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Social-Ecological Transformations of Supply Systems. Analysing Interactions of Provision and Demographic Change

DRAFT PAPER

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Abstract

Every society faces the task of providing its people with basic goods such as water, food or energy. Meeting basic needs and ensuring quality of life, while not deteriorating ecological conditions, provide the normative framework for structures of provision. Therefore, societies have developed specific structures and forms of regulation. Within Social Ecology these structures are conceptualised as supply systems, emphasizing dynamic relation patterns between natural and societal spheres. Supply systems cover material and energy dimensions as well as cultural-symbolic aspects; within supply systems “the social” and “the natural” interact and develop specific problem dynamics in which economic, technical, political and ecological problems are closely linked.

While provision is determined by demand, needs and necessities, which are inter alia influenced by demographic change directly or indirectly, population dynamics are of vital importance within the transformation of supply systems. Thus, this paper focuses on the interactions of supply systems and population dynamics. The paper (1) outlines the theoretical concept of supply systems and social-ecological transformations, (2) illustrates the analytical application of the concept with the example of water supply and (3) characterises the concept’s capacity for regulation. Finally, (4) the state of uncertainty and interrelated short- and long-term dynamics in supply systems are discussed.

1 Supply Systems in Social Ecology

The global demographic development has accelerated in the last century: Around 1900 global population numbers increased from 1,6 billion to more than 6 billion in the year 2000. Today, population growth is mainly found in developing countries, while developed countries are expected to face increasing population decline (Klein Goldewijk 2005, UN 2005). Within these general trends, demographic development occurs as a result of various interacting heterogeneous and asynchronous dynamics, which differ spatially and temporally. In past centuries, growing attention was paid to implications of population dynamics (esp. population growth) to the environment – in public discourse as well as in disciplinary and interdisciplinary research. CO_2-Emissions, climate change and its impacts on the hydrological cycle and agricultural production of food are only some of the important aspects in the discussion. The issue, where and when how many people at what age live and where to how many migrate, is a major concern of sustainable development and therewith also an issue of population's supply.

Provisioning the population with basic goods like water and food in sufficient quantity and quality is one of the urging global problems. Within Social Ecology structures of provision developed by society are reformulated as *supply systems*, emphasising dynamic relation patterns between natural and societal sphere.[1] Supply systems cover material and energetic dimensions as well as cultural-symbolic aspects; within supply systems "the social" and "the natural" are intricately linked in a certain way and develop specific problem dynamics in which economic, technical, political and ecological problems closely interact. Mostly, those problem dynamics do not concern individual, isolated environmental threads that can be avoided through sector-specific measures. Rather, the dynamics involve complex and potentially critical developments in which social practices are linked to ecological disturbances.

In this sense (socio-)demographic developments are vitally important: Scale and functional capability of supply systems depend on the present and future number of people to provide for, their needs and income, patterns of consumption and lifestyles. The functioning of supply systems is therefore closely correlated with population dynamics, differentiations in social structures and culture as well as macroeconomic trends. In the theoretical perspective of Social Ecology, every demographic development – growing and declining population or fertility rates, shifts in age structure and so on as well as qualitative changes like pluralisation of lifestyles or changes in norms and values – indicates a transformation of societal relations to nature. Such relationships to the natural environment, between individuals as well as to culture exist in all societies in a specific

[1] The social-ecological concept of supply systems was developed in interdisciplinary collaboration between natural and social sciences for analysing social-ecological problems within structures of provisioning. Furthermore, there is an heuristical function of the concept. The concept was particularly applied to water and food. The foundations of the concept are discussed in Hummel et al. (2004) and Lux et al. (2006), on which the following is also based.

form. Their continuous regulation enables human life and intergenerational continuable societal learning processes (Becker et al. 2006, Becker and Jahn 2003). Thus, societal relations to nature differ in various fields of social interaction and are materially regulated and culturally symbolised. Against this background supply systems are located at the meso scale, between on the one hand meeting (basic) needs on the individual level resp. micro scale and on the other hand social integration and societal reproduction on the macro scale.

The analytical concept of supply systems aims at tracing back the structures which provide the population with basic goods like water, food, transportation or housing as developed by society. Provision based on ecosystem services are pointed out, so that connections between natural resources and their utilisation can be emphasised in the analysis as well as handled as an abstract model. Supply systems are defined as complex, social-ecological systems, which can be described in their structure as well as their dynamics.

Key components of supply systems

Initial question for a social-ecological analysis of societal structures of provision is, how to explicate the process of resource utilisation for particular purposes. Natural resources on the one hand and users of these resources on the other hand are major structural components of this process (Lux et al. 2006): *Resources* include material and energetic as well as organic and spatial structures within ecological reproduction. Thus, renewable and nonrenewable natural resources as well as further ecosystem services like climatic regulations or sinks for pollutants and waste are considered resources. Nevertheless, this definition does not enclose any desired resources, but those relevant and (potentially) usable for the analysed supply system, e.g. water, energy or food supply (Hummel et al. 2006). *Users* are also part of supply systems and describe the actor network of providing and consuming services of provision. Thus, the user category includes producers as well as consumers and it can be distinguished between direct and indirect or quantitative and qualitative use of resources.

