

The SCATTER project – Sprawling Cities And Transport : from Evaluation to Recommendations

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1. General objectives of SCATTER

SCATTER is a project under the European Commission DG Research, “Energy, Environment and Sustainable Development Programme” (Key Action 4 – City of Tomorrow and Cultural Heritage), which started on January 1st 2002 and will last until June 2004.

The partners involved are STRATEC sa (Belgium), the Centre for Advanced Spatial Analysis CASA – University College London (United-Kingdom), Steinbeis Transfer Centre Applied System Analysis - STASA GmbH (Germany), LT Consultants Ltd (Finland), Trasporti e Territorio - TRT Srl (Italy), the *Centre d'Etudes sur les Réseaux, les Transports, l'Urbanisme et les Constructions publiques* - CERTU (France), the *Centre d'Etudes Techniques de l'Equipement de l'Ouest* - CETE de l'Ouest (France), and STRAFICA Ltd (Finland).

SCATTER tackles the issue of urban sprawl, in particular in the context of cities implementing new suburban public transport services.

Urban sprawl is widespread in Europe. In a growing number of cities, population and employment in central areas is declining while increasing rapidly in suburban and peripheral areas. This induces a high level of car use and, usually, congestion on roads with access to city centres.

To limit the damage caused by urban sprawl in terms of congestion, air pollution and energy consumption, many European cities are implementing (or planning to implement) suburban public transport services, such as heavy or light rail. But by improving accessibility, they create an incentive for a new wave of urban sprawl. Therefore, in parallel with these new public transport services, accompanying measures have to be elaborated and implemented, in order to prevent, mitigate and control the sprawl phenomenon.

The SCATTER project tackles this issue in which land use and transport are closely mixed.

The project comprises six case cities : Brussels, Stuttgart, Bristol, Helsinki, Rennes and Milan.

The final objective of SCATTER is to provide recommendations and guidelines to European cities, and design an “urban sprawl monitoring tool”.

It is difficult to draw conclusions and even to present a synthetic view of the project, at not even the half of the research. So, the adopted choice was to present a summary of the work carried out so far, focussing on the most interesting preliminary results (in particular for policy makers) and the inter-links between the different areas of the work.

2. Overall methodology

The study contains three major stages.

The first stage of the work aims to **improve the understanding of the mechanisms of urban sprawl and its effects**. This first stage includes a state-of-the-art review of urban sprawl impacts (work package 1), a systemic analysis of urban sprawl on basis of interviews of experts and authorities in the 6 case cities (WP2), and a statistical analysis of urban sprawl effects in the 6 cities (WP3).

The second stage of the project aims to **assess the impacts of policy measures aiming to wrestle with urban sprawl, and their overall efficiency**. At first, a review of measures aiming to wrestle with urban sprawl will be made, including the measures experienced in the USA, and their results (WP4). American cities have been subject to urban sprawl for a longer time than those in Europe and an extensive work already exists there. This part will also contain an analysis of institutional barriers and ways of cooperation between different institutional players. This WP will end with selecting the measures to be evaluated in the next task of the project.

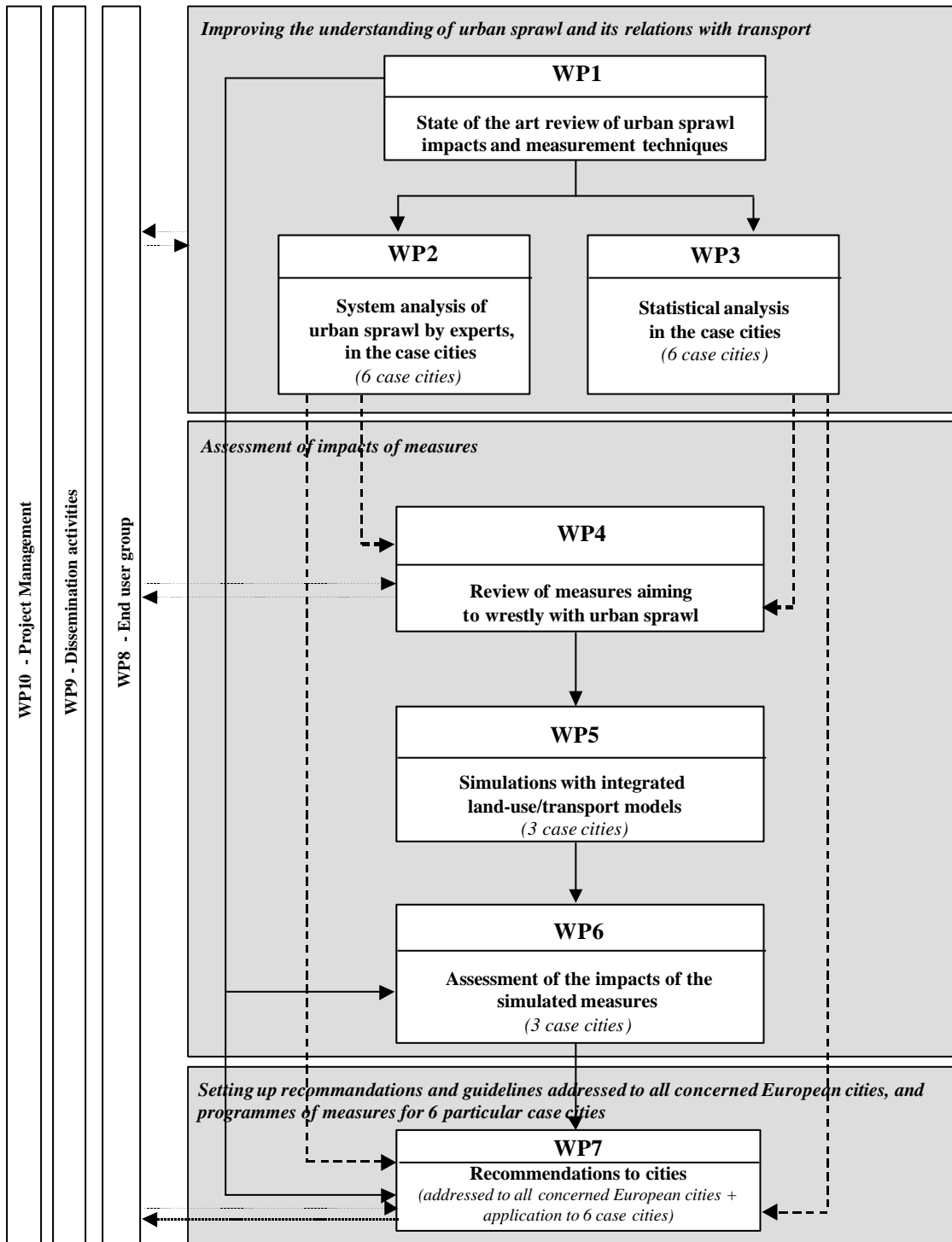
The second task of the second stage consists of simulations of measures aiming to prevent, mitigate or control urban sprawl (for example accompanying measures for cities implementing suburban public transport) in a sub-set of 3 case cities (Brussels, Stuttgart, Helsinki) (WP5). The simulations will be carried out using integrated land-use/transport models. The last task of the second stage (WP6) is the quantitative assessment of the impacts of the measures, on the basis of indicators built on the outcomes of the simulations.

The third stage of the project (WP7) will be **setting up concrete recommendations** to the cities. The WP7 will provide recommendations to European local authorities, concerned by urban sprawl, on policies to control urban sprawl, especially when a suburban public transport is implemented. A general “urban sprawl monitoring tool” will be designed, which could be used by any concerned European city. In parallel a practical programme of measures for each of the 6 case cities will be set up.

In parallel with these technical work packages, 2 workshops will be organised, which namely will gather together local authorities from the 6 case cities.

The project flow chart (Figure 1) provides an overview of the project.

