Chapter 3

A Multilevel Approach to Urban Regional Agglomerations: A Swedish Case of Transition Paths toward a "Fossil-Free Society" by 2050

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Additional information is available at the end of the chapter

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Abstract

This article has a focus on the changing patterns of connected urban spaces forming large super-regional aggregates made up of cities of various sizes and regional functions as well as the interconnecting space of much smaller municipalities of agricultural or forestry types of character. The multi-scalar level analysis of these connected clusters is pursued from the level of the individual to the regional, national, Nordic and EU levels. The enfolding of the regional pattern also has global connotations in terms of trade connections, but also in the context of bio-geo challenges as climate change, biodiversity depletion or food security considerations. The transition dynamics involves governance, economic, social and cultural aspects. International negotiations, as the Paris agreement on climate change and agreements at the UN level as the 17 "Sustainable Development Goals" (SDG), or agreements at the EU level, provide an international political frame to this process.

Keywords: urbanization, low carbon society, climate, sustainability, resilience, transformation, region, Stockholm, Sweden

1. Introduction

The interest in urban development has drastically increased during the last few decades. The focus has broadened to cover not only cities themselves but also more strongly the changing context within which a broader urbanized space is evolving—in particular reflecting sustainability and resilience systemic considerations and connected conditions. The tendency of such studies has stressed two different simultaneously existing directions. First, there exists a broadening from just the interest about individual cities themselves now moving toward an increased attention to the issue how a number of geographical sites with urban characteristics are linked to form a wider super-regional spatial and functional agglomeration with both urban and less urban features as parts.

In this direction it is the pattern of agglomeration—and its dynamics—that is at the core of interest. This involves technical (e.g., infrastructural considerations related to the transport system), administrative/political governance issues (as those dealing with the planning of a broader labor market) and other economic concerns. It also involves patterns of commuting preference of inhabitants, and quality of the livelihood in the involved communities. Also the spatial distribution of the knowledge centers of higher learning (and the distribution and roles of their competitive competences) as well as the industrial profile features of the region at large is of importance. This involves, e.g., the interplay between private companies and public bodies with regulating or supportive/promoting functions and the concerns of civil society at large.

The earlier analytical dichotomy, sometimes referred to as "cities-and-their hinterlands," has now been transformed into a much more complex concern about patterns in a set of micro-meso-macro cross-going links [1]. However, the framing—either based in a new increased complexity oriented fashion or in a more traditional way—indicates important choices between preferentially a bottom-up or top-down reform political philosophy (or variations of combinations of these). The earlier more "narrow" city focus has thus expanded to investigations over a much broader and more complex techno-bio-social geographically based pattern. In Sweden, the analysis and political considerations concerning the "Stockholm-Lake Mälar region" is such an agglomeration case in quick development.

The area spans some 100.000 km^2—and covers not only the Swedish capital Stockholm but also an array of larger and smaller cities—as well as rural areas in between dominated by agricultural sectoral activities and forestry. The area harbors around 1/3 of the Swedish population (of totally around 10 million persons) and a somewhat larger proportion of the Swedish economy. It is one of the fast growing regions of Europe and has a very strong innovation and research profile.

In Sweden, there are other emergent regions of a similar kind. One is in the south-west part of the country, in and around the city of Gothenburg. Another one is in the south around the city of Malmö, in that case with the connection to the large vital national capital of Denmark, i.e., the Copenhagen region (connected to Malmö with the strategically important Öresund Bridge).

These here indicated regional agglomerations have different features, but also similarities. They are all built on common Nordic history developments over at least 1000 years and the similarities could be seen in terms of cultural, economic and political styles in handling the different regional challenges, especially if comparing these regional developments with a wider set of similar European experiences and—of course—even more in a global comparison.

All these sub-national regions are bound together in a planned regional pattern of connecting infrastructure. The physical connections thus materialize different dimensions of connectivity

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between a number of cities within a broad geographical space. The patterns of cities (of different kinds and sizes) are embedded in the larger region of diversified space that also includes, in a complex interwoven fashion, less urban (or even non-urban) areas.

This development has a strong interest in a politico-governance-economic way, as well as in a scholarly way. However, that expansion of perspective toward a broader cluster or aggregation of mixed urban and rural is associated with an interest focusing on the characteristics of urban space itself facing transforming factors from outside that impact the respective city system within its own formal "boundaries." These dual interests have to consider a contextual multilevel connotation. It concerns ways to insert solutions (i.e., to respond to various "problems") related to the grand challenges of our time as they create the future framework for a particular urban space. Such "grand challenges" could, e.g., relate to

- climate change (in terms of demands of further "greening" the urban space);
- food security in terms of generating possibilities for growing food within the city limits (e.g., to improve the freshness of the produce, but also drawing its momentum from a social concern to provide a wide range of inhabitants better connection to the food generation process, and—for future problematic situations—to provide a "volume insurance" of availability of deliveries also in turbulent times);
- sustainability and energy efficiency considerations (by compacting the cityscape) and
- social wellbeing consideration (by not only designing the city from a technical-economic "rationality" point of view, but also framing the social setting involving considerations about "the good life" for different age groups—not least children and the aged—but also responding to gender considerations).

Our Swedish experiences are not least drawn on our work within the EU project COMPLEX, which was completed in 2016 [2]. In this context, we have used our investigation area as a sort of "laboratory" for reflections, data collections and various types of modeling. These studies have also provided a wide background for formulating policy advice aimed at a ladder of decision-making levels: municipalities, counties, regional and national bodies. In the end of this article, we will come back to some of these policy considerations.

