such as the Air Quality Management Areas in the United Kingdom and Environmental Green Zones in Germany, where dirtier vehicles, typically older ones, are prohibited from entering major urban areas. Also several Dutch cities have designated "environmental zones", where trucks and other vehicles with high emissions of nitrogen oxides and particulate matter are prohibited from entering inner cities. In The Netherlands, air pollution research and policy also focuses on especially sensitive locations such as senior citizens' homes, schools and children day care centres, taking into account a zone of 50 meters from provincial roads and 300 meters from highways (related to expected negative effect on air quality). Socioeconomically deprived neighbourhoods are not included.

While it makes sense to focus on transport to reduce local air pollution, since it is responsible for around 25 to 70% of urban outdoor air pollution, other sources of pollution should not be forgotten, including industry, power generation and heating of homes and other buildings.

A link can be noted with climate change: as increasing frequency and intensity of heat waves generally will have a negative effect on air quality, polluted areas can be addressed specifically in urban heat action plans and in long-term measures to reduce the burden of heat stress (Benmarhnia et al, 2014).

Policies addressing availability of and access to green spaces

Socially disadvantaged people more often live in places with poorer access to public green space (e.g., Kruize et al., 2007) than rich people. The share of green space in people's living environment is positively associated with the perceived general health of residents, and less-educated groups are more sensitive to the characteristics of their physical environmental (WHO, 2012). Hence, policies enhancing the extent, quality and accessibility of green spaces especially with socioeconomically deprived groups in mind will reduce socioeconomic inequality. WHO (2012) suggests the following mitigation actions:

- creation and maintenance of healthy built environments with accessible recreational and green areas of good quality;
- gaining the cooperation of urban planning, housing, transport and public health sectors in health inequality impact assessments;
- better reporting on the quality, dimension, ease and convenience of access, and perception of recreational and green areas by sex and socioeconomic group;

- better research into combined exposures to hazards and into resources beneficial to health in the built environment, including their distribution by sex and social position.

With the last three bullets addressing the building of a knowledge basis and the process of policy development and implementation, here we focus on policies related to the 1st bullet.

In its Urban Agenda the European Commission has recognized the challenges of urban development in Europe, including a significant increase in poverty, social exclusion, segregation and polarisation, and highlights the importance of environmental issues such as resource efficiency (EC, 2014). The issue of socioeconomic or socioecological inequality is not acknowledged explicitly. The Agenda however does follow the recommendation of the Cities of the Futures report (EC, 2011) that European cities should be "places of green, ecological or environmental regeneration". Separately, the Commission acknowledges the importance of green infrastructure in urban environments, delivering health-related benefits such as clean air and better water quality (EC, 2013). GI in urban areas would lead to a greater sense of community, strengthening of the link with voluntary actions undertaken by civil society, and helping combatting social exclusion and isolation, benefitting the individual and the community physically, psychologically, emotionally and socioeconomically (EC, 2013). The EU GI strategy will support the integration of GI into policy implementation in key sectors at national and subnational levels, using various funding mechanisms for encouraging GI deployment across the EU.

Box 2: Landscape as a vector for the metropolitan area, Montpellier Agglomeration (FR)

Bernard Reichen (urban planner) and Alfred Peter (landscape architect) were the main planners behind the concept of 'Landscape as a Vector for Development' in the Scheme of Territorial Cohesion (SCoT) for the Montpellier Agglomeration. The regional authority of the Agglomeration has adopted a planning discourse with a vision on green open space or landscape intertwined with urban structure and development in a functional and spatial manner, constituting an amenity for the metropolitan area and its residents, farmers. etc. From the tree on your doorstep, to the square in the neighbourhood, along the river to the beach to the sea. Such intertwining from the regional level down to the level of the capillaries of the urban structure contributes to availability of green open space throughout the agglomeration, for all income groups. Montpellier's SCoT connects all its method on an approach of landscape encouraging a 'sights inversion'. SCoT is presented as an integrated part of the reflection on urban development. Simultaneously the land policies include the instrument for postponed development (Zone d'Aménagement Référé) which enables to economize on public expenditures for buying land for urban development, leaving more budget for investment in public transport. Increased investment in public transport can also contribute to a better air quality in the agglomeration. Combined with compact building (not compact city!) this discourse provides a promising perspective for urban development. Bernard Reichen won the 'prix de l'urbanisme' in 2006.