But it must be pointed out that in most cases the process of resource utilisation is rarely a direct relationship between resources and users. Against this background, the interdisciplinary concept of supply systems stresses knowledge, practices, technology and institutions as intermediary elements.

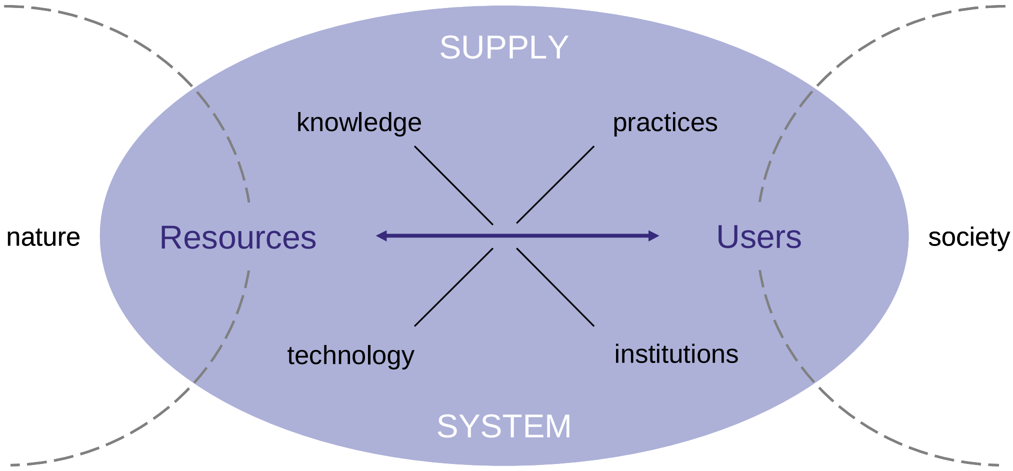

Figure 1 Structure of Social-Ecological Supply Systems
Source: Lux et al. (2006: 424)

It is assumed that knowledge, practices, technology and institutions determine scope and options of action for users; they determine ways and means of access and allocation of resources. All four intermediary elements are shaped by society and specify – in their context-defined peculiarity and interaction – different dimensions of resource-user-relations. Hence, depending on focussed problem situations, regional context, kind and purpose of provision, the specific relevance and relation between knowledge, practices, technology and institutions must be identified before applying the social-ecological concept of supply systems. Because of need for contextual specification as well as the need to enable application by natural *and* social sciences, the four intermediary elements are initially defined on a very broad scale (Lux et al. 2006: 424): *Knowledge* covers – according the trandisciplinary approach – scientific knowledge as well as expert knowledge and every day or pragmatic knowledge (Becker and Jahn 2006: 82f.). *Practices* are defined following Andreas Reckwitz (2002) as routinised types of behaviour which encompass inter alia forms of bodily and mental activities and their interactions. As suggested by D.C. North (1991), *institutions* are conceptualised as (informal) constraints and (formal) rules that structure political, economic and social interaction and perform the frame of action. *Technology* contains man-made material structures that serve specific purposes. It contains physical forms of infrastructure, logistics and other technical elements used by producers or consumers of provided services.

Hitherto, the structure of supply systems as conceptualised in Social Ecology is described. This can be the basis for using the model in a heuristic manner, e.g. for developing research questions or identifying and ordering analytical core elements. For a more dynamic perspective on the historical development and future design of supply systems, an approach of social-ecological transformation is developed within the concept. This transformation concept aims at emphasising developments within supply systems that enforce transition, upheaval, imbalance or evolution of new relations, patterns and coherencies. Insofar, transformations can be distinguished from linear developments like modification or optimisation of existing structures (Kluge and Hummel 2006). Important characteristics of social-ecological transformations are historicity, non-linearity, time-dependent structural interruptions as well as cross-sectoral and intricately linked effects (ibid.). To sum it up, social-ecological transformations interfere with continuously altering relations of natural and societal processes and result in new relations in processes of resource utilisation resp. processes of provisioning. By analysing knowledge, practices, technology and institutions as well as temporal and/or spatial modifications in structure and collaboration, social-ecological transformation can be identified.

2 Water Supply and Demographic Decline

Demographic decline is often narrowed down to declining population which is defined as decreasing number of people living in a certain area. But demographic decline as phenomenon of shrinkage also encompasses lower population density, trends of suburbanisation, increasing demographic ageing and changes in household structures (cf. Kaufmann 2005). The latter encompasses decreases in household size (resp. the number of household members) as well as an increase in the number of households in a certain area. The relationship between water supply and demographic decline is discussed in the following by the example of Germany.