Our chosen timeframe has been set to 2050. We are well aware that other time frames have been voiced in the political debate about specific solutions dealing with climate change by reducing the carbon emissions to the atmosphere. However, our timeframe is chosen to connect to some of the formal assignments of timeframes in the EU on these matters, as well as time frames expressed at the Swedish national level. This pertains, e.g., to the timeframe within which a net zero-carbon situation ("fossil-free society") should—as a goal—be reached in an overarching sense. However, strong efforts should be mobilized to shorten the time if possible until these goals have been reached. This holds true especially for specific partial goals associated with different sectors (as the transport or the building sectors just to take two examples). In 2017, the Swedish Parliament decided on a set of such targets for these purposes.

2. Agglomerated space and complexity patterns

In our approach dealing with a widened and "mixed" agglomerated regional space, the emergence of patterns and their complexity (as indicated above) comes into the forefront. It is here that the multilevel and multiagent phenomena are found and where the integrating aspects of the wider agglomeration challenge come fully into play.

So what could complexity mean in this "agglomeration" context? As we have addressed elsewhere [1], there are several ways in which complexity can be interpreted and studied, e.g., in terms of structure, dynamics, function and behavior.

2.1. On complex systems

Structural complexity can be seen as an expression of the degree of interplay of many elements in a varied fashion due to a great number of variables and structural constraints. *Algorithmic* complexity refers to the degree of complexity that can be measured in terms of information. ("The more information that is needed to describe a system, the more complex it is"). Another type of complexity is called *effective* complexity, which can be defined as the length of the descriptive code that is needed to describe its regularities. In addition, a study of complex adaptive systems has to separate regularities from randomness.

Yet, there is no obvious – or by all accepted – definition of complexity covering a wide range of contexts. It is measured in praxis by how well we understand causes, behaviors and – in assessment terms – achieved purposes. Hence, issues about large numbers of variables and non-linear relations among them, as well as aspects of the degree of openness of a system are important elements of scrutiny, especially considering the degree to which they present barriers to an improved understanding [3].

Characteristic features of complex systems have to do with the web of (often non-linear) interrelations between variables that may provide thresholds, lags and discontinuities. Feedback and feedforward loops enable amplification, as well as attenuation and control. This often results in unpredictable and non-intuitive behaviors. Complex systems are often self-organizing and adaptive, where spatio-temporal order may emerge out of disorder, and where new qualities may emerge above a certain threshold of complexity. Such systems could have a high degree of redundancy, which makes them less vulnerable to disturbances and malfunctioning parts. Examples of such systems are found among some ecosystems, or in some combined socio-natural systems, as well as those of socio-technical character [4, 5].

2.2. Micro-, meso-, and macroscale relationships

Many complex systems are characterized by a hierarchy of subsystems and different levels, both in time and space. In relative terms, these levels can be viewed as *micro, meso* (i.e., "the in-between level"), and *macro* levels, often equally applicable to temporal, as well as to spatial scales. In fact, often the temporal and spatial scales are correlated, so that spatially "microscopic" systems and structures are characterized by a "microscopic" time scale (i.e., "the smaller the system, the faster it moves"). Similarly, larger systems are typically characterized by longer time scales (i.e., slower motions). For example, the characteristic time scale of molecules is fractions of seconds, whereas the time scales of mesoscopic systems (such as "touchable objects") might be at the time scale of seconds to years, or macroscopic systems (such as planets or galaxies) relate to much larger time scales [1].

In our urban agglomeration spatial case, the time variation could at the level of the neurocognitive processes of individuals (dealing with reactions and decisions) span a frame of some 300 ms to a few seconds (depending on the art of the reaction). At another level the time frame for the decisions and strong transformation impact on the "realities" of a sub-national region is at the level of one to two (human) generations. The year of 2050 as a target year for the transition to a fossil-free society for our case region mirrors this chosen analytical time frame of our approach.

The characterization of agglomerated urban-rural systems requires an attention to the interactions between different spatial and temporal scales, with a focus on the mesoscopic level, between micro- and macroscopic level descriptions. The mesoscopic level can be seen as the level where bottom-up processes meet top-down processes in societal transformations.

Approaching a systems "organization" (as a region) through its micro-, meso-, and macroaspects, applies not only to its technical connotations but also to social structures. That approach is appropriate when discussing the relation between an individual ("microscopic") and the group or population ("mesoscopic"), within which it is a part, and to the entire socio-technical-ecological system ("macroscopic"). In our case, we regard the sub-national regional scale as the mesoscale, in relation to the micro-scale of individuals or households, and to the macro-scales of nations and the world at large.

In this context, it is worth focusing on the connectivity of network structures, whether they are hierarchical or not. Many properties of networks, such as stability, resilience, and flexibility, as well as diffusion of any kind, depend on the strength and types of the network connections. For example, strong connectivity may lead to local resilience, but may also result in fragmentation and social/cultural polarization, while weak connections are more likely to be more efficient for linking different groups to each other, and for creating a more stable relation between micro and macro levels in an organization [6].

Similarly, there seems to be an optimal degree of randomness in social networks, with regard to efficiency in information transmission and social learning, as is described through the concept of "small-world-networks" [7]. Analogue results have been found for models of neural networks [8–10].

Environmental changes occur at several time scales, but it is demanding to analytically describe the interaction between these scales when trying to match the characteristics of the different life processes (not least due to interesting time span overlaps). One attempt is to crudely relate to the average lifespan of an individual or a generation. This becomes obvious when we discuss the relation between individual choices and those policies taken by the society at large (e.g., with relation to a region as our case demonstrates). Recently the interest of inquiry has started to involve much longer time scales (several generations) than what politics normally has been used to do and involving all spatial (and associated time interval) scales up to the planetary one [11].