Figure 1. SCATTER project flow chart



Currently, the consortium has achieved the first stage (improving the understanding). That is why this paper is presenting results from WP1, WP2 and WP3. At the time of the Conference, also results from WP4 will be presented.

3. Outcomes of the state-of-the-art review (WP1) : How to define urban sprawl ?¹

3.1 A multi-dimensional definition

Clearly, urban sprawl is a multi-dimensional phenomenon, and hence, requests a multi-dimensional definition.

It is also difficult to make a clear distinction between the causes, conditions, and consequences of urban sprawl. The literature reveals a world of contradictory causal and temporal relationships between several events, sprawl being often just one of them.

Furthermore, beyond defining urban sprawl, a key issue is how to make a distinction between urban growth and sprawl.

Some of the main dimensions constituting “urban sprawl” are discussed below.

3.1.1 Uncoordinated growth and low density

Urban sprawl is usually assumed to refer to the uncoordinated growth of cities, particularly around their edges or peripheries.

The role of population density in urban areas is clearly central in the definition of sprawl. There may be pockets of high density in a sprawling landscape but the key issue is that uncoordinated growth leads to piecemeal development which in general is low density development. Therefore, sustainable planning which aims to reduce the problems of sprawl is essentially dependent upon the control of densities.

In the United States and in United-Kingdom at least², the argument about sprawl has been significant for at least 100 years if not longer. In the early and mid 20th century, sprawl was often confused with suburban development and there was considerable disquiet with the way lower density urban living was becoming the dominant way in which peoples’ aspirations about living in cities were moving. But in one sense this was a reaction to something new and the early suburbs now appear to be considerably more coordinated than the kinds of developments which have taken place in the last 25 years, particularly in North America.

¹ The text of Section 3 is drawn from Deliverable 1 of SCATTER, “State of the Art Review of Urban Sprawl Impacts and Measurement Techniques”, April 2002, whose main authors are Michael Batty, Nancy Chin and Elena Besussi from CASA – Centre for Advanced Spatial Analysis – University College London.

² Historically, the urban sprawl phenomenon was first a peculiarly British and American phenomenon, due probably to the relatively lower density of cities in both Britain and America and to the notion that home-ownership with a garden are core values of the Anglo-Saxon heritage. In continental European, the conditions for urban growth have more recently begun to mirror those in Britain and North America. Towns in continental Europe have tended to remain more compact with higher and more uniform densities.

As an illustration, between the 70s and 80s, ‘growth management’ legislation started in several American States leading to an attempt to control the spread of urbanisation. In the same time, in European countries, there was the first important wave of uncontrolled sprawl.

Finally, many definitions of urban sprawl use the concept of low density to identify sprawl, however, what is considered low-density is relative and varies with each country cultural expectations. For instance, in the U.S. low density is development of two to four houses per acre while in the U.K. low density would not consist of less than eight to twelve houses per acre.

3.1.2. The spatial scales relevant for research and action

One key issue relates to the scale at which urban growth and sprawl is identified. There is a strong disjuncture between thinking of cities as socio-economic nodes in a network and thinking of them as physical entities. This is reflected too in the literature on sprawl which spans the scales from low level physical concerns at the level of site development to much more abstract pictures of how cities are growing in terms of population and employment.

A typical example is the case of polycentric systems, which are often, described both as intra-urban patterns of clustering of population and economic activities (London, Paris, Milan) and inter-urban patterns such as the Dutch Randstad, the Flemish Diamond and the area of Padua, Treviso and Venice in Northern Italy.

This is not a trivial argument because the spatial scale at which urban sprawl is observed can heavily influence the identification of relevant issues and the selection and design of suitable indicators. It is also crucial to select the proper territorial scale in policy design and implementation, to have a chance to reach the goals. Finally, this twofold issue of “various analysis scales/proper scale for policy” is also related to the question of institutional barriers and modes of cooperation between different institutional players : one of the first questions facing local/regional authorities who wish to set up a platform of cooperation is “how to define the proper area for tackling urban sprawl”.

3.1.3. Different urban forms

A variety of urban forms have been covered by the term “urban sprawl” ranging from contiguous suburban growth, linear patterns of strip development, leapfrog and scattered development. In terms of urban form, sprawl is positioned against the ideal of the compact city, with high density, centralized development and a spatial mixture of functions, but what is considered to be sprawl ranges along a continuum of more compact to completely dispersed development.

At the more compact end of the scale, suburban growth (i.e. a contiguous expansion of existing development from a central core) was identified as sprawl in the early literature of the 1950's and 1960's, but this more compact form is no more classified as sprawl now.

“Scattered” or “leapfrog” development lies at the other end of the scale. This form exhibits discontinuous development away from an older central core, with the areas of development interspersed with vacant land.

Compact growth around a number of smaller centres which are located at a distance from the main urban core is also classified as sprawl. This is superficially similar to the poly-nucleated city (which is not referred to as sprawl) where the downtown is served by several more distant centres. The distinction between the two depends on the level of services offered by the centres and the level of interaction of the city centres with the surrounding suburbs. Linear urban forms, such as strip development along major transport routes have also been considered sprawl.

One problem with these definitions is that the resulting impacts of these different forms may be vastly different. As some other authors do, we would therefore suggest to acknowledge that there are different levels of sprawl which require different policy measures.

3.1.4 Land uses

Land use patterns are another element which can contribute to define sprawl.

Sprawl is commonly associated with land uses which are spatially segregated.

In the common view of sprawl which applies in the United States, for example, the characteristics of sprawl are among others homogenous single family residential development, with scattered units ; non residential uses of shopping centres, strip retail, freestanding industry, office buildings, schools and other community uses ; and land uses which are spatially segregated. This pattern of segregated land uses in turn induces a high reliance on private car for transport.

However “less dense” patterns don’t occur always and everywhere in the same way. As regards the distribution and organisation of land-use activities and urban functions, different patterns have been identified/may exist : mixed or single land-use patterns, patterns of different rural-urban relationships, concentrated, clustered or dispersed patterns.

3.1.5 Temporal dimension and urbanisation process

There is also a temporal dimension in the issue of urban sprawl. It is likely that the different forms and the different functional organisations mentioned above correspond to various “ages” of the phenomenon of sprawl. For example :

- first age: very scattered – only residential
- second age: progressive densification – addition of retail and public services (schools, etc), i.e. employment directly induced by the population
- third age: still densification – addition of jobs - evolution towards autonomous centres also providing jobs to their residents.

Urban sprawl can therefore also be considered as a (more or less long) stage in the evolution process of an urban region.

Urban population is still growing and the growth of cities is a significant phenomenon. As an example of what was suggested above, but at a broader temporal scale, there was some discussion at the United Nations (1998) of urban growth following a pattern of “urban transition” and urban sprawl corresponding to a phase of this growth. The first phase is of fastest growth in the core of the city, termed urbanization in the United Nations report ; the second phase is suburbanization with fastest growth just outside the city core; the third phase is counter urbanization, with population in the core and suburbs moving out to more rural areas, and the fourth phase is re-urbanization with an increase in population in the core of the city. According to this model, the phenomenon of urban sprawl would fall into the third phase of growth.

3.2. Contexts and causes

According most authors, the main causes of sprawl are as follows :

- the increase of income and the social demand for low density settlements
- the decrease in travel times and travel costs, from the periphery to the urban core

- the differences in housing market and the different tax rates, between the urban centre and the periphery
- the competition between administrative units (e.g. communes) to attract households or companies
- in some countries, national policies which favour low density settlements.

3.2.1 The consumer demand for single family low density housing

Some authors see the sprawl as a result of the consumer demand for low-density single family housing on large lots. According to this view, demand is driven by individual preferences : a strong desire for owning a single family home, having an adequate environment for raising a family, for privacy and for a rural ambiance.

Some authors also emphasize that, beyond the consumer preferences, this demand has been in some cases manipulated by public subsidies. In the United States for example, these took the form of federal assistance on mortgages.