Relevance of demographic decline to water supply

In urban and regional planning increased attention is paid to the overall population decline and especially to the problem of heterogeneous housing trends on the local level. Critical is the simultaneous existence of growing and shrinking populations on a large scale (East – West), but also on a smaller scale within a state, county or city. Especially in Eastern Germany plans to demolish apartments and modify areas for new users in cities with declining total population and decreasing population density are considered or even implemented, a process called '*Stadtumbau*' (Bundestransferstelle Stadtumbau Ost 2006; Lang and Tenz 2003). In the last years, it became obvious that infrastructures like those for energy, water, waste water or public transportation play an important role in this process, with regards to both, financial burdens (Just 2004) and to changes in demand for provision services (Koziol et al. 2006).

While disregarding the various facets of demographic decline, a simple proposition would be that less people demand less water, assuming that population size is the only explanatory variable for water demand. But the following examples from two federal states in Germany, Hesse and Saxony-Anhalt, show that this linear nexus can not be supported by empirical data.

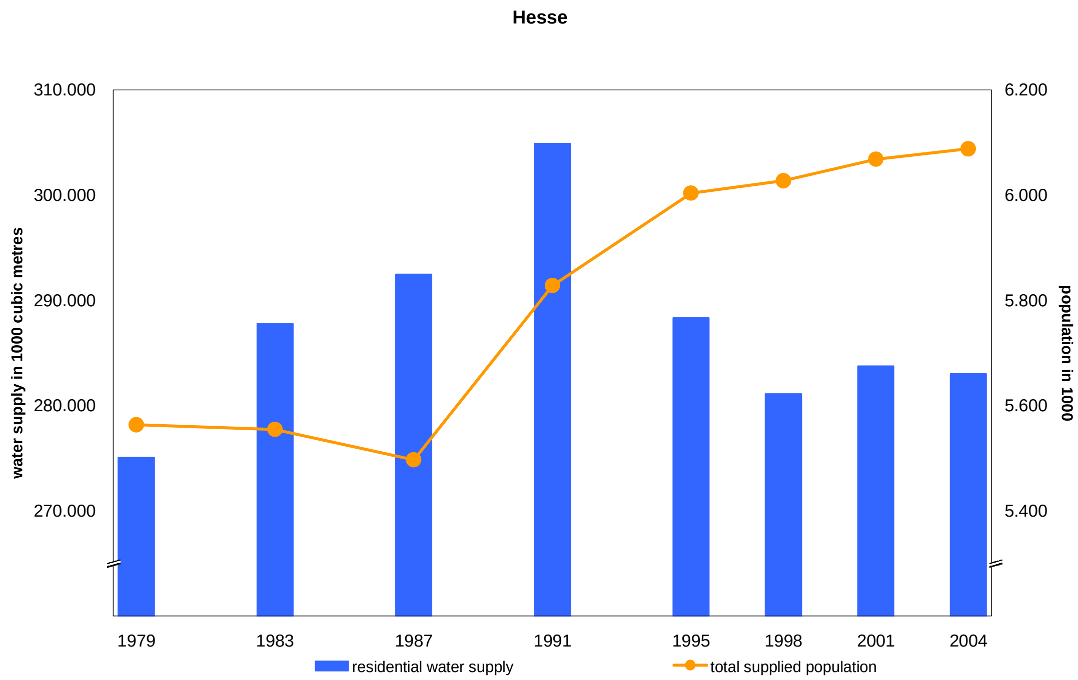

Figure 2 **Population (supplied for) and residential water consumption in Hesse**
Source: Lux (2007), based on data by Statistical Office of Hesse