Source: Buyck et al. 2010

Promotion of green areas is gaining more and more attention in urban policies in in Europe, with a variety of arguments evolving over time, enhancing climate resilience being one of the more recent arguments. While the share of green (and blue) spaces in urban areas in Europe is known (see maps in EEA, 2012), and it is accepted that "accessible, good-quality, well-maintained green spaces and playgrounds, modern transport systems and safe, walkable neighbourhoods that encourage physical activity and social interactions are key constituents of urban quality of life' (EEA, 2009), urban pressure on land is high. Main menaces to green open space faced by the seven urban agglomerations engaged in the PLUREL project were the development of housing and business areas and high land prices. Aalbers and Pauleit (2013) present an analysis of the effectiveness of policy arrangements at urban regional level in preserving green open space in urban areas. Among the most important means of influence are: the control over land resources; finances; policy discourses supported with a well communicated spatial vision and a legally binding zoning plan; and coalitions with relevant partners. Based on research

performed about 10 years ago, Baycan-Levent and Nijkamp (2009) report on a comparative analysis of urban green space policy in Europe, suggesting that—despite a variety in urban green space policies in cities in Europe—the critical conditions in planning and management of urban green spaces have emerged in four factors/attributes: (1) the share of green space in urban land use; (2) the changes in these shares over time; (3) the intensity of involvement of the city administration; and (4) the degree of citizen participation. It should, by the way, be noted that there can be large differences between the perceptions and the actual proportion of the urban area devoted to green open space (EEA, 2009). There are very many examples of local initiatives by city governments to enhance green spaces, but not so many which explicitly address the issue of socioecological inequity. The UCL Institute of Health Equity (UCL, 2014) provides an overview on how to enhance green space and address health inequalities on the basis of a number of examples in the UK, including the London Pocket Parks, the Glasgow Health Walks and Bristol's Parks and Green Space Strategy. Shrinking cities can create greener and safer single-housing areas to encourage population retention. By preventing urban sprawl, such cities can create urban quality and compactness, and so become more transport and energy efficient (EEA, 2009).

Box 3: City of Nijmegen (NL): 300 m indicator for at least 0.5 ha of green open space

The City Council of Nijmegen is actively investing in the quality of life in the city and especially in its public spaces. Over the last few years the council developed a policy aimed at ascertaining that each residence has green open space within reach. For those residential areas where this is not yet the case, officers are assigned the task to develop plans and ascertain that at least half a hectare of green open space is being developed in the from green deprived areas. The responsible officer developed a proposal for the council to use benefits of the sale of property by the city (2.3 million Euro) for investment in districts deprived of sufficiently green open space. The proposal was excepted by the City Council 2 October 2013.

Sources: (Gemeente Nijmegen, 2013); Anon. (2013)

Research question 4
What are existing and implemented policies and practices that (can) help avoiding or reducing socioecological inequality?

Spatial policies

Although concrete, specific spatial policies aiming at decreasing socioecological inequality at the urban level may be almost absent in Europe, various scholars and practitioners have addressed the need for spatial policies that focus on quality of life, social issues and functional relations of green open space with urban activity. Generally they are directed towards intertwining green open space with the urban fabric onto the lowest level of the veins of the city. They connect green open space with social interests and some advice to accompany it with an institutional approach involving citizens in planning, or even institutional reform.

Housing and social policies

The environmental aspects of social housing policies in Europe seem under-researched. In the early 20th century and post war period Howard, Le Corbusier and van Eesteren were promotors of green and spacious outdoor environments for public housing. Our review confirms that housing and social policies are important factors determining the extent of socioecological inequality, and hence these are not only a potential cause of it, but also offer tools for addressing the problem. We identified a large number of studies discussing the role of housing and social policies in addressing socioeconomic deprivation and, through this, socioecological inequality, both from Europe and the US. Although American circumstances tend to be different from those in Europe, the latter studies can provide inspiration for European applications, confirming the need for addressing the social dimensions of urban development. Suitability of specific types of policies depends on local circumstances and should take into account possible perverse effects. The boxes provide examples from Europe, but a more in-depth study would allow for the development of a wider set of examples.