In Europe, between the 70s and 80s, two simultaneous events opened the door to the first important wave of uncontrolled sprawl : the end of the welfare state, which dramatically reduced the level of national government subsidies to, among others, the housing sector; and the misinterpretation of demographic trends which, while showing a total decline of population (the end of the baby boom) were instead hiding an increase in the demand for new housing due to an unforeseen reduction in the size and lifestyles of households. The demographic explosion and immigration cycle of the post war period which had accelerated the concentration of population in towns and cities was now pushing towards the suburbs that part of the middle-class population which, helped by the economic expansion, the increased levels of income, the change in life-styles, and the affirmation of an anti-urban ideal chose to relocate in the outer suburban areas.

3.2.2 The influence of the transportation system

A drastic change in the transport systems, by drastically decreasing travel times and travel costs, is perhaps the single most important enabling factor leading to urban sprawl. In many countries, the development of the private automobile and the corresponding growth of the highway system played that role. But, it should be noted that in United Kingdom for example, the development of urban sprawl and suburban housing was more related to the growth in the public transportation network than to the increase in car use. In London, for example, the growth of the suburbs began with the extension of the rail network to the suburbs in the 1860's, producing a radial pattern of growth along the lines of transportation. The latter development of a more widely spread, circular pattern of growth was also a result of the development of public transportation, in this case by motor bus. The private automobile played little part in the development of urban sprawl.

3.2.3 A lack of coordination between policies

An indirect cause of sprawl, or at least a cause of the incapacity of the authorities to control sprawl in its early stages, is the fragmentation of the political decision-levels, due to multiple institutional levels involved (local/regional/national or federal), multiple administrative territories covered, and multiple fields of competences (land planning, housing, transport, ...) involved.

The fragmented planning systems and the parallel institutional fragmentation are considered by many authors the main barriers to an effective regulation of urban growth and therefore also urban sprawl. Countries with little or no spatial planning activity at the intermediate or regional level lack of the correct perspective to capture actual growth dynamics. Moreover,

due to uncoordinated and fragmented planning, policies to prevent sprawl have usually little effect, as they are uncoordinated and not implemented over a wide enough area. The negative effects of this spatial fragmentation are clear, for example, in the case of fiscal policies.

In some countries, not only co-operation between administrative units is poorly practised, but also they compete with one another in the quest for collecting more population (i.e. housing) and jobs (i.e. business and industrial enterprises) as this will lead to higher public revenues (by means of local taxes). In such countries where each unit autonomously sets its own rates of taxes, less-urbanised communes in the peripheral areas will be likely to set low rates to attract economic activities and new residents.

3.3. Effects and costs

The effects of urban sprawl are one of the most hotly debated issues in the literature, with most usually focus on the negative effects.

3.3.1 The relation between urban form and sustainability

It is also now generally accepted that urban form has an effect on sustainability. However, at the level of the researchers, the current debate on the sustainability of different urban forms, roughly grouped into compact models and diffused models, is still open, among others due to the complexity embedded in a concept such as “sustainability”³.

As regards the ecological dimension of the sustainability concept, both the United Nations and the European Union have moved in favour of a the compact town model embracing the position, supported by research, that more dense cities consume the least amount of energy for transport.

At the macro-economic level, issues of economic efficiency and economic performance of cities emerge.

The European Union has pronounced itself in favour of the compact city model (European Commission, 1990) and of the polycentric regional systems (European Commission, 1997). In this sense the EU has embraced a successful approach adopted in some European countries where policies of urban containment have been balanced by strategies of “concentrated de-concentration”.

3.3.2 Negative and positive effects

The effects of sprawl can be divided into five groups, namely : public and private capital and operating costs, transportation and travel costs, land/natural habitat preservation, quality of life and social issues.

Another approach is to divide the effects into 3 groups according to the three dimensions of the sustainability concept : ecological effects, economical effects, social effects.

Anyway, the usually admitted negative effects are listed below :

- consumption of land, loss of high quality agricultural land and open space
- destruction of biotopes and fragmentation of eco-systems
- higher costs of new neighbourhood infrastructures
- higher costs of public services and especially transport services

³ The sustainability concept is made up of three components : environment, economy, social aspects.

- land use patterns which are unfavourable to the development of collective and other sustainable transport modes ; hence, increase of the level of use of private car
- increased trip lengths
- congestion on the radial roads giving access to the urban centres
- increase in fuel consumption
- increase in air pollution
- contribution to the decay of downtown areas
- social segregation (concentric model of population distribution on the base of age, family size, social and professional class) and reduction of social interaction, but authors are not quite unanimous on this point ; anyway, note that the housing market plays a major role in nurturing the social segregation
- poor access to services for those with limited mobility such as the young and elderly.

The pattern of spatially segregated land uses also raises the issue of possible spatial mismatches within intra-urban poly-centricity : mismatch between population and jobs location ; spatial mismatch of professional skills, where jobs and unemployment lie side by side ; and finally, the hypothesis that job decentralisation harms low-income residents of central cities because of barriers that limit their access to suburban labour markets.

Another effect, without “positive” or “negative” label, concerns the origin-destination distribution of transport : the part of “tangential traffic” (suburb-to-suburb) seems to increase constantly. Note that, in the last decades, investments in public transport were focussed on connecting inner and outer suburbs and peripheries to the central business district, thus supporting a centripetal transport model and a monocentric urban system. Little attention was given to the problems of transit within the emerging intra-urban polycentric systems, especially with regards to the so called “tangential” mobility.

On the other hand, the positive effects are mostly situated at the individual level :

- access to cheaper private residential developments : middle-class households have the possibility to become owners of single family housing, with enhanced personal and public open space;
- access to cheaper private non-residential developments : young SME and companies have more pleasant work environment than what they could have afforded in the urban centre.

The debate on sprawl can also be considered as a set of arguments, between those advocating a planning approach and those advocating the efficiency of the market. Those from the “planning” family usually support compact development and advocate greater regulation and planning to solve the “problems” of sprawl. They justify intervention on the grounds that the market is not efficient due to externalities, or unintended effects of actions, the costs of which are not borne by the producer, the existence of public goods which are freely available and therefore not provided by the market, and lack of equity in that the goods and services are not distributed evenly among areas.

The other group is those who take an economic perspective – in this group there are both supporters of compact development and of sprawl, however, in both cases the view is that the economic market will ensure efficient development. Those advocating the free market approach assume competitive and efficient markets and point out that actions should be taken to place the cost of externalities on the producer rather than using regulation

4. Outcomes of the interviews of local/regional authorities and experts (WP2) – How do authorities perceive urban sprawl ?⁴

The purpose of WP2 was to detect and understand the local events and rationale involved in the emergence of urban sprawl, its relevance in the decisional agenda of local authorities and experts, and the overall level of awareness of this particular urban phenomenon. Such goals were achieved by analysing interviews conducted with local authorities' representatives and experts in the six case cities of Bristol, Brussels, Helsinki, Milan, Stuttgart and Rennes.

The first stage of analysis consisted of making a synthesis of all interviews performed in one single city (on average 4 interviews per city). The second stage, more difficult to achieve, consisted of making a transversal synthesis of all the interviews performed in the six case cities. In this stage, the aim was to identify and highlight common factors and events. This section presents the main results of this latter stage.

The synthesis of all the interviews performed is based on the *concepts* and *categories*, which have emerged during the interviews, some of which had not been pre-determined in the interview framework (see Figure 2 below).

The common factors having emerged are summarised below.

In the perception of the interviewees, urban sprawl is mainly originating in situations when new demands arising for the increase in households' incomes are met mainly by the private sector. The housing and land market and the lack of measures to control the increasing use of private means of transport are the main causes.