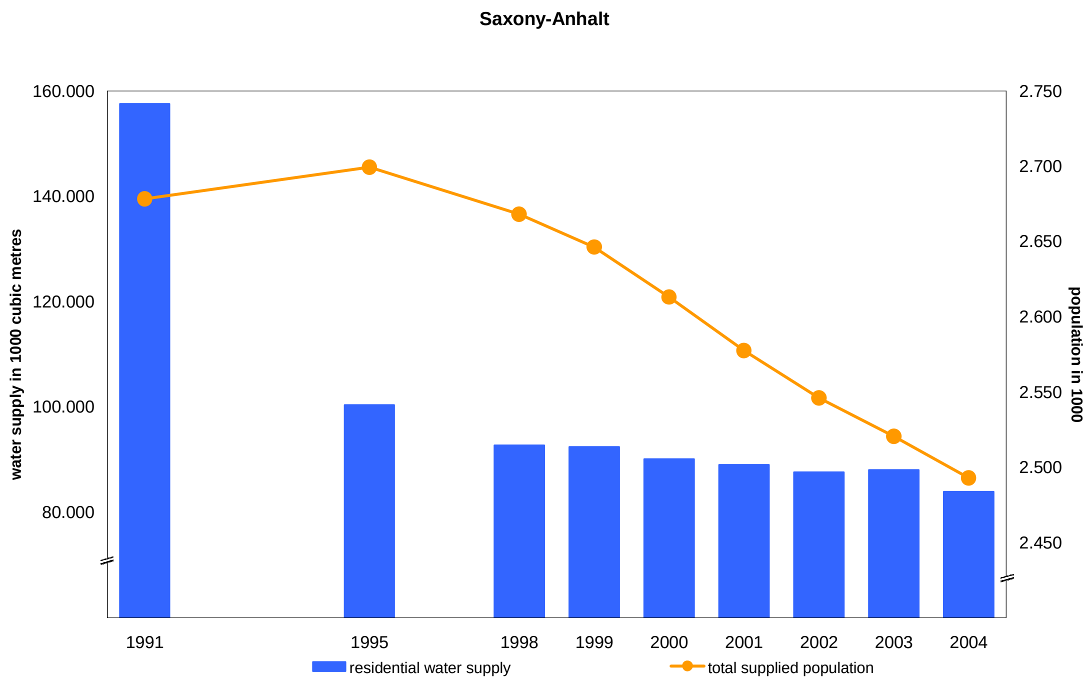

Figure 3 **Population (supplied for) and residential water consumption in Saxony-Anhalt**
Source: Lux (2007), based on data by State Statistics Office Saxony-Anhalt

While in Hesse the population declined slightly in the 1980's, residential water consumption increased at the same time. On the other hand, the population increased again in the 1990’s, but water consumption settled at a lower level. In Saxony-Anhalt residential water consumption also levelled off in the 1990’s, but the population decreased dramatically during this period. From this it follows that the simple assumption of a linear relationship between a decline in population and water demand does not account for existing complex relationships between the demographic decline and demand for provision. Further factors are determined by specific (per-capita) consumption as well as total water supply delivered by utility companies.

Green (2003: 222) distinguishes between technological, demographic and social resp. cultural aspects that influence individual patterns of water consumption and aggregated supply. Price-related, (socio-)demographic and behavioural factors as well as technical equipment in households are included in the first group. The second group relates rather to climatic and hydrological factors or issues of water management. Focussing on demographic aspects and settlement structures, various relevant demographic trends could be identified. They are summarised in the following table – considering today’s conceivable demographic trends of population decline in Germany and their impact on individual consumption patterns and total water supply by water utility companies. It is expected that conflicting impacts will arise, since both demand increasing and decreasing effects are identified.

Demographic trend	*Trend in Impact on Water Supply*
decreasing population	• reduces amount of water supply on aggregated level due to fewer consumers
decreasing household size	• increases water consumption on household level due to inefficient water use (e.g. with dishwashers)
increasing number of house-holds	• intensifies the effects of inefficient water use in smaller households (see above)
suburbanisation	• increases water supply in the surroundings due to population increase and eventually due to new water use patterns (e.g. gardening); but compensation because of more possibilities for alternative water sources like rain-water cisterns may occur • decreasing water supply in inner cities by virtue of population loss
declining population density	• increase of total water supply in some cases because of additional rinsing of pipelines (and sewers) to secure functionality of technical infrastructure • potential loss of economies of scale in water supply
demographic ageing and diversification of lifestyles	• effects depend on quantitative shifts in age composition, but have not been investigated sufficiently yet

Figure 4 **Summarised effects of demographic and settlement trends on water supply**
Source: adapted from Hummel and Lux 2007

Although we have seen above that population size is not an exclusive explanatory variable of water consumption, it has to be mentioned here. Less people use less water, *but* further demographic trends effect water demand on individual, household and aggregated levels – as well as the technological and behavioural impacts mentioned above.

Especially the trend to smaller households is contrary to reduced water demand, because of less water efficiency on household level related to losing household related economies of scale. While, for instance, a household with four persons or more could benefit from economies of scale, households with one to three members consume more water and produce more waste water per capita (Lenzen and Foran 2001). Björnsen and Roth (1993) pointed out that for Germany the reduction in household size between 1980 and 1990 caused an increase in water consumption by 3 liters per day and capita. An increase in the number of households intensifies inefficient water use in smaller households.

Additionally, shifts in the number of households are often associated with urban sprawl resp. suburbanisation, which in sum effect the water supply due to the need for new pipeline grids in development areas of the surrounding countryside (Bölting 2004, Boberg 2004). Thus, changes in population distribution and settlement patterns inter alia due to intra- and interregional migration are important to structure and organisation of water infrastructures – especially, because demographic decline as reverse side of suburbanisation in inner-cities is often associated with decreasing population density. This is enforced by declining fertility rates. At first, diminishing water consumption in inner cities can be expected. Adoption of physical infrastructure (pipeline grid and its regulation) is necessary if demolition of buildings takes place like outlined above for the process of *Stadtumbau* in Eastern Germany.