Environmental policies

The promotion of green spaces is gaining increasing attention, with a variety of arguments that evolved over time, enhancing climate resilience being one of the more recent arguments. Among the most important means of influence for regional authorities to preserve green open space for the urban agglomeration are: the control over land resources; finances; policy discourses supported with a well communicated spatial vision and a legally binding zoning plan; and coalitions with relevant partners. An overview study on European policies suggests four factors with critical conditions for successful promotion of urban green spaces: (1) the share of green space in urban land use; (2) the changes in these shares over time; (3) the intensity of involvement of the city administration; and (4) the degree of citizen participation.

As to air pollution, our quick scan of policies addressing poor outdoor air quality in Europe suggests that policies that take into account disproportionate impacts on disadvantaged neighbourhoods would be justified and options are available, but in practice the issue of socioecological inequality has not yet entered the political agenda and hence no clear examples of targeted air pollution policies have been found. At the same time it should be noted that generic air pollution policies also have a positive effect on remediating socioecological inequity related to air quality. For many situations in which poor air quality and poor socioeconomic conditions are clustered, local traffic and urban planning policies that focus specifically on air quality hotspots are important.

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5 Towards a better assessment and understanding of socioecological inequalities and policy development

Introduction

This report is based on a quick scan of available information to assess the relevance of socioecological inequality in Europe, the availability of relevant socioeconomic and environmental data at a European scale, and of policies at various scales that influence socioecological inequality and its drivers. The scope of issues that can be included in the concept of socioecological inequality includes issues related to indoor pollution and occupational circumstances, but this report is limited to the ambient environmental issues usually covered by the EEA. Within those issues, we focused on air quality and access to green space, as two influential environmental characteristics. Future work could include other issues, such as climate risks (flooding, drought, heat stress, exposure to storms), drinking water quality, soil pollution, inadequate waste services, noise (air and or ground traffic), and environmental safety.

Conceptual framework – future improvements

In Chapter 2, we presented a simple conceptual framework that can be used to structure the analysis of socioecological inequality in European urban areas. It highlights the different policies that affect the drivers of socioecological inequity, and the systems on which these policies have an effect. The characteristics of each of these systems can be captured by indicators. We believe these aspects to be the most important in an EEA context. However, the framework could be further developed in various ways:

- *The framework could be further expanded, e.g. from a DPSIR perspective* that is often used by the EEA, by distinguishing between the driving forces of demographic, social and economic changes ("Driving forces"), environmental, locational and income changes at the level of the urban agglomeration ("Pressures") and these changes themselves ("State" e.g. quality of living, quality of life). Health and well-being form the impacts (I) component of this expanded framework and the 6 types of policies the response (R).
- *The presented framework does not highlight the nature of the relationships between various system components* (included implicitly in the arrows), which can be important for a detailed analysis of socioecological inequality (e.g., sensitivity/susceptibility of population groups to specific pressures such as poor air quality or poor accessibility to green spaces; relevance of specific indicators, such as green space edge density or share of green space for capturing accessibility of green space).
- *The framework does not make the importance of various geographic and administrative levels transparent.* Both drivers and response policies are important at international, European, national and local level. Higher level policies can provide the incentives and the boundary conditions for developing and implementing lower level policies. Local problems are influenced by global, European and national socioeconomic and environmental changes.
- *The framework does not always explicitly highlight the difference between socioeconomic deprivation or poor environmental quality at the city level on the one hand and the clustering of these problems at the neighbourhood level on the other hand.* Environmental, social and health policies are not necessarily spatially explicit, whereas housing and urban planning policies are. Some cities may do well at an average city level, but still have specific hotspots plagued by socioecological deprivation.

Follow-up work could address these challenges and try to incorporate the above factors if needed.

Adequacy of availability of data and possibilities for improvements

The general picture of data availability is that there is a lot of both socioeconomic and environmental data available at the European level, as a result of formal requirements (e.g., air pollution legislation) or more voluntary (e.g., based on periodic surveys, like the Urban Audit). The available databases can be

used for a rough explorative analysis of socioecological inequality, but this has not been done yet at a European scale. In addition, more information is available for various individual cities, which is not compiled at a European level, but which may be interesting for specific case studies. We note four potential weaknesses in the availability of data:

- *The available indicators in EU-wide databases may have a coverage that is insufficiently complete for a reliable detailed assessment of socioecological inequality in European urban areas.* Most information is not be available at the neighbourhood level, or the coverage of cities by particular indicators may be incomplete. For example, although the number of cities represented in the Urban Audit has grown from about 370 for the 2009 survey, to more than 900 for the most recent one (2014), still cities are missing. Moreover, not for all cities included in the Urban Audit the information on variables that are relevant for the analysis of socioecological inequality are included.
- *Data relevant for assessing socioecological inequality available for individual cities are poorly accessible and possibly not comparable.* Data on specific aspects of socioecological inequality is available from various European projects as well as national research and policy programmes for specific individual cities (e.g., project case studies). Accessibility of this information is often limited (not publically available, not in English), while it usually covers only a subset of the information required for a comprehensive assessment of socioecological inequality. Nevertheless, follow-up work focusing on a number of cities may build the basis for a better assessment in the future.
- *The available indicators may not be the best indicators to assess socioecological inequality.* Various available indicators may relate to socioeconomic deprivation or environmental pressure at neighbourhood level, but the nature of this relationship may be more or less direct, i.e. many characteristics are proxies rather direct indicators of socioeconomic deprivation or environmental pressure. Examples of such proxies include indicators on the drivers of socioecological inequality indicators of the outcome of socioecological inequality (geographic inequality in quality of life, well-being, health) phenomena related to the same causal factors (e.g. traffic noise for air pollution). Recommendations of which available (proxy) indicators would be the most relevant for an analysis of socioecological inequality or which additional (proxy) indicators may be included in new data collection efforts is beyond the scope of this report.
- *The currently available indicators do not yet allow for a reliable Europe-wide assessment of socioecological inequity.* In the literature, socioecological inequality is usually analysed at the level of individual cities, i.e. the literature does not allow for a comparison between different cities within or across European countries. The available data would allow for overlaying socioeconomic and environmental data for urban areas in Europe, but the data are not yet easily available at the level of streets and neighbourhoods, which would be required for a meaningful assessment. We do not think that the city typologies currently explored by EEA provide a sound basis for comparing the extent of socioecological inequality at the city level between European cities.

Inventory of policies

In this quick scan, we have found a large amount of policies that are implemented at various administrative levels to address the drivers and impacts of socioecological inequality individually, like spatial, environmental, social, economic, housing and health policies. Also, an extensive literature discusses the pros and cons of a wide variety of policy instruments and their effectiveness in addressing the drivers of socioecological inequality. In general, addressing socioeconomic deprivation and poor environmental conditions separately, will also reduce socioecological inequality. However, while the existence of socioecological inequality is found to be real in various European countries, we did not find policies specifically targeting the clustering of socioeconomic deprivation and poor environmental conditions jointly. The issue appears to be an emerging new policy issue, the seriousness of which is in general not yet sufficiently recognized to place it high on political agendas. Probably also lack of knowledge, uncertainties and the large variation in local conditions within and across countries make it a difficult problem to tackle directly. More research is needed to get a better understanding of the situation and the possible response options.

Table 4 summarizes very concisely our findings with respect to our research questions. The reality of socioecological inequality with regard to poor air quality and poor access to urban green space and other environmental pressures seems to be undisputed, but the magnitude and other characteristics are very different between different regions and individual cities. In order to better understand the drivers and consequences at a Europe-wide scale, and build the evidence basis for possibly targeted policies, further research and analysis of available databases and actual examples in European cities is required. Such a more in-depth analysis of the causes, characteristics and effects of socioecological inequality, taking into account the full range of relevant socioeconomic and environmental dimensions at different levels, requires the involvement and integration of a range of social and natural science expertise beyond the scope of this project. Further interdisciplinary research is needed to deepen the understanding of the relation between socioeconomic inequality with respect to air quality and/or access to green open space, and possibly to expand the analysis to include additional environmental stresses. To evaluate the potential importance of socioecological inequality for future EEA products, such as its indicator system, reports on urban sustainability and the periodic State-of-the-Environment and Outlook reports, it is recommended to start with organizing a workshop that brings together experts and practitioners from various relevant disciplines and regions.

Usefulness of EEA typologies for assessing and comparing cities on socioecological inequality

At the moment the EEA is developing three possible city typologies that contribute to the final Urban Sustainability report: Typology of cities, Typology of urban sprawl, and Typology of urban green infrastructures. To what extent may these emerging typologies be consistent with or relevant for the assessment of socioecological inequality? For the current report, this question cannot be adequately addressed because details about the typologies available were very limited. Nevertheless, below, we provide a number of considerations.