Sprawl is also perceived as relating mainly to housing rather than to an 'ill' structure of land-use distribution and planning. This is due to a tradition in planning analysis and practice that looks at spatial functions as alternative and mutually competing uses of scarce land. Although there is a call for mixed land-use planning as a possible solution in particular to the mobility problems induced by sprawl the attention to the possibility offered by economic and fiscal measures is still scarce. Costs and benefits have been since long investigated by the American literature but planning practice in Europe has focused mainly on the possibility to control sprawl by means of land-use and transport planning. To control the process and dynamics of urban sprawl is in so far very difficult, since often a mixture of different types of urban sprawl can be found. Finally, there is a need to define the 'proper institutional level' at which policies to control urban sprawl should be implemented. On this issue, the debate is still open.

The knowledge framework

The analysis of interviews revealed a general concern about the knowledge framework adopted to investigate urban sprawl, in particular as regards the geographical extent of the area of analysis.

The extent used by SCATTER shows urban growth processes as a centrifugal dynamics. A monocentric structure emerges, based on concentric rings of decreasing density that have their core in the main urban centre. Urban sprawl is a local process of population dispersion and growing land consumption and infrastructure congestion.

⁴ The text of Section 4 is drawn from Deliverable 2 of SCATTER, "System Analysis of Urban Sprawl by Experts, in the Case Cities", October 2002, which was written by Elena Besussi from CASA – Centre for Advanced Spatial Analysis – University College London.

Several interviewees suggest that a larger geographic extent of the areas of investigation could be adopted. Such enlargement reveals more complex dynamics and interactions among the main and secondary urban centres of the region, which often lead towards a polycentric territorial structure. At this scale several and interesting explanatory factors emerge: the role of population and jobs redistribution processes; the role of conflicting and/or cooperating planning interventions among the involved municipalities; the impact of regional, national or even international infrastructures investment. Moreover urban sprawl ceases to be only the cause of negative impacts and becomes also a virtuous phenomenon promoting local development of small and medium urban centres.

The level of awareness of local authorities

To understand the level of awareness of local authorities with regards to urban sprawl, the analysis of interviews has focused on the relevance of the topic in the decisional agenda of planning offices and on the level of knowledge exhibited by the interviewees.

The former has been assessed by the attention given in the design of policy measures or planning interventions to issues such as mobility and congestion, land consumption and the quality of the urban environment. With this regards there is a growing consideration among individuals responsible (in different ways and at different institutional levels) for planning to problems such as the increasing congestion and traffic not only within urban centre but also in peripheral areas and in the surrounding regions. The necessity to provide for a better coordination of land-use and transport planning also at the neighbourhood scale as well as to control the production of the built environment to prevent land-use and social segregation and the impoverishment of the urban quality are perceived as crucial steps in the struggle against urban sprawl.

The latter is demonstrated by the above-mentioned concerns on the necessity of an improved knowledge and analytical framework for urban sprawl.

However, this generally high level of attention is hardly ever accompanied by a shared awareness that sprawling processes are careless of institutional boundaries. This is the source of undetected and unplanned processes of urban growth, which can lead to sprawl but also of institutional conflicts among the different local authorities affected. These conflicts, based on the competition among different areas and urban centres, which try to capture or reject population, employment, new development areas, wanted or unwanted land-uses are one of the main barriers for inter-institutional cooperation.

Almost all the respondents have proved sensitive to recognizing that a common understanding of what urban sprawl is and how it works is crucial to build a strategic, shared and far-sighted vision of the future of their urban areas and regions. These factors as well as the definition of the proper institutional level for decision-making are crucial to the success of any policy measure designed with the purpose to mitigate the impacts of urban sprawl.

The debate on the 'proper institutional level' is still open. Opinions collected through the interviews range from the definition of a metropolitan or regional authority with land-use and transport planning competences to the formula of voluntary bottom-up cooperation among local authorities, which has been successfully tested in some cases.

Four profiles of urban sprawl

Another interesting aspect arising from the analysis of interviews is the necessity to structure further research and the design of policy measures around different types of urban sprawl. Four main types of sprawl were identified :

- sprawl as an emergent polycentric region : characterised by the emergence or development of secondary urban centres ;
- sprawl as a scattered suburb : characterised by infill process by which scattered and low density housing developments locate between centres or between transport infrastructures ;
- sprawl of peripheral fringes : characterised by higher densities than suburban developments and inhabited by groups of population who have to relocate because of the increasing costs of life in the urban centres ;
- commercial strips and business centres : located following a rationale based on accessibility, low cost of land and agglomeration economies.

5. Outcomes of the statistical analysis (WP3) – Defining statistical indicators to identify and quantify urban sprawl⁵

The objective of WP3 was to design a statistical analysis framework aiming to identify and quantify urban sprawl, and to apply it to the six case cities.

The developed statistical framework consists of :

- a specially designed generalized shift-share analysis ;
- a new measure of concentration, called *H*- indicator ;
- the application of local spatial autocorrelation statistics ;
- as well as the calculation of more traditional indicators like densities, shown on maps.

This seems to provide sufficient and necessary conditions for the identification of different urban pattern, including urban sprawl.

5.1 The data base

The variables investigated were :

- total population and total employment, for all the cities
- income per capita, number of commuters, commuter trip length, house prices, number of dwellings, residential buildings, and number of jobs directly induced by the population, in some cities.

The analysis was applied on time-series data, covering a 20-years period or more, for most of the cities (10 years period for one city).

5.2 Definitions of the indicators

The indicators which were calculated are defined in detail in Deliverable 3 of SCATTER. We provide here only a succinct, summary definition which is sufficient to understand the interpretations and conclusions.

5.2.1 Generalised shift-share analysis applied on growth rates

The generalised shift-share framework consists of :

- calculating an average annual growth rate (?), for the whole study area, at each year, for each considered variable ;
- calculating the annual deviation (?) from this average annual growth rate, for three macro-zones defined as the urban centre, the outer urban ring, and the hinterland of the city, at each year, for the same considered variable ;
- and doing all this using a smoothing procedure, in order to smooth noisy patterns which would be due e.g. to possible data uncertainties.

5.2.2 New measure of concentration *H*

The new concentration-measure called *H* was inspired by physics and is defined as :

⁵ Section 5 is drawn from the Deliverable 3 of SCATTER “Statistical Analysis in the six Case Cities”, December 2002, whose main authors are Guenter Haag and Jan Binder, from STASA (Stuttgart).

$$H = \int \mathbf{r}(\bar{r}) \bar{r}^2 dA(\bar{r})$$

where the density (e.g. population density) $\mathbf{r}(\bar{r})$ at distance \bar{r} from city centre is weighted with the square of distance from the city centre. The integration $dA(\bar{r})$ has to be performed over the whole case study area (A being the urban area). This formulation translated in discrete terms leads to :

$$H = \sum_i X_i r_i^2$$

with :

$i = 1, 2, \dots, n$ being the zones of the study area

X_i being the value of the stock variable X in i (e.g. population, employment)

r_i being the distance between the centre of gravity of each zone i and the centre of gravity of the whole study area.

The indicator H_{rel} is then defined on the same way than H , but considering relative values $X_i/X_{average}$ instead of X_i .

5.2.3 Indicators of spatial autocorrelation

The indicators of local and global spatial autocorrelation allow to estimate whether, as regards the value of a particular variable (e.g. population density), a zone i is surrounded rather by zones exhibiting close, similar values, or on the contrary, very dissimilar values, or is surrounded by a heterogeneous, patchy pattern of similar and dissimilar values.

As an example, when local spatial autocorrelation statistics is applied to population density, it may highlight a pattern as follows : the urban center (high autocorrelation - similar high densities), the rural hinterland (high autocorrelation - similar low densities), possibly including urban poles (low autocorrelation – urban poles surrounded by rural zones, with much lower densities), and finally a zone in-between characterized by very low spatial autocorrelation, because it corresponds to the suburban area, which is a mix of more or less recently urbanized communes and other still rural communes.