This also involves “grand” approaches to the issue of the historical period we are living in, seemingly moving into the Anthropocene—the time period in which humans have at least the same level of impact on the planet as all other more “natural” processes demonstrate [5, 12, 13]. This already has strong and increasing implications at lower levels of aggregation—as the regional one—as is shown by the handling of the climate change issue (with global causal connotations and local impacts).

In a social system, e.g., dealing with the structure of decisions, the multilayered structures play more and more important roles [14]. This was one of the important starting points for the development of sustainability science [15]. Globalization phenomena (macro) meet phenomena at a local level (micro). However, it is very difficult to deduce the effects at one level to those generated at another. Of course, global tendencies are built up by ensembles of micro events. But what are the mechanisms of shaping (potentially appreciated) coherence on the way up the ladder? And to which extent do globalization phenomena really frame local events, more than just preconditioning them in certain fairly vague directions?

Analyses about such layered interdependencies [16] need to start with the understanding that no specific actor may claim full knowledge about the total system. In fact, the problem of an inadequate overview of multilayered phenomena from any particular point of view is in itself of importance. This contributes to the complexities in understanding the interplay between different spatial as well as temporal scales. This also explains—to some extent—the difficulties in creating a deepened understanding of such nested systems and to find appropriate operational designs of processes of governance. In itself these concerns call for new and important research efforts—also with regard to agglomeration phenomena.

Social phenomena are often generated in an interplay with phenomena emerging in the natural environment. Thus these connections—operating at a sequence of levels—can be visualized as two inter-related ladders of description: one of socio-economic-cultural character, and one of natural origin—sometimes referred to as the issue of “fit” [17, 18]. The specificities in these two realms, and the logic running them, may be very different. However, when combined these two systems connect—and even become a joint new type of system (e.g., what sometimes has been called a socio-ecological system—currently often adding the technological features to the social frame).

Then, the issue of how to organize the match between these parts becomes paramount. One example is the handling of a watershed geographic area and its management, e.g., connected to a river and its contributing water bodies. Here the natural system of the water flow has to be managed (i.e., providing the relevant “fit”) within a socio-economic and cultural context, which comprises the other part of the joint socio-natural system. In our case region the waterbody of the large lake Mälaren (and its watershed area) and all its urban, semi-urban and rural subareas connected to it provides an example of this type of integrated connectedness. The interplay between the levels—and the specific role of the mesoscale—is here of strong importance.

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For an earlier study (with relation to one of the authors of this paper—US) about the interplay of humans and the environment in a sustainability and democracy context with relevance for Swedish regions, these issues were exemplified with the two municipalities of Linköping and Åtvidaberg [19]. A number of other studies have been devoted to regional developments of this kind [20–23].

2.3. Dynamics and transitions

Features of systems in terms of their development over time are, of course, highly interesting. In particular in our case, this holds true for social systems, including the changes in cultural patterns. In order for individuals and societies to survive in a complex and changing environment, they need to be able to respond and adapt to environmental events and changes at several time scales. In particular, actors have to learn from experience. At a general level, "learning features" in systems often provide early warning capacities and starting points for solutions. The capacity to transform such signals to adaptive changes of various systems makes them more robust and increases their resilience.

We usually try to distinguish the evolution of a system under "normal conditions" (which often means slowly varying conditions), from those which are due to unexpected external shocks, such as a meteorite plunging the surface of the earth (or an unexpected financial crisis, such as the one in the early 1930s or in 2008). Examples of how the dynamics of a specific complex system can change due to various intrinsic and extrinsic effects are given in [10].

When discussing the long-term evolution of complex systems, we sometimes have to deal with catastrophic events, analyzing them in terms of intrinsic and external influences, respectively. Mostly, catastrophic events (such as a hurricane or a tsunami, mass extinctions of species, or breakdown of a technical or social system) are considered to occur due to external "forces" acting on the system (such as a sudden weather event, an earthquake, the eruption of a volcano or the impact of a meteorite—or due to "external" societal factors, e.g., changes in global trade patterns). However, there is a need also to reflect on the intrinsic factors of the system itself, which either enables the impacts of the catastrophic event to be very severe (flooding in a landscape with insufficient preventive measures or insufficiently reflected zooming spatial policies), or even as being the real source of such a catastrophic events (e.g., long-term developments within a financial system of destructive corruptive practices).

Small fluctuations might inevitably, sooner or later, bring the system across the threshold of instability. This phenomenon is sometimes referred to as "self-organized criticality," and has popularly been illustrated by the growth and collapse of a sand pile [24].

2.4. Resilience and vulnerability

An interesting question in this perspective is when microscopic fluctuations can have effects at a macroscopic level, and become the roots of shocks to the entire system. Many examples can be given from the physical sciences, but different types of systems in the socioeconomic domain express similar features. It is generally considered that the joint action of a large number of stockholders can avalanche into a stock market crash.

An important feature of a combined social and ecological system is its *resilience* [25, 26]. When such a system loses its capacity of resilience, it becomes vulnerable to change in a way that previously could be avoided through risk absorption [27]. Many of these features have to be understood in terms of multiscale interplays.

A closely connected issue deals with the role of diversity—including the layered structure connecting different roles of organisms and their functions. In the societal management of such combined bio-social systems also multilayered governance systems have to be designed and mobilized in which the stratification of the appropriate roles at the various levels and their interplay should be outlined. This often happens as a social nested process within which political will is only one of the components in the causal chain leading to a specific situation (see Svedin *et al*. in [16]).