Typology of cities. The ETC/SIA is working on a set of generic typologies for cities based on statistical analysis of a large set of indicators, in support of the EEA urban sustainability report. Main objectives are the identification of groups of cities that share similar properties; characterisation of European cities for environmental reporting and statistics. According to the ETC/SIA, the city typology refers to "a both quantitative and qualitative characterisation of cities, which should be structured in hierarchical systems providing a broad view on cities, their situation and basic functions, their individual performance and main activities, their threats and their most important changes (i.e. potential pressures and development paths)". 40 indicators/key figures are currently being prioritised by a working group. Further work should limit the amount of indicators to max. 3-4 per domain (climate, socioeconomics, waste etc.). The typology is implemented through targeted clustering by applying 3 statistical analysis methods to find correlations that would allow for clustering cities.

The application of the clustering led to 6 clusters of city typologies: (1) scoring very high on changes in compactness and very low on "high density areas" (2) very high on "number of inhabitants" and very low on "green urban areas" (3) very high on "low density areas" and very low on "green urban areas" (4) highest value in "Changes of Government effectiveness index" and very low score on "change of number of inhabitants, growth and shrinkage" (5) very high "administrative area" value and very low value for "Lights in the night UMZ inside core city (Energy)" (6) very high on "population density" value and very low on "green urban areas". This effort doesn't seem to lead to usable typology from a perspective of socioecological inequality, because (a) administrative boundary is used as a reference unit to provide the statistical information on cities, implying that this typology is not suitable to assess socioecological inequality at neighbourhood or street level, and (b) the indicators that are highlighted in the six preferred clusters are not those which we would recommend from a perspective of socioecological inequality.

Typology of urban sprawl. The main objectives of this typology are the assessment of compactness of the built-up areas and dispersed urban pattern, has four metrics and is based on a method developed by the Federal Office of Spatial Planning in Switzerland at European level. Urban sprawl is a phenomenon that

can be visually perceived in the landscape. A landscape suffers from urban sprawl if it is permeated by urban development or solitary buildings. Urban sprawl denotes the extent of the area that is built up and its dispersion in the landscape, in relation to the utilization of the built-up land for living and work. Therefore, the more urban area present in a landscape and the more dispersed the urban patches, and the less the utilization, the higher the degree of urban sprawl. The relationship with socioecological inequality is indirect, because the typology only refers to morphological features of urban landscapes, and not to the socioeconomic characteristics of the population.

Typology of urban green infrastructures. Main objectives are the characterisation of green infrastructure of 400 cities, to be based on four metrics inside and outside the cities (50 km), already discussed before (see chapter 3).

Acknowledging that we have incomplete information on the details of the indicator sets, we consider none of the three typologies currently being developed at the EEA and ETC/SIA directly suitable for exploring socioecological inequality. However, an eclectic combination of indicators included in the city and green infrastructure typologies can probably provide insights into the subset of socioecological inequality issues dealing with green spaces. For air quality, an additional effort to combine selected socio-economic indicators with air pollution information from AirBase (traffic stations) and/or the urban audit (to our understanding currently not yet included in the city typology) would allow for exploration of socioecological inequality for air pollution. Various combinations of indicators could be implemented, varying for one socio-economic and one environmental indicator considered to be the most relevant for socioecological inequality, to a weighed set of different socio-economic and environmental indicators. The selection and weighing of the indicators can be based on expert judgment, and could be explored during the workshop proposed above. It should however be noted, as discussed in Chapter 2, that the resolution and coverage of many of the available indicators is insufficient to allow for an analysis at neighbourhood or street level and to compare between cities in all 33 states. This means that such an inter-city comparison may give some indication of where socioecological inequality may potentially occur (high scores on both socio-economic and one environmental indicator), but to be sure, corroboration at a more detailed level is absolutely required. If the combination of indicators would have a low score on both socio-economic and one environmental indicators at city level, socioecological inequality at the neighbourhood or street level is less likely.

References

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Table 4: Concise summary of the report's findings with regard to the research questions

