ADAPTING CITIES TO CLIMATE CHANGE: GOAL CONFLICTS AND METHODS OF CONFLICT RESOLUTION

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Summary: Decision-making concerning adaptation to climate change often involves choosing between different options, each of which can have important implications for the achievability of other goals and policies. In this article, adaptation measures and goal conflicts are investigated using the City of Stockholm as an empirical basis. The investigation shows that goal conflicts in adaptation are common phenomena. This points to the need for assessing and predicting the environmental, social and economic impacts of adaptation measures, strategies and policies at an early stage in the decision-making process. To ensure the coherence with other policy goals, there is a need for tools to assess and predict outcomes, but also to balance those outcomes in situations where they are not easily reunited.

Key words: Climate change, adaptation, urban areas, City of Stockholm, goal conflicts, conflict resolution.

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I. INTRODUCTION

Urban areas are at particular risk from the impacts of climate change. At present, a majority of the world's population live in cities, and their quality of life is largely dependent on how well these environments will succeed in mitigating the threats posed by climate change. It is expected that in the future, the living conditions of hundreds of millions of urban citizens worldwide will be affected by weather-related events, with some of the most negative impacts concentrated in the most vulnerable populations. Also urban citizens in developing countries are expected to suffer from the effects of climate change. In Europe and North America, for example, many urban citizens will have to endure more frequent periods of hot weather, more drastic flooding, and deteriorations in air and water quality (IPCC TAR, 2001; Rosenzweig and Solecki, 2001; LCCP, 2002; Peltonen *et al.*, 2005).

Two fundamental policy approaches exist to reduce the environmental, economic and social threats posed by climate change: mitigation and adaptation. Whereas it has long been acknowledged that mitigation (reduction of greenhouse gas emissions) is needed in order to combat climate change, adaptation (responses to coming climate changes) has received much less attention by political decision makers and planners at the city level (Pielke, 1998). This is beginning to change now as scientists and decision makers have come to realise that changes in climate are unavoidable, even if we succeed in reducing greenhouse gas emissions considerably.

Decision-making concerning adaptation to climate change is a complex issue. It often involves choosing between different options, each of which can have important implications for the achievability of other goals and policies. Sometimes, conflicts arise between the goal of adaptation and other policy goals. This happens when an adaptation measure inflicts on the achievement of some other goal that the decision maker wishes to achieve. To avoid such conflicts, local decision makers must have a good understanding of the long- and short-term consequences (environmental, economic, social and ethical) of their decisions. Before an adaptation measure is decided on, it must be established how successful the measure will be in terms of expected effectiveness and cost efficiency and how appropriate it is given the decision makers' other aims and goals. Ideally, an adaptation measure should be sustainable in the sense that it is effective in abating the negative effects of climate change (or seizing new opportunities engendered by such changes) without adversely affecting other goals and values.

The aim of this article is to give an idea of what sort of goal conflicts local decision makers in Sweden are likely to encounter as they make decisions concerning adaptation at the city level.[1] Adaptation measures are identified and potential conflicts with environmental goals, health and recreational goals, and social justice goals are discussed using the City of Stockholm as an example.

II. CLIMATE CHANGE IN THE CITY OF STOCKHOLM

Stockholm is located in Eastern Svealand, at the mouth of Lake Mälaren. The city centre is situated on the water, in the bay Riddarfjärden. Stockholm has a population of around 810,000 in the city centre and around 1.3 million in the urban area. The city is distinguished by large green areas and waterways; around 30 per cent of the city area is made up of waterways and another 30 per cent consists of green spaces.

Stockholm has a humid continental climate (www.worldweather.org). Summers have an average daytime temperature of 20-23 °C and an average nightime temperature of 11-13 °C. Winters have an average temperature of -3 to 1 °C. Annual precipitation is around 540 mm with light to moderate rainfall and around 173 wet days. Snow mainly falls between December and February.

Stockholm is already experiencing changes in climate. Changes in average temperature during the years 1961-1990 demonstrate an increase in Stockholm of 2.5 °C. The climate change scenarios produced by SMHI’s Rossby Centre (www.smhi.se) indicate that Stockholm will become even warmer in the future. In the year 2100, the annual mean temperature will be around 4 °C higher according to the B2 scenario and around 5 °C higher according to the A2 scenario. Annual precipitation will increase by 15 per cent up to 2100 in both scenarios. Precipitation will increase in the autumn, winter, and spring, whereas summers are likely to be dryer than at present.