Are there general features of resilient systems which can recover smoothly after shock treatments? It is very difficult to provide a list of general features making a system resilient. However, some properties that make systems less vulnerable to shocks include: an appropriate network structure with a carefully designed type of high interconnectivity, a high degree of redundancy, heterogeneity, elasticity, and self-organized regulatory mechanisms (i.e., relevant forms of negative feedbacks).

A reduction of resilience creates an increased vulnerability to societies. For example, freshwater systems may have their vulnerability increased with regard to flood events, but also to toxic algal blooms, which originates from intensified fertilizer use, higher densities of animals and poorly performed other types of agricultural practices. (For general surveys about resilience and socio-ecological systems approaches, see e.g., [26, 28].) At a very general level, Hägerstrand [29] trace**s** some of the dangers to our planetary socio-natural systems to the split between the external world and the "projects" within our minds. "It is as if our well-developed capacity to store and hold together systems of ideas makes us unable intuitively to feel the limitations of the external world to accommodate our projects." Indeed, this is an expression of a severe vulnerability of our civilization.

3. A guide to our case region: the Stockholm-Mälar region and its various parts

We now go back to our case region. We are zooming in on the Swedish geography in order to point at the place from which our examples are drawn.

Our studies of the Stockholm-Mälar region within the EU project COMPLEX [2] have given an array of very different insights about this regional system and its potential capacities to transform into a (net) zero-carbon emission region by 2050.

The selected case region has a central place in the history of Sweden. Without going into details it spans in time about more than a millennium of development—and with an even deeper time depth to Viking times and before. It is easily stated that the region is the holder of the

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combination of central (royal) governmental functions (including the democratic institutions later in history) for the country at large. It has been and still is a key holder of network nodes of trade, the seat of many internationally renowned academic institutions and others of highly qualified character (e.g., at university level from 1477 in Uppsala and later in many other places in the region as – in the present days – world-leading institutions in Stockholm). The region also has a history of carrying the seat of central church offices over at least half a millennium. It has been a vibrant mining (mostly iron-based) area, today spilling over to the high tech industries in the modern world in sectors as manufacturing, forestry, agriculture and financial services.

In short, this has been—and continues to be also in our times—a deeply European core region over a millennium and a carrier today of both long tradition and very advanced technology of contemporary excellence. It is a still expanding global network hub for industrial endeavors. It is also a region balancing the formal role as holder of the capital of Sweden (i.e., Stockholm) with its highly urban features structurally based on a core associated with integrated medium and smaller urban nodes as well as regionally embracing a rural countryside area with highly developed agricultural and forestry activities—and upgrading facilities of these raw material contributions. It is also a region with new types of functions and capacities, from emergent types of consultancies (e.g., in the finance sector) to the sector dealing with a considerable

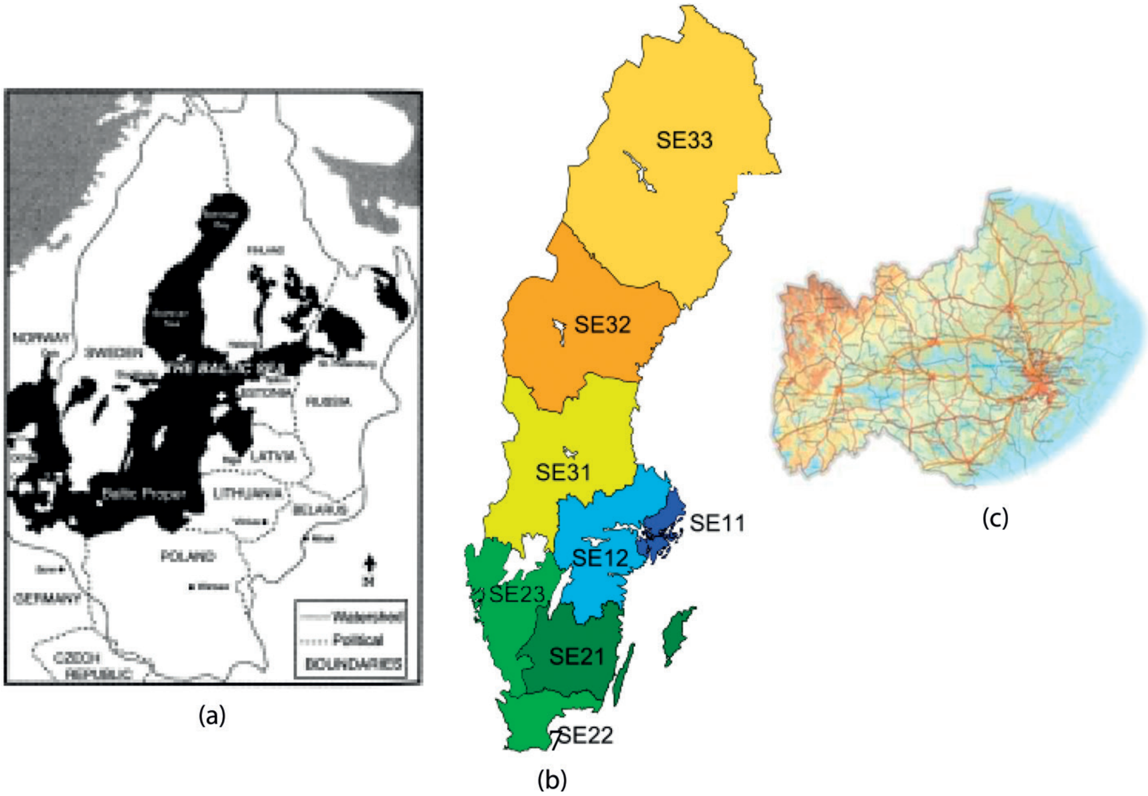

Figure 1. (a) (left) Map over northern Europe. Black part in the center is the Baltic Sea. (b) (middle) Map over Sweden with labels of European regions inserted. (c) (right) Map over the Stockholm-Mälar case region. (Stockholm city is the center in the east where all the communication lines—here the rail lines—converge. The connections over the region correspond to railway links between different medium-sized cities in the region). Our case region relates roughly to the two NUTS regions SE 11 and SE 12 (see **Figure 1(b)**).