With more heterogeneous patterns in demographic development and settlement on a small scale, problems of decreasing population density intensify: If declining fertility rates and interregional migration gets meshed with small-scale suburbanisation, under-utilisation of water infrastructures could occur simultaneous with further need of infrastructure (and further demand) in the surrounding countryside (Kluge et al. 2006a). Spatial distribution of hot spots and cold spots of demand changes with urban sprawl (Monstadt and Naumann 2004).

Additionally, with more settlement in the surrounding countryside, new patterns of water use and purposes can arise. Especially gardening and related irrigation has to be mentioned as further source of water demand. But it remains to be seen, whether this additional demand or other water use purposes like toilet flushing can be met by alternative water sources like rainwater cisterns or private wells.[2] If a water utility company operates in inner cities as well as in the surrounding countryside, it faces the challenge of shrinking and growing settlement patterns at the same time.

While effects of changes in population size and density, household size and number as well as impacts of suburbanisation processes can be qualified regarding their relevance to water demand and consumption, there is not enough evidence of impacts on water consumption by demographic ageing. Nevertheless, significant changes in water consumption can be expected as the percentage of elderly people in society increases. Corresponding studies provide antithetic results: While Lyman (1992) shows for some western states in the USA that adults use less water than children but more than teenagers, outcomes for the Netherlands indicate that water demand is a function of age that has its maximum at the group of '18 to 24 years' (OEDC 2002). Russac et al. (1999) recognise also household size and structure and argue for the UK that retired persons have a 70% higher consumption of water than adults at working age, both living in a single-household. Reasons are seen in spending more time at

2 Water statistics show that per-capita water consumption in urban areas is higher than in rural areas. Against this background, the practical relevance of alternative water sources in suburbs and rural areas can be assumed.

home and age-specific diseases (e.g. diabetes, incontinence) resulting in more water consumption, personal hygiene and washing clothes (see also Green 2003: 224, Memon and Butler 2006). In the case of Germany, no comparable research is currently available, but all international studies indicate, that quantitative effects of demographic ageing for aggregated water supply depend on shifts in the proportion of the elderly in relation to shifts in the proportion of younger people. Furthermore, is has not been sufficiently investigated how changes in water use patterns are indicated by diversification of lifestyles and an ethnic-cultural heterogeneity resulting inter alia from foreign immigration. Again some indications can be obtained from the Netherlands: Dalhuisen (2003) shows that large differences in the population structure of Amsterdam compared to other areas in the Netherlands are in part explanatory for Amsterdam's residential water consumption above the Dutch average.

Implications for Infrastructure

The section above provided evidence for the relevance of demographic development and change of settlement patterns for water supply. Nevertheless, technical, ecological as well as economic implications for water infrastructures cannot be understood without knowing that there is a continuous general trend to reduced water consumption in Germany since the 1980's: While per-capita water consumption in 1983 was 147 liters per day on average (former territory of Germany), in 2004 averagely 126 liters were consumed per capita and day (Federal Statistical Office 2006). As seen in the case of Saxony-Anhalt, in the last decade the reduction in water consumption was significant and in some municipalities under-utilisation is obvious – just because infrastructure grids are designed for flows of averagely 150-250 liters per capita and day (Koziol et al. 2006, Kluge et al. 2003: 42). A meshwork of related effects occur that cause under-utilisation of infrastructures and already show restrictions in functional capacity and related costs (see in detail Lux 2007, Kluge et al. 2006, Koziol et al. 2006, Leist 2004 and Tietz 2003 for the German case).

Main issue from an economic point of view is the cost effectiveness of under-utilisation which results in sum from interlinked (socio-)demographic impacts as discussed above, but also behavioural and technological impacts on water consumption. Conceivable increase in both, cost of operation and cost of capital result from technical measures and investments to avoid loss of quality as one consequence of under-utilisation and investment needs for modernisation and rehabilitation of infrastructure but also for extensions to the suburbs and simultaneous reduction network capacities in shrinking areas (e.g. reduction of internal diameters or demolition of parts of the grid). Against this background average unit costs rise, especially fixed costs that account for about on average 80% in water supply, and turnover in supply companies are reduced due to sales deductions. If population size decreases the average cost per capita for the supply of water will rise subsequently – and thereafter prices for drinking water by virtue of cost recovery. Increase in prices on the other hand could lead to further reduction in individual or household water consumption as consequence of water price elasticity. Consequential, at least three associated feedback loops can be identified that are outlined in the following figure (cf. Libbe and Moss 2006, Bernt and Naumann 2006, Kluge 2005, Schiller and Siedentop 2005, Haug 2004, Just 2004).