Besides changes in air temperature and precipitation, the climate scenarios indicate that Stockholm could experience (City of Stockholm, 2007*a*):

- a harvest season between 1-2 months longer
- spring flood 2-4 weeks earlier
- rising sea levels
- reduced sea salt content
- rising sea and lake temperatures
- more frequent storms and torrential rains

[1] The article is based on a report by Edvardsson Björnberg and Svenfelt (2009) that was produced within the scope of “Climatools”—a four-year research programme financed by the Swedish Environmental Protection Agency, which aims to develop tools that can assist us in adapting to climate change (www.climatools.se).

Higher temperatures and more frequently occurring heat waves are expected to cause increased mortality and morbidity, particularly among vulnerable groups (Rocklöv and Forsberg, 2008). Among the groups that are most at risk are the elderly, people who suffer from pulmonary diseases, cardiovascular diseases or impaired kidney function, and people who are on particular medications (Rocklöv *et al*., 2008).

More numerous incidents of extreme weather, such as floods, rains and strong winds are expected to cause damage to infrastructure, buildings and the environment. In the city centre, the roads around The Old City (Gamla Stan), Slussen and Tegelbacken are particularly vulnerable together with Stockholm's Central Train Station and the tunnel underneath Riddarholmen (City of Stockholm, 2007*a*). A flood event in these areas would bring a complete halt to the railway traffic through the centre of Stockholm as well as the underground services.

Increased precipitation, increased flows and higher groundwater levels could contribute in releasing and disseminating pollutants in the city (City of Stockholm, 2007*b*). At present, there are numerous contaminated sites in the Stockholm area, such as refuse tips, closed down petrol stations, and industrial sites. According to a map produced by the Stockholm City Environment and Health Administration, the city has 170 closed down petrol stations that could be in need of decontamination (City of Stockholm, 2007*a*).

Higher temperatures and increased precipitation could alter dispersion patterns for infectious diseases and cause the spreading of new water-, food- and vector-borne diseases. For example, toxic algal blooms, which benefit from higher water temperatures, could occur more frequently in the Stockholm area, causing gastrointestinal problems and skin infections. Higher temperatures in the summer are also expected to increase the number of cases of food poisoning.

Higher temperatures in the winter are likely to benefit the survival rate for species that spread infections. In Stockholm, Lyme disease and TBE (Tick Borne Encephalitis) are among the diseases that will produce the greatest risks to human health as a consequence of climate change. At present, the risk of catching Lyme disease and TBE is greatest outside the city kernel, such as in the Stockholm and Roslagen archipelagos and around the eastern parts of Lake Mälaren. However, a milder climate is expected to boost tick populations and increase the risk of these diseases spreading, even to the city centre where more people will spend time in parks and other green areas to cool off during high temperatures (Svenska Dagbladet, 2008).

III. CONSIDERED ADAPTATION MEASURES

To mitigate the negative effects of climate change on human health, buildings, and developments, a number of adaptation measures will have to be taken. This section summarizes the most important adaptation measures that may have to be taken in the City of Stockholm (see also *Table 1*).

1. High temperatures

In the future, measures that decrease indoor temperatures, such as *air-conditioning*, will have to be taken in Stockholm. Air-conditioning will be particularly important at hospitals, nursing homes, and other premises where elderly or ill people are staying, and should be introduced as standard in Stockholm's emergency, intensive care, and cardiac departments.

Awnings that are attached to the exterior walls of buildings can be used to shade building interiors from the sun's heat and glare. Alternative adpatation measures include using *window blinds* or *shutters* and *planting trees* outside buildings. Indoor temepratures can also be kept at comfortable levels by *cutting internal loads,* i.e., the power output of lights and machines, and possibly by *lowering the density of occupants* (Roberts, 2008).