capacity to harbor large streams of tourists, not least during the summer period when the large cruiser ships arrive from all over Europe to Stockholm. It is definitely a region with very high innovation orientation. This holds true in many cases of global high tech features as in telecom, electronics, robotics, medical and pharmaceutical specialities, and in other areas of cutting-edge technologies.

Thus, due to its modern societal features and cultural value frame as well as its technological knowledge capacities this region is a part of the world where a successful experimentation leaning toward the "nonfossil society" transition in principle could take place. A great deal of the necessary conditions for this change already exist that are needed for the low carbon trajectory to be possible – or at least are potentially available. The character of the region is thus not only providing means for itself to face the challenges needed now to address the operative requirements. It is also a region with a potential development path that is of strong interest for a wider European (and even global) set of actors in a time when solution structures are searched for in many places of the world in order to manage the climate change challenges within less than a generation.

The Stockholm-Mälar region is the home of some 3 million inhabitants which is about a third of Sweden's total population—and it is quickly expanding in terms of its population. It consists formally (i.e., politically) of the five Swedish counties (län) Stockholm, Uppsala, Örebro, Västmanland and Södermanland with close connections to other counties close by, dealing with similar challenges. And it is one of Europe's approximately 500 regions, in this case with strong expansion and leadership ambitions in the sustainability and other arenas. (In its broader context of the SE11 and SE12 regional areas still other counties—i.e., "län"—are included).

To sum up: the region has several interesting characteristics, such as:

- A great variety of geographic and social features—i.e., it is diverse
- A long historical evolution in a socio-economic cultural frame
- A layered governance structure
- A high cultural profile and with several academic institutions
- A highly qualified "high-tech" type of industry

1. Reasons for regional possibilities to move successfully toward low carbon targets by 2050

What speaks for the capacity of the region to evolve into a low carbon society in a few decades? Main features are of course coupled to the high innovation profile of the current technologically inclined industry. This in turn is embedded in a large, regionally distributed and competent university/university colleges structure with considerable attendance in terms of percentage of the population living in the area. This research and education structure has in addition the last decade advanced strongly in undertaking sustainability-oriented research and educational tasks and developed new types of institutions for promoting such ideas. This holds true not only for the climate-related part of issues but for the broad set of challenges outlined in the set of the UN defined Sustainable Development Goals (the 17 SDGs).

Several of the current industries work within such sectors that are candidates to become lead sectors for the path to a low carbon society (i.e., what could in this sense be labeled as a "fossil free society"). The existing industrial sector also has the potential to expand into new areas of possible innovative solutions with products (and processes) of strong future interest for the world market, i.e., key innovations that might be of crucial importance for the transition in many places. Solutions exist both in the technological domain as well as in the social one—or are born from a combination of both. One example is provided by the municipality of Eskilstuna. The decision-making body has seen to it that the technical solutions of solar panels have been installed on the roof tops of many of the municipality buildings. This in turn has already given encouragement to private house owners to follow this trait in that direction. This is a social structure contribution.

The currently existing professional planning employees in many of the municipalities are already well educated in these matters and there has become a competitive mood among the cities and the municipalities to be on the "leading edge" for these efforts. And a reasonably large fraction of the population of voters are favorably inclined toward such measures. Many individuals are already trying to set up production units for wind power—although still there are a lot of rules and regulations that have to be upgraded in order to make a smooth passage for decentralized extra electric power production (solar or wind as examples) to be fed into the grid from such sources.

Also the formal governance (in the architecture of the current multilayered system) tries to address these issues in terms of concerted efforts outlining a sequence of investigatory innovation projects with such types of aims. Parallel activities are going on, e.g., in the bio-fuel industry and in other parts of industry and civil society in order to promote sustainability-oriented innovations—and to some degree also raise the early investments for such prototype actions. This is obvious, e.g., in the transport sector, not least in the introduction rush for electricity cars (or as an interface in time hybrid versions), including the need to promote and develop the supporting infrastructure for such solutions—be it public or privately owned or a mixture of these.

Thus, indications of alertness in the population at large in promoting such development lines are definitely there, although it is at every time step difficult to fully assess to which extent such support also carries over to acceptance of extra cost implications, e.g., for new solutions for private cars. Here it should be mentioned a rising interest for other forms of ownership of vehicles, e.g., through new type of taxi business models, but also of car pools ("circular economy" business models). Promotion of public transport solutions for large segments of persons—especially in the larger cities—should be noticed, through the provision of the services (prolonging subway lines or added parallel railway track for increased temporal services for regional trains). One example is the line between the university city of Uppsala and Stockholm some 70 km to the south. This is a very intense commuting line with high demand on performance. The connection of this expanded capacity of service for transport has also been made in such a way as to improve the number of connections to the large international airport Arlanda situated between Uppsala and Stockholm. But there are also social innovations coming along as those recent advances in the way how the ticket cost arrangements are done (including monthly based cards for the system in the region at large providing sufficiently inviting fees for the travelers).

Such thought patterns and ambitions within the more formal public sphere of operators are distinctly and rather quickly seen in terms of the number of officials employed to serve such coordinating and planning tasks and the quality of their educational support and thus mounting professional credibility.