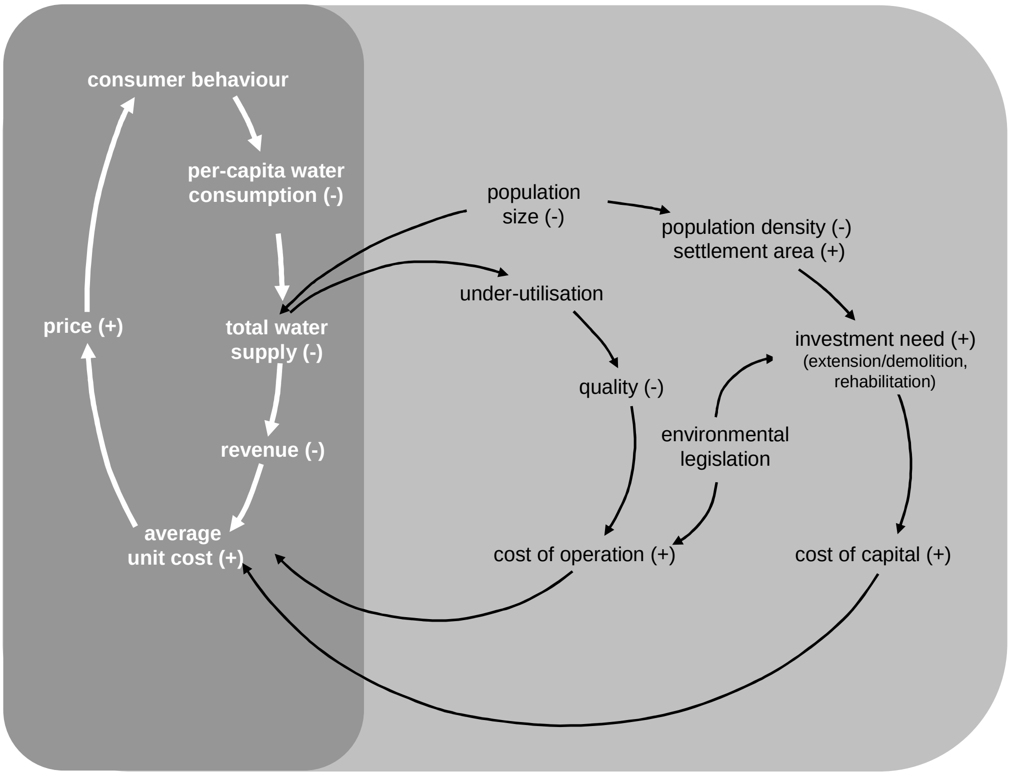

Figure 5 **Feedback loops of reduced water consumption**
Source: Lux (2007)

With respect to the introduced interdisciplinary concept of supply systems, demographic change, consumer behaviour, under-utilisation of infrastructure and developments in costs and prices within these feedback loops are identified as part of the mediating elements in supply systems (knowledge, practices, technology and institutions). The outlined problem situation in the context of demographic decline and water supply is characterised by path-dependency in the technical infrastructure and subsequently in the economic basis of supply on the one hand, because pipelines are durable and water supply is capital-intense. On the other hand, demographic change and consumer behaviour are critical drivers of transformations within supply systems, which also effect natural resources (e.g. rising groundwater tables or water protection areas, see Lux and Hummel 2007). The interaction of both calls for regulation in order to break through the cost-price-loop. Therefore, regulation must consider existing feedbacks carefully as well as potentially new feedbacks triggered by regulation as (non-)intended impacts (Hummel and Kluge 2006).

3 Adaptivity in Future Design of Supply Systems

Regulations based on traditional infrastructure policy developed in the 1960s for example by Jochimsen (1966) and others are build upon the assumption of market failure (public goods, externalities). They focus on governmental provision respectively governmental control of provision activities, especially for infrastructures like water, sewage, energy, public transport etc., for ensuring proper allocation of resources, market integration and macroeconomic growth. The economic-political debate of the last decades indicates a regulatory shift, culminating in privatisation, commercialisation and liberalisation in several sectors. But what does this mean on the local level? Problems or crises of provision occur on the local level and often affect not just one sector. As seen above, development of infrastructure is closely linked to settlement patterns and demographic changes. Until recently, only little attention was paid to ecological issues, but as outlined in the theoretical concept, natural resources as well ecosystems are prerequisites for providing for the population and it is obvious that resource scarcity – may it be in a quantitative or qualitative manner – can also lead to problematic situations. Vice versa, transformations in resource utilisation can effect natural resources.

Against this background and for developing regulative approaches, governance concepts that recognise the relevance of institutions, different forms of knowledge, technology and practices become significant. Hummel and Kluge (2006) conclude: Every social-ecological regulation refers to the interaction of societal, natural and technical processes and must consider positive and negative feedbacks. Feedbacks are twofold here: Firstly, because they describe (non-linear) system immanent linkages. Secondly, they are adapted as regulatory instrument with respect to informational feedbacks that allow the monitoring of (non-)intended consequences triggered by regulatory measures.