Another way of mitigating the negative effects of higher temperatures on people's health is to use *cool roofs* and *cool pavements* in the city centre (Akbari, 2003). Cool roofs and pavements are built from materials with high solar reflectance and high thermal emittance. On hot sunny days, they absorb and store less solar energy than ordinary low reflectance roofs do and are consequently not major emitters of heat into the urban atmosphere at night. In this way, they mitigate the urban heat island effect.

Urban heat island effects can also be mitigated through the *promotion of green and blue infrastructure* at the individual building or neighbourhood level (Gill *et al*., 2007). This can, for example, be done by constructing *green roofs.* In addition to reducing temperatures, green roofs (and other green areas) have a number of ancillary environmental effects; they help to retain storm water and reduce runoff (McEvoy *et al*., 2006); they improve urban air quality by absorbing volatile organic compounds and other particles (Banting *et al*., 2005); and they provide valuable habitats for spiders, birds, butterflies, and other insects (Johnston and Newton, 2004).

Tall buildings and narrow streets contribute to the urban heat island effect as they create 'canyons' that prevent heat from escaping at night. *Open spaces between buildings* help to reduce the urban heat island effect and can be used as a means of mitigating the negative health effects associated with high temperatures (Smith and Levermore, 2008).

Heat wave warning systems, i.e., systems that use meteorological forecasts to initiate public health interventions, can be introduced at the city level. Heat wave warning systems usually describe different interventions depending on the confidence of the heat wave forecast, ranging from issuing general advice to the public and health care professionals to distributing fans and keeping in contact on a daily basis with at-risk individuals living at home (Kovats and Ebi, 2006).

2. Flooding and increased precipitation

To avoid flooding in Stockholm, the Swedish Commission on Climate and Vulnerability (SCCV) suggests that the *capacity drawn at from Lake Mälaren should be increased* and that the *floodgates at Södertälje should be reconstructed* more than double the current capacity (SCCV, 2007). Water can possibly also be *transferred to other discharge areas*. In addition to these measures, *abstaining from building in risk areas* is recommended until additional facilities for drawing off water exist. Also *mapping* is recommended to identify areas where flooding could cause particular damage to the Stockholm network of underground tunnels (City of Stockholm, 2007*a*).

Avoiding building in risk areas is an option that is available when new developments and buildings are planned. However, measures also need to be taken in existing developments. Here *relocation*, i.e., moving buildings and technical infrastructure further from the water, may come out as an alternative adaptation measure. Other measures include making space for excess water by establishing more *green areas* and *waterways*.

Modifying the use of buildings is another way of avoiding damages from flooding (SCCV, 2007). For example, cellars and basements in high-risk areas can be used for purposes not susceptible to flooding. In the future, it will be particularly important not to locate vital public services, such as emergency service centres, water supply and sewage management plants, power plants and telecommunications, in premises that are at risk of flooding.

Also a number of technical measures could be taken to reduce the risk of flooding in Stockholm. For example, *elevating buildings and developments* in relation to surrounding bodies of water is a pro-active and planned adaptation measure that prevents flooding. In addition, existing *flood barriers* in the form of embankments could be reinforced and new barriers could be constructed to protect cable tunnels and other important infrastructure (www.stockholm.se).

As precipitation increases in frequency, intensity and quantity, water conduits and other *technical water infrastructure will have to be reinforced*. Increasing pipe diameters and regularly cleaning and inspecting drainage and sewage systems are, for example, important means of preventing blockages and possible backflows (SCCV, 2007). *Rainwater harvesting* and urban greening measures can be used to capture and divert rainwater before it reaches the pipes (Shaw *et al*., 2007).

At the policy and regulatory level, *modifying regulations and guidelines*, alternatively adopting *new regulations and guidelines*, concerning flood and sea level controls and construction, will be needed. These regulations/guidelines will primarily be adopted at the national level, i.e., by the Swedish Parliament or the National Board of Housing, Building and Planning (Boverket), but it is possible that some regulations/guidelines could be issued at the local level.

As with heat wave warning systems, a *flood warning system* can be used to maximize the probability that people at risk will take appropriate measures to protect themselves in the event of flooding (Health Canada, 2008).

3. Soil contamination and spread of infection

A number of measures will have to be taken to counter soil contamination caused by increased precipitation and higher groundwater levels. *Decontamination* can be used at specific sites that are considered valuable from a water provision or recreational perspective, but cannot be used at a large scale for economic reasons.