But also in society at large it is possible to identify a rising citizen concern and interest with regard to these issues about the direction of development. This provides an important basis for the policy formation for the future in the broader democratic system.

4. The issue of paths toward a fossil-free society

The strong increase all over the world in the tendency for urban spaces (in close connection to non-urban areas) to conglomerate into a vast system of linked patches holds true also for a highly industrialized country like Sweden. And it is clearly demonstrated in our chosen case region, the Stockholm-Mälar region. But what does that mean considering the major grand challenges our world is facing at the moment? A very clear example is the needed build up of a capacity to handle the strategic challenge of climate change. Sweden has as a country (at the level of parliament) recently defined—as a national goal—to aim to be in the forefront of measures to handle these and connected emerging issues. This means that there is a formal aspiration to be at the leading edge among industrialized countries in the world for these purposes. This means in an operative way a deliberate effort to address problems in an array of sectors to reduce carbon emission to the atmosphere in a historically unprecedented speed.

Efforts have to be launched in an array of sectors, such as dealing with the energy production systems for the future in order to eliminate the current fossil fuel component within a few decades. This should be done without jeopardizing the need for Swedish industry—also in the future—to have sufficient access to energy. In technical terms, this means the development or establishment of new sources of energy as solar, wind and bio, which should be done in parallel to the process of facing out the present nuclear component (although this long-term decision is still contested in the Swedish political environment). The build up and expansion of the new energy sources—with a strong electrification tendency on the distribution side—have to go hand in hand with strongly increased energy efficiency efforts both in industry, but also in a broader sense in society as a whole.

All of this has put pressure on the urban segments of society in several ways. One aspect is the push for low (or zero) net energy housing in the building sector. The development has already started and prototype housing and Avant-guard testing sites are already being built in many places (e.g., a student housing complex connected to the campus of the KTH—the Royal Institute of Technology in Stockholm). A possible shift toward wood as building material, also for several level housing is going hand in hand with the low carbon efforts in the energy domain.

At a more aggregated level (i.e., in terms of city planning), the climate concerns—through the push for better energy efficiency—has evoked an increased search for compacting the

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city space, e.g., creating more housing functions (including offices and other uses) per square meter than has been the case before. In a recent information technology-oriented methods study (led by KTH and Stockholm University) in Upplands Väsby—i.e., one of the fairly new Stockholm suburban agglomeration hubs—people in the street were asked to judge how they wanted the balance to be struck in their urban neighborhood between the compacting tendency versus the "greening" of the city interest (including, e.g., protecting the already existing parks). It is interesting—but not surprising – to note that the answers differed considerably between different types of actors and between people with varying socio-economic types of background. Here the interplay between the level of personal preferences and the level of collective outcome for an entire municipality/small town is demonstrated. A socio-technical rationality in handling the sustainability issue is here competing with a socio-cultural and behavioral type of rationality and connected sets of values.

Also the vaster urban agglomeration transport system is under quick transformation. The connectedness in the core parts of the cityscape (e.g., through the widening of the already existing Stockholm subway net) is further emphasized and given space in an investment perspective. But also the wider frame of sprawl related to the region in its totality calls for increased public transport (rail) development, but with a somewhat other technical sets of means than within more limited patches of urban space with high density. In areas with less compactness of "town connectedness" a system of public transport based on busses might be the solution, often connected to already activated change of the fuel base (e.g., biogas) but also on innovation in logistic handling in terms of new business models. Somewhat further into the future (already heavily discussed and also started to be tested in prototype arrangements) electric battery-based technologies for busses and cars enter the picture. Here, it is the interplay between a sequence of levels: the individual user ("the citizens") preference, the type of local/municipality reach and character, and in the case of the greater city level with its heavy long-term investment capacities expansion of the subway system. At even larger agglomerate regional level over a vast territory (with speed trains in focus) calls for technical, organizational and economic types of solutions. The transport sector concerns do not stop at the regional borders (if such could be considered to really and fully exist, considering the constant inflow and outflow of goods through trade arrangements among conglomerates and into the international hinterlands).

The air traffic component is here of great importance for links between several super regions within the nation (in this case Sweden as a country with quite a wide geographic space of which some parts are more thinly populated than others – especially in the north of the country). But further on—at even higher levels of geographical organization, Nordic constellations are of importance as indicated by interests in binding together Stockholm and Oslo, or Gothenburg with Oslo—or as some futurists have considered long ago, to bind together (probably in another political situation) Stockholm, St. Petersburg, Helsinki, the coastal parts of the Baltic republics, the north part of Polen, north Germany and Denmark in what could be called a "neo-Hansa." Some elements, although still limited, could already be seen in new transport lines across the Baltic Sea, but also in the domain of electricity transfer as well as the Russian driven efforts to build gas lines ("the North stream") on the bottom of the Baltic sea connecting the producer Russia to the EU user markets—with entry in northern Germany. With regard to an even grander agglomeration it could be contemplated how the strategic interests of the Republic of China strongly promoting cross-continental lines from the East coast of China into the markets of Europe under the label of the new "Silk road." In such a perspective the classical trade routes between the continental east and the continental West could be contemplated as a mega agglomeration of "bands of affinity" where the trade routes could be more tightly connected through large infrastructural investments over a long time and with mixtures of super urban nodes and integrated non-urban areas as very long strings of connected urbanized space from Shanghai and Bejing to Frankfurt, London—and why not Stockholm. These possibilities are still to some extent only on the strategically drawing board (especially led by China). But there is already more de facto existing physical infrastructure in place, e.g., in terms of trans continental railway systems for goods, oil pipelines of considerable extension, and similar trade arrangements manifesting sea scape solutions in global connectivity. All these future mega agglomerations with their internal urban nodal points at different hierarchical levels should not be considered—even today—as science fiction. But at the same time such heavy trends for future mega global structures are discussed we also can elaborate with some more precision the ongoing development of more limited (e.g., at regional level as in our Swedish case) agglomerations characterized by strong features of "urbanness"—but intertwined with other types of spatial functions, i.e., a sort of "big cake with raisins everywhere in the bun." Already now, there is a strong interest in mega city connectivity at a global level—i.e., the issue of "teleconnections" [30], which corresponds to the issue of "agglomeration emergence." This type of connectivity is already now applied in more limited nationally existing super regions as those existing in many places in Europe (and also elsewhere in other continents).