	Research question	Short answer
1	Which existing English language literature provides knowledge and insight on socioecological inequalities in European urban areas?	The literature on socioecological inequality in urban areas in Europe is limited, but studies are available for the United Kingdom, Netherlands, France, Norway and Denmark, as well as overview studies by the WHO. Though the literature is limited, it generally leads to the conclusion that socioecological inequality does exist, also in Europe: clustering of socioeconomic deprivation and adverse environmental conditions occurs and the two forms of deprivation tend to be associated. However, there are variations in this general pattern, with sometimes more wealthy people living in neighbourhoods with bad environmental conditions. Specifically for green space, the definition that is used differs widely between studies. For example, sometimes agricultural areas are included and sometimes they are not, which may make a lot of difference. Furthermore, the issue of the importance of the quality of the green space with regard to well-being and health effects has been hardly addressed. As for factors influencing the incidence of socioecological inequality, housing supply and demand, urban structure and environmental policies seem especially relevant.
2.a	Which databases are available on European cities that provide information on neighbourhood or street level on the presence of low income and/or low education?	From EUROSTAT, a large number of potential indicators describing aspects of socioeconomic deprivation are available. The strength of the relationship with socioecological inequality, the coverage of European cities and the spatial resolution however varies, and a more in-depth analysis of the most appropriate indicators is required. More adequate data for devising policies are probably available locally, at the offices of the authorities of the cities and urban areas.
2.b	Which databases are available on European cities that provide information on neighbourhood or street level on air quality?	Regularly updated Europe-wide information on key air pollutant concentrations is available from AirBase, the European air quality database managed by the EEA. For urban analyses, the traffic-related measurement stations are of particular importance. Additional information for selected cities may be available as a result of local programmes, projects or campaigns, but is not collected centrally at the European level.
2.c	Which databases are available on European cities that provide information on neighbourhood or street level on green urban areas?	The most detailed data including remote sensing data are available from the Urban Atlas, managed by the EEA. More up-to-date are the results of the Urban Audit, based on surveys approximately every three years, which is used by the ETC/SIA for a number of green space indicators. Additional information for selected cities may be available as a result of specific European, national or local projects, but is not collected centrally at the European level. Satellite data are available for a Europe-wide assessment, but it would require a dedicated effort to put theory into practice.

3	How to interpret this information in relation to socioecological inequalities?	There seems insufficient information available, in terms of data availability, as well as in terms of process understanding, to perform a European comparison between urban areas or cities on socioecological inequalities. Though certain relevant data are available, most of them do not cover all 33 countries. It would be risky to derive and relate relevant indicators from the available datasets at a European level and properly connect them in an inter-relational scheme. Alternatively, the possibilities can be explored to do a limited number of case studies for cities where an interest in this issue exists. Such an effort could also help formulating recommendations for using, c.q. adapting the current collection systems for (proxy) data.
4	What are existing and implemented policies and practices that are directed at avoiding or reducing socioecological inequality?	Housing, welfare and other social policies, and economic and employment policies all affect the socioeconomic drivers of socioecological inequality. Environmental and spatial planning policies influence the environmental pressures and health policies can alleviate the impacts on health and welfare. European and national policies provide the boundary conditions for policies at the municipal or metropolitan level. The number of such policies is enormous and beyond the scope of this report. Although the reality of socioecological inequality has generally been confirmed by a number of assessments in various countries, policies specifically designed to address the problem have not been identified.
5	What insights or data are missing that can help identify and understand the development of socioecological inequality within urban areas?	The available data allow only for a very rough assessment of socioecological inequality across European cities with a rather limited reliability. Such an assessment would still be time and resource intensive. Reasons include that the link between available data and socioecological inequality is often indirect and the data coverage is incomplete, while the situations between European cities varies a lot because of physical, socioeconomic and political differences. Increasing the coverage of relevant indicators as well as the development of a number of targeted case studies could enhance the understanding of the problem in Europe.
6	How can the different relations identified that could form the traits of an analytical framework be depicted?	The relationships derived from our inventory of existing literature and data sources were translated into a simple conceptual framework with an emphasis on the key components of socioecological inequality and the various sector policies addressing these components. The framework can be further developed to meet the needs of possible future EEA assessments.
7	Which indicators for the mentioned socioecological inequalities within urban areas are relevant and how can these be measured?	We observe that many of the available indicators are relevant on the one hand, but tend to be proxy indicators at the other hand. An improvement of the existing reporting systems both in terms of spatial coverage and in terms of relationship with the actual problem is considered to be feasible but specific recommendations are beyond the scope of this report.

8	What is the meaning of the typologies of Cities, of GI and of Urban Sprawl for comparing between cities on these inequalities?	Since the three typologies are still partly under development, it is still early days to assess their relevance and usefulness with regard to assessing the incidence of socioecological inequality within cities, and compare European cities on this dimension. However, thus far the indications are not very promising, mainly because of the higher level of spatial detail that is required for such an assessment than the typologies (are likely to) offer.