Greater consideration of risk of soil contamination will have to be taken in physical planning and infrastructure development. *Abstaining from building in risk areas* is a possible alternative. Subjecting those building projects and construction works that are located at instable soils to *more thorough impact assessment* is another alternative.

Technical measures, such as soil nailing and other *soil stabilizing actions*, may have to be taken in areas at threat from erosion. Choosing *building materials* that contain small doses of toxic substances and drawing up *guidelines* for the use of materials that release toxic substances in consequence of precipitation are other possible measures.

The increased risk of the spread of infectious diseases in bathing waters will require *stricter surveillance policies and regulations*. More frequent testing and monitoring of Stockholm's beaches is a step that can be taken toward managing the health risks associated with higher water temperatures and more precipitation.

Controlling disease vectors through biological or chemical larvacides (e.g., contact poisons, stomach poisons and biological control agents) and *vaccination* can be used to prevent mortality and morbidity associated with some vector-borne infections (Health Canada, 2008). In addition, *risk information* containing advice as to how to dress and behave to avoid tick bites and vaccine recommendations may need to be updated.

The spread of food-borne infections can be prevented through *disseminating information to consumers about basic hygiene and food handling* and information to producers about food production and food storage processes (Commonwealth of Australia, 2007).

IV. EXAMPLES OF GOAL CONFLICTS

In this section, potential conflicts are discussed based on the adaptation measures that have been identified in the previous section.

1. High temperatures

Using air-conditioning and other mechanical cooling facilities could lead to an increase in carbon dioxide emissions to the atmosphere (and hence counteract mitigation targets), for example, if the electricity that is used is supplied by coal-powered plants (Hacker *et al*., 2005). Mechanical cooling also produces waste heat to the environment surrounding the building, which could intensify the urban heat island effect and conflict with goals concerning human health and well-being (Smith and Levermore, 2008).

Although awnings and sun screening are energy-efficient alternatives to air-conditioning, they are associated with other problems. In some built areas, particularly those that have a high historic value, awnings and other facilities attached on the walls or roofs of buildings are not allowed or are only allowed as an exception, since they may inflict on cultural heritage goals. In Stockholm, putting up awnings could be problematic from a cultural heritage viewpoint, for example in the Old City.

Arranging buildings and transportation routes in a way that allows for sufficient ventilation and the escape of excessive heat is an adaptation measure that is difficult to apply in those parts of the city that have already been built. Furthermore, less dense environments tend to be more scattered, creating longer distances between different city areas. Longer distances could mean longer transportation routes, which, in turn, could give rise to increased carbon dioxide emissions, more severe air pollution, and increased traffic noise.

Urban encroachment also tends to create land use conflicts at the urban-rural fringe. Settlements that are allowed to spread can cause loss of important farm-land, rendering it more difficult to reach food and biological production goals. They can also damage or make wildlife habitats more fragmented, which means that certain species will find it difficult to survive. Moreover, urban encroachment can inflict on important recreation values, rendering it more difficult for people to exercise or simply enjoy the nature that surrounds their living environment.

As in the case of open spaces between buildings, larger proportions of green and blue infrastructure tend to create longer distances to services and facilities, which means that these adaptation measures face the same difficulties as the ones described above. Another difficulty that has to be taken into consideration regarding green areas is that some species of trees (for example pine, oak and willow) are associated with the emissions of ozone precursors, i.e., biogenic hydrocarbons, which lead to increased local and regional formation of ground-level ozone (Air Quality Expert Group, 2007). Yet another difficulty associated with urban greening measures is that green areas (including green roofs) could harbour animals that serve as reservoirs for infectious diseases, such as Lyme disease, TBE, and the West Nile virus (Daniels *et al*., 1997).