5.3 Main results

As a first conclusion, the application of the statistical analysis method showed that the development of the urban centres of all six case studies Milan, Brussels, Stuttgart, Bristol, Helsinki and Rennes are behind the average growth path of the whole conurbation areas over the last decades, while the deviations of the outer urban ring and often also of the hinterland are above the average growth path.

The shift-share analysis indicated that in all case studies the main growth poles of population and employment are situated in the outer urban ring or the hinterland or in both. This leads to an increase of the investigated stock variables (population, employment, commuters, dwellings and residential buildings) mainly in the outer urban ring accompanied by an increase of the investigated density variables (income per capita, commuter trip length and house prices) in some but not all zones belonging to the outer urban ring and the hinterland. Milan is in so far an exceptional case, since total population and commuters are decreasing (stagnating). However, this could be related to the fact that the study area adopted for Milan could be too small.

Urban sprawl can be identified per definition, if the growth of the investigated indicators are more or less scattered over the whole region, with the urban centre of the region as source. The detailed statistical analysis indicates urban sprawl in the case studies of Milan and Bristol. Here, the necessary condition for urban sprawl, namely a strong de-concentration effect must be stated as well as scattered growth rates, distributed over the whole study areas.

In the case studies of Stuttgart and Brussels only a moderate to stagnating de-concentration is observed. The scattered growth rates of all indicators of Stuttgart and the spatial autocorrelation pattern exhibits that urban sprawl in the Stuttgart Region exists but is rather moderate. The spatial re-orientation of Brussels follows more a diffusion pattern (associated to the urban growth) with some implemented scattered structures. Several poles exist in Brussels periphery. A moderate sprawl phenomenon of jobs and population can be identified.

Helsinki and Rennes still tend to concentrate its activities close to their city centres. In so far both case studies do not exhibit all conditions of urban sprawl. Nevertheless, Rennes and Helsinki show some typical aspects of urban sprawl, e.g. scattered spatial development of population and of workplaces. However, the spatial autocorrelation analysis and the shift-share analysis shows that for both variables only around the rather small urban centre a high spatial correlation can be found, despite the unbalanced and widely spread growth of population and workplaces in the outer urban ring of Rennes and Helsinki.

The global spatial autocorrelation indicators (global Moran's I) for the different case study areas provided a ranking of spatial autocorrelation: The communes belonging to the Brussels study area are much more similar in population density and workplace density than communes of Rennes and Bristol. Milan, Helsinki and Stuttgart are in-between.

The pattern of local spatial autocorrelation indicators (local Moran's I) indicated that the urban centres of Brussels and Helsinki and some neighbouring communities show strong spatial autocorrelation in population density and density of workplaces.

To summarise, one of the main results of the analysis was that the six cities all exhibit de-concentration behaviours, but with different modalities. They can be clustered into three groups :

- Milan, Bristol : *continuing and rather strong spatial de-concentration of activities* (activities include population and employment), with local specificities such as:
 - Milan: population and employment are out-migrating to areas which are more and more distant from the centre;
 - Bristol: it exhibits a more polycentric pattern, with 2 other urban poles included in the hinterland;
- Stuttgart, Brussels : *moderate spatial de-concentration of activities, tending towards a stagnation of the pattern*; in the case of
 - Brussels: it seems that the sprawl, as regards population, has slowed down these last years, and even stopped very recently;
 - Stuttgart: sprawl can be stated for population on a low level but in case of employment sprawling seems to stagnate;

- Rennes, Helsinki : *continuing spatial concentration of activities*: these two metropolitan areas do not exhibit all conditions of urban sprawl, but the growth of the population and of the employment is nevertheless scattered to a certain extent. In both areas, there is in the same time an out-migration of the rural population towards the urban centre and especially the outer urban ring, and a scattered growth pattern, but at a lower level than in the 4 other cities.

Finally, the work done so far in designing a statistical analysis framework will also contribute in the design of the “urban sprawl monitoring tool” to be set up at the end of the project (in work package 7). This tool is intended for all concerned cities and will be designed in order to be used without sophisticated models.