To make this kind of monitoring effective, adaptivity on different levels is necessary. As seen in the example above, technical and economical path-dependency make it difficult to adapt supply systems to challenges raised by interactions of demographic development and changes in consumer behaviour. Regarding this and the limits of sectoral approaches, future shaping of supply systems could be more sustainable when considering adaptivity on a technical, institutional and behavioural level together with ecology, society and economy as dimensions of sustainability (Hummel and Lux 2007, Kluge et al. 2005).

Performance indicators could be an instrument to support such a monitoring system, which cover processes of change, their impacts and general conditions of operation. Such instruments are well known in the business sector as part of internal controlling. To continue the systematic approach to regulation of supply systems, it must be recognized that there are several actors, like water utility companies, several departments of the local government and consumers, that influence transformations in supply systems. This calls for accountability on different levels: First, objectives of regulation must be defined in an open and participatory process.[3] Second, on basis of an impact assessment, critical points of regulations, decisions or general conditions, which might achieving the objectives put at risk, can be identified and incorporated into the monitoring system. Such a set of indicators has not an end in itself, but allows transparency to all involved actors and the public. Simultaneously, it is an instrument that is open to actor-specific interpretation and yields from their inputs.

In Sweden such a system was implemented (cf. Winkler 2005): 'VA-Plan 2050' connects short-term corporate management with a long-term strategy for the water sector on the local level. The latter is developed in cooperation with municipality and operating company but also further groups or persons concerned are involved. General aims are threefold: a continuous improvement processes in performance of operation, establishment of a control instrument for administrative management and implementation of an information instrument to the public. Accordingly, efficiency and sustainability objectives are represented by significant indicators. The possibility for municipality and utility company to agree on ideal values that derive from a long-term strategy is of vital interest. From comparison with actual values, action plans are decided jointly. Furthermore, strategic objectives can be adopted continuously against the background of experiences, new technological options, legislation amendment or economic change.

4 Uncertainty of Future Planning

Adaptivity as discussed above is one way to deal with uncertainties of future states and developments. Uncertainties in supply systems come alongside with long- and short-term dynamics. Past decisions and path-dependencies, especially in the area of material infrastructure, are difficult to rectify in the short- and medium-term. Challenge to future design of infrastructures is to identify the optimal size. In fact, establishing the 'optimal size' is anything but trivial. With respect to the interdisciplinary concept of supply systems, different sources of uncertainty can be identified.

First, fluctuations in water availability are possible. While – in order to continue the example – in Germany about 20% of available, renewable water resources are used for different purposes (BMU 2001: 7, StBA 2006c: 296), there is no doubt on sustainable water extraction as long as long-term average rates are observed. But this point of view does not consider temporal and spatial fluctuations of water availability (Kluge 2003). There is evidence that in the Alps and in Central German Uplands precipitation is higher than evaporation, while in East-

[3] Regulation in this context could also encompass finding strategic solutions and action plans for facing a specific problem situation. Referring to the example above, possible strategies could be in finding technical alternatives for water supply on decentralised level or implementing coordinated plans between urban development, infrastructure development and business development.

ern Germany it is the exact opposite (Zebisch et al. 2005: 47f.). Furthermore, seasonal changes in water flow (e.g. in summer) but also medium-term variability between wet and dry periods are relevant to secure the water supply. In the long-term, climate change does also effect water availability as the most recent IPCC-reports show (IPCC 2007a, 2007b). Nevertheless, local impacts of climate change – that are vital for water supply – disperse highly geographically and temporally as first studies show (e.g. HLUG 2005, Arbeitskreis KLIWA 2006). Against this background the ecological basis of supply is not as certain as it may seem.

Second, uncertainty arises when it comes to the prognosis of future water demand. This kind of prognosis is important for planning and investment decisions, because some technical components, esp. the pipeline grid, are being maintained for about 40 to 80 years. As seen above, water consumption can alternate faster as technical infrastructure could adapt. Such a forecasting problem can relate to demographic change, rather to migration than to changes of fertility or mortality because of migration’s strong political, economic and social background and its immediate impact. Furthermore, individual water consumption patterns are – especially for the German case – not sufficiently investigated yet for solid forecasts on residential water demand. In particular, for long-term and small-scale forecasts, socio-demographic development, technical development on household-level as well as other behavioural changes are most relevant.

As Green (2003) points out, uncertainty is intricately linked with decision making. It is based on wrong assumptions on future developments and relationships, inadequate data or measurement errors as well as surprising developments that could not be foreseen in advance. And it is obvious that not all of these uncertainties can be managed by expanding research or computational modelling. Stressing systemic perspectives, adaptive management approaches are seen as one possible way out (e.g. Holling 1978, Gunderson and Holling 2002).