2. Flooding and increased precipitation

Physical planning may be a successful way to avoid the consequences of flooding, erosion and landslide in built areas, but it can also make it more difficult to realize certain other goals and interests. Flood risk areas, as well as areas prone to erosion and landslide, are often close to rivers, lakes and the sea—areas that are usually considered attractive from an aesthetic and recreational perspective. Hence, abstaining from building in risk areas is a measure that could conflict with municipality development goals as well as the aesthetic and recreational interests of individual residents.[2]

[2] The present trend among Swedish municipalities (including the municipalities in the Stockholm region) is to be aggressive in developing shoreline areas, which is clearly in conflict with the need to avoid developments prone to flooding (SOU 2005:77).

Regulating Lake Mälaren by *directing flows to discharge areas* could increase competition over land. Land is needed to satisfy the demand for food, fibres and energy, as well as for the fulfilment of environmental and recreational goals. Directing flows to discharge areas could pose threats to natural and cultural elements that are considered valuable and it could impose on the availability of areas for outdoor recreation.

Constructing *flood barriers* in and around Lake Mälaren could infringe on tourism and recreational values; unless designed properly they could be perceived as an ugly and disturbing feature in the cityscape. Other technical adaptation measures to avoid flooding, such as *elevating buildings* from street levels, can compromise accessibility for disabled persons and thus make it more difficult to reach disability policy goals.

3. Soil contamination and spread of infection

As in the case of flooding, *abstaining from building* in areas that have instable soil conditions could conflict with municipality development goals and with the aesthetic and recreational interests of individual residents.

Using *pesticides* and other chemicals to combat and control disease vectors is problematic since it can release toxins into the environment. Pesticides also have negative effects on human health.

As noted above, *public education campaigns* can be used to raise awareness of health risks associated with climate change and to induce risk-reduced behaviour. However, to reach its designated ends, public education campaigns must wisely balance the risk of harm to human health against the risk of upsetting people unnecessarily. Too much information in low-risk situations can cause ‘warning fatigue’ by the time the risks have materialized (Australian Greenhouse Office, 2007) and, hence, render it more difficult to influence the behaviour of people at risk.

V. CONFLICT RESOLUTION

The identified goal conflicts (and others) constitute a major policy challenge for local decision makers involved in adaptation. Unless goal conflicts are properly addressed in the decision-making process, there is a risk that measures for adapting to climate change will counteract the achievement of other goals and values. The measures may even fuel climate change themselves and, consequently, accelerate the need for further adaptation.

To avoid maladaptation, strategies and tools for managing goal conflicts need to be developed. This will be an important next step in the Climatools research programme. In this section, some preliminary thoughts on how to deal with conflicts in adaptation are provided. These ideas will be further developed as the Climatools research programme proceeds.

Making sure that goal conflicts do not arise

Perhaps the most obvious strategy to avoid goal conflicts in adaptation is to make sure they do not arise. Goal conflicts can, for example, be avoided through intensified action to mitigate climate change. Given that mitigation strategies are successful in halting climate change, fewer adaptation measures will presumably need to be taken. This reduces the risk of conflict between adaptation goals and other policy goals.

The City of Stockholm is thoroughly engaged in mitigation to climate change. In 2003, the Stockholm City Council adopted the *Stockholm Action Programme Against Greenhouse Gases*, according to which the long-term target for Stockholm is to become a fossil fuel free city by 2050 (City of Stockholm, 2003). However, since some climate changes will occur regardless of Stockholm's mitigation efforts, local decision makers still need to focus on adaptation. This means there will be goal conflicts that have to be dealt with even if the City's mitigation work turns out to be highly successful.

Choosing a different adaptation measure or strategy

In many situations, conflicts can be avoided by exchanging the considered adaptation measure to an alternative (more sustainable) one. The alternative adaptation measure may not be equally successful in preventing harm (or taking advantage of opportunities) as the former one, but may result in better overall goal satisfaction and, hence, come out as a preferred alternative to governmental decision makers who are generally responsible for working towards many different goals.

For many of the adaptation measures that could be taken in the City of Stockholm there are more or less realistic alternatives. For example, instead of installing air-conditioning, which is problematic from a mitigation perspective, other (more sustainable) measures could be considered, such as using awnings or window blinds, planting trees, and constructing green roofs. By pro-actively working with goal conflicts at an early stage in the decision-making process, local government decision makers can play an important role in promoting sustainable adaptation at the city level.