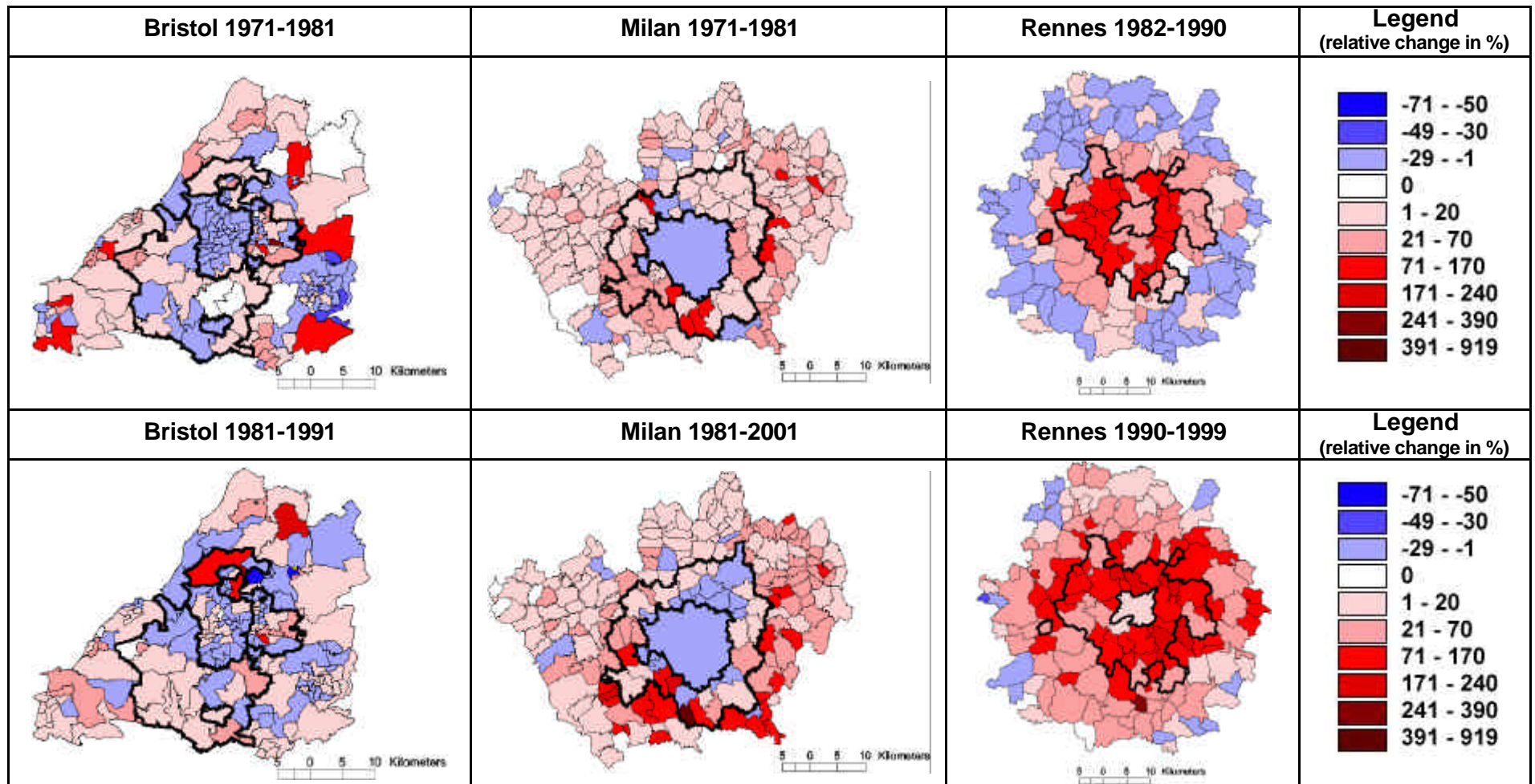


Figure 3a. Change in density of population by zone

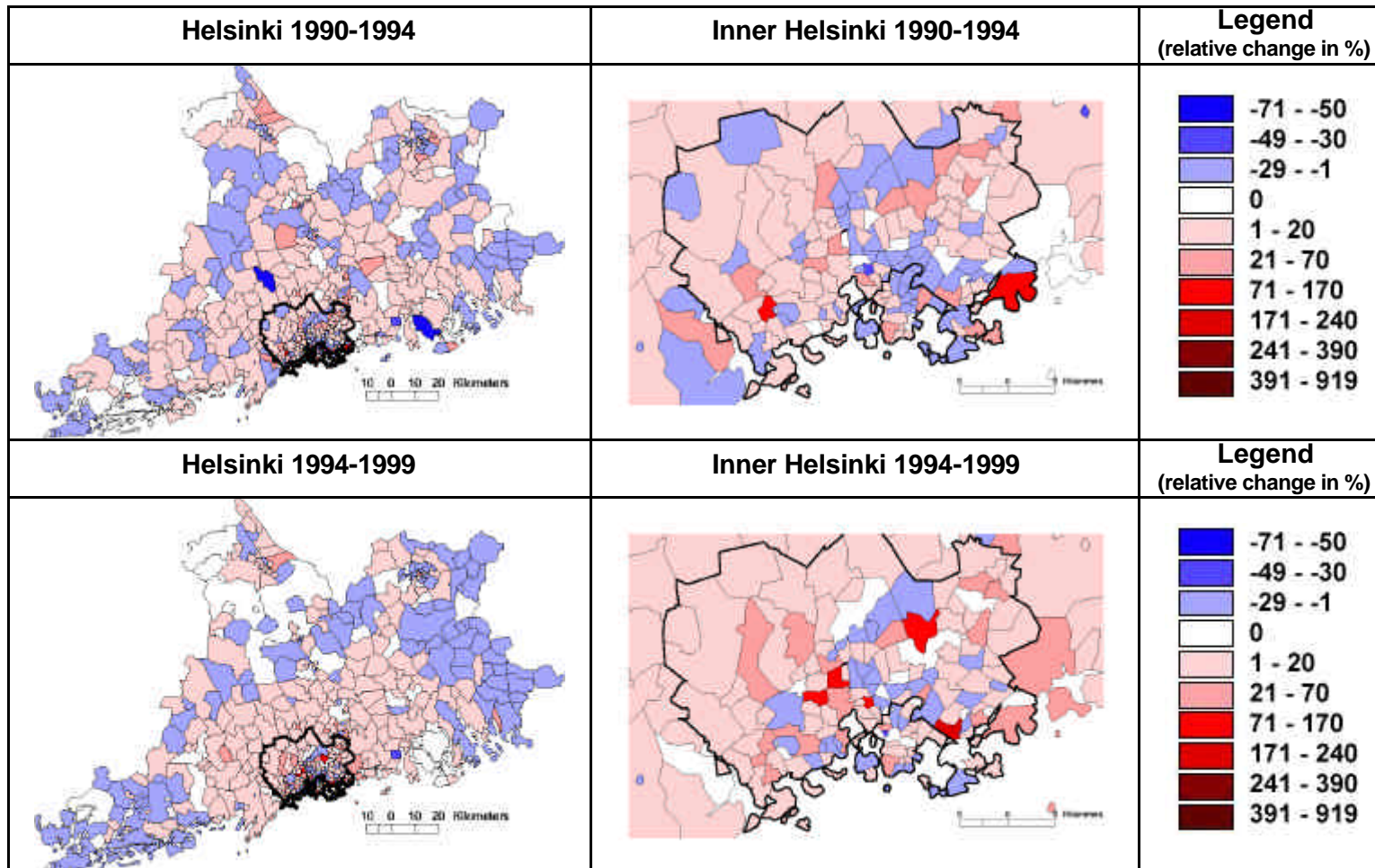


Figure 3b. Change in density of population by zone