Analysis of these emergent structures also has to be devoted to what it means in terms of the aggregated effects on core issues of deep concern for the planet as a whole, as codified in analytical approaches as "planetary boundaries" or development within a safe planetary frame [11]. This also connects to a rising concern about what could constitute a new area of the "Anthropocene" [12, 13], i.e., the current time when humankind has evolved in its global operations to be at least on equal par with the natural phenomena in the capacity to transform the world at a planetary scale [5]—disregarding the qualitative direction by which this change is taking place.

Returning to our more limited regional considerations in the Stockholm-Mälar region, it should not be forgotten that transport of people and transport of goods are not the same thing. At a somewhat limited part of this region in terms of a few collaborating municipalities (as is under development among a set of suburban municipalities in the south part of the greater Stockholm conglomerate) incentives have been struck to generate socio-economic solutions (and not only technical ones) addressing the efficiency of transport of goods. Here, new and thoughtful combined logistics have been mobilized to use the fleet of the lorries to provide schools, houses for elders, etc. with their daily supports. In combination with computerized informatics control systems, distinct advances have been reached to boost efficiency considerably, both with regard to limitations of greenhouse gas emissions (per unit of function), but also in a direct economic way. Here, the innovation profile is on the organizational side with logistic renewal based on support by technologies from the IT sector. It is also an example of a level-depending type of solution.

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At another level, an increased load of regional transport of goods is gradually shifting the interest and possible emphasis on to boat/ship transport solutions—especially in a region as the Stockholm-Mälar region with its vast seascape as a core geographic feature of the region.

But transport by sea is not only confined to bulk transport (or heavy products from industrial endeavors) connecting inflows to the region from vaster "hinterlands" to spotlike places in the regional agglomeration. Transport by sea can also take place within a partial cityscape as in the core ("inner") Stockholm City. A new set of lines for commuters within this geographical space is tried out at the moment. Here the level in the geographical hierarchy between the individual and the region is "in between"—i.e., not in any way binding together the region, but making a part of it (those with a reasonably dense cityscape) more connected, and thereby providing solutions for choices by individuals about how to handle (and "smoothing") their calendar relation between housing—jobs—and free time.

An early considerable (and internationally recognized) contribution to such types of space-time thinking was already expressed in the 1960s by the late Swedish cultural geographer Torsten Hägerstrand. Among other topics, he also raised concern for the uncontemplated development of not sufficiently connecting physical structures (and organizational ones as bus line connections over county borders between too limited regions, which together could otherwise have been linked—i.e., been made to agglomerate—into a greater urban-rural conglomerate).

Finally, we should also indicate that not only the energy sector, the building sector, the transport sector, but also the food sector (production, distribution and consumer preferences) has a strong part and role in the transformation into a fossil-free society.

5. The multilevel considerations

As we have just seen, when contemplating various examples from the Stockholm-Mälar region, a key feature is that the various levels are all very important—but somewhat different in character. Thus, any set of solutions has to recognize this insight and use it analytically in a way to bind together the different level qualities, constraints and possibilities. Further, we have been using the case of the transformation of this Swedish "test" society toward a fossil-free fuel society, not only as a tool to find solution responses to the (grand) task to better and more forcefully mitigate (and not only adapt to) the grand challenge of climate change.

We have through this choice of scrutinizing the functional challenge in the region of climate change been provided a sort of "fiber optics" to the more general issue of the agglomeration process of systems challenges. We can thus draw from these types of insights and to some extent generalize the findings. However, this should not be done in an overextended way as many of these processes are contextual in their nature, i.e., different cases have both similar, but also deeply dissimilar characteristics, which should be taken into account when reflecting on any urbanized space in its connection to other linked areas in the larger conglomeration.

In order to give some structure to this multilevel (which also is a multi-actor) issue, let us make a few summing up remarks on this issue

- We have discussed different levels of the following kinds. The level of
- the individual
- the local municipality (Swedish:“kommun,” with strong taxation and planning authority in Sweden)
- the county (“län”)
- the region (the set of a number of counties collaborating in an organized way on certain issues. In our case region the formal body is “Mälardalsrådet”—an organized body of politicians from the region, but the individuals have been elected to functions at other levels, e.g., the municipality level)

Outside the region and providing the context and sometimes resources for its operations we encounter the following levels and concerns:

- the national
- the EU
- the planet as a whole
- Different actors (the public official bodies, industry/companies, representation of associations covering in terms of NGOs various interests of civil society) have different types of presence at the different levels
- The processes of transformation are both top-down and bottom-up—often in a mixed fashion
- Different actors at different levels have different time frames
- Different actors have different focus of interest (choice of questions, of strategies, of endurance, etc.)
- Different actors engage in varying patterns of alliances in a dynamic fashion
- Different actors have varying political influence and financial resources at varying times

Within this mosaic realm of interests, political and economic power and focus and different time frames the agreement on components and overarching architecture of solutions in a systemic way on “paths toward a fossil-free society within a few decades” has to be dynamic, evolving, explorative. It also has to be served by a process that is democratically considered as legitimate. And it has to be connected to a broad process of participation in the population at large, including strong educational components.