Developing new technologies

Sometimes, there are no sustainable options available when a goal conflict appears. One way of managing those situations is to suspend the implementation of the adaptation measure for some time and instead search for new alternatives that involve a lesser degree of conflict with other goals. For example, investing in research for the development of new technologies can serve adaptation by coming up with alternatives that make it possible to reconcile previously conflicting goals.

The problem with developing new technologies is that it is usually a time-consuming activity. This means that it is a less appropriate strategy in situations where the harm associated with climate change must be addressed promptly. In those situations, ethical and economic reasons may speak in favour of some adaptation measures being implemented right away. This does not preclude local decision makers from simultaneously searching for new and better options for later reconsideration of the issue, as long as the initial adaptation decision is reversible (Hansson, 1994).

Prioritizations

When goal conflicts cannot be managed, for example, by selecting an alternative adaptation option or through technological development, the decision maker has to give priority to either goal. Once the adaptation strategies or measures are defined, prioritizations can be made using various methods. According to Lim and Spanger-Siegfried (2004), four methods are particularly useful in prioritizing between adaptation measures: cost benefit analysis (CBA), cost effectiveness analysis (CEA), multi-criteria analysis (MCA), and expert judgment. In an adaptation context, MCA may come out as a preferred option, since as an analysis tool it is particularly applicable where single-criterion approaches (e.g., cost-benefit analyses) fall short.

To make the right decisions, local decision makers need user-friendly tools (checklists, manuals, etc.) that can assist in their prioritizations. Developing such tools is one of the main objectives of the Climatools research programme.

Multi-sector integration

Integrating adaptation policies and measures between different sectors is an important means of identifying and avoiding or limiting potential goal conflicts between proposed adaptation measures and other policy goals. Because of the multifarious interrelationships that exist between different policy sectors today (at national and local levels), adaptation strategies need to be developed in an integrated fashion to be effective and sustainable. Developing sound adaptation measures in the human health and agricultural sectors is, for example, not feasible without considering the water sector (Lim and Spanger-Siegfried, 2004).

VI. CONCLUSIONS

Taking the City of Stockholm as a starting point, this article argues that goal conflicts are common phenomena in the context of adaptation to climate change. Sometimes, adaptation conflicts with mitigation efforts, such as when air-conditioning and other mechanical cooling systems used to reduce heat-related mortality also increase carbon dioxide emissions. At other times, adaptation conflicts with goals concerning the preservation of natural, cultural and recreational values, such as when directing flows to discharge areas pose threats to biodiversity and impose on the availability of areas for outdoor recreation. Often, adaptation conflicts with some goals while at the same time benefits others, which makes choices concerning adaptation complex and difficult to manage.

The fact that local adaptation decisions often produce more than one outcome points to the need for assessing and predicting the environmental, social and economic impacts of individual adaptation measures, strategies or policies at an early stage in the decision-making process. To ensure the coherence of adaptation measures with other policy goals, there is a need for decision tools that can be used to assess and predict outcomes, but also to trade them off in situations where they are not easily reunited.

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Table 1. Adaptation measures for the City of Stockholm.

Adaptation measures	**Climate change impact**		
	High temperatures	**Flooding and increased precipitation**	**Soil contamination and spread of infection**
Technical measures	Air conditioning Use awnings, window blinds, shutters, etc. Plant trees Cool roofs and cool pavements Green roofs	Increase the capacity drawn at from Lake Mälaren Reconstruct floodgates at Södertälje Transfer water to discharge areas Elevate buildings and developments Flood barriers Reinforcement of technical water infrastructure Rainwater harvesting	Decontamination Soil stabilizing measures Control disease vectors Vaccination
Physical planning and infrastructure development	Promote green and blue infrastructure Open spaces between buildings	Abstain from building in risk areas Relocation Plan for green areas and waterways Mapping	Abstain from building in risk areas More thorough impact assessment
Policy and regulatory measures	Cut internal loads Lower the density of occupants	Modify the use of buildings Modify or adopt new regulations and guidelines concerning flood/sea level controls and construction	Choose different types of building materials New guidelines concerning building materials Stricter surveillance policies/regulations for bathing waters
Communication and education	Heat wave warning systems	Flood warning systems	Risk information concerning water-, food- and vector-borne infections