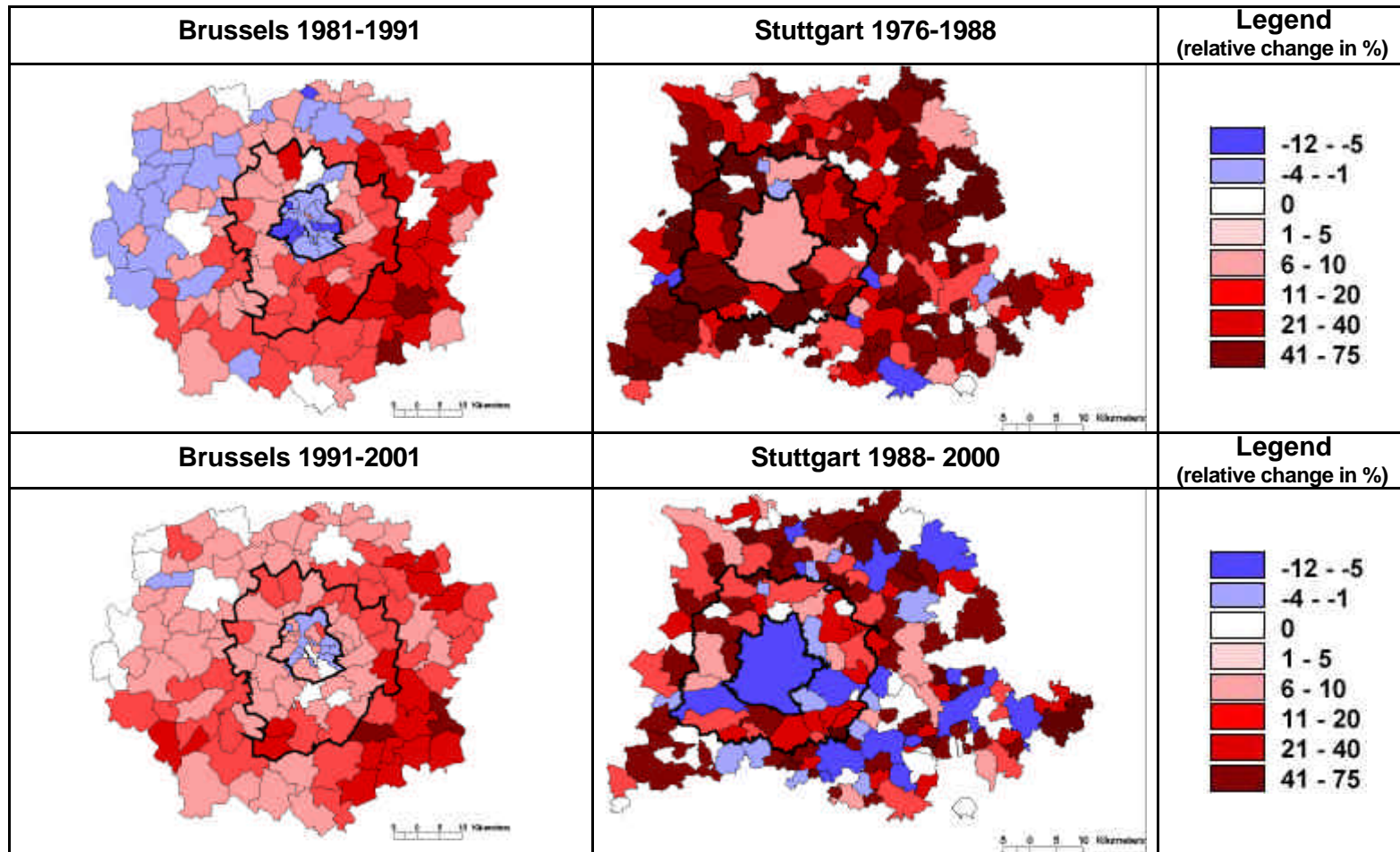


Figure 3c. Change in density of population by zone

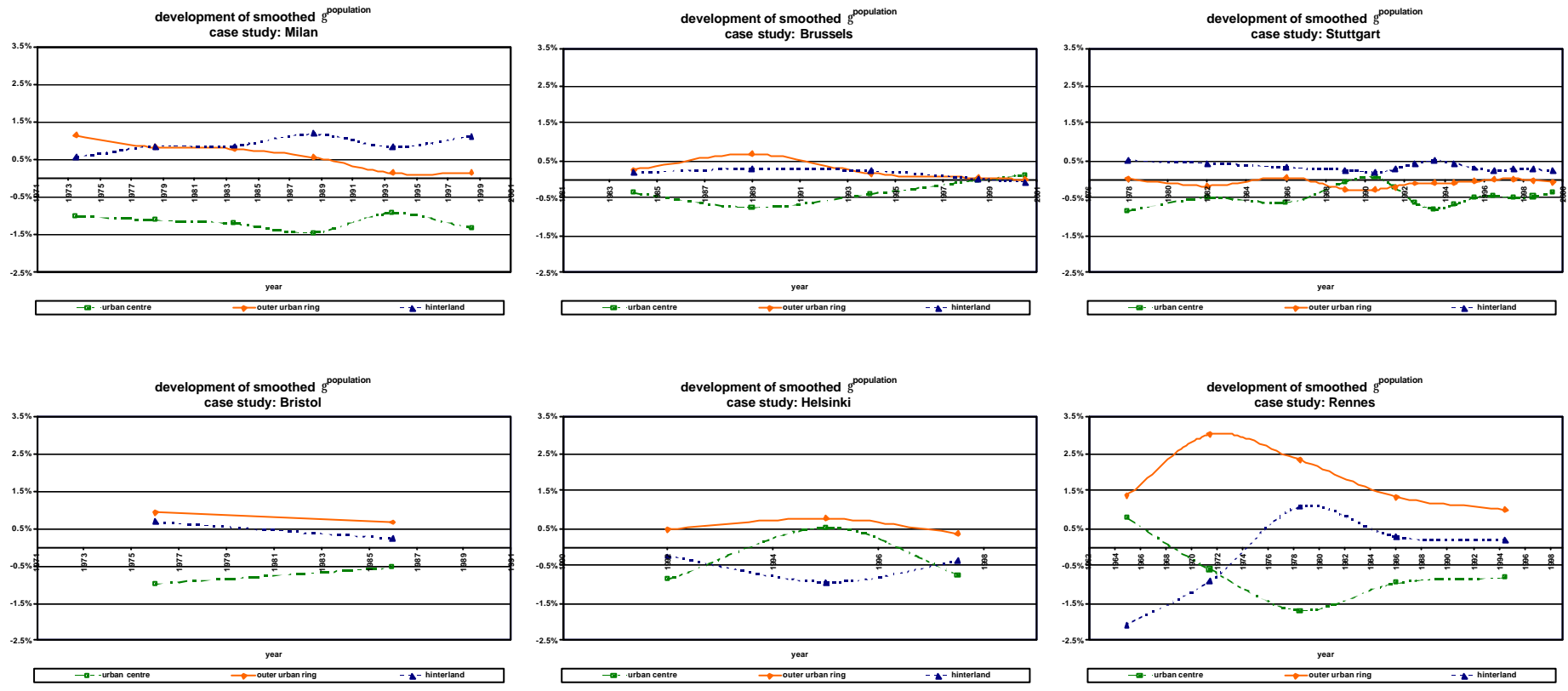


Figure 4. Deviation of the average growth path of $\tilde{g}^{\text{population}}$