6. Policy considerations aiming at a path toward a fossil-free society at a regional level

In shaping the process that should lay the foundation for a successful transition to a fossil-free society by 2050, the following elements are important to consider, with special regard to

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the body responsible for our case region (The Stockholm-Mälar region) [2]. (But the points of recommendations also pertain to other levels, as well as other configurations of regional agglomerations in Sweden):

I. The character of the transformation

a. *The transformation to a low carbon society includes all aspects of society*. It relates to different levels of society and types of actors, including all sectors, forms of stakeholder types and has to involve civil society at large. It concerns the living conditions of all citizens of the region and spans the generations. This means that it is not only an issue of change of the technical aspects that is at stake, e.g., of the energy system and related infrastructural mechanisms. The transformation also connects human factors as consumer behavior, and in more general terms issues about where we want to live and work in the future. The overriding perspective has to be how the inhabitants of this region within a few decades would consider what a well-functioning society might entail, especially caring for the different and particular needs of persons of all ages and gender.

b. *The transformation thus requires a mobilization of the entirety of our society*. This means that our democratic processes have to involve a wide array of instruments enabling all citizens to be encouraged to invent and implement changes, i.e., using a deepened planning process with democratic consolidation. Innovations should be encouraged—not only with regard to technology, but also with regard to how society could be changed, e.g., through changes of laws, rules, administrative processes, stimulation to risk taking and renewal in all sectors and by all actors—as well as through the creation of new patterns of collaboration. There will be a need to creatively scrutinize our current patterns of values, facing the new challenges within all strata of society—public official structures, the business community and civil society alike. The further move toward an increased interest in future-oriented activities and openness toward change will be of considerable importance. But this will also put pressure on the "stronger" and more affluent segments of society to responsively constructively relate to the parts in society with more limited capacities and resources.

II. Governance

a. *The transformation is being performed in a societal context within which there are several interplaying levels* (e.g., the level of the individual, of the local municipality, the county, the sub-regional, the region, the national and the EU levels—also influenced by the constantly changing international conditions at larger frames). This means that the interplay between levels has to be given considerable attention and institutional innovative consideration. What once was a reasonable distribution of labor and responsibility might not be the same in the future due to changed conditions. The pressure to move quickly to a fossil-free society thus also puts stress on the governance architecture. Different versions of interplay between "bottom-up" and "top-down" solutions have to be conceived, developed and tested.

b. *The transformation is made within a very large complex system with many partial couplings*. This means that the complexity will have to be orchestrated in partially new ways. This can be prepared through various ambitious experiments both at limited levels and in a variety of actor spaces, but also in large constellations involving the needed investments for such actions. Such transformation experiments must be conducted in line with the goals of a fossil-free society—and be done through strong encouragement, maybe deliberate relaxation of certain rules in combination with appropriate new ones. This must be done by setting up a metric of several partially new and diversified "mirrors" reflecting varied starting points. However, the total overview of the process will never exist at any one time. Thus, the constant upgrading of the vision in relation to path experiences has to be developed in a dynamic interplay over time.

c. *The broad transition has distinct regional operational connotations*. This means that the societal conditions that historically have been developed over long time in our specific case region also in the future must be guarded and cared for—but now in a directed fossil-free context. The new possibilities that probably might be generated should be encouraged. An essential factor for success in this endeavor is a well-spread sense of participation in the change process by large segments of the population in society. This means that all persons in society should be needed in one way or the other—and this should be conceived of in a multi-generational perspective

III. Necessary, doable and emerging possibilities

a. *The change toward a fossil-free society is necessary*. However, it can also provide advantages for other aspects of change in society. This means that a diverse set of solutions developed for the purpose to bring us to a fossil-free society might also be supportive of other changes that are needed. One already very well-known example is that goals related to the handling of climate change may go very well hand in hand with efforts to reduce health effects from harmful components in the atmosphere—not least in heavily urbanized areas. Such synergies have to be better explored and mobilized—much better than what is the case today. This also calls for more cross-sectorial connectivity innovations.

b. *The changes are in most cases very doable.* If the time horizon is creatively used for early investments in what could fit the goals of a longer time frame vision, the costs are more restricted than those emerging in connection with actions taken later under more chaotic and drastic circumstances. But the changes have to be anchored in a transparent and broadly agreed societal process.

c. *The transformation process could not only be used to meet the challenges of change, but might also open up for many new possibilities that may emerge.* This means that although the change is necessary and deep going, it may also provide new competitive means in an international context—given that a change trajectory is chosen that encourages such possibilities. Thus, the region should use the transformation process to serve these purposes—also as input to discussions at national and European levels to demonstrate solutions developed in the societal, technical and ecological domains. In practice, this means to foster "Avant guard" forms of societal competitive ways to operate—as well as supporting and collaboration with other countries with less initial advantages for such performances. This may also be a competitive advantage for Swedish interests abroad.

As a closing line we consider these recommendations in many cases to be of a broader character than just pertaining to the target case of "transformation of society toward a fossil-free society by 2050." Indirectly, these particular points also say something about the decision-making challenges related to territories of agglomerations with strong urban connotation in our time. This holds true in our case for the level of a region in a European historical and political context. But it also has wider relevance for linked urban and nonurban agglomerations at even wider geographical and institutional space.

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