With strong emphasis on (strategic) decision making on municipal level Kluge et al. (2006b, 2005) introduced an adaptive instrument which focuses on choices between alternative actions concerning infrastructural development. Four steps of decision making are defined, which are integrated in an iterative process.

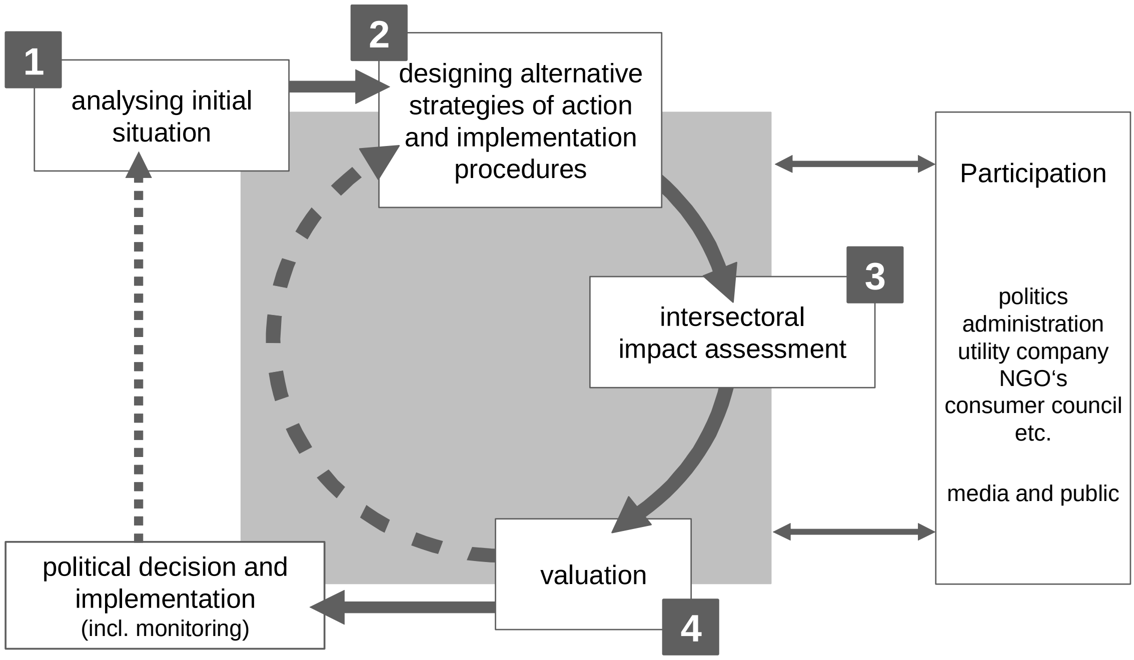

Figure 6 **Adaptive Management Approach to Development of Infrastructure**
Source: Kluge et al. (2006b: 35)

The adaptive management approach by Kluge et al. (2006b, 2005) starts with an analysis of the initial situation that also covers general conditions. This first step aims at identifying context-specific problem dynamics on the one hand and assembling views of different actors concerned on the other hand. By doing so, distinguishing or collaborating objectives and interests of different actors come to the fore, but also first communication on possible interventions or strategies of action may occur. A systematic merge of objectives and alternative strategies is part of the second step that is followed by developing procedures for the implementation of different strategies. Thirdly, an impact analysis is scheduled that not only covers impacts on the water sector but on the local level as a whole. Potentials, restrictions and unintended impacts are investigated. Uncertainty of future developments and incomplete knowledge can be explicated here. The fourth step, a step of valuation, compares the different alternatives. Adaptivity and sustainability may be crucial as criterion here, but also a comparison of meeting overall objectives and results of the impact assessment. If there is no sufficient strategy in the decision making process so far, there is a feedback loop into step two. If the process identifies an adequate strategy, the political process of implementation can follow. Implementation is accompanied by a monitoring system as discussed above that might detect changes that call for adaptation. If new strategic orientation is needed as part of the adaptation, the process of decision making will start again in similar way. But it has to be mentioned here, that the process of decision making is discussed here in an ideal way, while implementing it might incorporate inconsistencies.

To sum it up, this process is designed transparent and accountable, participatory openness is part of the game, but phases of openness and closeness are provided to strengthen adaptive regulations – in particular in case of high uncertainty. Against this background, the implications of adaptive management and the relevance of demographic decline as discussed above, utilities and infrastructure can not be longer discussed in terms of growth in regional and urban planning. Under the current and expected future demographic development, these growth-oriented plans need to be critically scrutinised – not only by substituting the assumptions of growth with a paradigm of shrinkage, but by taking occurring transformations in supply systems as chance for reconsidering.

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