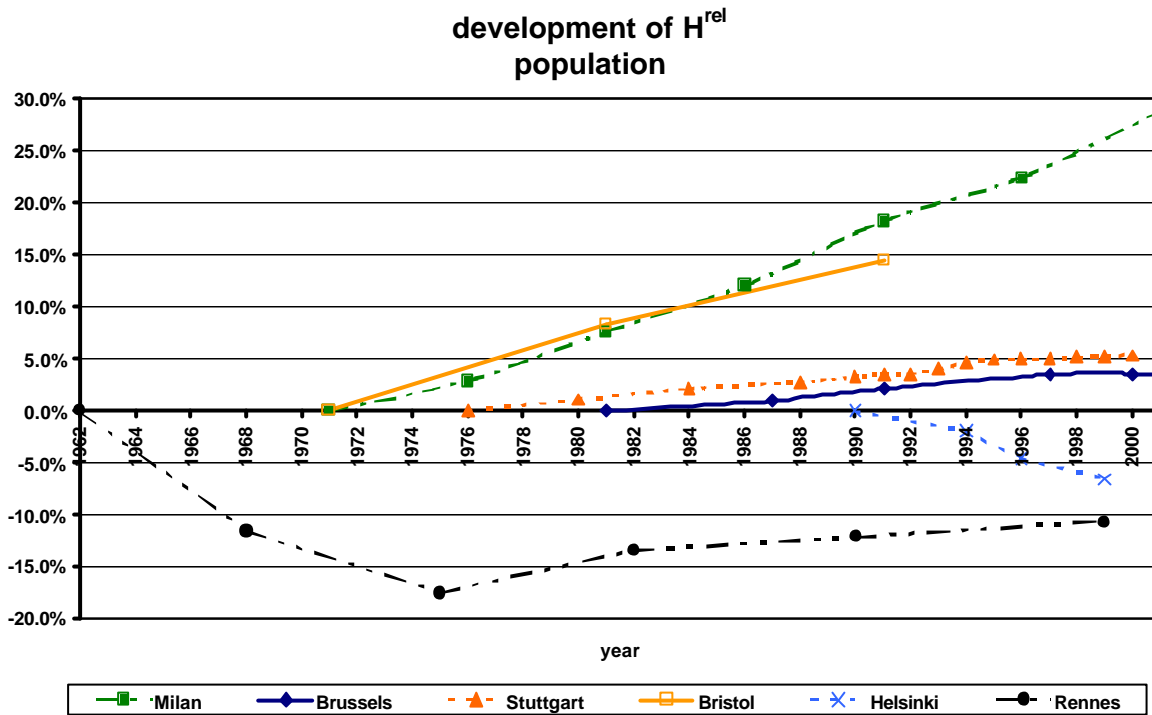


Figure 5. Concentration measure H^{rel} for population for all case studies

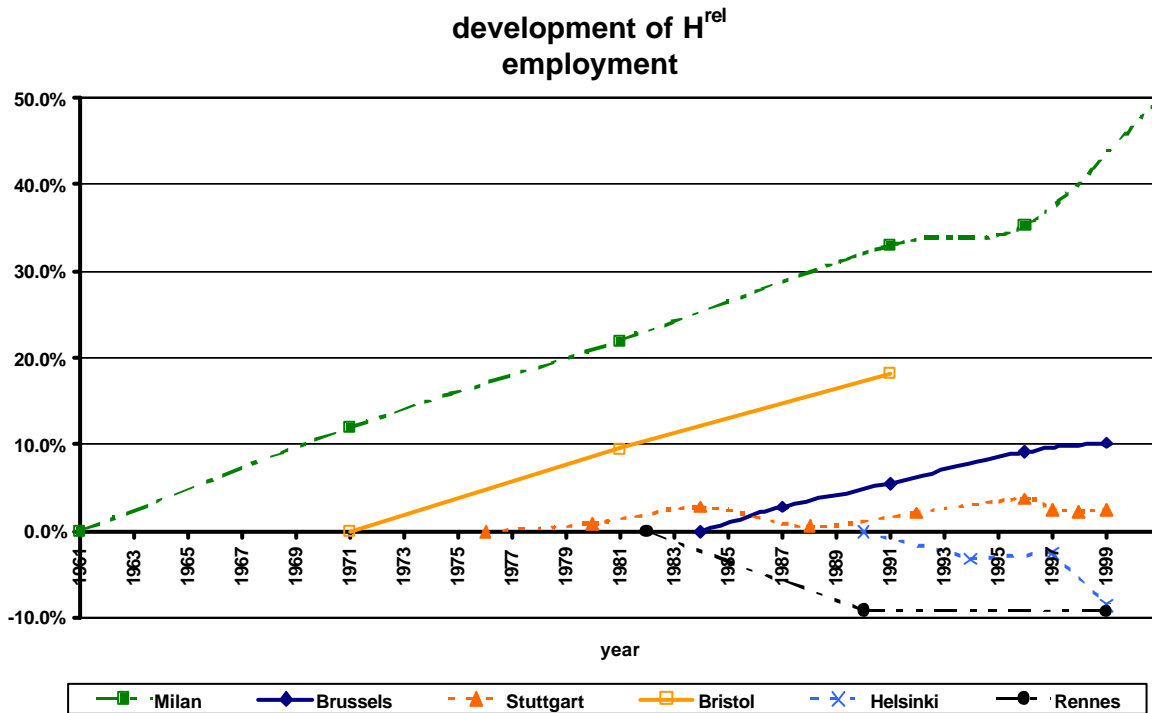


Figure 6. Concentration measure H^{rel} for employment for all case studies

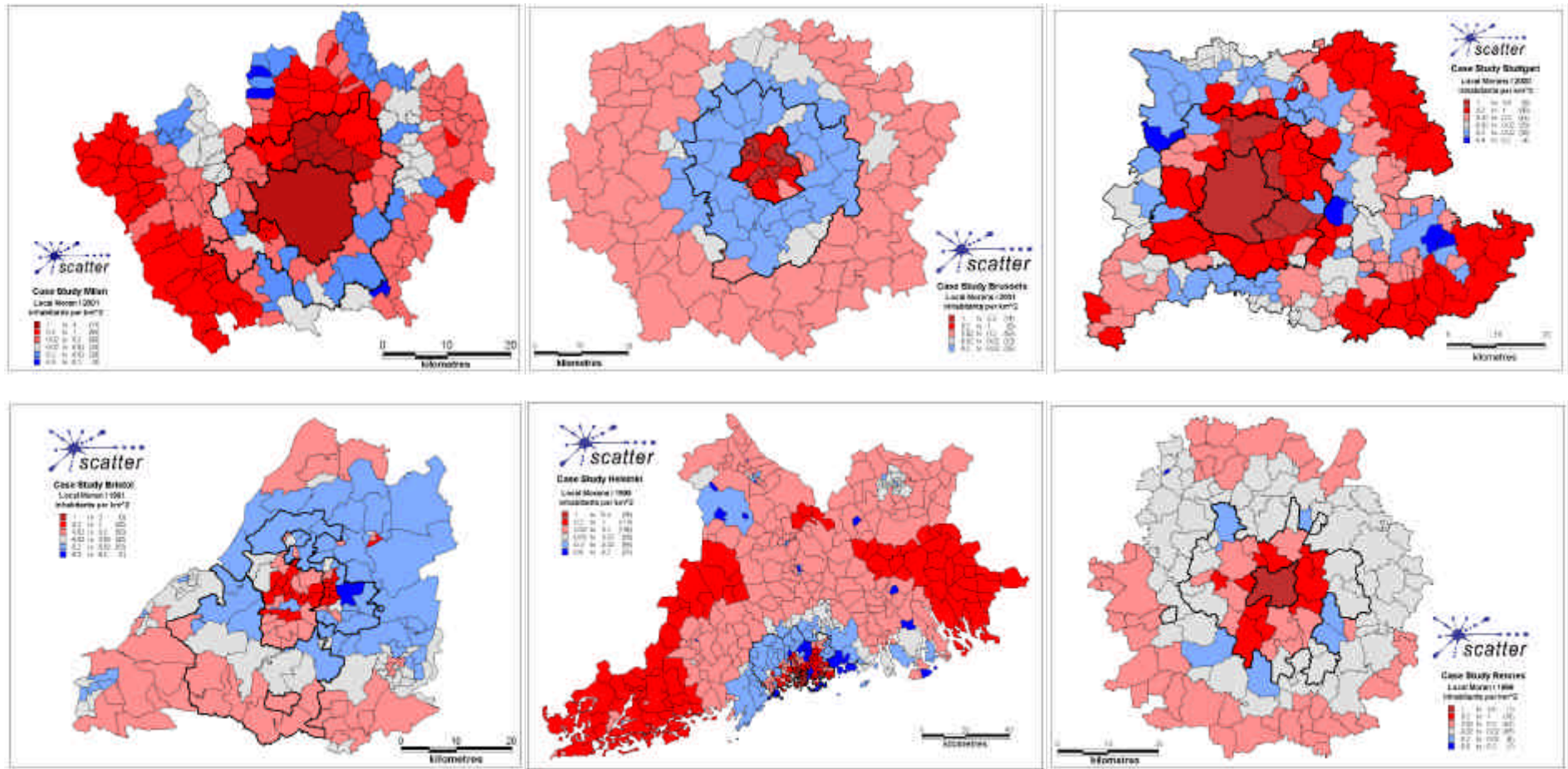


Figure 7. Spatial distribution of Local Moran I for inhabitants per km²

6. Expected outcomes of WP4 – Qualitative assessment of policies, on the basis of the existing experiments and the literature - Comparative analysis of various modes of cooperation between different institutional players.

Work package 4 is currently in progress, no results are available yet (results will be available in spring 2003). Therefore, only the objectives and the overall methodology are presented below.

The objectives of WP4 are twofold.

A first task is to carry out a review of policies aiming to mitigate or control urban sprawl, in Europe and in the USA, on the basis of the literature and case studies, in order to draw a first qualitative assessment of the comparative overall efficiency of these policies. In its last stage, this review should allow to select the measures to be simulated and quantitatively assessed in the next work package of the project (WP5). Work package 5 will use land-use/transport integrated models to simulate policy scenarios in 3 cities (Brussels, Stuttgart, Helsinki).

The review will tackle all types of policies : legal and regulatory land use measures, land use plans and schemes, tax and pricing policies, urban design strategies, housing policies, transport policies.

As a reminder, the combined overall objective of WP4 (review), WP5 (simulations) and WP6 (calculation of indicators) is to assess policies in order to be able to set up recommendations in the final stage of the project (WP7) and to design a practical “urban sprawl monitoring tool” intended for local/regional authorities (also WP7).

The second task in WP4 is to carry out a analysis of the institutional barriers to the design and implementation of efficient integrated policies to tackle urban sprawl. This issue was acknowledged in many studies and confirmed in the interviews (WP2) : there is often a lack of coordination, or even competition, between various decision-levels, various territorial units, and/or various fields of competences (e.g. land planning, transport, tax policies, etc). The task in SCATTER also consists of analysing and comparing various ways of cooperation between institutional players.

There is in fact a whole range of ways of cooperation, from formal institutionalisation (e.g. the creation of new institutions, like the “urban communities” in France – *communautés urbaines*) to rather informal cooperation between existing institutions (without the creation of a new formal institution), including, somewhere in-between, forms like “contractualisation” (“contract” between two institutional players). The final aim is to draw conclusions on the advantages/disadvantages and the overall efficiency of various ways of cooperation and to provide recommendations to authorities which would like to set up a platform of cooperation.

7. Conclusions

As it was said in the introduction of this paper, it is difficult to draw conclusions at not even the half of the project. However, some elements already emerge.

Urban sprawl is a complex and highly multi-dimensional phenomenon, involving many private and public players. Political decision-makers, as well as researchers, are now aware of this complexity. The authorities are also aware of the negative effects of sprawl and are progressively setting up tools to cooperate with each other, between different institutional decision-levels and different areas of competences.

Finally, sprawling cities exhibit de-concentration behaviours characterised by different modalities. Well-designed statistical indicators may help authorities to better distinguish the local specificities and to better fit their actions.